

UNIVERSITY OF KWAZULU-NATAL

**CHALLENGES IN GREEN SUPPLY CHAIN MANAGEMENT IN THE PULP
AND PAPER INDUSTRY: A KWAZULU-NATAL CASE STUDY**

**A dissertation submitted in fulfilment of the requirements for the degree of
Master of Commerce**

By

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2017

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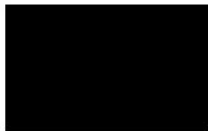
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ACKNOWLEDGEMENTS

I would like to thank the Almighty for His wisdom, strength and guidance through this journey, it was not an easy one but by His grace, I have made it.

To my supervisor thank you, your patience and guidance made this Masters journey bearable.

To my family for the support financially and spiritually, thank you!

My friends Nyasha and Babongile, you gave me a place to stay and drove me around as I conducted my data collection, you are greatly appreciated.

ABSTRACT

Although, the pulp and paper industry makes a substantial contribution to South Africa's Gross Domestic Product (GDP) it is also considered to be a major contributor to industrial pollution. As a result, various stakeholders have voiced their concerns forcing companies within the industry to seek alternative practices that support more environmentally friendly operations. This study sought to establish the impact of the industry on the environment as well as the green practices being implemented in the KwaZulu-Natal operations of a pulp and paper company to reduce this impact. The literature consulted for this study suggested that stakeholders such as customers, suppliers, activists and government, may influence a supply chain to become more environmentally friendly or may hinder its efforts to do so. These stakeholders were subsequently identified and their influence assessed. In many other industries, the integration of lean and green supply chain practices results in less operational waste and environmental harm because both paradigms support waste minimisation and both engage employees in continuous improvement. This research suggested ways in which these paradigms might be considered in a more holistic way to exploit possible synergies for the pulp and paper industry. The research was exploratory in nature and a case study approach was used. The transcripts of semi-structured interviews with senior managers in the chosen pulp and paper company were analysed in combination with secondary data. This direct content analysis provided insights into the current green practices of the company and the influence of stakeholders. Evidence was presented on the company's considerable progress towards a greener supply chain through the introduction of appropriate technology and practices which mitigate its effect on the environment. Stakeholders played a significant role in enabling the company to achieve this. Customers demand certification by standards bodies such as the Forest Stewardship Council and the International Organisation for Standards regulates the industry and ensures that it protects the environment while local communities use waste produced by the company to produce value-added products. However, some suppliers hinder these efforts. It was concluded that the further integration of lean and green practices will allow the company to continue to reduce its impact on the environment.

Keywords: green supply chain management; pulp and paper; lean and green practices

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CHAPTER 1: INTRODUCTION

1.1 Introduction

Mollenkopf, Stolze, Tate and Ueltschy (2010: 14) observed that, “three supply chain trends are converging to create an increasingly complex business environment: a move towards green initiatives, the utilization of lean processes and globalization”. These three elements pose challenges to supply chain managers because they often appear to be in conflict. There is pressure from customers to reduce carbon emissions while globalisation encourages international sourcing with associated increases in transportation. Lean requires reduced inventory and short lead times while good environmental practice may require infrequent bulk delivery of materials. Globalisation has put enormous pressure on organisations to reduce costs while quickly bringing a greater variety of products to the market yet today’s customers also expect businesses to demonstrate social and environmental responsibility. Dhingra, Kress and Upreti (2014: 1) commented on the importance of industrial activities in enabling the development of mankind. However, these activities unavoidably cause environmental harm and businesses are challenged to develop appropriate technologies that enable the growth of industry but do not exceed the ecosystem’s carrying capacity (Gibbs and Deutz, 2005: 453; Dhingra et al., 2014: 1).

Harrison and van Hoek (2011: 23) defined the triple bottom line as “a way of considering environmental issues, social values and the business decisions contributing to economic value.” Similarly, Winter and Knemeyer (2013: 22) referred to the triple bottom line as the 3P’s of sustainability: people, planet and profits. Green supply chain management (GSCM) focuses on reducing the environmental impact of business activities while lean is a management technique that aims to increase economic value for stakeholders through reducing waste and eliminating non-value adding activities (Nightingale, 2005: 3; Johansson and Sundin, 2014: 104). Lean was described by Dües, Tan and Lim (2013: 98) as providing a sound basis for the implementation of green practices. Bashkite and Karaulova (2012: 345) also mentioned that integrating green and lean thinking will redefine lean techniques from an environmental perspective. This will enable manufacturers to meet modern market demands. According to Dhingra et al. (2014: 2), “in this era of increasing environmental responsibility it makes good business sense to implement green initiatives in addition to lean ones.”

Lean and green paradigms have much in common but there are some contradictions which may require a compromise. As cited by Martínez-Jurado and Moyano-Fuentes (2014: 140), several studies have agreed that lean might conflict with environmental performance in certain areas. Lean considers the environment as a resource to be fully utilised, while green considers the environment as a scarce resource to be used wisely. However, lean may create significant opportunities for environmental progress as it promotes waste reduction and continuous improvement.

This study assessed the green supply chain practices at a pulp and paper company in KwaZulu-Natal, South Africa. The potential role of lean as an enabler of supply chain greening was considered, as both paradigms support waste elimination and should consequently result in cost savings while improving environmental performance.

1.2 Background to the study

When economic growth occurs, the level of energy and material consumption increases, and thus environmental and social burdens increase. Internationally, the pulp and paper industry is regarded as a major contributor to pollution (Galeazzo, Furlan and Vinelli, 2014: 191; Ince, Cetecioglu and Ince, 2011: 223). Rizvi, Shafi and Khan (2012: 528) advocated the need for industry to adopt sustainable practices. They highlighted that most of this industry's contribution to carbon emissions is from the logging and paper manufacturing processes (87.3% of the pulp and paper industry's emissions). The World Wide Fund for Nature (WWF, n.d.: 1). Similarly, a Food Agricultural Organisation of the United Nations (FAO) report (2010: 17) stated that the manufacturing of forest products results in a net release of greenhouse gases from manufacturing facilities despite plantations serving as carbon sequestration facilities.

Firms have responded to globalisation, which comes with challenges that entail different environmental regulations. Despite lean being well-established, the rising concern with sustainable practices has increased the interest in some industries in the synergy between lean and green. Lean supports waste elimination to achieve cost savings, while green is concerned with environmental conservation for future generations. Adopting the two paradigms simultaneously is a strategy to remain competitive while achieving sustainability, especially in the pulp and paper industry. Forests are widely acknowledged as essential for regulating water

cycles and mitigating climate change. Consequently, it is crucial to meet the increasing demand for paper from sustainable forests managed using sustainable practices.

According to Dües et al. (2013: 98) and Martínez-Jurado and Moyano-Fuentes (2014: 139), lean and green have complementary core principles namely waste reduction, people and organisation, lead time reduction, supply chain relationships, key performance indicators (such as service levels) and tools/practices (such as value stream mapping). Despite the differences between the two paradigms, they share some similarities that can facilitate a synergistic relationship to improve performance of the company and preserve the environment (Dhingra et al., 2014: 3). Helldal, Tenne and Lindahl (2009: 1) stated that the integration of the two concepts will “strengthen lean on aspects where it has been considered to be weak”, particularly the view that the environment is a valuable resource to exploit when in fact the environment is a constraint. The simultaneous pursuit of lean and green supply chain initiatives resolves these conflicts by seeking practices that satisfy both economic and environmental goals.

The lean and green topic is relatively new and lacks a clear theoretical understanding; especially the use of the two paradigms interdependently. Nonetheless, results from previous research suggest the two paradigms overlap and achieve cost savings and environmental conservation (Pampanelli, Found and Bernardes, 2017:21; Dües et al., 2013: 93). Therefore, this study aimed to gain insights into how integrating the two paradigms will yield cost benefits and how environmentally sustainable lean initiatives may be implemented in the pulp and paper industry.

1.3 Research problem

Green thinking has become a necessity for companies to survive in the global market place where consumers now choose to associate with companies that are seen to be environmentally responsible. The pulp and paper industry has been identified as a key polluter and is under pressure from various stakeholders to reduce its emissions and its use of natural resources, such as water. While South African paper producers are actively pursuing greener practices, there may be further opportunities based on international practice. The lean management approach may offer tools which will assist the pulp and paper industry in improving its environmental performance.

1.4 Research questions

- What has been the impact of the pulp and paper industry on the environment and which green supply chain practices are currently being implemented to reduce this impact?
- How do stakeholders (suppliers, customers, community and government) influence the achievement of a green supply chain in the pulp and paper industry?
- How can lean practices be a catalyst for greening the pulp and paper supply chain?

1.5 Research objectives

- To evaluate the impact of the pulp and paper industry on the environment and to ascertain which green supply chain practices are currently being implemented to reduce this impact.
- To assess the influence of stakeholders (e.g. suppliers, customers, and government) on the achievement of a green supply chain in the pulp and paper industry.
- To suggest how lean practices could be a catalyst for greening the pulp and paper supply chain.

1.6 Conceptual framework

A conceptual framework was developed to demonstrate the proposed linkages between the research questions which have been posed.

The first research question interrogates the impact of the pulp and paper industry on the environment. This impact arises from the practices of the entire supply chain of the industry, from suppliers to customers. Furthermore, it is proposed that this impact may be mitigated by the introduction of greener, or more environmentally friendly, practices. The theory referenced for this part of the framework includes that of green supply chain management (GSCM) as well as literature which describes the negative environmental effects of the industry.

The second research question interrogates the role of stakeholders, and the proposal that these influence the focal pulp and paper company and enhance or hinder its ability to improve its green supply chain practices. Literature which investigates these influences on the supply chain was consulted.

The third question introduces lean supply chain management as a potential technique to reduce waste and thereby enhance efforts to attain a greener supply chain. Lean supply chain literature,

with reference to the relationships between lean and green, was accessed to respond to this research question.

The framework applied in this study was adapted from two particular sources. Seuring and Müller, (2008: 1706) saw stakeholders as influencing supply chains to adopt sustainable practices while Azevedo, Carvalho, Duarte and Cruz-Machado (2012: 756) were concerned with the influence of supply chain practices on the sustainable development of businesses. Linking these two frameworks in the pulp and paper supply chain, while focusing on the environmental aspect of sustainability, encompasses the scope of this research project. This conceptual framework is shown in Figure 1.1, with sustainability outcomes that fall outside the scope of this study greyed out.

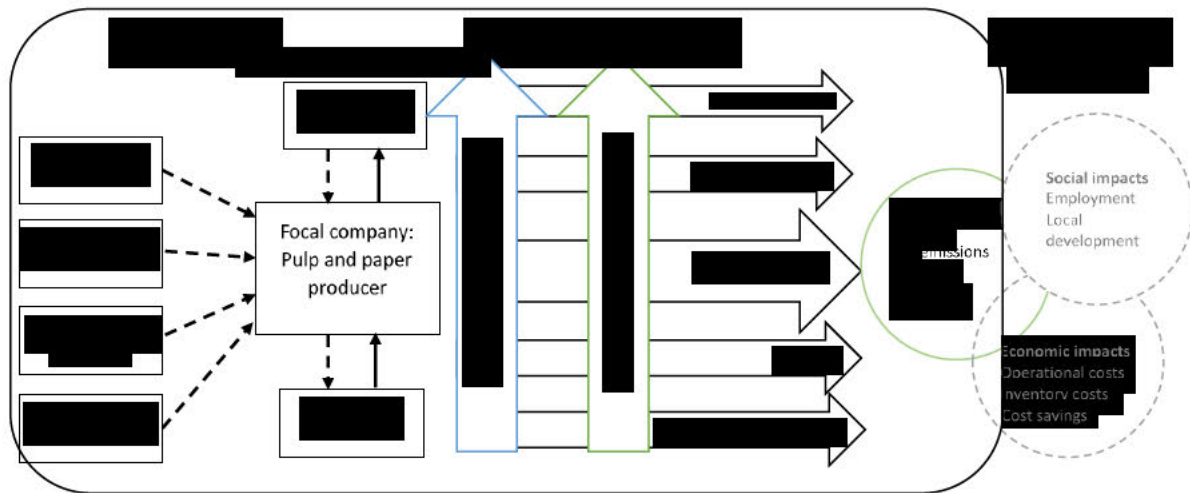


Figure 1.1 Conceptual framework (Source: Adapted from Seuring and Müller, 2008: 1706 and Azevedo et al., 2012: 756).

This framework can be simplified to show the essential elements as seen in Figure 1.2.

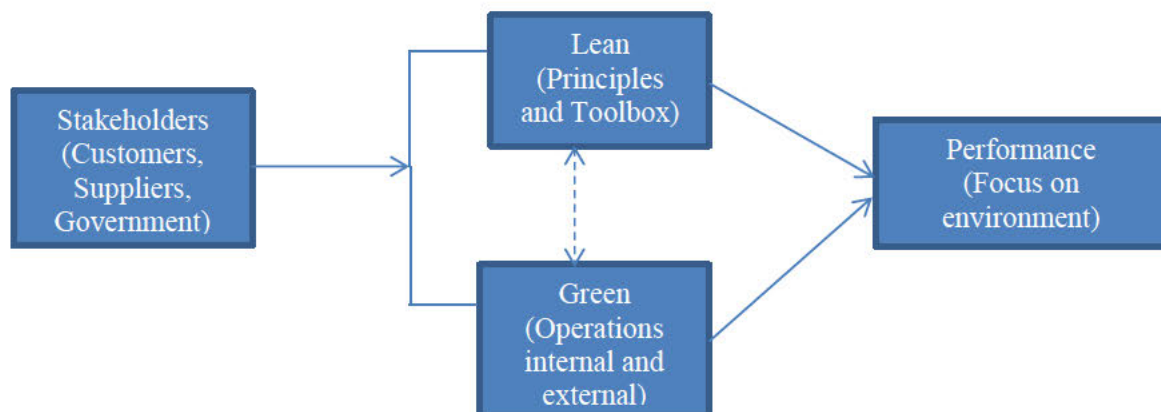


Figure 1.2 Essential elements of the conceptual framework (Author's own work)

1.7 Overview of methodology

The study was exploratory research as not much was known about the progress made towards a greener supply chain in the pulp and paper industry, particularly in the context of the South African paper industry. This research was not expected to provide conclusive solutions but to explore possible relationships which might provide avenues for future research towards a more sustainable supply chain for the industry.

Qualitative data was collected using both primary and secondary sources. Secondary data, mostly for the literature review, was gathered from journal articles, textbooks and online articles. Primary data was collected through semi-structured interviews using interview guides which provided the researcher with discussion topics linked to the research questions. The population of company staff was purposively sampled to engage four participants. These were the heads of departments from four sections in the selected pulp and paper company. They were best placed to answer the researcher's questions based on their experience and their positions.

The data recorded during the interviews was then converted into transcripts which were then analysed using conventional content analysis. This enabled the researcher to identify themes from the secondary data, while allowing new categories and codes to emerge from the primary data. These codes gave the researcher insight into how the secondary data were related to the practical side of the pulp and paper business. The practices which are implemented at this company as well as the benefits derived from them were assessed.

1.8 Significance of study

The pulp and paper industry has been identified as a major source of pollution and one with high levels of competition. Most paper companies have been working towards reducing their impact on the environment. As a result, the aim of the study was to analyse progress made thus far with companies in the industry and also to investigate how applying lean may assist pulp and paper companies to improve their environmental performance.

To the best of the researcher's knowledge, this study is one of the few studies with reference to lean and green in the pulp and paper industry in South Africa. Hence this study is regarded as an addition to the body of knowledge. The study is likely to help the pulp and paper industry

to realise that lean and green could reduce their impact on the environment while realising the cost savings normally associated with lean supply chain management.

1.9 Justification

Failure to have conducted this study would have left a gap in the body of knowledge concerning how the two concepts may produce good results for the paper industry. Some researchers (Azevedo et al., 2012; Reyes, 2015; Dües et al., 2013; Johansson and Sundin, 2014) have mentioned that the body of knowledge does not include much information concerning how integrating the two concepts can achieve synergies that will provide positive results. This study attempts to bridge the gap in the body of knowledge of the two concepts and shed new light on the topic, as well as providing another platform for those that wish to conduct further studies in this field.

1.10 Ethical considerations

Ethical considerations, such as privacy, anonymity and informed consent, are important and should be observed. The researcher ensured that privacy was maintained throughout the data collection process. Ethical approval for this research was obtained from the University of KwaZulu-Natal Ethics Committee and a gate keeper's letter from the pulp and paper company gave permission for the research to be conducted at the company. Furthermore, the researcher and the company signed a non-disclosure of information contract. The contract clearly emphasised the consequences should the researcher fail to comply and the university ethics department countersigned the agreement. The researcher obtained informed consent from respondents before interviews. This gave the participants the choice to participate or not based on an adequate knowledge of the study that they were provided with. Participants signed informed consents to continue with the interviews. They were all willing to answer any questions and thereafter to provide clarity on some issues which were not fully addressed in the interviews. Privacy and confidentiality was upheld: participants remained anonymous and any other private information that they deemed unfit to share with the public was withheld. The data collected will be kept for a period of 5 years by the researcher's supervisor.

1.11 Limitations and delimitations of study

The case study method was used in this research, and data was collected from only one company in the industry, to which the study was delimited. This limits the extent to which the

findings can be generalised to the population of companies operating in the pulp and paper industry. Furthermore, only two of the company's plants were included in the data collection process. Time and resource limitations hindered the researcher's access to the other plants which could have provided more information. Hence this delimits the researcher's results geographically to two plants in the KwaZulu-Natal region in which the participants were situated. However, the participants were chosen with regard to their positions so that the assumption could be made that they have extensive experience and have a clear understanding of the entire value chain.

Some limitations resulted from a shortage of journal articles, particularly on the third research problem in relation to lean practices in the pulp and paper industry. This was discussed in the literature review (Section 2.2.4). This may also be a result of large companies keeping information about their management practices confidential. Since the third research question was intended to be answered using the secondary data, the findings became largely speculative and conclusions were drawn from information on other industries.

Green supply chain management has only gained prominence in recent years and as a result when conducting primary research the researcher found that environmentally responsible practices are still being implemented. This means that the findings are not as stable as they might be with more established practices since they are likely to change over time.

1.12 Chapter overview

Chapter one provides the background and introduction of the study. It gives an insight into the research problem, identifies the research questions and describes the objectives set by the researcher that seek to answer the research problem. The chapter also gives an overview of the framework used to guide the research and an overview of the research methods used by the researcher to collect data. The ethical procedures observed by the researcher and the limitations that were encountered are described.

Chapter two presents a more detailed review of the available literature on the two practices (lean and green) and the pulp and paper industry.

Chapter three gives a detailed explanation of the research methods used to collect primary data. It informs the reader of the choice of target population, interview process, analysis of the data and measures taken to ensure the data collected was valid and reliable while also ensuring that ethical issues were taken into consideration.

Chapter four presents the data collected and summarises the data in a way that is easier to comprehend and draw conclusions from.

Chapter five discusses the data collected and what the literature contributes. It shows where there are discrepancies and reflects if the data collected (secondary and primary) achieved the set objectives.

Chapter six provides a conclusion to the study and also outlines recommendations on other approaches to be considered to achieve more with the two paradigms.

CHAPTER 2: LITERATURE REVIEW

The council of supply chain management professionals (CSCMP, 2015: 2) defined supply chain management (SCM) as, “the planning and management of all activities involved in sourcing and procurement, conversion and all logistics management activities.” This suggests that SCM extends beyond the boundaries of the focal company to include customers and suppliers as partners in the supply chain. This distinguishes SCM from operations management, which occurs within a single company. Firms must improve productivity and efficiency throughout their supply chain to remain competitive in the globalised market. The increasing attention on the environment has also required firms to change their supply chain practices.

2.1 From traditional supply chains to lean and green supply chains

Fu and Piplani (2004: 281) described traditional supply chains as characterised by functional and geographical silos which do not share information within the organisation and across the whole chain. This results in missed opportunities for increased value creation through collaboration. Traditional supply chains often operate on a push strategy, producing units to a production schedule determined by operating capacity, rather than responding to the pull of customer demand (Gunasekaran and Ngai, 2005: 426). Modern supply chains make use of networked electronic (smart) devices and technologies such as radio frequency identification (RFID) that enable visibility across the network. The entire supply chain can be integrated through technology, even beyond the point of sale, using data gathering and processing systems to enable quick decision making (Wu, Yue, Jin and Yen, 2016: 408). Figure 2.1 depicts the difference between traditional supply chains and modern supply chains which are more demand driven and “smart”.

The movement away from traditional systems has been influenced by uncertainty, growing competition, shorter product cycle times, more demanding customers and pressure to cut costs, which are just a few characteristics of the 21st century business environment (Stefanovic, 2014: 2). This is sometimes termed VUCA: volatility, uncertainty, complexity and ambiguity (Packowski and Francas, 2013: 131). Resta, Powell, Gaiardelli and Dotti (2015: 12) contended that the move towards modern systems is driven by the expectations of customers who now demand more than simply a product. The dichotomy between product and services is no longer clear-cut and the modern supply chain must operate on a product-service continuum, providing a greater range of benefits.

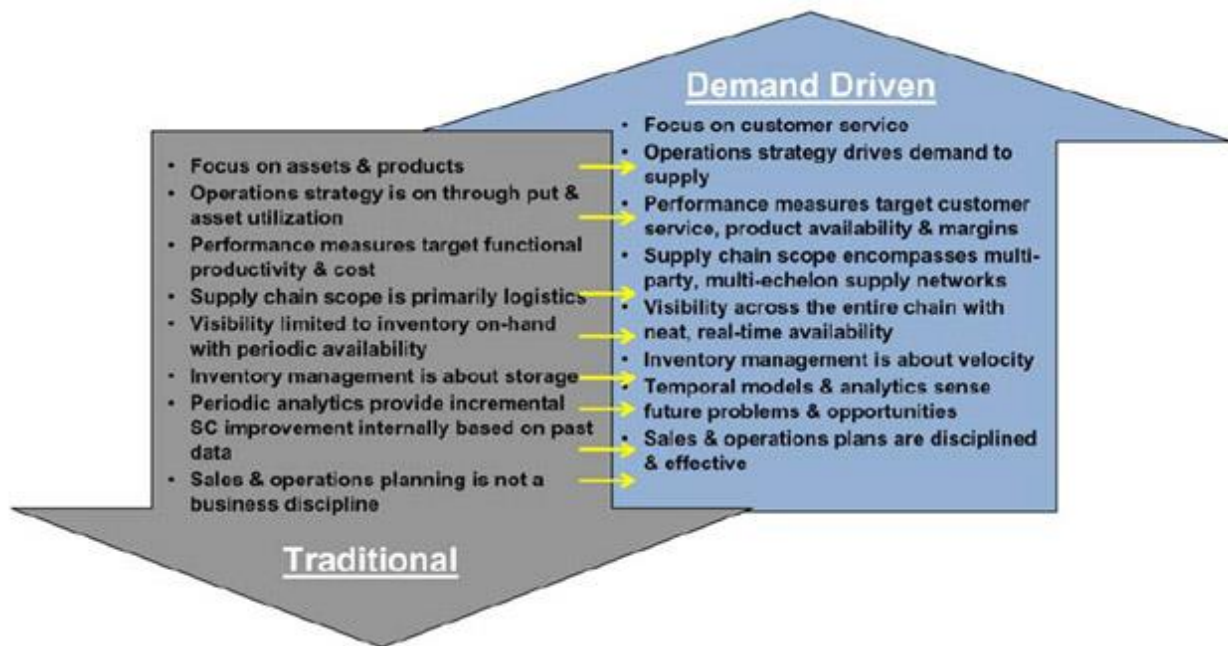


Figure 2.1: Traditional vs. Demand driven supply chain (Source: Nielsen, 2012: 4).

Mollenkopf et al. (2010: 14) identified three convergent supply chain trends: globalisation, lean processes and green initiatives. They found that firms seek low cost suppliers and new markets across borders while implementing world class manufacturing approaches to meet the needs of all stakeholders. Green supply chain management (GSCM) seeks to ensure that the impact of business activities on the environment is minimised.

The pulp and paper industry has been identified as producing harmful emissions, using toxic chemicals and engaging in other activities that are harmful to the environment. Setthasakko (2010: 318) contended that “the growth of the pulp and paper industry has been accompanied by an extensive negative impact on health, livelihoods, food security, the environment and natural resources. Without a wider commitment to corporate responsibility, economic growth will come at the expense of the environment and society.”

21st century supply chain stakeholders, which include consumers, suppliers and governments, demand that companies develop sustainable supply chains (Meixell and Luoma 2015: 69). Fahimnia, Sarkis and Eshragh (2015: 173) found that it is possible to achieve economic growth without increasing the burden on the environment and suggested trade-offs that must be made in supply chain planning. Governments have implemented policies such as carbon taxes to deter companies from contributing towards global warming.

Packowski and Francas (2013: 132) explained how supply chain management and advanced planning and scheduling techniques allow organisations to manage complex global networks. However, they suggested that the requirement for accurate forecasts well in advance of production dates limits the responsiveness of such organisations and suggested that integrating lean supply chain practices such as reduced setup time and end-to-end synchronisation can make process industries more responsive to variations in demand. This contradicts the view that lean supply chain management is only appropriate where uncertainty is low and demand predictable (Nel and Badenhorst-Weiss, 2012: 192). Purvis, Gosling and Naim (2014: 102) reconciled these two points of view with their contention that lean manufacturing systems can provide a high level of flexibility in the mixture of products they deliver while being highly inflexible in terms of volume. In spite of these arguments, some elements of lean systems can benefit most supply chains. These principles include information sharing across the supply chain, customer responsiveness and supplier development. Integrating lean and green will help practitioners to discover other practices that could conserve the environment while ensuring that costs are minimised.

2.2 The pulp and paper industry

The pulp and paper industry of South Africa is one of the highest value exporting industries in the country, producing approximately 2.3 million of tons of paper every year between 2013-2015 and exporting approximately 700 000 tons of this (PAMSA, 2015: 4). Of the approximately 2 million tons of pulp produced, over 50% is exported. The industry has also created jobs and helped alleviate poverty. According to PAMSA (2015: 3), paper consumption in South Africa is just under the world average at 50kg per capita. This includes printing paper, packaging and tissue. Despite rapid technological developments which reduce the need for printed documents, this shows that paper is still an essential product. In 2015 the pulp and paper industry contributed R5 billion to the South African economy's balance of trade (PAMSA, 2015: 2). However, conserving the environment is now a major concern, especially with the impacts of global warming and pollution.

2.2.1 Overview of the supply chain

The stages of the pulp and paper supply chain are shown in Figure 2.2 and are briefly described below.

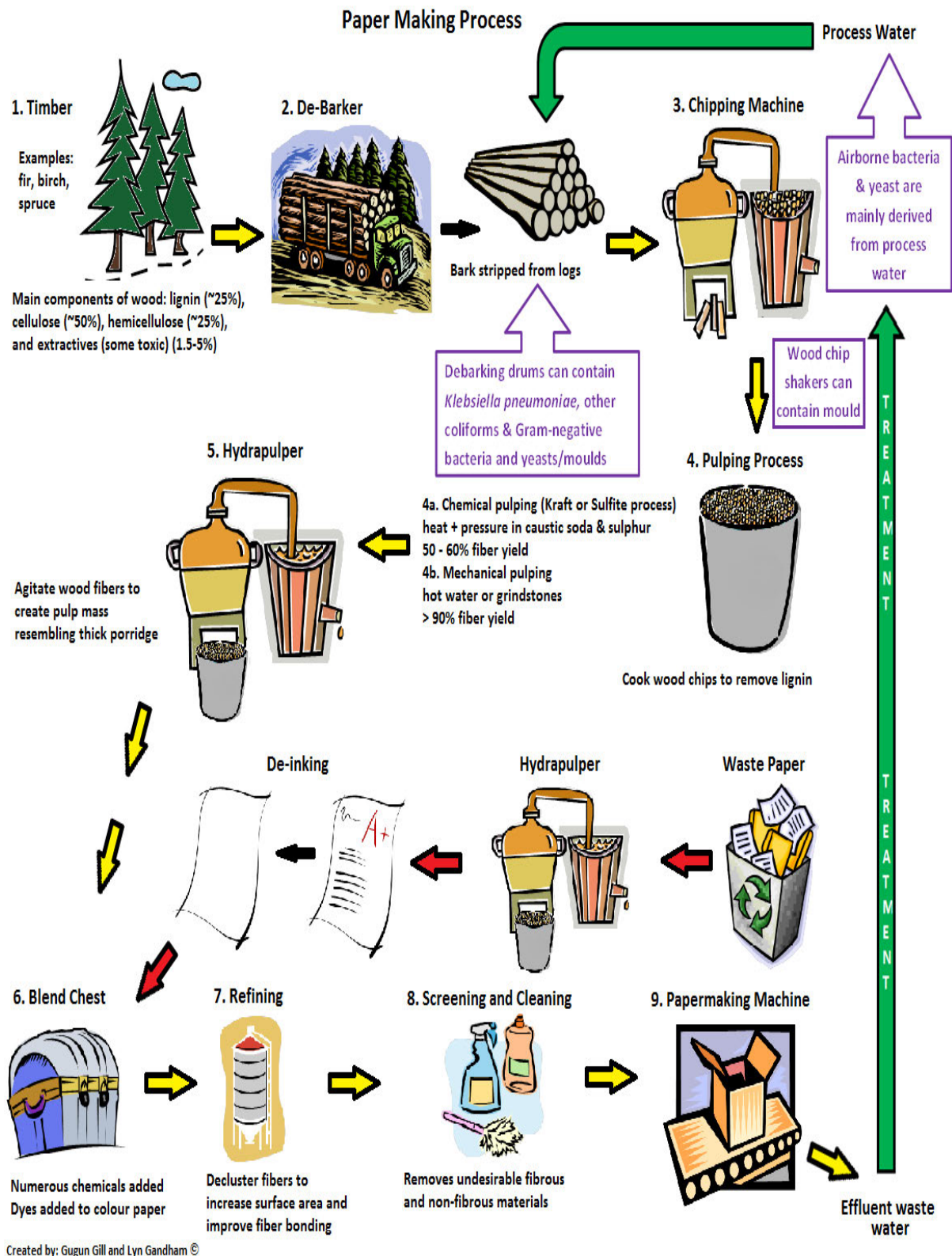


Figure 2.2: The paper making process (Source: Gandham, 2013: 4)

2.2.1.1 Tree production

The pulp and paper making process is a resource intensive process, with wood being used to provide more than 95% of the cellulose fibres required for paper products (Carlsson, D'Amours, Martel and Rönnqvist, 2009: 170). Eucalyptus (gum trees) and conifers (pine trees) are important sources of the pulp needed to make paper. In South Africa these are cultivated in plantations. When trees have reached the appropriate size, they are harvested and moved to the pulp mill.

2.2.1.2 Wood preparation: Debarking and chipping

The tree logs must be debarked and this is usually carried out by drum debarking. When the drum rotates, the logs rub against each other and the bark is removed by abrasion. This can be a dry or a wet debarking process. The debarked logs are cut into chips that are suitable for pulping (Environmental Protection Agency (EPA), 2010: 3).

2.2.1.3 Pulping

After debarking and chipping, the chips are used to produce pulp. EPA (2010: 3) explained that lignin must be removed to separate out the cellulose fibres. The most commonly used methods are chemical and mechanical. In chemical pulping the raw materials are processed using chemical solutions, high temperatures and pressure to extract pulp fibres (EPA, 2010: 3). Pulp from the chemical process is usually very strong and can be bleached to a high brightness (Chamberlain, Essop, Hougaard, Malherbe, and Walker, 2005: 20). This chemical pulp is used for fine papers (e.g. printing paper) and packaging paper (Sappi, 2011: 118). If a mechanical process is used, the raw materials are separated using physical energy: grinding with a grindstone or rotating metal discs known as refiners (Dudley, Stolton and Jeanrenaud, 1996: 20). However, pulp from the mechanical process is weaker than chemical pulp and yellows with age. Mechanical pulp is used for papers such as newsprint. The semi-chemical process is a combination of chemical and mechanical processes (Chamberlain et al., 2005: 22). Wood chips are softened with chemicals and then a mechanical process completes the pulping process (Beschkov, 2009: 147).

Approximately one million tons of dissolving pulp, also known as chemical cellulose, is produced per annum in South Africa and this is used for products other than paper, such as viscose (Sappi, 2011: 118). The cellulose textile and chemical industries are the main users of dissolving pulp (Chamberlain et al., 2005: 22).

2.2.1.4 Bleaching

Initially wood pulp is brownish in colour and it must be bleached to obtain white cellulose. According to EPA (2010: 4), the commonly used chemicals are pure elemental chlorine, chlorine dioxide, hydrogen peroxide, oxygen, caustic (sodium hydroxide) and sodium hypochlorite. Bleaching is a complex process consisting of several stages with washing taking place between chemical treatments.

2.2.1.5 Chemical Recovery

For environmental and economic reasons the pulp and paper industry has included a chemical recovery process (black liquor recovery) in their production process (EPA, 2010: 5). According to Harris, Riddlestone, Bell and Hartwell (2008: 1977) this process is designed to:

- Treat the black liquor to recover pulping chemicals
- Use organic non-cellulose material to generate energy for the pulp mills
- Recycle process water.

EPA (2010: 5) stated that the recovery process includes:

- Black liquor concentration: weak liquor from pulping process consisting of wood lignin, organic materials and oxidised inorganic is concentrated through a series of multiple-effect evaporators to form strong black liquor.
- Recovery furnace: black liquor is burnt in the recovery furnace and steam is recovered, which has a high energy and can be used for processes such as cooking wood chips.
- Causticising and calcining: white liquor is formed at this stage which can be recycled to the digesters in the pulping process.

2.2.1.6 Paper manufacture

At this stage the pulp is prepared by screening and cleaning to prepare for paper manufacture. After screening and cleaning, pulp slurry is created as the first stage taking place in the paper machine (EPA 2010: 6). This slurry goes through a press in which water is removed and then into the sheet forming stage of the process (Bajpai, 2012: 13). The formed paper sheet is put through a dryer and a sequence of booths for coating and dyeing (Mustapha Consulting Limited, 2012: 21). Finally, the finished product may go through a calendar to reduce thickness and to smooth the surface. At this stage paper, will be customised in terms of roll or sheet sizes, paper weight, colour and finish (EPA, 2010: 6, European Commission, 2015: 670).

2.2.2 Environmental impacts of the pulp and paper industry

Many industrial processes release harmful emissions into the atmosphere, soil and water. The pulp and paper industry is no exception to this. Dsikowitzky, Botalova, Illgut, Bosowski and Schwarzbauer (2015: 254) concluded that it makes one of the most significant contributions to water pollution worldwide. This is attributable to the use of harmful chemicals in its processes and the by-products of cellulose removal, such as lignin. The industry is energy-intensive; in many instances fossil fuels provide the energy source and the production of greenhouse gases results (Ashrafi, Yerushalmi, and Haghghat, 2013: 463). The gases released during the process include CO₂ (carbon dioxide), CH₄ (methane) and N₂O (nitrous oxide) and these have been implicated in global warming and damage to the ecosystem and human health (EPA, 2010: 6). Rizvi et al. (2012: 527) described the pulp and paper industry as a resource-intensive industry and listed its contributions to environmental problems including the degradation of the natural environment, carbon emissions contributing to global warming and toxic emissions which pollute the air, soil and water.

Ashrafi, Yerushalmi, and Haghghat (2015: 147) emphasised that the most pollutants and wastewaters are produced in the pulp and paper industry in the following stages: wood preparation, pulp washing, pulp bleaching and paper making processes as well as in the digester house where waste is processed. The contents and volume of wastewater and related pollutants produced depends upon numerous factors including the scale of production, raw materials and technology used. Below is an explanation of how each stage of the production of paper and pulp impacts the environment.

2.2.2.1 Tree production

The pulp and paper industry cultivates plantations of trees. However, this results in a loss of natural vegetation and may affect water supply (Karumbidza, 2006: 42). Plantations disturb water cycles, consuming water that could otherwise have flowed into streams and rivers. According to WWF (n.d.: 4), 12-15 million hectares of forest are lost each year, making deforestation responsible for 15% of all greenhouse gas emissions. Deforestation affects biodiversity, water cycles, soil erosion and human livelihoods.

Plantations have contributed significantly to the deterioration of the environment as a result of insecticides, herbicides and other chemical products used to promote growth. These cause soil and water pollution (Naidoo, Davis and Van Garderen, 2013: 8). Karumbidza (2006: 16) warns that contaminants in the soil may accumulate over time. This can affect biodiversity (variety

of species) above ground and in the soil where microorganisms form an essential part of the ecosystem. With the removal of cover, wildlife habitats are destroyed and animals become more vulnerable to hunting. Plantations eliminate most non-timber uses of forests crucial to communities.

Vehicles and equipment (chain saws) used when cutting down trees affect the environment with pollution including engine oil spills and exhaust fumes. Vangansbeke et al. (2015: 101) state that whole tree harvesting (which is practiced in South Africa) is unsustainable and results in plantations not performing the same role in the ecosystem as natural forests.

2.2.2.2 Wood preparation

The wet debarking process consumes more water than dry debarking. Organic compounds (fatty acids) which leak out of the bark are likely to contaminate water streams (European Commission, 2015: 63). This affects living creatures in rivers making the water uninhabitable (Ince et al., 2011: 227).

2.2.2.3 Pulping

Bajpai (2013: 1) explained that the pulping and bleaching steps in paper production generate most of the liquid, solid and gaseous waste due to the high consumption of water, chemicals and energy of these processes. In the generation of power to pulp wood, fossil fuels are burnt and greenhouse gases are emitted (Ashrafi et al., 2013: 463). CO₂ (carbon dioxide), CH₄ (methane) and N₂O (nitrous oxide) are some of the greenhouse gases released during the pulping process (EPA, 2010: 6). Toxic gases also have an effect on the environment, human health and eco-systems.

The high biological oxygen demand caused by lignin and other organic materials discharged in wastewater stresses living organisms (Setthasakko, 2010: 318; Saritha, Maruthi and Mukkanti, 2010: 9). According to Ranjith and Pradeep (2013: 406) “the industry generates more than 12 million tons per year of solid waste, consisting primarily of de-watered sludge.” The standard treatment for these wastes in the past was to deposit them in landfills. Solid wastes such as boiler ash, when sent to landfill and not managed properly, can emit methane which is a greenhouse gas (Sappi, 2013: 110). Similarly Ince et al. (2011: 223) citing Monte et al. (2009) stated that “disposal of solid wastes such as lime mud may cause environmental problems because of high organic content, partitioning of chlorinated organics, pathogens ash and trace amount of heavy metal content.”

2.2.2.4 Bleaching

The use of chlorine raises concerns for environmental, health and safety reasons (Pokhrel and Viraraghavan, 2004: 38). Wastewater and emissions generated from bleaching contain chlorine compounds such as dioxins, furans and chloroform, considered to be highly toxic substances which can cause skin disorders, cancer, reproductive abnormalities and effects on the immune system (Munkittrick, McMaster and Servos, 2013: 729; EPA, 2010: 5; Harris et al., 2008: 1971; Ali and Sreekrishnan, 2001: 181). These compounds have an effect on freshwater and marine ecosystems and damage fisheries and the health of people eating contaminated fish (Timber Watch Coalition, n.d.: 14).

2.2.2.5 Chemical Recovery

The chemical recovery process has created some problems for the industry. In the process of recycling, emissions are released which impact the environment. According to Tran and Vakkilainen (2008: 4) the main environmental challenges with the chemical recovery process are:

- how to reuse various aqueous effluents within the pulp mill and
- control of air emissions from the recovery cycle.

2.2.2.6 Paper manufacture process

The effluents from the coating process require isolated pre-treatment, because mixing the effluents may cause a disturbance in the performance of a biological wastewater treatment plant. Furthermore, the colouring process uses large amounts of water and the darker coloured water produced is unsuitable for recycling. Energy is required to run the calendaring machine and this impacts the environment indirectly (European Commission, 2015: 676).

2.2.3 Green supply chain practices in the pulp and paper industry

According to the WWF (n.d.: 1), “Paper products are crucial to society as they have enabled literacy and cultural development. However, without changing current paper production and consumption practices, our growing demand for paper threatens the earth’s last remaining natural forests and endangered wildlife.” Due to public pressure concerning the deterioration of the environment, the pulp and paper industry has found it necessary to adopt green practices to reduce the environmental impact and hence to improve its public image.

Pokhrel and Viraraghavan (2004: 42), advocated the minimisation of pollution from the pulp and paper industry by the application of Best Available Technology/Technique (BAT). The most recent BAT reference document for the pulp, paper and board industries provides guidance on integrated pollution prevention and control (European Commission: 2015). BAT suggests that technology change has a role to play in sustainable development transition (González, 2005: 20). Christov and Driessel, (2003: 444) described some of the processes which have been modified, including dry debarking, increased cooking time for further lignin removal or pre-treatment by oxygen delignification as well as elemental chlorine free (ECF) and totally chlorine free (TCF) bleaching.

Dry debarking provides a useful example of a cleaner technology which reduces emissions and waste water effluents (Zhang, Chen and Wen 2012: 24). This practice reduces wastewater discharge, reduces chemical oxygen demand in wastewater and increases energy efficiency because the dry bark can be used to feed the boiler.

Some strategies to improve environmental performance in the pulp and paper industry are described below.

2.2.3.1 Reduction in greenhouse gases

To reduce greenhouse gas emissions caused by fossil fuels, the paper industry has converted to using some renewable energy (ASME, 2009: 9). This is derived mainly from black liquor, sludge and biomass which generate energy and heat for processes. This reduces energy costs and also reduces dependency on the national grid (Sappi, 2013: 98; Mondi, 2013: 25).

Sappi has reduced emissions in their logistics by making use of innovative vehicle technology which is precisely designed to transport timber to Sappi mills. The vehicles are suitable for South Africa roads and are authorised by the Department of Transport (Sappi, 2013: 101). Mondi has also attempted to reduce carbon emissions, and optimise logistics. In Europe, Mondi uses ships to transport less urgent products and this is desirable as ships produce lower carbon emissions (Mondi, 2013: 33).

2.2.3.2 Reduction in toxic gas emissions

Emission reduction technology at paper mills may include flue gas desulphurisation in order to reduce sulphur dioxide (SO₂) emissions (Hale and Way-Jones, 2011: 10).

2.2.3.3 Improvements in wastewater treatment

Chemical and physical methods have been used to remove chloro-organics and other effluents, however the methods are costly and they fail to reduce chemical oxygen demand (COD) and biological oxygen demand (BOD) (Saritha et al., 2010: 10). These approaches are more effective in the decolourisation of pulp and mill waste waters. Therefore, many mills have moved to focus on biological treatment of effluents and wastes (Buvaneswari, Damodarkumar and Murugesan 2013: 50). This is termed bioremediation and is intended to break down toxic wastes and even to produce useful products (Murugesan, 2003: 1239). Bioremediation is not only environmentally friendly but also less expensive (Christov and Driessel, 2003: 444).

Biological methods use different types of micro-organisms (bacteria, algae and fungi) to degrade the waste products, such as lignin, from pulp mills. However, Gandham (2013: 2) suggested that the microorganisms for bioremediation must be carefully selected to process the particular toxins present in the wastewater and to avoid negative side effects. Saritha et al. (2010: 9) recommended fungi as natural decomposers found in ecosystems – a method sometimes called mycoremediation. Prasongsuk, Lotrakul, Imai and Punnapayak (2009: 37) and Raghukumar, D'Souza-Ticlo and Verma (2008: 190) focussed on white rot fungi for effluent treatment in the pulp and paper industry since they are capable of degrading lignin. Pulp and paper mills have also contributed to soil contamination with the discharge of effluents. Mycoremediation may be used to degrade toxic effluents such as persistent pesticides (Singh and Sharma, 2013: 200). It also converts some of these toxic substances into a nutrient source and converts them to simpler fragmented forms (Singh and Sharma, 2013: 200; Murugesan, 2003: 1239).

2.2.3.4 Improvements in chemical use

Changes to the chemicals used in various stages of the pulp and paper manufacturing process have reduced the environmental impact. In the pulping stage, oxygen delignification can replace chlorine delignification and reduce BOD and colour in wastewater. A mixture of elemental oxygen, sodium hydroxide and magnesium hydroxide is mixed into the pulp suspension (Susilo and Bennington, 2007: 872; Ali and Sreekrishnan, 2001: 187). Lignin is dissolved and will eventually be recovered as black liquor (Selvam, Priya and Sivaraj, 2011: 1766).

Thompson, Swain, Kay and Forster (2001: 276) found that concerns first arose in the 1970s regarding the production of chlorinated substances (dioxins and furans) from the use of chlorine in the bleaching process when producing of pulp and paper. In response to public concerns several mills changed to produce Elemental Chlorine Free (ECF) and Total Chlorine Free (TCF) paper. ECF paper production avoids the use of pure chlorine but uses chlorine dioxide for bleaching (Harris et al., 2008: 1974). TCF paper is paper bleached without any chemicals containing chlorine, thereby avoiding the presence of chlorine in the pulp and waste water stream. Hydrogen peroxide is used and this is also known as an oxygen bleaching process (Timber Watch Coalition, n.d.: 19). Eliminating chlorine will reduce toxic emissions such as dioxins and absorbable organic halides.

2.2.3.5 Reduced waste to landfill

Solid waste disposal to landfills is a major concern, because it emits methane which is a greenhouse gas as mentioned above. However, to control and reduce greenhouse gases emitted from landfills, EPA (2010: 28) recommended dewatering and burning the wastewater treatment plant residuals in an on-site boiler, or burning landfill gas in an on-site combustion device.

2.2.3.6 Role of recycling

The recycling of paper reduces demand for virgin raw materials, thereby reducing deforestation of natural forests and the need for more artificial plantations. Solid waste removal and disposal volumes and costs are reduced compared to sourcing virgin raw materials. This eliminates the need for scarce landfill space and reduces methane production by landfills, which is critical since methane has a significantly greater greenhouse gas effect than carbon dioxide (Sappi, 2013: 110). Recycled paper uses less water, saves energy and produces less pollution.

Apart from recycling paper, the industry has also adopted the recycling of chemicals and water used during paper production. Water may be recycled to improve the quality of water returned to the environment. Companies can reduce water usage by recycling and returning clean water for use by other stakeholders. Chemical recovery processes are now a part of the paper making process. This has reduced emissions by using the effluents for other purposes, for instance the use of black liquor for energy generation. Chemical recovery results in cost savings as well as a reduced inorganic and organic load on the wastewater stream (Steffen, Robertson and Kirsten Consulting Engineers, 1990: 13). This also benefits the organisation through the generation of energy from residue burning (Meliton, n.d.: 4).

Sappi has been recycling waste from the processes and passing on the waste to other parties who can make use of it. According to the Sappi Sustainability Report of 2011 (Sappi, 2011: 6) they have been combusting waste sludge for heat gain and using waste products in the production of value added products such as:

- Use of waste sludge in the production of bricks, cement or soil substrates for landscaping.
- Dried residual sludge is used as animal bedding material.
- Reusing waste oil after physically and chemically treating the waste oil which is then, refined and filtered for reuse in various grades of base oils.
- Excess lime-mud generated from the liquor recovery process is provided to farmers to enrich the land as fertiliser.

2.2.4 Lean practices in the pulp and paper industry

In their review of the application of lean to process industries, Panwar, Nepal, Jain and Rathore (2015: 571) identified only one study which investigates the paper industry, which was Lehtonen and Holmstrom (1998). Similarly, a search for “lean supply chain” or “lean manufacturing” and “paper and pulp” in the EBSCO Host databases returns three or four papers reflecting lean principles (supply chain integration) but only the “lean and green” study of Vais, Miron, Pedersen and Folke (2006) has “lean” in the title. This scarcity of literature may reflect the difficulties encountered with the implementation of lean in a context very different from the component assembly industries in which it was developed. The American Technical Association of the Pulp and Paper Industry (TAPPI) has issued some industry publications (e.g. Burton, 2005) on the subject but these are not peer reviewed.

Panwar et al. (2015: 565) point out that lean originated in what they term “discrete manufacturing” where products are put together that can be taken apart, such as cars, computers and appliances. They review studies of process industries where chemical as well as physical processes may be applied and mixing, separating and forming often produce materials that must be containerised. These non-discrete products may be further processed, as in the paper industry, to form discrete products. Panwar et al. (2015: 566) further distinguish between batch process industries and continuous process industries. They investigate which lean practices are most useful in both these types of process industry.

Lehtonen and Holmstrom (1998: 26) were concerned with Just-In-Time and found that application of these practices could reduce inventory levels and reduce machine cycle times

while maintaining customer service levels. Vais et al. (2006) investigated the application of the lean tools; Kaizen, 5S, TPM, Cellular manufacturing, JIT, Six sigma and TQM as well as the 3Rs (reduce, reuse, recycle) in a Romanian paper mill. Their study did not include the pulp production process. While they were successful in increasing profits, reducing water consumption and making several significant technical changes, the only lean practice which was explicitly applied in this process was TPM. A clear need for greater employee involvement in problem solving was also identified.

Van der Wal and Lynn (2002: 365) studied the implementation of TPM in one of Sappi's South African paper mills and found that it was effective in involving all employees in quality improvement.

Due to the shortage of specific information on the paper industry, the suggestions of Panwar et al. (2015: 582) for process industries in general provide some guidance. They advocated 5S, TPM, TQM, VSM, work standardisation, team-based problem-solving and continuous improvement as the most suitable lean tools for process industries. They suggested that SMED, cellular manufacturing, JIT, Kanban and small batch production would be less useful.

2.3 Green supply chain management

Traditional supply chains focused on cost, efficiency, and product variety with less regard to adverse environmental consequences. The industrial revolution, along with developments in science and technology, radically increased the ability of humans to exploit natural resources. Seman, Zakuan, Jusoh and Arif, (2012: 1) pointed out that economic growth has contributed to the environmental issues that we are currently experiencing through higher energy and raw material consumption as well as increased waste production. Green supply chain management (GSCM) is an environmentally responsible approach that has been developed in response to these problems (Seuring and Müller, 2008: 1700).

GSCM forms part of sustainable supply chain management (SSCM). SSCM aims to ensure that the company's social, environmental and economic impacts are balanced (Nelson, Marsillac and Rao, 2012: 37). This is achieved through environmentally sound processes and engagement with social programmes while maintaining economic viability. Figure 2.3 illustrates the interaction between these different aspects of a firm's performance.



Figure 2.3: Sustainable Supply Chain Management (Source: D’Innocenzi, 2013: 1)

2.3.1 Green supply chain evolution

According to Dawei, Hamid, Chin and Leng (2015: 15), the green supply chain concept was first proposed in 1996 in the publication “Environmentally Responsible Manufacturing” by the Manufacturing Research Consortium (MRC) of Michigan State University. This study advocated consideration of the environment and improved use of resources in the development of manufacturing supply chains.

The evolution of supply chain management (SCM) in the 1990’s stressed that instead of having separate organisational units with responsibility for environmental management, the best practice was to integrate environmental management across supply chain partners (Srivastava, 2007: 53). Incorporating the “green” strategies addresses the influence and relationship between supply chain management and the natural environment. However, Burt, Petcavage and Pinkerton (2010: 258) highlighted that environmentally sensitive supply chains can improve business performance in terms of both profits and public image.

Environmental impacts to be considered by 21st century businesses include carbon emissions, the release of toxic gases, disposal of pollutants in water and soil and the depletion of natural resources. The public sentiment has moved towards conserving the environment and consumers now choose to associate with and support organisations that show concern for the environment (Nelson et al., 2012: 36). The importance of implementing strategies that are sustainable has resulted in the development of global standards such as International Organization for Standardization (ISO) 14000 and the Kyoto protocol. This is further evident with the recent signing of the Paris agreement (April 2016) by world leaders committing their

countries to adopting practices within their industries that will combat pollution and conserve the scarce resources at our disposal for future generations, address climate change issues and preserve biodiversity.

Table 2.1 Green Supply Chain Management definitions.

Author(s)	Definition
Kumar and Chandrakar (2012: 3) (cited in Zhu, Sarkis, Cordeiro and Lai, 2008)	“A simple green purchasing relationship between a buyer and vendor. In other cases more extensive concepts of “closed-loop” supply chains are employed which consider GSCM to be an unending logistics cycle of materials and products use, reuse and management from both an inter- and intra-organizational perspective.”
Dawei et al. (2015: 16)	“An innovative supply chain which complies with social development trends. It integrates economic performance, environmental performance and resource efficiency into the entire spectrum of supply chain activities involving raw materials and component purchasing, manufacturing, packaging, distribution, retailing, and the subsequent recycling of the products.”
Hugo and Badenhorst-Weiss (2011: 93)	“GSCM can be defined as an integrating environmental thinking into supply chain management including product design, material sourcing, manufacturing and delivery of the final product to the consumer as well as end-of-life management of the product after its useful life.”

Due to the fact that GSCM is still a relatively new field, it remains vaguely defined. Different researchers have different definitions depending on the investigative goals of the research. Table 2.1 contains a variety of definitions, but all are in agreement that that GSCM stems from

both supply chain management and consideration for the natural environment. In this study, Green Supply Chain Management is defined as “the process of designing, consuming raw materials, producing, packaging and delivering the final product to the consumer in the most environmentally friendly possible manner, while ensuring that reverse logistics is possible (closing the loop)”.

2.3.2 Green supply chain principles

To achieve a green supply chain, organisations should assess environmental performance using methods such as life cycle assessment (LCA) and implement eco-efficiency and cleaner production. According to Zhu, Sarkis and Lai (2008b: 262) firms need to ensure that every tier of the supply chain is environmentally sustainable and some practical approaches to implementation on a tier-by-tier basis are described in Section 2.3.3.

2.3.2.1 Life cycle assessment (LCA)

LCA is used to examine the total environmental impact of the inputs and outputs associated with a product through every step of the product’s life from procuring raw materials, production, use of product and disposal (Hellweg and i Canals, 2014: 1109). It offers a “cradle to grave” analysis which quantifies these impacts and supports decision making for industrial organisations. LCA is a standardised process used in the ISO 14040 series of sustainability accreditation (Finkbeiner, Inaba, Tan, Christiansen and Klüppel, 2006: 1109). This assessment is becoming more challenging as supply chains extend across the globe and impacts are consequently more widely distributed. To address the three pillars of sustainability, LCA can be combined with Life Cycle Costing (LCC) and Social Life Cycle Assessment (SLCA) to form a Life Cycle Sustainability Assessment tool to determine if processes are socially, economically and environmentally viable (Kloepffer, 2008: 90).

2.3.2.2 Eco-efficiency

Eco-efficiency is calculated by dividing economic value added by the environmental impact of the product or process (Yu, Shi, Wang, Chang and Cheng, 2016: 511). It can be improved by increasing the value of produced goods and services while reducing the ecological impacts and the resources required for the production process. Value is increased when customers are provided with higher quality products with additional functionality to prolong the product life-cycle. The ecological impact can be reduced with the use of renewable resources, reduced emissions and processing of toxic effluents. Reduction in the consumption of resources

practices such as recycling, reuse and remanufacturing (3R's) should be considered. (DeSimone and Popoff, 1997: 3).

2.3.2.3 Cleaner production

Cleaner production (CP) is a business strategy for the preservation of the environment while still generating profit. It aims to reduce or eliminate waste and emissions, reduce resource consumption and minimise the risk of accidents (Nowosielski, Babilas and Pilarczyk, 2007: 527-530). Khalili, Duecker, Ashton and Chavez (2016: 31) drew parallels between the theories of lean production and CP, with both approaches emphasising the reduction of waste at source. Khalili et al. (2016:31) see CP as a voluntary practice in contrast to pollution control, where governments legislate against harmful business processes.

Traditionally businesses responded to pollution in different ways which included dilution and dispersing. These “end-of-pipe” approaches are those in which processes are added on to improve the quality of effluent or to reduce its impact on the environment (Frondel, Horbach and Rennings, 2004: 1; UNEP, n.d.: 2). Continuous improvement and innovation in clean technology avoids the need for end-of-pipe technology and may improve the quality of products, lower the cost of production and build a good name for the firm.

The implementation of GSCM starts from product design to end in a final product which can be recycled. Table 2.2 summarises the practices which are recommended for the implementation of GSCM.

2.3.3 Green supply chain practices

According to Hervani, Helms and Sarkis (2005: 334) GSCM comprises green purchasing, green manufacturing, green distribution and marketing along with reverse logistics. Wang and Luo (2010: 11) added green design to this list. Figure 2.4 shows how these different aspects of the green supply chain can be integrated in an industry that involves production from raw materials.

2.3.3.1 Green design

Green design, sometimes called Eco-design, incorporates environmental considerations into the planning stage of products and processes. Green design is a proactive measure that keeps undesirable materials and processes out of the supply chain, in contrast to the traditional

approach of dealing with environmental issues after production, which is reactive and also less efficient (Nelson et al., 2012: 38).

Table 2.2 Green Supply Chain Management Practices

GSCM practices	Requirements
Internal GSCM practices	<ul style="list-style-type: none"> • Commitment of GSCM by senior managers and mid-level managers • Cross-functional cooperation for environmental improvements • Total quality environmental management • Environmental compliance and auditing programs ISO 14001 • Environmental management systems
External GSCM practices	<ul style="list-style-type: none"> • Providing design specification to suppliers that include environmental requirements for purchased item • Cooperation with suppliers for environmental objectives • Environmental audit for suppliers' internal management • Suppliers' ISO 14000 certification • Second-tier supplier environmentally friendly practice evaluation • Cooperation with customer eco-design • Cooperation with customers for cleaner production • Cooperation with customers for green packaging
Investment recovery	<ul style="list-style-type: none"> • Investment recovery (sale) of excess inventories/materials\ • Sale of scrap and used materials • Sales of excess capital equipment
Eco-design	<ul style="list-style-type: none"> • Design of products for reduced consumption of material/energy • Design of products for reuse, recycle, recovery of material, component parts • Design of products to avoid or reduce use of hazardous products and/or their manufacturing process

Source: Hasan (2013: 42-44); Kumar and Chandrakar (2012: 3); Ninlawan, Seksan, Tossapol and Pilada (2010: 4); Zhu and Sarkis (2004: 267-268); Zhu, Sarkis and Lai (2008a: 2-4).

Green design addresses not only environmental management (pollution prevention, resource conservation and waste management), but also product safety and occupational health and safety, thereby contributing to the social aspect of sustainability (Srivastava, 2007: 55). It is ideal to have good supplier relations so that when a product is being designed all parties can collaborate to ensure that the requirements of green design are met (see Table 2.2).

2.3.3.2 Green procurement

Traditional supply chains were mainly concerned with quality, delivery on time, price, risk, safety, capability, flexibility and reputation when selecting suppliers (Ji, Ma and Li, 2015: 155).

However, with the rising interest in sustainable practices these have become fundamental to supplier selection in many supply chains.

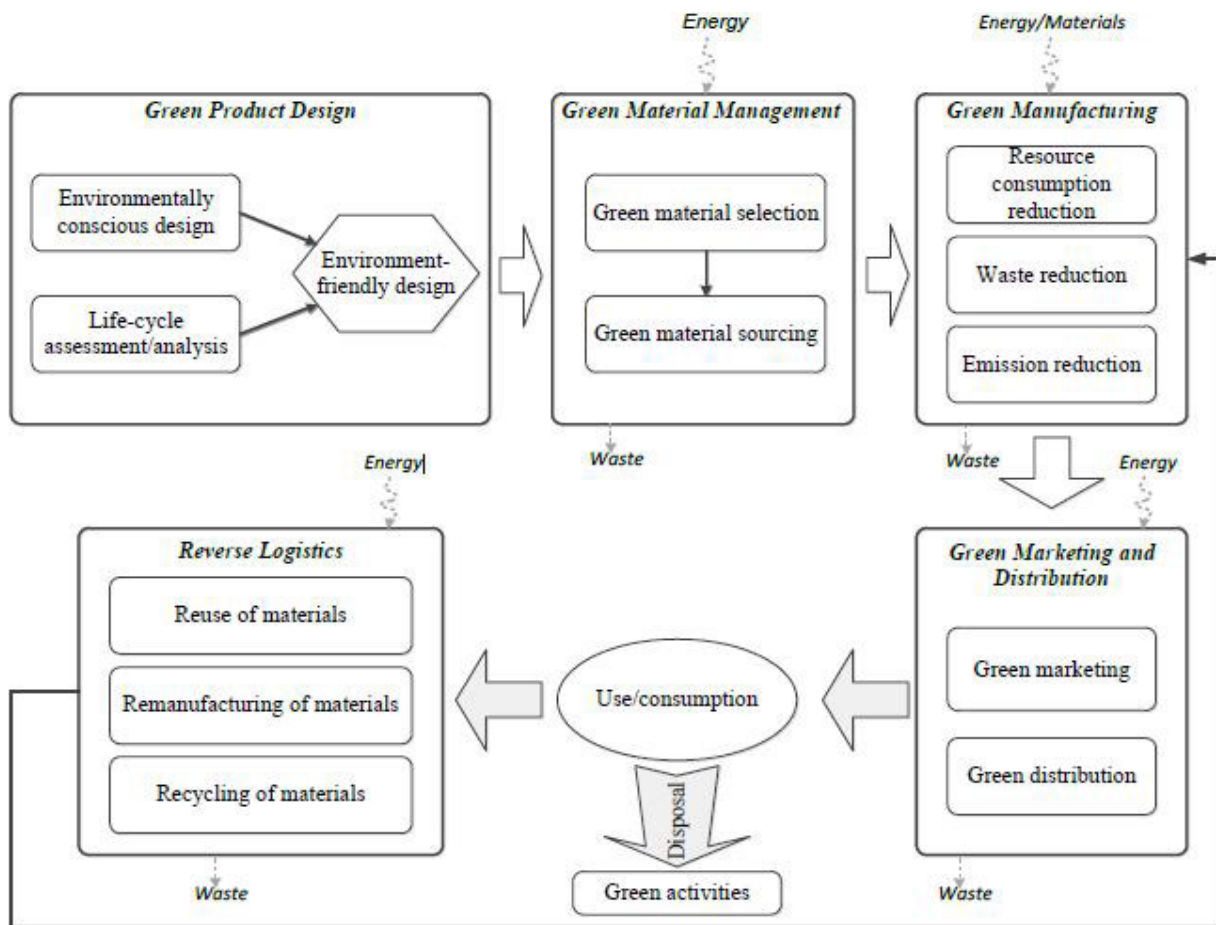


Figure 2.4 Framework for green supply chain process implementation (Source: Kudroli, 2014: 29)

Large and Thomsen (2011: 177) defined green procurement as “the integration of environmental considerations into purchasing policies, programmes and actions”. Green procurement strives to reduce the environmental impact by replacing previously purchased inputs with those that can perform the same functions but that meet predefined environmental criteria (Mosgaard, 2015: 267).

Appolloni, Sun, Jia and Li (2014: 122) noted that with the tendency of companies to focus on core functions and outsource others, the procurement function becomes critical in ensuring that the supply chain meets its environmental responsibilities. This strategic role provides an opportunity for procurement to integrate environmental aspects into all processes of a company.

Four criteria that may be recommended for green supplier selection are: ISO14001 certification, contribution to eco-design, use of clean technologies and eco-efficiency (Liu and Zhu, 2005 cited in Dawei et al., 2015: 19).

2.3.3.3 Green manufacturing

Govindan, Diabat and Shankar (2015: 182), citing Melnyk and Smith (1996), defined green manufacturing as an emphasis on the integration of manufacturing planning and control with the minimisation of waste. This allows resource efficiency to be maximised as environmental impacts are reduced. Nelson et al. (2012: 40) had a simpler approach, that green manufacturing reflects the use of sustainable material and technologies. Govindan et al. (2015: 182) further stated that the 3R's of supply chain management (reduce, remanufacture and recycle) are used to achieve this sustainability. Kudroli (2014: 29) preferred to see the 3R's as logistics issues, stating that they are major functions of reverse logistics that serve green supply chain management, but "reduce" can be interpreted as the role of manufacturing in using fewer resources to produce the same (or even a better) product, while remanufacturing necessarily involves both logistics and operations functions of the supply chain. Srivastava (2007: 59) used the term remanufacturing to describe manufacturing that integrates recycling into its processes.

Maruthi and Rashmi (2015: 3352) described techniques that can be implemented to achieve green manufacturing including lean production practices and the zero emissions approach. Kudroli (2014: 29) suggested that there are two methods of emission reduction which can be used in green manufacturing: collecting emission and effluents and then disposing of them using pollution control equipment (end-of-pipe solutions) and then the proactive method which works on preventing emissions use of sustainable products/materials when producing (cleaner production).

2.3.3.4 Green marketing

Green marketing cannot take place if the product is not produced in a sustainable manner (Dahlstrom, 2011:6). Engagement with customers is necessary to ensure that the use and recycling of materials takes place. Chan, He and Wang (2012: 557) and Kudroli (2014: 29) made the link with the upstream processes in the supply chain, emphasizing the need for green operations and green supply management to create green brands. Brindley and Oxborrow (2014: 46) further reinforced this concept, stating that there is a need to integrate marketing and the rest of the supply chain.

2.3.3.5 Green distribution/logistics

The increase in global sourcing has resulted in an increase in transport-intensity. Christopher (2011: 245) defined transport-intensity as the miles/kilometres travelled per unit of product shipped. There is a correlation between a supply chain's transport-intensity and its carbon footprint, contribution to environmental degradation and resource consumption. Christopher (2011: 245) linked green transportation to the concept of eco-efficiency and suggested several ways to reduce the transport-intensity including: increasing the fuel efficiency of vehicles, increasing load sizes and better scheduling. A transportation system that is sustainable not only serves the environment but also reduces costs for the organisation.

2.3.3.6 Reverse logistics

Reverse logistics is generally described as closing the loop of the supply chain (Christopher, 2011: 248). This takes place when companies follow up on products delivered to the final customer and bring back the products into the supply chain for purposes of reuse, remanufacturing and/or recycling.

Rogers and Tibben-Lemke (1998: 2) presented the Council of Logistics Management definition of reverse logistics as, "the process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal." They noted that the activities are the same as those of logistics but operating in reverse. Agrawal, Singh and Murtaza (2015: 76) described these activities of collecting products from customers, inspecting and sorting them and then disposing of the products for repair, remanufacture, recycling, reuse or final disposal.

Turrisi and Bruccoleri (2012: 565) investigated the impact of the implementation of reverse logistics on the performance of supply chains and discovered that apart from product recovery and reuse lessening the environmental impact of industries, it could also increase profitability and reduce the bullwhip effect through improved information flow in the supply chain.

2.4 Lean supply chain management

Lean is normally simply described as the elimination of waste (Womack and Jones, 2003:15). More comprehensive definitions include: "a management philosophy that enhances customer value through waste elimination and continuous improvement in a system by applying lean

principles, practices and techniques” (Ugochukwu, Engström and Langstrand, 2012: 87) or “a system that supplies the customer with exactly what the customer wants when the customer wants it, without waste, through continuous improvement” (Heizer and Render, 2014: 662). The main feature in lean is continuous value creation through the elimination of all non-value adding activities (Johansson and Sundin, 2014: 104). From the definitions one can conclude that lean is a process that ensures that the customer gets value with use of minimal resources and ensuring waste is eliminated along the value chain.

The origins of lean thinking were in the Japanese car manufacturer Toyota. What came to be known as the Toyota Production System (TPS) gave the car manufacturers a competitive edge by reducing costs, allowing the production of a high variety of products and improving productivity and quality (Bhamu and Sangwan, 2014: 876). The term lean production was popularised in the West by Womack and Jones’s 1990 book entitled ‘The Machine that Changed the World’ (Womack and Jones, 2003: 6).

2.4.1 Lean supply chain principles

Elimination of waste and the creation of value are often labelled as the pillars of lean, enabled by continuous improvement and a focus on people (Larman and Vodde, 2009: 6; Sundar, Balaji and Satheesh-Kumar, 2014: 1875). Over the years, lean has evolved, incorporating advances in information technology that enable companies to meet customer demands on time. Integrating systems such as enterprise resource planning (ERP), customer relationship management (CRM), supplier relationship management (SRM) Real Time Data Interchange (RDI), barcodes, point of sale (POS) systems, computer aided design (CAD) radio frequency identification (RFID), has allowed lean to adapt and deliver greater efficiency and quicker response.

The five key principles of lean which must be implemented for the benefits of lean to be realised are:

- Specifying value from the customers’ perspective: offering the highest customer perceived value in the market (Kotler, Armstrong and Tait, 2010: 27).
- Identifying the value stream or set of activities required to bring the product to being (Shrivastava, Anupam and Sharma, 2015: 103).
- Making the product flow through the supply chain: ensuring that value is added to the product step by step (Womack and Jones, 2003: 24).

- Implementation of pull based production: production responds to demand and hence supply and demand are balanced (Tyagi, Cai, Yang and Chambers, 2015: 209).
- Continuous improvement: continually striving for perfection (Thangarajoo and Smith, 2015:4).

Piatkowski (n.d.: 2) identifies three key activities in a lean system: cost reduction by elimination of waste, creating conditions to guarantee product quality and creating a work site with operators in mind.

2.4.2 Lean wastes

According to Pieńkowski (2014: 3) the Japanese understanding of waste is defined by the three “Mu’s”: Muri (unreasonableness), Mura (inconsistency) and Muda (activities that do not add any customer value).

Muda is the focus of lean and the origin of the seven wastes to be eliminated from the value stream (Chase, Jacobs and Aquilano, 2011: 472; Paton, Clegg, Hsuan and Pilkington, 2011: 323; Harrison and van Hoek, 2011: 229). These seven wastes are:

- *Overproduction*: producing an excessive amount of product and producing before the product is required (Georgescu, 2011: 7).
- *Waiting time*: delays due to breakdowns or changeovers, poorly planned layouts (e.g. distances between work centres are too large) and work flows (Smalley, n.d.: 11).
- *Transportation waste*: the unnecessary movement of materials, work in progress or finished goods (Georgescu, 2011: 7).
- *Inventory waste*: having excessive raw materials, more work in progress than necessary and an over-supply of finished goods in the warehouse.
- *Processing waste*: under-processing or over-processing, usually as a result of poor tools or product design (Georgescu 2011: 7).
- *Waste of motion*: the unnecessary movement of people.
- *Product defects*: results in scrap and rework.
- *Knowledge disconnection*: lack of communication in the supply chain (Dennis, 2007: 25),

To achieve a successful lean system the first step is identifying the above-mentioned wastes.

2.4.3 Lean supply chain practices

The lean literature offers a range of practical methods, sometimes called lean tools, which can be used to identify and eliminate waste (Rivera and Chen, 2007: 687). The implementation of lean in a company may be assessed by the extent to which the use of these tools is apparent (Belhadi, Touriki and El Fezazi, 2016: 801).

2.4.3.1 Value stream mapping

Pepper and Spedding (2010: 139) citing Rother and Shock (1999) stated that value stream mapping (VSM) emerged as a tool to identify waste. Bamford and Forrester (2010: 44) define VSM as, “map out the processes, identify those activities that add value and improve these, and eliminate non-value adding activities.”

2.4.3.2 Kaizen – continuous improvement

The continuous improvement philosophy, also known by the Japanese term *kaizen*, centres on the belief that almost any aspect of a process can be improved and that those who are hands-on (shop-floor workers) are in the best position to identify the changes that should be made (Krajewski, Ritzman and Malhotra, 2010: 201). Goodwin and Griffith (2008: 103) advocated Deming’s wheel (the Plan-Do-Check-Act cycle) as a tool that can be used to implement continuous improvement. According to Soković and Jovanović (2009: 6) total quality management (TQM) tools can be used to support implementing PDCA, for instance flowcharts to check the current process before implementing change.

2.4.3.3 5Ss

The 5S tools are Sort (Seiri), Simplify/Straighten (Seiton), Sweep/Shine (Seiso), Standardise (Seiketsu) and Sustain (Shitsuke). These tools result in greater productivity, quality and profits achieved with minimal cost, time and effort invested (Elmoselhy, 2013: 599; Heizer and Render, 2014: 663; Titu, Oprean and Grecu, 2010: 2; Krajewski et al., 2010: 323).

2.4.3.4 Just In Time (JIT) - Kanban

JIT focuses on managing material flow in industries to reduce the inventory levels at each stage of production (Singh and Garg, 2011: 27). In a JIT system materials and parts are moved through the chain in response to demand from the end-customer: a “pull” strategy that results in product moving downstream through the supply chain as information moves upstream (Harrison and van Hoek, 2011: 223; Venkat and Wakeland, 2006: 2). JIT requires trust and

good supplier relations so that good quality products will be delivered on time and it favours local suppliers due to shorter lead times.

A kanban system is described by Bamford and Forrester (2010: 107) as the use of cards which accompany parts through the production system. As soon as parts have been used, the kanban is returned to act as a trigger for the supply of more parts. The kanban system puts a limit on inventory that cannot be exceeded: the system only produces items used to make the customer's final product (Paton et al., 2011: 314).

2.4.3.5 Heijunka: Production levelling

Heijunka aims to distribute the volume of goods produced evenly while adjusting the mix through the use of small batch sizes (Dennis, 2007: 73; Landry and Ahmed, 2016: 2). Information technology systems become essential in facilitating tools such as master production schedule (MPS) development, economic order quantity (EOQ) calculation and point of sale (POS) information gathering.

2.4.3.6 Single Minute Exchange of Dies (SMED)

SMED is a technique of changing machines on the production line from one product to another in less than 10 minutes, also termed rapid changeovers. This method helps reduce lot sizes and improves the flow of work, eventually reducing production time and costs (Dave and Sohani, 2012: 28).

2.4.3.7 Total Quality Management (TQM)

TQM is a philosophy that stresses customer satisfaction, employee involvement and continuous improvement. According to CIPS (2012: 48) the principles on which the philosophy operates include: get it right the first time, quality chains, quality culture, total involvement, quality through people, team based management, process alignment, quality management systems and continuous improvement.

The TQM tools are: check sheets, scatter diagrams, cause and effect diagrams (Ishikawa diagrams), Pareto charts, flow charts, histograms and statistical process control (SPC) (Heizer and Render, 2014: 254; Kerber and Dreckshage, 2011: 170).

2.4.3.8 Quality circles

Employee involvement is regarded a key element of lean production (Dombrowski, Mielke and Schulze, 2011: 428; Bhuiyan and Baghel, 2005: 766). Quality circles are groups of employees that meet regularly to discuss and solve problems relating to the tasks in their work area and to develop new ideas to increase efficiency (Heizer and Render, 2014: 250). Employees feel empowered through the trust placed in them by their employer.

2.4.3.9 Six Sigma

Six sigma seeks to improve the quality of process outputs by identifying and removing the causes of defects (errors) and minimising variability in manufacturing and business processes (Monczka, 2013: 61). It is specified that there should be less than 3.4 defects per million products. The DMAIC (Define-Measure-Analyse-Improve-Control) improvement process is a standardised and systematic method of problem solving used in six sigma projects (Gygi, DeCarlo and Williams, 2005: 42; Panneerselvam, 2013: 549).

2.4.3.10 Jidoka and Poka-yoke

Jidoka can be regarded as a self-check system which allows defects to be detected before moving on to the next process and includes poka-yokes or foolproofing devices. Landry and Ahmed (2016: 2) state that achieving a defect-free process involves manual checks or equipment with sensors built in to alert workers when a defect is detected. This control method detects problems and stops production lines/processes immediately so that mistakes can be corrected (Burlikowska and Szewieczek, 2009: 98).

2.4.3.11 JIT layout

Lean organisations normally incorporate systems such as cellular layouts or group technology that enable quick response to the customer and produce quality products (Sharma, 2013: 167). Products/parts are grouped according to families, with the goal of identifying a set of products with similar processing requirements and ensuring that each cell is capable of satisfying all the requirements of the component family assigned to it (Krajewski et al., 2010: 325). The main aim of this system is to minimise inter-cell movement and machine changeovers or setups.

2.4.3.12 Total productive maintenance (TPM)

Preventive maintenance involves periodic inspection and repair designed to keep machines reliable. This is normally done by operators as the impression is that those who are more hands-

on are more familiar with their machines (Chase et al., 2011: 404). TPM aims to reduce waste created by breakdowns, long setup times, idle machinery, mechanical or quality problems which reduce the speed of the machine below optimum levels, quality defects in products due to machine malfunction and losses due to unstable conditions during machine start-up (van der Wal and Lynn, 2002: 360). These authors also link TPM to safety and the prevention of adverse environmental effects.

2.5 Lean and green integration

The lean philosophy has provided manufacturers with ways of maximising productivity, conserving resources, reducing waste and minimising costs while promoting continuous improvement. However, the growing concern regarding pollutants, waste and landfill disposal green has shifted the focus to maximising the value throughout the supply chain through both lean and green techniques (Al-Aomar and Weriakat, 2012: 289). Some manufacturers who were already on the lean production path have included green practices and have benefitted from working with both approaches simultaneously. Wal-Mart, for example, has adopted green and lean across the supply chain and this has driven improvements in both the financial performance of the company and its brand (Mollenkopf et al., 2010: 17). Dhingra et al. (2014: 2) also observe that as markets have become globalised and as the economic climate has become more challenging, lean and green manufacturing offers a competitive advantage.

2.5.1 Common principles of lean and green

Martínez-Jurado and Moyano-Fuentes (2014: 145) point out that lean and green complement one another and share the principles of waste reduction, focusing on process (reducing waste at source) and involving people in the initiative.

2.5.1.1 Principle of waste reduction

Lean and green share a common goal of waste elimination and the two set of practices are complementary even though they tackle different types of wastes (Bortolini, Ferrari, Galizia and Mora, 2016: 884; Johansson and Sundin, 2014: 15). The seven lean wastes are: overproduction, excess inventory, transport, waiting time, over processing, motion and product defects. Green waste, on the other hand, is excessive use of water, energy and other natural resources, and the production of pollution, rubbish, greenhouse gases and eutrophication (Bortolini et al., 2016: 884). Lean focuses on reducing waste within the operations of supply

chain partners but green practices expand the scope of these efforts beyond the supply chain to also benefit the environment.

In their *Lean and Environmental Toolkit*, the United States Environmental Protection Agency (EPA) (2007: 13) proposes that the seven wastes of lean can be linked with environmental impacts. This suggests that implementing lean may result in improved green performance. Table 2.3 shows how lean wastes may impact on the environment.

Table 2.3 Environmental impacts of lean wastes

Waste type	Environmental impacts
Overproduction	<ul style="list-style-type: none"> • More raw materials and energy consumed in making the unnecessary products • Extra products may spoil or become obsolete requiring disposal • Extra hazardous materials used result in extra emissions, waste disposal, worker exposure, etc.
Inventory	<ul style="list-style-type: none"> • More packaging to store work-in-process • Waste from deterioration or damage to stored WIP • More materials needed to replace damaged WIP • More energy used to heat, cool and light inventory space
Transportation and Motion	<ul style="list-style-type: none"> • More energy used for transport • Emissions from transport • More space required for WIP movement, increasing lighting, heating, and cooling demand and energy consumption • More packaging required to protect components during movement • Damage and spills during transport • Transportation of hazardous materials requires special shipping and packaging to prevent risk during accidents
Defects	<ul style="list-style-type: none"> • Raw materials and energy consumed in making defective products • Defective components require recycling or disposal • More space required for rework and repair, increasing energy for heating, cooling and lighting
Overprocessing	<ul style="list-style-type: none"> • More parts and raw materials consumed per unit of production • Unnecessary processing increases wastes, energy use and emissions
Waiting	<ul style="list-style-type: none"> • Potential material spoilage or component damage causing waste • Wasted energy from heating, cooling and lighting during production downtime

Source: EPA (2007: 14)

2.5.1.2 Reducing waste at source

The main objective of lean is to achieve quality throughout the supply chain while ensuring that any problems are identified from the point of origin (prevention is better than cure) (Rothenberg, Pil and Maxwell, 2001: 236). Therefore, the cleaner production approach which stresses the prevention of emissions rather than end-of-pipe technology that will clean up after the effects is analogous to the quality at source approach of lean production. These two can be implemented concurrently. Dües et al. (2013: 97) observe that lean emphasises optimising the

entire supply chain from end-to-end rather than creating islands of improvement and highlights that this should also be applied when implementing green.

2.5.1.3 People involvement and participation

The lean philosophy of continuous improvement relies on employees in decision making and focuses on achieving congruent goals throughout the supply chain (Dües et al., 2013: 95). The lean principle of reducing the number of hierarchical levels enables full visibility and gives responsibility to employees. Rothenberg et al. (2001: 239) noted that in lean manufacturing environments, the practices of quality circles and worker suggestions could also contribute to environmental performance. This existence of participation practices simplifies green implementation and thus lean creates an enabling environment for green.

2.5.1.4 Delivering value to the customer

Lean supply chains strive to deliver a product that is attractive to the customer while green supply chains deliver a product that is environmentally benign. However, as consumers become more environmentally conscious, green value becomes part of the customer value which drives the lean supply chain. Thus, the production of products in a green way in addition to being lean, will increase value delivery to customers.

2.5.1.5 Developing relationships in the supply chain

Collaboration and information flow through the supply chain assists the development of lean by reducing lead times and matching supply with demand. Martínez-Jurado and Moyano-Fuentes (2014: 144) citing Florida (1996) stated that the success of lean and green integration revolves around good internal and external relationships and Galeazzo et al. (2014: 197) suggested that lean and green practices particularly require supplier involvement. Suppliers play a significant role in enabling the two approaches to work together and achieve synergies. Information sharing with systems such as EDI (electronic data interchange), will be essential to enable a quick response to both quality and environmental issues.

A comparison of the lean and green paradigms and their distinguishing attributes is summarised in Table 2.4. Dües et al. (2013: 93) highlight that lean is beneficial for green practices and the implementation of green practices in turn also has a positive influence on existing lean business practices.

Table 2.4: Lean and green comparison.

Attribute	Lean Paradigm	Green Paradigm
General purpose	Profit maximisation through cost reduction	Reducing environmental impact through adopting sustainable practices
Goals	Creation of value for the end consumer through elimination of non-value adding activities (waste)	Ensure the development of products that are environmentally friendly
Value	Delivering a product that the customer finds attractive	Delivering a product that is environmentally benign
Waste	Activities that are not value adding labelled as the seven wastes	Physical wastes: emissions, wastewaters going to landfills.
Focus	Cost reduction through elimination of waste with continuous improvement	Environmental protection
Customers	Economic customers driven by costs and quality	Planet and people who live on it
Customer satisfaction	Low costs of production which result in a low price and short lead time	Satisfying customers by being green: eco-design, eco-labelling
Supply chain (lead time)	Short lead times as long as that does not affect the price	Delivering the product to final user should not result in increased carbon emissions
Relationship with suppliers and customers	Synchronised supply chain that allows information flow to enable quick response from point of origin to the final point and to enable application of new practices (supplier/customer development)	Inter-organisational collaboration allowing sharing of green information (reverse logistics) to enable achieving a green supply chain
Product design	Maximise product performance and minimise cost	Eco design and Life-cycle assessment for evaluating risk and impact of the product during and after use
Raw Material Sourcing	Supplier attributes include low cost and high quality and ability to respond quickly (JIT)	Green purchasing
Manufacturing	Mostly pull strategy (demand driven)	Resource efficiency, waste reduction application of the 3R's (reuse, remanufacture and recycle)

Inventory	High turnover with the aim eliminating unnecessary inventory	Minimal inventory by embracing reuse/remanufacturing
Transport	One of lean wastes. Results in problems such as breakage, double handling. JIT can cause frequent small deliveries	Reduce frequency of deliveries with the aim to reduce carbon emissions
End-of-life	Not much concern with fate of product after purchase	Considers the impact of the product from design through LCA until end-of-life in the form of re-use or recycling
Business Results	Low cost, quality, quick response, eventually achieving customer satisfaction	Quality in terms of environmental impact, process waste e.g. carbon emissions, waste-waters
Principal Tool	Value stream mapping main tool that offers an in-depth understanding of the process required to bring a product to market	LCA vital tool for green paradigm that shows the process of bringing a product to market that is environmentally friendly
Waste Reduction Techniques	Identifying the seven wastes thereafter application of tools to eliminate the waste	Product redesign, process redesign through embracing clean technology (proactive measure), reuse, recycle, remanufacturing 3R's
Tools/Practices	VSM, JIT, Kaizen, 5S's, TQM, information sharing	Sustainable value stream mapping

Adapted from Dües et al. (2013: 96) and Bortolini et al. (2016: 885)

2.5.2 Lean and green practices

Some studies suggest that firms are making a “natural progression” from lean to green (Dhingra et al., 2014: 2). Simultaneously lean and green practices or processes are essential tools to integrate the two paradigms and create an implementable model that prioritises the environment and efficiency simultaneously. Pampanelli, Found and Bernardes (2014: 21) further emphasised that integrating the two to form a lean and green model would mean “producing exactly what the customer wants, at the right time, at fair price, with minimum waste and environmental impact and maximum productivity in the use of natural resources.” Chiarini (2014: 226) examined the potential for lean tools to improve environmental performance. He noted that very little research has been carried out apart from studies of environmental value stream mapping.

2.5.2.1 Environmental Value Stream Mapping

Value stream mapping (VSM) is an important lean tool that allows any activities that do not add value in the chain to be eliminated. The use of VSM in a green environment would allow the assessment of environmental metrics such as usage of water, energy, resources, level of pollution, greenhouse gas effects and eutrophication (Wills, 2009: 16). This is described as environmental value stream mapping and can be extended to include social metrics in sustainable value stream mapping (SusVSM) (Faulkner and Badurdeen, 2014: 8). This tool plays an important role in the identification of opportunities for environmental improvements in a company. Martínez-Jurado and Moyano-Fuentes (2014: 145) correspondingly observe that it is imperative to adopt SusVSM to put ecological thinking into practice throughout the supply chain. They further comment that SusVSM can act as an enabler for achieving greater cooperation between supply chain partners in the design and development of new more environmentally sustainable products, as well as the management of the end-of-life of the product.

A green and lean model using value stream mapping was also identified by Pampanelli et al. (2014: 22). Five main principles identified by the researchers were:

1. Identify a stable value stream.
2. Identify the flow of value and its environmental aspects and impacts.
3. Measure value stream environmental impacts and the use of natural resources.
4. Identify alternatives to impact reduction and resource productivity.
5. Pursue perfection with continuous improvement.

The model they presented is an amalgamation of pure lean and pure green thinking. The study concluded that lean to green is an expansion of lean practices to achieve broader objectives that will not focus only on costs. Hence VSM can be regarded as a useful tool for both lean and green.

2.5.2.2 5S implementation

Chiarini (2014: 230) found that the 5Ss could improve the management of garbage in factories and reduce the amount of space and hence land use required for manufacturing activities. Cleaner practices resulted in reduced waste production and leakage of toxic materials.

2.5.2.3 Cellular manufacturing

Reduced movement of work in process and hence reduced transportation can reduce energy consumption in manufacturing enterprises (Chiarini, 2014: 230).

2.5.2.4 Total productive maintenance (TPM)

TPM can improve the efficiency of operation of machinery and reduce emissions (Chiarini, 2014: 231). Electricity savings may be achieved through effective maintenance and through shorter setup and standby times.

2.5.2.5 Lean and green supplier selection

Certain metrics must be applied to suppliers for a company to succeed in implementing lean and green. An example is ensuring that prospective suppliers have ISO 14000 and 9000 certification before conducting business with them. This will eliminate all suppliers that are not environment and quality conscious. Being in close proximity to the supplier supports lean, allowing delivery and production when the pull from the customer occurs. It also minimises the costs of warehousing and reduces the carbon footprint created by the transportation of supplies.

2.5.3 Lean and green synergies

An example of lean and green synergy in the pulp and paper industry is presented in a research thesis by Mansfield (2005). By developing an optimum wastewater treatment method through the systematic reduction of water consumption and wastewater generation (water pinch analysis), several methods were integrated to reduce energy, water and raw material consumption, greenhouse gas emissions and wastewater generation. This type of analysis allows companies to see where reuse standards can be applied and to avoid treatment to an excessively high standard (Brouckaert and Buckley, 2001: 1). This method creates both cost savings and environmental sustainability (lean and green), demonstrating the synergies between the two concepts.

Most firms are reluctant to adopt green practices due to the notion that they are costly, but incorporating lean into the green strategy will allow firms to achieve cost savings. Hajmohammad, Vachon, Klassen and Gavronski (2013: 314) observed that applying lean management can reduce marginal costs associated with environmental practices, either by lowering their implementation costs or by providing insights on where cost savings may be

achieved. The EPA promotes the elimination of environmental wastes as a cost-saving strategy (EPA, 2007: 4). They point out that pollution control is costly and non-value adding, and advocate chemical substitution and changes in processes to reduce the need for it. They propose that lean principles should be applied to environmental waste management and use as an example of expired obsolete chemicals which become hazardous waste but which would not arise if lean inventory management was practiced (EPA, 2007: 5). Business wastage, green image and carbon emissions are some of the performance metrics to assess if lean and green are achieving synergies.

Galeazzo et al. (2014: 192) and Dhingra et al. (2014: 2) found that lean has a positive impact on environmental performance because lean practices enable easier introduction of green practices. Yang, Hong and Modi (2011: 258) stress that lean on its own will not improve environmental performance but that integrating the two paradigms will achieve economic, environmental and social benefits. Manufacturers have realised that adopting lean and green together has allowed them to achieve reduced costs, increased revenues and an improved brand image (Fercoq, Lamouri, Carbone, Lelièvre and Lemieux, 2013: 117).

In their study of the environmental and economic outcomes of lean practices, Herrmann, Thiede, Stehr and Bergmann (2008: 86) simulated the effects of different combinations of five lean methods. They used energy consumption to measure environmental performance and found that increasing standardisation improved performance. Other lean practices, such as Andon or the stoppage of the production line when a defect occurs, increased energy consumption and hence were detrimental to environmental performance. They mentioned JIT as a lean practice with particularly negative environmental consequences.

Companies attempting to implement lean and green practices in a holistic way face a range of challenges. Cherrafi, Elfezazi, Garza-Reyes, Benhida and Mokhlis (2017: 4) identified several these and used the term “Green Lean” to describe the combination of these two philosophies. They emphasised that government support is an important component of the success of green lean. Furthermore, they found that human factors such as skill levels among employees constitute a barrier to the integration of lean and green in organisations (Cherrafi et al., 2017: 10).

2.6 Role of stakeholders

Pressure groups have played a significant role in encouraging the pulp and paper industry to practise business in a sustainable manner. Institutional theory states that external forces play a significant role in shaping organisational activities and stresses the importance of legitimacy for an organisation to remain competitive (Berrone, Gelabert, and Gómez-Mejía, 2007: 4). Pressure groups and public awareness of the impact that the paper industry is having on the environment have pushed the industry to act responsibly and to adopt sustainable practices. Government and other stakeholders, including suppliers and customers, influence a company's ability to stay in business.

Pokhrel and Viraraghavan (2004: 38) discuss the role of public awareness of pollutants and government regulations in forcing the pulp and paper industry to treat its effluent before discharging it into the environment. External stakeholders that have played a role in the development of the pulp and paper industry in South Africa include the International Organisation for Standards (ISO), the Forest Stewardship Council (FSC), the World Wide Fund for Nature (WWF) and the South African government through various pieces of legislation such as the National Environmental Management Act (NEMA) and the National Forestry Act.

2.6.1 Suppliers

Suppliers play a significant role when a business aims to achieve certain environmental goals. Many businesses have incorporated supplier development into their business strategy to improve the performance of their suppliers. To achieve green targets, suppliers have to be willing to adopt waste elimination practices and to avoid introducing any harmful materials into the value chain. Regulatory bodies have assisted in ensuring that suppliers comply with environmental standards, such as ISO 14001, and many companies now choose to associate with compliant suppliers only. Green purchasing provides guidelines to ensure that suppliers adopt environmentally acceptable practices. The chain of custody guidelines adopted within the pulp and paper industry allow wood to be tracked through the supply chain from forests to the retailer and hence ensures that suppliers of raw material follow green cultivation practices (Stryjewski, 2007: 19).

2.6.2 Government

The increasing concerns with climate change have resulted in governments responding through implementation of policies that will protect the environment.

2.6.2.1 Carbon taxes

The carbon tax bill is among the new legislation which the South African government plans to put in place to reduce the country's contribution to climate change. This policy is a tax that is designed to help reduce greenhouse gas emissions to achieve the national emissions targets: a reduction of 34% by 2020 and 42% by 2025 (Alton et al., 2014: 351). The main concern about this tax is avoiding the transfer of the burden to the consumer, therefore implementation should be done carefully to strike a balance between energy, development and environmental goals (National Treasury, 2013: 58). The initial marginal carbon tax rate is likely to be set at R120 per tonne of carbon emissions. The tax base comprises emissions from fossil fuels, combustion emissions from industrial processes (including the pulp and paper industry), product use and fugitive emissions. Greenhouse gases covered include carbon dioxide, methane, nitrous oxide, perfluoro carbons, hydrofluoro carbons and sulphur hexafluoride. The importance of reducing emissions of greenhouse gas is due to their effects on the environment, human health and ecosystems (EPA, 2010: 6).

2.6.2.2 National Forests Act

The Act aims to protect all of South Africa's forest resources to save the forests for future generations (Republic of South Africa, 1998a). According to the Institute of Natural Resources (2002: 4) "sustainable forest management principles and policies in the act are promoted through a set of criteria, indicators and standards (CI&S) that are reported on a regular basis through the State of the Forests." The move to adopt FSC certification in plantation forestry shows that the pulp and paper industry to some extent already follows these principles and policies voluntarily.

2.6.2.3 National Environmental Management Act (NEMA)

NEMA guides all parties in the pulp and paper industry to conduct their activities in a sustainable manner (Republic of South Africa, 1998b). Chapter one emphasises sustainable development and requires the consideration of all relevant factors including the following:

- i. Avoiding or minimising the disturbance of ecosystems and loss of biological diversity;
- ii. Pollution and degradation of the environment are avoided, minimised and remedied;
- iii. Landscapes and sites that constitute the nation's cultural heritage should not be disturbed where it cannot be altogether avoided, activities should be minimised and remedied;

- iv. Waste is avoided, minimised and reused or recycled where possible and ensure disposal of it in a responsible manner;
- v. Responsible use and exploitation of non-renewable natural resources, and consideration of the consequences of the depletion of the resource;
- vi. Ensure that the development, use and exploitation of renewable resources and the ecosystems of which they are part do not exceed the level beyond which their integrity is jeopardised;
- vii. That a risk-averse and cautious approach is applied, which accounts the limits of current knowledge about the consequences of decisions and actions; and
- viii. Negative impacts on the environment and on people's environmental rights be anticipated and prevented, if they cannot be prevented, are minimised and remedied.

2.6.3 United Nations

The Kyoto protocol, adopted in Kyoto, Japan in 1997, sets binding greenhouse gas emission reduction targets for industrialised countries (Brown and Durst, 2014: 16). It is an international agreement which forms part of the United Nations Framework Convention on Climate Change. The main objective is to facilitate, promote and enforce compliance with commitments under the protocol to meet emission reduction targets. The protocol is based on the premise that global warming exists and human-made gas emissions have contributed to this.

2.6.4 Forest Stewardship Council (FSC)

According to Teketay, Mbolo, Kalonga and Ahmin (2016: 4), forest certification is a way of promoting sustainable forest management, through the inspection of forest management activities and the tracking of forest products through the supply chain to ensure that a strict set of environmental, social, and economic standards is maintained. Companies such as Sappi and Mondi realised that to gain consumer trust, their products should not endanger forests and it would be ideal to certify their forestry. The Sappi Group Sustainability Report of 2013 states that all their owned and leased plantations are 100% FSC certified and 86% of fibre used is certified (Sappi, 2013: 99). The Forest Stewardship Council (FSC), mission is:

- To ensure environmentally proper forest management, harvest timber and non-timber products, preserve the forests biodiversity, productivity and ecology.
- Be socially beneficial practising corporate social responsibility helping both local people and society at large. To enjoy longstanding benefits and to provide enough

incentives to local people to withstand the forest resources and adhere to long-term management plans.

- Economically sustainable forest operations structured and managed to be sufficiently profitable without generating financial profit at the expense of the forest resources and ecosystem of affected communities (FSC, 2012: 4).

The FSC also ensures that forestry products on the shelf come from the same forests that have been certified through the chain of custody certification. Chain of custody allows wood to be tracked through the supply chain from forests to the retailer (Stryjewski, 2007: 19). This encourages the pulp and paper industry to avoid further depletion of indigenous forests.

2.6.5 International Organisation for Standards (ISO)

The International Organisation for Standards introduced the ISO 14001 accreditation, which ensures that organisations conduct their operations in a sustainable manner and reduce the environmental impact of their organisation (De Mendonça and Baxter, 2001: 52). Objectives and targets can be set to monitor if the organisation is controlling significant impacts and if the organisation is improving on environmental performance. ISO requires that the organisation complies with the following criteria to be certified (Whitelaw, 2004: 8):

- Develop an environmental policy
- Identify environmental aspects and evaluate the associated environmental impact
- Establish appropriate legal and regulatory requirements
- Develop and maintain environmental objectives and targets
- Implement a documented system, including elements of training, operations and dealing with emergencies
- Monitor and measure operational activities
- Audit the internal environment to monitor progress
- Manage reviews of the system to ensure its continuing effectiveness and suitability

ISO certification puts pressure on the organisation to keep their activities environmentally friendly before and after certification. It motivates the organisation to have a planned mechanism for continuous improvement. It also creates a good public image and can enable a company to gain market share since consumers prefer associating with organisations that are certified.

2.6.6 World Wide Fund for Nature (WWF)

WWF has played a significant role in saving the planet. Its mission is “to end the degradation of planet's natural environment, and build a future in which humans live in harmony with nature” (WWF, n.d.: 1). WWF and Mondi have formed a partnership to try and mitigate the impact of Mondi’s operations on forests’ climate and water, and to encourage sustainable development within the paper industry. The partnership focuses on three main areas (WWF, n.d.: 4):

- Ecosystem stewardship: promoting high conservation and value of ecosystems
- Manufacturing stewardship: reducing water and climate footprint and promoting recycling
- Product stewardship: enhancing environmental performance of Mondi’s products.

2.7 Conclusion

Industry stakeholders, ranging from customers to regulatory bodies and government, demand that companies conduct their business in such a way that environmental impact is minimised. Green supply chain management provides principles and practices that can improve the environmental performance of businesses. The pulp and paper industry is known to be one of the heaviest polluters in the world and is therefore under pressure to change its industry practices. Nonetheless, it must continue to generate profit and must seek to integrate its environmental goals with cost reduction and improvements in product quality. Lean supply chain management aims to reduce waste and increase profits and may therefore be able to contribute to improved environmental performance while maintaining profitability. This study sought to assess the extent to which a South African pulp and paper company has improved its environmental performance and to investigate which stakeholders have influenced changes in its supply chain practices. This literature has suggested that lean practices may make a further contribution to these efforts.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

Chapter 2 explored previous research concerning the phenomenon of green supply chain management, its integration with lean management and application to the pulp and paper industry. This secondary data provided the researcher with an understanding of the background and gaps in the body of knowledge in this field.

The purpose of this chapter is to consider and explain the logic behind the research methods and techniques used to gather information needed for the study (Welman, Kruger and Mitchell 2005: 2). It also presents the methods used by the researcher and how these were applied to answer the research questions and address the research problems.

This chapter comprises sections explaining: the *purpose* of the research, *research objectives* from the research problem, *research design* used to gather information to achieve objectives set, and the *research approach* adopted. The chapter will then look at the *research instrument* used for data collection, and method used to *analyse collected data*, while ensuring that data collected remains *reliable and valid* for future use. The last section will cover the *ethical considerations* that were taken into account during the course of the study.

3.2 Purpose of the study

The increasing concern for the environment among consumers and the increase in competition has led to most organisations incorporating practices that conserve the environment. Incorporating both green and lean practices within global supply chains has become the norm in some parts of the world (Mollenkopf et al., 2010: 14). However, only a few researchers have looked at the potential to improve supply chain performance by applying lean and green practices, particularly in developing countries.

This study aims to provide a deeper understanding of the two practices in relation to the pulp and paper industry to see if they can yield better results from an operational and environmental performance perspective. To the best of the researcher's knowledge no researchers have considered this relationship in this particular industry. There may be potential for the industry to make improvements and this research may provide a basis for future studies to guide the industry on how to be environmentally responsible while remaining profitable.

3.3 Conceptual Framework

The framework illustrated in Figure 3.1 proposes that stakeholders, including government, activists, shareholders and employees, play a significant role in putting pressure on focal firms to support sustainable development (Hassini, Surti and Searcy, 2012: 69). The influence of stakeholders is indicated with dotted arrows in Figure 3.1. It is in the focal company's interest to ensure that all parties along the supply chain are committed to reducing the supply chain's impact on the environment. The product flow through the supply chain is indicated with solid arrows, while the practices which mediate the supply chain partners' impacts are shown with horizontal arrows. Green supply chain practices are instrumental in reducing the adverse effects of the supply chain on the environment and research suggests that lean practices can make a further contribution. The aim of this study was to analyse the influence of stakeholders on the pulp and paper supply chain, the green practices within this supply chain and the potential for lean practices to contribute further to the environmental performance of the supply chain.

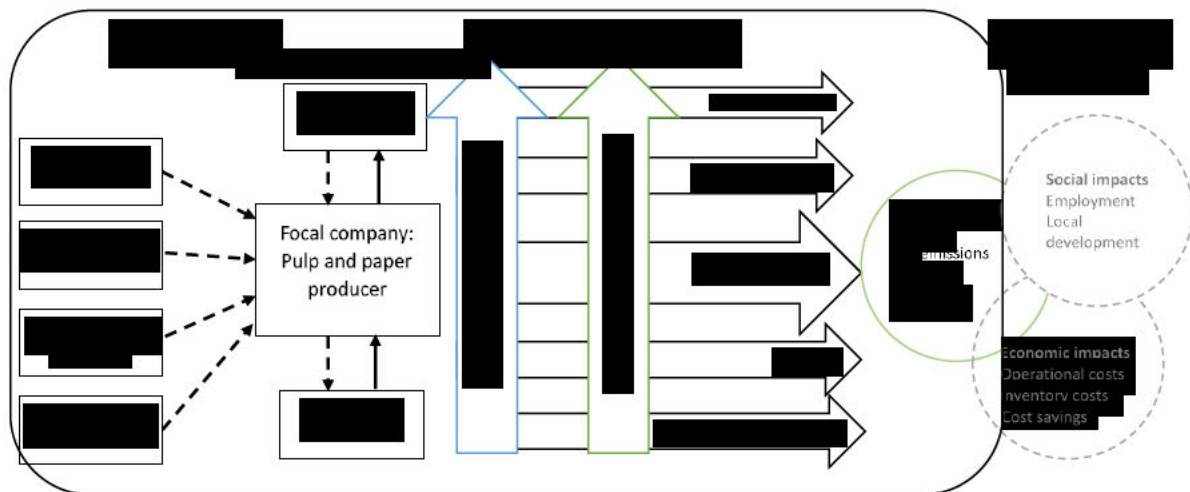


Figure 3.1 Conceptual framework (Source: Adapted from Seuring and Müller, 2008: 1706 and Azevedo et al., 2012: 756).

This conceptual framework provided tentative *a priori* constructs which shaped the research design and did not constitute a theoretical framework since this was exploratory research aimed at laying the basis for theory building on the integration of lean and green (Barratt, Choi and Li, 2011: 330; Imenda, 2014: 186).

3.3 Research objectives

These objectives were used to guide the researcher while conducting the research and helped to indicate which methods should be used to yield the best results:

- To investigate the impact of the pulp and paper industry on the environment and to ascertain which green supply chain practices are currently being implemented to reduce this impact.
- To explore the influence of stakeholders (e.g. suppliers, customers, and government) on the achievement of a green supply chain in the pulp and paper industry.
- To suggest how lean practices could be a catalyst for greening the pulp and paper supply chain.

3.4 Research design

Sekaran and Bougie (2013: 95) defined research design as, “a blueprint for the collection, measurement, and analysis of data, based on the research questions of the study.” The research design is influenced by the purpose of the study and may depend on how well the phenomenon has been investigated by previous researchers. This study was exploratory because the researcher aimed to gain an in-depth understanding of the paper and pulp industry to provide insights into the problems it faces in greening its supply chain, as well as to provide a basis for future research (Cooper and Schindler, 2014: 129). Although relationships between stakeholders, practices and impacts are proposed in the conceptual model, this research did not attempt to quantify any of these and it was not certain before the start of the research whether the proposed relationships were sufficient for theory building. Before a viable theoretical framework can be developed, specifically for the pulp and paper industry, more information is needed and this study aimed to contribute to this (Sekaran and Bougie, 2013: 97).

The research study was conducted by means of analysis of secondary data from the academic literature and publicly available documents from companies in the pulp and paper industry (e.g. annual reports). A case study approach provided specific information regarding the practices of a major pulp and paper company in South Africa (Stuart, McCutcheon, Handfield, McLachlin and Samson, 2002: 420). Semi-structured interviews elicited the primary data in this aspect of the study. This design allowed flexibility as the research progressed, meaning the researcher could investigate practices that emerged if necessary.

3.5 Research approach

This study had a qualitative approach. Qualitative case study research can be defined as “empirical research that primarily uses contextually rich data from bounded real world settings to investigate a focused phenomenon” (Barratt et al., 2011: 329). Sodhi and Tang (2014: 29) suggested that this approach allows exploratory research to lay the foundation for theory building by identifying important concepts and the relationships between them. This suggests that the company chosen provides a “revelatory” case which is compatible with an inductive approach where the aim is theory generation (Bryman and Bell, 2015: 62).

Company websites, journal articles and interviews are some of the methods of data collection that may be used when following a qualitative research approach and for this study these three types of source were available and appropriate (Barratt et al., 2011: 331). A single company was approached and in-depth analysis of its supply chain was conducted in a single case study approach. This case study attempted to explain the phenomenon from the perspective and experience of the chosen case (Zainal, 2007: 1). Nonetheless, the combination of primary data from the exploratory case study research and secondary data from journals gave the researcher a broader view of the research problem and led to more generalizable recommendations and conclusions (Sekaran and Bougie, 2013: 97).

3.6 Study site

The study site for this research was the KwaZulu-Natal Province of South Africa, specifically the company’s locations near Pietermaritzburg and Durban. This gave the researcher the opportunity to get information from the supply chain’s beginning where the trees are grown to the end of the paper production process.

3.7 Target population

The target population within the case study company, was the supply chain and environment employees, as staff members are responsible for the supply chain activities of the company. Thus, the phenomenon under investigation – green supply chain – is best explicated by this population.

3.8 Sampling design

There are two types of sampling method, non-probability and probability sampling. In the latter approach, all elements of the population have a known probability of being selected (Sekaran and Bougie, 2013: 247). An example of this would be simple random sampling. This approach was not suitable in this study since only certain staff were available for interviews and, more importantly, only certain staff had the breadth of knowledge needed to provide insights into the phenomenon being studied. Non-probability sampling was used in this study, with no probabilities being attached to the likelihood of participants being chosen (Sekaran and Bougie, 2013: 252). Welman et al. (2005: 56) described non-probability sampling as when elements in the target population have “an unknown chance of being selected as sample subjects.” Only the staff at a particular company were interviewed and the size of the entire population was not ascertained. Furthermore, the sampling approach was purposive and judgment-based in that the participants were selected based on their expertise and involvement in the areas of the supply chain under investigation – they were “in the best position to provide the information required” (Sekaran and Bougie, 2013: 252). The chosen participants were the heads of sections which enabled them to give a more detailed and analytical view of their lean and green practices than staff with less responsibility in the company. The company itself was chosen because it was known to be adopting the supply chain practices under consideration and was willing to participate in the study.

3.9 Sample size

The sample comprised four participants but one participant was on leave. Due to time constraints, the researcher engaged one of the other participants who had taken over the absentee’s tasks. Although this is a small sample of the population of supply chain staff, as senior managers they were in possession of all the required knowledge about supply chain practices and the researcher was able to obtain information on all sections of the supply chain.

The participants were:

- **Logistics and Fibre Supply Manager:** This participant supervises all movement of materials in forestry areas and to pulp and paper mills. This participant provided information regarding the logistics of the company which is the principle contributor to carbon emissions.

- Divisional Environment Manager: This participant is responsible for practices which protect the environment in the forestry division and promote sustainability. This participant had a broad view of practices across the supply chain.
- Development Manager with responsibility for Safety, Health, Environment and Quality (SHEQ): This participant gave insights into the practices in the operations management of the company. The SHEQ role is cross-functional and this participant provided insights across the supply chain.

3.10 Data collection

The chosen data collection method was influenced by the nature of the study and involved the collection of secondary data and primary data. Cooper and Schindler (2014: 96) and Sekaran and Bougie (2013: 116) described secondary data as that which has been collected previously by other researchers and this includes the academic literature. Company websites, journal articles and textbooks provided the secondary data for this study and were used in the development of the conceptual framework and in answering the research questions. These sources provided data on environmental impacts and green practices in the pulp and paper industry. They were also used to answer the third research question proposing a role for lean in greening the pulp and paper supply chain.

Primary data is gathered directly by the researcher through instruments such as surveys or interviews (Choi, Cheng, and Zhao, 2016: 381). For this research, semi-structured interviews were conducted. The interview guides had a list of topics to be covered, although the participants could answer in several different ways and new questions could be posed if the interview raised unforeseen issues (Bryman and Bell, 2015: 467). The interview guides were customised to each section: the logistics section had a set of seven questions, environment and procurement had eight questions and operations had thirteen questions. The interview guides are attached as appendices A to D. The questions were open-ended, allowing flexibility and giving the researcher opportunities to probe for views and opinions of the interviewee and to explore new aspects that became apparent as the interviews progressed (Bryman and Bell, 2015: 469). This was appropriate in this exploratory research which aimed to elicit new ideas on the phenomenon being studied in addition to those proposed in the conceptual framework. The interviews were set to last 20-30 minutes. However, the times varied depending on the respondents' answering styles and the time taken by the researcher to probe for more information.

Recordings were done to allow the researcher to take note of everything and refer to the information for future use.

3.11 Data analysis

Data analysis is required to ensure data collected is interpreted correctly and provides meaningful answers to the research questions. Cooper and Schindler (2014: 86) defined data analysis as, “reducing accumulated data to a manageable size, developing summaries, looking for patterns, and applying statistical techniques.” Sekaran and Bougie (2013: 337) further stated that data analysis comprises three steps: data reduction, data display and the drawing of conclusions.

The secondary data was derived from an extensive literature review while the primary data was collected during the interviews with company managers. The recordings from the interviews were converted to transcripts and combined with the notes taken to provide the researcher with a complete record of the interviews for reference purposes (Welman et al., 2005: 211). This information is attached in Appendix E. Transcripts are essential because field notes can be fragmentary, incomplete, or cryptic due to time constraints during fieldwork (Yin, 2015: 166). The secondary and primary data were then combined through the content analysis process.

Qualitative content analysis was performed on the data collected for this study to achieve an in-depth understanding of the green supply chain phenomenon (Cooper and Schindler, 2014: 144). This method must be distinguished from quantitative content analysis which attempts to identify codes in the text and then count the frequency of occurrence (Drisko and Maschi, 2015: 83). The quantitative method carries a risk of missing important ideas if they don't arise more than once and since this was an exploratory study it was decided to take the broader, qualitative approach (Schreier, 2014: 171). Drisko and Maschi (2015: 86) suggested this method for the exploration of new topics and the description of complex phenomena.

Qualitative content analysis reduces the amount of material so that the researcher can focus on those aspects that will assist in answering the research questions (Schreier, 2014: 170). It bears a close resemblance to the technique of thematic analysis (Drisko and Maschi, 2015: 85). Categories or themes related to the research questions were identified from secondary sources and these are represented in the conceptual framework (Bogdan and Biklen, 2007: 173). This acted as a coding frame for the next step of analysis (Schreier, 2014: 171). Schreier (2014: 176) describes this as working in a “concept-driven way” and explains that this forms the basis of

directed content analysis. This is useful where theory exists but is not complete enough to describe the phenomenon in its entirety (Hsieh and Shannon, 2005: 1281). This was followed by analysis of the primary data (transcripts of interviews) through a process of coding, which allocated segments of the transcripts to the categories. This part of the analysis followed a subsumption strategy in which sub-categories were developed in a data-driven way as new ideas arose which had not been anticipated from the coding frame but which fitted into the conceptual framework.

3.12 Reliability and validity

Silverman (2011: 360) described reliability as whether other researchers would achieve the same results and draw the same conclusions if the study was repeated while Yin (2015: 78) defined valid data as “data that has been properly collected and interpreted, in a way that the conclusions accurately reflect and represent the real world that was studied.” Sekaran and Bougie (2013: 350) pointed out that reliability and validity are not achieved in qualitative research in the same way as they are in quantitative research. This is confirmed by Bryman and Bell (2015: 43), who suggested that alternative ways of judging qualitative research are needed.

Two aspects of reliability may be important for qualitative research: category reliability and interjudge reliability (Sekaran and Bougie, 2013: 350). The first of these relates to whether categories used in the research are well defined. The second measure is consistency between different judges and is related to the first in that clear categories improve consistency of rating between different people. Ideally category development and coding would be carried out by more than one person and their results compared, but this was not possible in the present study. However, Barratt et al. (2011: 331) suggested that reliability in case studies can be improved by using multiple data sources and this was the approach taken in this research. Documents such as sustainability reports, which describe the green supply chain practices of the company, were consulted to corroborate the data collected from the company managers. These also improved the category reliability of the conclusions since they provided guidance in the selection of themes for content analysis.

Case study research does not usually produce results that can be generalised to other contexts which is the aim of ensuring external validity (Bryman and Bell. 2015: 61). These authors maintain that generalisation (and hence transferability) should not be the aim of case study research but they do point out that the concepts which are generated may be used in other cases

or further research. However, Sekaran and Bougie (2013: 351) stated that validity can be improved by ensuring the representativeness of cases and the company studied in this research is one of the largest in the pulp and paper industry in South Africa and hence might be expected to demonstrate practices common to many. This was also confirmed through comparison with green supply chain practices described in the literature. Bryman and Bell (2015: 43) suggested credibility as a better descriptor of internal validity for qualitative studies and interpret this as how believable the findings are. Once again, triangulation with documentary evidence suggested that the interviews produced credible primary data (Sekaran and Bougie, 2013: 351). The semi-structured nature of the interviews also allowed the researcher to probe the participants' understanding of the questions and ensure that meaning was consistent with that found in the secondary data.

3.13 Ethical considerations

It is essential to ensure that ethical considerations are observed such as privacy, anonymity and informed consent when carrying out interviews. Ethical approval for this research was obtained from the University of KwaZulu-Natal Ethics Committee and a gatekeeper's letter from the pulp and paper company confirmed the company's willingness to participate in the study. A non-disclosure of information agreement was signed between the company and the university and another was signed between the university and the student. This was to ensure that confidential information would not be disclosed to any third parties. The researcher obtained informed consent from respondents and allowed them to make the decision to participate based on an explanation of the aims of the study. Privacy and confidentiality were upheld in that participants remained anonymous and were free to withhold any information they did not wish to share with the university. To ensure that information was not distorted and manipulated recordings of the interviews were made and these will be retained by the student's supervisor.

3.14 Conclusion

In this chapter the researcher explained the methods used for data collection to answer the research questions. A case study approach was considered appropriate for this exploratory research and the collected data which was qualitative in nature. This gave the researcher the opportunity to gain more insights in a research area that has not been covered extensively in the literature. Participants were selected using the non-probability sampling method of judgement sampling and data was collected during semi-structured interviews. An interview

guide with open-ended questions ensured that questions were targeted at each participant based on their role in the supply chain. Data was analysed using content analysis in which themes were developed and the data was reduced by allocating segments of the transcripts from the interviews to these different themes. This summarised data provides information to answer the research questions.

CHAPTER 4: RESULTS

4.1 Introduction

A case study approach was chosen to investigate one of the leading companies in the pulp and paper industry, not only in the country but in the southern region of Africa. Themes were developed from the secondary data to provide a framework for the information provided by the company participants. These themes were related to the research objectives and directed the content analysis of the interview transcripts, allowing the researcher to arrange the collected data in a logical manner. The semi-structured nature of the interviews encouraged participants to answer questions fully and allowed unexpected ideas which related to the research objectives to arise.

The research objectives were:

- Objective 1. To evaluate the impact of the pulp and paper industry on the environment and to ascertain which green supply chain practices are currently being implemented to reduce this impact.
- Objective 2. To assess the influence of stakeholders on the achievement of a green supply chain in the pulp and paper industry.
- Objective 3. To suggest how lean practices could be a catalyst for greening the pulp and paper supply chain.

The findings presented below will focus on the first two objectives, while the third objective will be addressed briefly in this chapter and covered more comprehensively in the discussion in the next chapter.

Company X has made progress on cost-saving measures and environmental protection in its efforts to develop a sustainable business. Based on all participant responses, their practices have moved from just focusing on revenues to being more environmentally friendly, even at the expense of their profits. All participants mentioned this impact on profits and acknowledged that the phenomenon of green supply chain management is fairly new and further effects on the return on investment could be experienced. Nevertheless, participants (B and C) felt that it was important to reduce the company's impact on the environment as this not only impacts the company's reputation but is necessary for the sake of future generations.

Themes were created from the literature and the ideas used by participants to explain the current strategies were categorised and coded to allow the researcher to fully analyse which green supply chain practices the company implements. The findings also outline how other stakeholders inside and outside the supply chain have enabled the company to achieve better environmental performance or have made it more difficult. The analysis also provided an insight into how the lean paradigm may enable further greening of the supply chain.

4.2 Organisation profile

The chosen Company X is regarded as one of the leading players in the pulp and paper industry. It has international operations but was founded in South Africa. Company X has a vertically integrated operation, owning over 70% of the trees from which pulp is produced and operating five mills in KwaZulu-Natal and Mpumalanga. The Southern African division produces over 2.3 million tons of pulp and paper per year and is the world's largest producer of dissolving wood pulp. Their business strategies include: cost savings that also promote sustainable practices, expanding on product portfolios and ensuring they produce high quality products. These strategies have enabled the company to remain competitive and keep ahead of changes in the globalised market. Hence the choice of the company was ideal as this is a developed company with the capacity to implement the practices which are the focus of this study and with the likelihood of providing insights into the research problem.

4.3 Participant profiles

Three departmental heads were chosen as participants and they represented four sections that the researcher selected. The departments covered the core supply chain functions of logistics, operations and procurement and also the cross-functional environment/corporate social responsibility section. This enabled the researcher to gain insights into the current processes of the company and particularly its green practices. The interview guide for each section carried a minimum of eight questions, with operations guided by the highest number of questions. Each question had a section explaining what the researcher was looking for, though this was used by the researcher only as a guide to ensure that the participant answered reliably, while also allowing the participant to add any relevant information since the questions were open ended. Participants are referred to by the letters listed in Table 4.1 to maintain confidentiality as agreed when the gatekeeper's letter was obtained.

Table 4.1 Participant profiles.

Participant	Position	Section Covered on Interview Guides
Participant A	Logistics and Fibre Supply Manager	Logistics
Participant B	Divisional Environment Manager	Environment/CSR
Participant C	Development Manager SHEQ (Safety, Health, Environment and Quality)	Operations and Procurement

4.4 Objective 1 - Current environmental impacts and green supply chain practices

The first research objective was to investigate the environmental impacts of the pulp and paper industry and the current green supply chain practices. The themes for this objective were derived from the green supply chain management structure described in the literature review. Ideas contained in the participants' responses were categorised under these themes and summarised in segments of text which form the codes shown in Table 4.2. A brief description of the most important ideas which emerged from this follows.

Green marketing has not been included in the table since this was not an area of expertise for any of the participants and furthermore the literature suggests that green marketing must be derived from green practices in the supply chain.

4.4.1 Green design

This category aims to evaluate how the company designs its products in such a way that undesirable materials are kept out of the supply chain. Company X owns most of the plantations which supply its mills with wood so it has control over the way these plantations are designed and operated. Furthermore, the company investigates alternative sources of fibre that might result in cost savings, but also considers the environmental impacts of these materials. The company has redesigned some of its processes to avoid the use of chemicals, such as elemental chlorine, which may be harmful to the environment.

Participants B and C provided information about this section specifically. However, the other participant also contributed to the category indirectly with a few insights that also linked with the responses of participants B and C.

Table 4.2 Current green supply chain practices

Theme	Key elements from literature	Key ideas in the primary data	Codes from primary data
Green design	<p>Planning stage of products and processes</p> <p>Keeps undesirable materials out of the supply chain</p> <p>Links to cleaner production</p>	<p>Plantations – location and design</p> <p>Use of bagasse as an alternative fibre source</p> <p>Redesign of bleaching processes</p>	<p>Engineering outsourced</p> <p>Delineation of wetlands, streams and rivers</p> <p>Choice of tree species to reduce impact</p> <p>No irrigation</p> <p>Oxygen produced and CO₂ reduced by trees</p> <p>Long term tree farming, Indigenous forest not cut down</p> <p>Benefiting ecosystem not harming</p> <p>Bagasse a versatile alternative to wood</p> <p>Seasonal supply a problem</p> <p>Irrigated sugar cane for bagasse not environmentally friendly</p> <p>TCF adoption 24 years ago (use of chlorine dioxide)</p>
Green procurement	<p>Inputs meet environmental criteria</p> <p>Supplier selection requires certification, eco-efficiency</p>	<p>Supplier selection</p> <p>Supplier evaluation: performance analysis of all suppliers</p>	<p>Sustainability considered in supplier selection</p> <p>SHEQ rather than sustainability</p> <p>On-site audits of suppliers</p> <p>Chemicals imported from overseas – certificate of analysis required</p> <p>ISO certification required – usually for quality purposes</p>
Green manufacturing	<p>Minimisation of waste</p> <p>Maximising resource efficiency</p> <p>Use of sustainable materials and technologies</p> <p>Reduce, reuse, recycle</p> <p>Reduced emissions through cleaner production and end of pipe technologies</p>	<p>Waste and emission management (carbon emissions, heavy metals, coal ash, lignin)</p> <p>Use of water limiting equipment</p> <p>Energy saving (e.g. condensing turbines)</p> <p>Recycling of process materials</p>	<p>Internal audits using check sheets, external legal review</p> <p>Employee training</p> <p>Analysis chemicals with heavy metals sealed and sent to hazardous landfill</p> <p>Coal ash used for block making</p> <p>Bark for garden compost</p> <p>Liquor from calcium cooking for road making</p> <p>Magnesium recovery process – 98% recovery and reuse of magnesium oxide</p> <p>BAT: Condensing turbines result in 60% energy self-sufficient</p> <p>No biological degradation</p>
Green logistics	<p>Reducing transport intensity</p> <p>Increased fuel efficiency, increased load sizes, better scheduling</p>	<p>Performance based standards</p>	<p>PBS leading to reduced carbon emissions</p> <p>Trucks as light as possible, maximum payloads</p> <p>Driver training to ensure fuel efficiency</p> <p>Truck design for fuel efficiency</p> <p>Use of rail to reduce emissions</p> <p>On-board computers monitor payload</p> <p>Back hauls to ensure trucks full on both legs</p>
Reverse logistics	<p>Facilitating recycling and remanufacturing</p>	<p>Recycling through another KZN mill</p>	<p>Recyclers have profit rather than environmental motive</p>

4.4.1.1 Plantations

Participant C provided insight into the location and design of plantations. He highlighted that there are certain misconceptions about plantations and their impact on the environment. The main points he made were: Firstly, that plantations benefit from natural rains and are not artificially irrigated. Secondly, plantations create a balance in the ecosystem, generating oxygen and reducing carbon emissions by capturing carbon dioxide. Participant C went on to say that, *“from that perspective we also do plant a lot of trees than we harvest every year so it is a misconception that we are harming the environment and ecosystems. The land is allocated for the trees and it’s been like that for many, many, years we do not cut down indigenous forest it’s all plantations – tree farming if you want to call it that.”*

Company X has implemented changes to the design of plantations to ensure that they respond to the challenge of trees drawing water from streams and concerns regarding pollution of water with chemicals. Participant B reinforced this by mentioning that they have ensured they plant trees on the “right places” by delineating all wetlands, streams and rivers so that trees will not be planted on such areas where they will extract too much water. They have also ensured that they plant the right species that do not require excessive use of chemicals or any other inputs that could harm the underground organisms and soil balance.

4.4.1.2 Bagasse

The company has investigated the use of bagasse as a substitute for pulp from trees. The aim was to assess how efficient the substitute is and its level of impact on the environment as a raw material. Participant C explained that bagasse is a raw material from sugar cane, generated as a by-product in the production of sugar. The raw material is very effective and versatile as it can be used for a range of products from high-end quality paper for glossy magazines to tissue paper. However, the participant also mentioned that the use of this material has its certain limitations and fully depending on it is problematic. The main problems are the availability of the input as sugar cane production is seasonal. Furthermore, most sugar cane farms use artificial irrigation systems, as sugar cane requires a great deal of water, and this places a strain on the water supply.

4.4.1.3 TCF and ECF processes

The negative environmental effects of chemicals containing chlorine that are used in the bleaching process led companies to move towards totally chlorine-free (TCF) and elemental

chlorine-free (ECF) processes. Elemental chlorine free means that pure chlorine gas is not used in bleaching. In explaining these processes, participant C states that, *“What we have done is the chlorine used to be the first stage of the bleaching process we substituted with chlorine dioxide which is made from sodium dioxide which is elemental free. Although it is chlorine dioxide there is no chlorine in there so it has not changed our process it actually turned out to be a more efficient bleaching chemical than what chlorine used to be.”* The findings suggested that the elemental chlorine free bleaching process is efficient, adding economic value to the company and benefiting the environment.

4.4.2 Green procurement

To ensure that inputs are reliable and authentic the company controls both the selection of suitable suppliers and the ongoing monitoring of selected suppliers with a set of purchasing procedures. These include measures to ensure that suppliers are compliant with environmental protection standards. This category overlaps with the second research objective, as it reflects that suppliers play a significant role in ensuring that environmental goals are met.

4.4.2.1 Supplier selection

The company has rigorous procedures that it follows when engaging a supplier. Participant C stated that *“BEE status has to be there; the letter of good standing from whichever municipality; the trade permits, the tax clearance certificate; all those type of things come into play from a procurement perspective to make sure we are dealing with a reputable company.”* The participant also noted that the company ensures that they deal with larger companies in the market that share their goals, to ensure they perform their activities in ways that do not harm the environment. Company X focuses on ISO certified companies.

4.4.2.2 Supplier evaluation

After suppliers are engaged there are structures that Company X puts in place to ensure that suppliers remain competitive and compliant. Company X’s vendor assessment process ensures that all SHEQ factors are considered, covering environment, health and safety factors as well as the commercial aspect. It is also a legal requirement that they must fulfil and they are audited on a regular basis to check on compliance.

The assessment is not outsourced: responsible team members personally go and conduct the vendor assessment on potential suppliers or on the existing suppliers. Participant C mentions that, *“We do all of them to make sure we are happy with whatever it is they’re doing.”* This

enables them to ensure that suppliers are aware of quality parameters and to check if they can sustain their business. This system promotes green practices and ensures that products that enter the supply chain meet environmental as well as quality standards.

4.4.3 Green manufacturing

The pulp and paper industry in general is regarded as very resource intensive, using large quantities of water and energy in its manufacturing processes. It is criticised for the emissions which contaminate soil, water and air. It is also responsible for carbon dioxide emissions, from both the transport of materials and the production of energy needed in manufacturing, thereby contributing to global warming.

To remain competitive in the international markets in which they operate and to achieve more cost savings, Company X has adopted new technologies that have also enabled them to mitigate issues that affect the environment. These systems have proved to be efficient and this category will cover a few of those mentioned by the respondents, particularly Participants A and C.

4.4.3.1 Waste and emission management

The pulp and paper industry produces waste in different forms which may be liquid, solid or gas (air pollution). This category focuses on these different types of waste and the ways in which Company X has been managing them. The findings are summarised in Table 4.3.

The company has also realised benefits from managing wastes and emissions which has the long-term effect of reducing the impact on the environment and providing economic and social benefits. According to participant B, *“It is all part of efficiency and part of sustainability costs, you have to maximise your social benefits, maximise your economic benefits and minimise your environmental negative impacts or maximise your environmental positive impacts, so you have to integrate you cannot look at the things separately.”*

4.4.3.2 Water saving

To address water usage issues, Company X upgraded its factories with technology that allows them to monitor the water usage within their factories. Although as a company they already have limits from the municipality they have taken it further by ensuring they keep within their limit by installing measuring instruments that help them to control the usage by employees in the industrial processes. The parameters set enable them to reduce their water usage. Where employees in the factory exceed their limit, it must be justified.

Table 4.3 Green manufacturing - Waste and emission management

Type of waste	Management of the waste
Carbon emissions	Emissions come from different sources and among them, for Company X, are exhaust fumes from trucks used to transport materials. To ensure that they curb that problem considering that movement of loads for production is on a regular basis, they invested in PBS vehicles (performance by standard). (see Section 4.4.4).
Heavy metals (lead and mercury)	Chemicals used at some plants for analysis of products produce hazardous heavy metals including lead and mercury. The company has responded by ensuring that the hazardous materials are disposed properly in tight containers and sent to Class 1: hazardous landfill sites. At the landfill site they are properly managed as mentioned by participant C, “Substances like mercury cannot be destroyed in the sense that it will eventually end up in your ground water, hence the special care.”
Coal ash	One of the biggest wastes produced from coal boilers is coal ash. However, this by-product is now reused for building blocks by those from the community instead of sending them to landfill where they end up producing more emissions.
Lignin	There are two cooking processes and one of them calcium cooking process, produces lignin. Lignin is an organic waste material that has negative effects on the environment if sent to water-streams. However, Company

	<p>X has formed a partnership with a recycling company that uses lignin as their main raw material. Reinforcing the statement participant C states that, <i>“What happens from the liquor there that contains the lignin is sent to our neighbouring company which we have a 50/50 partnership with called Y. They actually evaporate the moisture off, that lignin is actually sold.”</i> Lignin is a versatile product as it can be used when making roads as an adhesive known as bio-asphalt.</p>
<p>Black liquor</p>	<p>During the cooking process the lignin comes out and leaves a black-coloured liquid which is then cooked during chemical recovery process to form black liquor. This is now used as a source of energy for the recovery boiler. This reduces carbon emissions as well as preventing pollution.</p>

4.4.3.3 Energy saving

To improve the efficiency of the use of black liquor as an energy source, Company X has invested in condensing turbines that have further reduced their demand on the national grid. This use of a renewable energy source reduces the company’s reliance on fossil fuels, usually coal, to generate electricity. Continued research and development and awareness of new practices from other international competitors have enabled the company to increase their self-sufficiency in energy. According to Participant C, *“We have installed two brand new condensing turbines in order to generate electricity we are at this point about 60% self-sufficient from a electricity perspective and only about 40% of our requirements are supplied from Eskom, the rest we generate ourselves. These condensing turbines means we generating steam, that turns the turbine and during that process the steam gets condensed back into water and goes through the system again to get generated into the steam so it’s just a circle and so the only benefit out of that for us is you don’t get to lose the water but you generate electricity in the process.”*

4.4.3.4 Recycling of process materials

Apart from the recycling of black liquor for energy production in boilers, the magnesium recovery process allows magnesium oxide required for the cooking process to be recovered. At Company X this results in a 98% recovery and reuse of magnesium oxide in Company X's process.

4.4.4 Green logistics

The trucks used for carrying logs and other loads have issues of pollution, fuel efficiency and full capacity utilisation. Company X uses Performance Based Standards (PBS) vehicles to move wood and finished products. The PBS vehicles produce lower carbon emissions through better fuel efficiency and a reduction in the number of loads. This has resulted in a reduction in costs (fuel savings) and environmental benefit. Quoting participant A the *“Net effect of (PBS) is we are now able to carry higher pay loads on the same trucks so it eliminates trucks in the system which obviously reduces the carbon emissions.”* They have also converted to the use of other modes of transport that emit less CO₂, such as rail where possible.

They mention that they keep researching in other markets, as participant A stated: *“We spend a lot of time on R&D finding the most fuel efficient trucks, bringing the latest engines from Europe which are far more efficient and environmentally friendly as well and we are trying to put them onto our fleet as well.”* As a result, the use of smart vehicles and driver training has enabled them to keep their costs minimal, while emitting less to the environment.

4.5 Objective 2: Stakeholders' impact on sustainable development of the company

For an efficient and sustainable supply chain to be achieved all stakeholders should participate in a collaborative effort. This objective was to investigate how the stakeholders, both those in the supply chain and external to it, assist Company X to achieve improved environmental performance and to assess how Company X manages the influences of its stakeholders.

Stakeholders mentioned by the participants included customers, suppliers, government, local communities and certifying authorities. Table 4.4 provides a summary of the themes and codes from this construct. While most of these stakeholders were mentioned in the literature, the theme of communities as stakeholders emerged from the primary data.

Table 4.4 Stakeholders' impact on green practices of the company

Theme	Key elements from literature	Codes from primary data
Customers	Demand sustainable products Participate in recycling initiatives	Customer focus Export customers have stringent requirements Customers insist on company and suppliers ISO certification
Suppliers	Willingness to adopt green practices ISO certification Allow chain of custody tracking	Original equipment manufacturer suppliers (OEM) SHEQ rather than purely environmental selection Overseas suppliers of chemicals Require ISO certification from suppliers Quality control most important
Government	Carbon taxes National Forestry Act: reporting on sustainable practices National Environmental Management Act (NEMA): protection of biodiversity, cultural sites, avoidance of waste, responsible use of resources	Carbon taxes: forests sequester carbon or are carbon neutral Approximately 28 acts to comply with Water Act Forestry Act NEMA Fertiliser legislation Yearly external legal review
Local communities		Employment Block making
United Nations	Kyoto Protocol: Emission reduction, reduction of anthropogenic global warming	Evidence of efforts to reduce emissions, use of renewable energy No direct references to Kyoto protocol
Forestry Stewardship Council (FSC)	Ensure environmentally proper forest management Practice corporate social responsibility Chain of custody certification	All forest owned or leased 100% certified Regular FSC audits
International Organisation for Standards (ISO)	Reduction of environmental impacts Document operations & training Review and audit performance	ISO 9 000 and ISO 14001 accredited Suppliers ISO accredited
World Wide Fund for Nature (WWF)	Encourages ecosystem stewardship Reduce water and climate footprint Promote recycling	30% of land reserved for conservation No direct references to WWF

4.5.1 Customers

Customers are regarded as the main stakeholders as they keep the company in business. They also play a role in influencing companies to deliver quality products: participant C mentioned that *“Customer focus is key, without customers we have no reason to be in business, 98% of our stuff gets exported therefore we are under very stringent quality parameters, very stringent contractual obligations towards our customers with regards to our quality specifications and the volumes we supply them. Our being ISO certified is not good enough for them anymore, they now want us to make sure our suppliers are ISO certified make sure our suppliers are environmentally friendly and so on.”* Foreign markets such as Europe are well advanced in their views on green issues and failure to comply with internationally accepted standards of practice will result in severe penalties. Export customers form the greatest part of Company

X's market and these customers place pressure on the company to use appropriate technologies to reduce environmental impacts. It is crucial for the company to ensure that the customers are satisfied in keeping with global market changes.

4.5.2 Suppliers

Supplier willingness to commit to sustainable development has a positive impact on the whole supply chain. However, as mentioned, some suppliers in the recycling sector make it difficult to strive for less waste as *“They are supposedly the experts in handling all sorts of waste but if they come up with solutions with regards to a certain waste stream or certain type of waste or certain course of waste; it will not be worth it for them from a financial perspective because they make their money by having more in their landfill so it's difficult to fight with these guys or sit around on the table and discuss these things with these guys because they are only interested in what volumes can they get into the landfill because that is where they get their money from.”*

While the company does have a stronger emphasis on quality control and the broader SHEQ compliance, the requirement for ISO certification for suppliers ensures that they comply with environmental standards.

4.5.3 Government

The government enacts legislation that protects the environment and ensures that companies do not over-exploit natural resources. Company X is subject to a range of regulations. According to Participant B the company has ensured that both internal assessments and external audits are done regularly to ensure all processes and procedures are carried out within the law. From the findings, it emerged that the government provides an enabling environment that promotes green supply chain management practices. Participant B commented on the new carbon tax policy: *“As long as that money drives the right behaviour its fine, it is a cynical thing, a company or industry can't just change if you are carbon heavy it is difficult to just suddenly change the process there are billions invested so if that carbon tax and the money that the tax raises is used to drive the right behaviour to make it easy for the everyday person then I will be right behind it.”* As part of the company's vendor assessment process to engage a potential supplier there are documents required according to the laws governing companies, for example BBEE compliance. This shows that the government also plays a role in ensuring that fair and sustainable business is conducted which protects both the supplier and client.

4.5.4 Local communities

Society enables the business to remain operational within a community; dissatisfaction can result in disruptions or even the discontinuation of operations. This is perhaps particularly relevant in South Africa where companies based in rural areas may be located among disadvantaged communities. They must engage with local people to ensure job creation and to maintain good relationships regarding land and environmental issues.

The findings showed that apart from providing employment, Company X has made a positive impact on the community from one of the waste materials which is now reused. *“What we have done there is we have managed to get a licence and are in the process of applying for a licence where we are helping the people apply for it for what we refer to as the Umkomaas Block Makers Association. We supply the ash to these guys to make building blocks so they can build houses and whatever else building construction they may need there by diverting what could have gone to landfill into a useable product.”*

4.5.5 Other stakeholders

Company X claims that 100% of its owned or leased plantations are Forestry Stewardship Council certified. Participant B commented that *“All our operations are certified by the FSC which is internationally recognised.”*

The FSC promotes responsible forest management and offers forest certification as well as chain-of-custody certification to ensure that certified wood is handled separately from any that may not be. This requires independent auditing of the supply chain. Company X uses both types of certification and is therefore held to certain standards of forest and supply chain management.

Company X is both ISO 9001 and ISO 14001 certified and requires their suppliers to be certified as well. This means the company is certified for quality and for environmentally sound practices. Participant A said *“As we are an ISO certified company we require our suppliers to be ISO certified as well.”*

No evidence was presented to suggest that activism plays a major role in influencing the policies and practices of Company X. Bodies such as WWF were not mentioned.

4.6 Objective 3 – Lean practices and their impact on green supply chain management

Participants provided little direct evidence of lean practices. These few ideas were grouped under themes derived from the literature on common principles of lean and green. As a general comment on lean and green practices Participant C said: *“There are definitely synergies (lean & green) there but the only problem there with the green philosophy is it’s relatively new and we are very much in the process of trying to implement and from an environmental perspective it’s easy to see the benefit of what it’s supposed to be but it’s not that easy to get that thinking across to someone that has been in the plant for so many years. We have adopted lean and we are taking all employees through this process and the green philosophy to get them to understand the benefits not just for us but for future generations too.”*

Furthermore, participants believed green practices represented a cost and did not produce savings in Company X. Participant B mentioned that *“environmental activities have not brought any savings it is probably striking a balance and if we were ruthless the company could ignore the environment but paying to rectify would have cost the company more, so being sustainable at no savings in the meantime will be better.”*

4.6.1 Principle of waste reduction

The PBS system introduced to manage the company’s truck fleet is a waste reduction system which reduces costs while reducing carbon emissions. However, the principle of larger loads is not necessarily compatible with lean. The PBS vehicles have computer systems that monitor every load as a precaution against hijacking, which is one of the main challenges in South Africa. This also enables performance, including driver effectiveness, to be monitored.

When asked about the control of water and energy use Participant C commented *“From a lean perspective is we have gone through the process to determine the best efficiency for each individual plant. We are now able to monitor each individual user to make sure that they comply with the requirement and if they don’t we seek a valid reason. So, it’s all about monitoring and making sure the guys stay within their working parameters.”*

4.6.2 Employee involvement and participation

Employees are an essential asset for the organisation to achieve set targets. As mentioned by one of the participants, employee resistance to change can affect performance; hence the need for regular training. Participant C mentioned the adoption of Multi Discipline Teams (MDT) which are used for decision making, discussing problems and providing feedback on how problems were solved, mostly in the production and engineering sections. These are similar to the lean concept of quality circles. This employee involvement philosophy not only makes the employees feel a sense of belonging but it also improves their sense of self-worth and appreciation by the company. This contributes to the personal development of employees and the efficiency and profitability of the company.

The company also recognises employees who have put in effort to solve issues. This employee engagement is said to be very effective: it has made employees realise their importance. The company uses visual displays where everyone can see, which is a constant reminder and promotes greater effort. This has made employees realise that for systems to be efficient they must be involved. Participant C noted: *“From a lean perspective that has actually made a difference to get the people to do what they actually need to do to help the process.”*

4.6.3 Pull strategy

In a lean production system, products move through the supply chain on a pull strategy. From a logistics perspective, Participant A mentioned that despite having production targets they also move timber when the production mill meets targets, to avoid inventory waste. He stated, *“On that basis we only move what is require so if the mill has not met its production target we do not supply digital volume which impacts our carbon foot print we will supply what we have to supply.”*

4.7 Conclusion

The interview guides and transcripts enabled the researcher to group participants' responses in categories under themes derived from the literature. This was to ensure that all findings were considered which were relevant to the research objectives. Better visibility of the collected data was achieved through this process of data reduction.

The findings gave indications of current green practices of the company. In addition it gave an insight into how the company keeps striving for efficiency and improvement through the

adoption of better practices that will address environmental problems that affect not only the company but the entire value chain. Additionally, other stakeholders were found to be relevant to the achievement of environmental targets. Two examples of technology innovations are the condensing turbines that have reduced their electricity demand on the national grid and the adoption of PBS vehicles that reduce emissions and are more fuel efficient. This results in lower costs but also improves environmental performance. This suggests that there may be potential for lean practices to enhance environmental performance.

CHAPTER 5: DISCUSSION OF RESULTS

5.1 Introduction

The previous chapter was focused on summarising the findings from primary data collected for the research. The main purpose of this chapter is to discuss the findings and analyse links with the secondary data from the literature review and documentary sources such as the company's sustainability reports. It also aims to identify where there are discrepancies between theory and practice: how the research supports or is different from the practical point-of-view. The findings are related to the research problem and hence the research objectives were used for guidance in this chapter.

- To evaluate the impact of the pulp and paper industry on the environment and to ascertain which green supply chain practices are currently being implemented to reduce this impact.
- To assess the influence of stakeholders on the achievement of a green supply chain in the pulp and paper industry.
- To suggest how lean practices could be a catalyst for greening the pulp and paper supply chain.

5.2 Objective 1

To evaluate the impact of the pulp and paper industry on the environment and to ascertain which green supply chain practices are currently being implemented to reduce this impact.

All industrial processes affect the environment but the extent of the harmful effects depends on how the individual company responds to this challenge. The pulp and paper industry impacts the environment through emissions to water, air pollution and greenhouse gas emissions from transport and energy use. However, there has been a growing awareness of the importance of conserving the environment and the pulp and paper industry as well as the academic community have responded to this by improving management practices and investing in new technology to mitigate these impacts.

Company X has outlined how they can achieve a more environmentally friendly approach throughout their supply chain. As a vertically integrated company, they have control over their

supply of wood as well as their distribution and logistics. Their green supply chain practices can be considered in three areas which are internal to the company: forestry (supply), operations and logistics. External suppliers include suppliers of chemicals and providers of reverse logistics for paper recycling. The remanufacturing process takes place at a paper mill owned by the company but which did not form part of this study.

5.2.1 Forestry

From a forestry perspective Company X has ensured that more trees are planted in plantations than are harvested, thus benefiting the ecosystem by capturing carbon. They also preserve natural wetlands which are also responsible for carbon sequestration. They have ensured that the right species are planted that require fewer herbicide and pesticide chemicals that harm the ecosystem. The participants also clarified the misconception that plantations cause deforestation of natural forests (Karumbidza, 2006: 16) since they practice tree farming and do not harvest indigenous trees. They plant their own trees on land specifically designated for this purpose and without affecting natural forests. They also set aside 30% of their land for conservation and hence demonstrate a commitment to preserving biodiversity.

Company X has a tree breeding programme to enable them to develop tree species that are drought resistant. Trees are not planted in areas that are close to water courses and this helps to prevent the plantations from drying up streams. This also assists the company's efforts to minimise the impacts of plantations on the ecosystem by ensuring that water and soil pollution, as mentioned by Naidoo et al. (2013: 8), are reduced. Nonetheless, the company's sustainability reports acknowledge that plantations may use up to 14.5% of the water in primary catchments and the increased production of dissolving wood pulp requires the planting of more hardwood eucalyptus (gum) trees which draw more water than the softwood pine trees planted for paper production.

5.2.2 Operations

In their operations, Company X has implemented several environmentally friendly processes. An example is the change from elemental chlorine bleaching practiced in some of Company X's plants up until 2005 to ECF and TCF bleaching. This was a response to the toxic effects of polychlorinated dioxins and furans in effluent which result from chlorine bleaching (Munkittrick et al. 2013: 729). These adversely affect human health and the environment (Weldon and LaKind, 2015: 2). The outcry from the public led to the change to TCF practices in many countries. Company X completed the changeover to the use of ECF and TCF 12 years

ago, and they acknowledge the benefits of the chlorine-free practice not only from an environmental perspective but state that they have achieved greater efficiency and a positive impact on costs.

Company X has also ensured that the different types of waste they emit are disposed of in an environmentally sound manner. One of the participants confirmed that lignin is one of the main wastes from the cooking process. In order to manage this waste, they have formed a partnership with a local manufacturer. The manufacturer uses lignin as a raw material for road building and hence recycling and reuse takes place, thereby avoiding sending this waste to landfill. This reduces the danger of greenhouse gas emissions or contamination of wastewater which would cause excessive biological oxygen demand which stresses living organisms in the water (Setthasakko, 2010: 318).

Reduction in water and energy use are two critical areas for the company, since their processes are regarded as water and energy intensive (Timber Watch Coalition, n.d.: 1). Over a hundred million cubic metres (a hundred thousand million litres) are required by the company every year and over 220 MW of electricity. Company X has adopted a chemical recovery process which not only reduces the amount of lignin waste material, thereby minimising the impact of chemicals on the environment, but also allows the company to make cost savings and to reduce their dependence on energy derived from fossil fuels. By using by-products from the cooking process, such as black liquor, to provide a source of energy the company simultaneously reduces waste discharge to streams and reduces their carbon footprint. Recovered magnesium oxide is reused in the digesters and lime is produced which can be used as a fertiliser to reduce soil acidity.

The company noted in their 2016 annual sustainability report that nearly 90% of the water drawn for use in the pulp and paper process is returned to the environment and this value has increased over the last five years. Evidence based on Participant C's contribution is that the company has upgraded their mill operations by adding measuring equipment that limits the amount of water that can be used for all processes. Controls are in place that curb the system so that mill operators will only get more water when it is justified that they need more water. This illustrates Company X's efforts in mitigating the excessive water usage and this will reduce the impact on the environment in the long-term. The company will also achieve cost savings due to reduced use of water from the municipality (used in two mills in South Africa) and electricity charges for water pumped from rivers and dams.

Efforts to reduce operational waste and environmental harm by adopting BAT (best available technology/technique) has proved to be effective. Company X has integrated BAT within their processes and practices and one example is the use of condensing turbines. The condensing turbines are used to generate electricity so that at this point the company is about 60% self-sufficient from an electricity perspective and only about 40% of their electricity is derived from the national grid from Eskom. The net effect of that is lower costs for the firm, while at the same time it reduces their usage of energy from the national grid. Hence Eskom can meet other users' needs while the company reduces its use of fossil fuels to generate energy, which will reduce carbon emissions.

Different types of waste are sent to landfill during the pulp and paper production process. Company X sends over 300 000 tons of waste to landfill annually. Among these wastes is boiler ash, a solid waste type generated from coal boilers. In another partnership with stakeholders to ensure that they reduce their impact on the environment, Company X recycles their coal ash waste by supplying the ash to builders within their community. It provides a raw material for building blocks which are used to build houses. Other forms of waste include bark which can be used as compost for gardens. Although technically it is landfill, it is widely distributed in this way and it decomposes in a less harmful way. Company X has started a joint venture initiative to compost bark but this is still a small proportion of total landfill waste (less than 6 tons in 2016).

Air emissions include greenhouse gases (GHG) and sulphur dioxide (SO₂) which results from the acid sulphite pulping processes. Direct and indirect GHG production for Company C is over 3 million tons per year, because of the use of technologies including coal-fired boilers and the purchase of electricity from coal-fired power stations. The recovery processes which allow power to be generated using black liquor and increasing use of steam turbines is reducing this impact but the paper and pulp industry remains an energy intensive one. Sulphur dioxide emissions at the company's single mill producing this gas have been reduced by over 20 times since the 1980s and fall within regulatory levels. Nonetheless this gas is the cause of acid rain and poses a nuisance to local communities along with other harmless but malodorous gases. The company still faces a number of environmental challenges, particularly in its core operations.

5.2.3 Logistics

To survive the current competitive environment and reduce some costs of production there is a need to engage new technologies and invest in research and development (R&D). Company X has invested in R&D as mentioned by one of the participants and this has enabled them to replace their fleet with performance based standards (PBS) vehicles. This is an innovative vehicle design and management system originally developed in Australia. The PBS vehicles have enabled them to reduce emissions due to lower fuel use and increased efficiency as the load per kilometre has improved. Despite the lean notion supporting quick delivery of smaller batches to market, this approach has reduced costs for the company. It has also improved environmental sustainability which focuses on reducing the use of resources and reducing emissions. The use of SMART vehicles shows that if lean and green integration is to take place there is need for trade-offs where lean practices could hinder the main goal of elimination of environmental harm. The use of larger loads in this instance is an example of a green practice which is not necessarily lean but is nonetheless economically viable.

5.3 Objective 2

To assess the influence of stakeholders (suppliers, customers, activists and government) on the achievement of a green supply chain in the pulp and paper industry.

5.3.1 Customers

Customers and other stakeholders are now very much aware of the negative impact on the environment should a company not practice green supply chain management. Incorporating green in a company's processes has a positive impact in its image in the eyes of customers. Supporting this assertion, participants indicated that sustainable practices are what keeps a business surviving. They emphasised that 98% of Company X's product is exported and this creates an imperative to satisfy markets that demand high environmental standards. Mollenkopf et al. (2010:17) stated that the move to embrace other markets comes with different needs that must be considered. Consequently, Company X's international markets have significantly influenced their environmental, quality and other standards that have enabled them to remain competitive. Company X has ensured that it practises continuous improvement in its processes in terms of reducing environmental impacts while maintaining its profitability. Nelson et al. (2012: 37) stated that "triple bottom line involves the use of ecologically-sound practices and procedures, achieving societal endorsements for the firm's products and services in addition to

maintaining economic viability while promoting the concept of green products, eventually balancing out the triple bottom line.” In an informal survey, reported in its 2014 sustainability report, the company found that the environmental issues that its customers were concerned with are: water usage in the production process, recycling of paper, certification of the supply chain and carbon footprint of the company. The company must address these concerns if it is to remain competitive.

As mentioned by Participant C, their foreign market mostly now requires Company X to associate with suppliers that are also engaged in green practices. ISO 14001 certification for the company itself is not enough: other upstream suppliers need to be ISO certified as well. This shows that customers play a significant role in ensuring that a green supply chain is achieved.

5.3.2 Suppliers

Suppliers are the business’s upstream stakeholders and hence it is of paramount importance to ensure that the best suppliers are engaged from an environmental perspective. Participant C highlighted that the supplier selection criteria are stringent measures that will ensure the focal firm’s network is sustainable. Azevedo et al. (2012: 756) confirmed that putting suppliers under pressure will have a ripple effect on the supply chain performance. The green issues highlighted by these authors were also mentioned by the participants. These include:

- First tier supplier to have environmental management systems (ISO certification) - *“Our being ISO certified is not good enough for them anymore they now want us to make sure our suppliers are ISO certified and are environmentally friendly and so on.”*
- Monitoring supplier’s environmental performance – regular supplier evaluation.
- Using green procurement guidelines and sourcing from environmentally responsible sources.

The company has a policy of supporting local suppliers where possible, although participants indicated that chemical suppliers are based in Canada, Saudi Arabia and China. Bagasse used for fibre production is supplied by local growers, including previously disadvantaged farmers. In the company’s 2014 sustainability report, they emphasised that this policy reduces carbon emissions while improving profitability.

5.3.3 Government

Company X is obliged to comply with legislation, standards and other voluntary regulations that play a role in ensuring companies in different industries are practising good business in all aspects. The company is subject to emissions standards for its mills and is engaging with government in the introduction of a carbon tax. Their 2016 sustainability report indicates that this tax will be introduced in 2018.

It is crucial to ensure that constant audits and training are in place. Participants also highlighted that the environment team ensures that the operations employees have constant training and updates on environmental issues. The company also ensures that external auditors are engaged twice a year and internal audits are carried out on a regular basis to ensure that the company's practices are still within the parameters set by stakeholders and the company itself.

The government and other regulatory bodies are also crucial stakeholders for any industry to ensure fair practices for both the company and other stakeholders. Company X, according to Participant B's contribution, is subject to 28 laws and regulations to which it must adhere and these include NEMA and the National Forests Act. To ensure that they are compliant, internal and external audits are conducted on a regular basis.

5.3.4 Local communities

The company's practices have made an impact on their communities where their plants are situated. They have created jobs and some of their timber comes from BBBEE suppliers although the figures were not available when data was collected. Company X supports community tree-farming. They have engaged with education in local communities, from training early childhood educators through to tutoring high school learners in science. The company has received awards for its community engagement projects.

Company X has also ensured that their waste material is recycled where possible instead of sending to landfill. Over 30% of all paper sold is derived from recycled fibre. Recycling provides employment as well as reducing the need for new material entering the supply chain. As mentioned above, the use of coal ash for building blocks has created homes for the community and contributes to a livelihood for the block makers and builders. Lignin is used as a raw material for road building which also makes an impact on local communities.

5.3.5 Other stakeholders

Company X has ensured that their plantations are certified under the Forestry Stewardship Council (FSC). This ensures that the virgin fibre injected into the value chain is environmentally sound. Being an international player (90% of their product is exported, mostly as pulp) they have ensured that their supply chain network is fully ISO certified because the European market demands high quality, green products.

5.5 Objective 3

To suggest how lean practices could be a catalyst for greening the pulp and paper supply chain.

Despite questions in the semi-structured interviews which referred directly to lean, not much information was given about the lean practices of Company X and hence there may be potential for a number of other lean techniques to increase profits and contribute to further greening of the supply chain of Company X. Multidisciplinary teams and quality management (e.g. ISO accreditation) are both aspects of lean and these were mentioned in the interviews.

According to Pampanelli et al. (2014: 22), in a lean and green model it is crucial to ensure that employees are involved, highlighting the importance of lean tools including visual displays and daily meetings. These are practices that are already in place in Company X. However, there are other lean tools which are identified by the literature as enablers of green.

Value stream mapping (VSM) is a tool that offers an in-depth understanding of the process required to bring a product to market through eliminating non-value added activities and increasing the value-added activities (Shrivastava et al., 2015: 103). This is often the first step towards lean production. The extension of VSM to promote sustainability involves the assessment of environmental metrics such as usage of water, energy, resources, level of pollution, greenhouse gas effects and eutrophication. This is described as sustainable value stream mapping by Faulkner and Badurdeen (2014: 8). This illustrates how lean can act as a catalyst to green the supply chain. Further discussion of this objective is included in Chapter Six.

Company X has introduced several environmental initiatives as mentioned in the previous section. This has resulted in a reduced impact on the environment. However, participants have mentioned that they have not realised significant cost savings as the green philosophy is

relatively new in South Africa. This finding contradicts research stating that the adoption of green will result in cost savings. However, it is possible that the environmental approach has increased revenues (e.g. from the premium paper made from bagasse) and improved brand image (e.g. from wetland preservation initiatives) (Fercoq et al., 2013: 117). Hence the effect on the economic bottom line may only be fully realised in the long-term: the company's participants currently feel they have been investing more compared to the return on investment. Similarly, Mollenkopf et al. (2010: 24) stated that to make processes more environmentally responsible requires more investment for which the return is likely not to be realised in the short-term, as it is with lean cost-reduction strategies. Future integration of lean with green may enable the benefits to be more fully realised as the two approaches complement each other.

5.6 Conclusion

Company X was seen to be making efforts to have a greener supply chain with several processes in place that reduce negative impacts on the environment. The data collected also showed that external parties influence the company's sustainability practices. It emerged that Company X's own focus on improved sustainability is not always shared by suppliers while customers demand environmentally sound products.

Although the literature suggests that lean is a catalyst to greening the supply chain and that the two paradigms create synergies, most of the responses of participants indicated that the implementation of green practices has so far occurred independently of any lean initiatives. The participants felt that there was room for improvement and lean might provide a mechanism to achieve this.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

Lean practices are a well-established part of supply chains' efforts to reduce the cost of production. Green practices are, however, relatively new especially in the South African business sector. Some research suggests that greater environmental gains might be achieved with a holistic approach that incorporates lean practices with a simultaneous focus on the environment. The aim of this study was to gain an understanding of green practices in the pulp and paper industry, to investigate the role of stakeholders in green supply chain management and to assess the environmental benefits that may be achieved by the application of green practices.

Previous chapters explored the current literature on lean and green with a comparison of the two paradigms and a discussion of how they can enable one other. The literature on management practices and sustainability in the pulp and paper industry processes was explored. Furthermore, an empirical study was conducted and the findings were summarised under themes which related to green supply chain management and stakeholder engagement. Codes were created from the findings which were linked with the objectives of the study through the themes. The empirical data enabled the researcher to discuss to what extent the findings agree with the literature, and to highlight where there was disagreement with the literature. This chapter will explain the conclusions of the study and provide recommendations on how further lean and green implementation might achieve cost savings and environmental conservation.

6.2 Conclusions

The company under study mentioned several practices that they have implemented which have made changes to their environmental impact. These include:

- Recycling/reusing lignin, an organic waste material. They have partnered with a recycling company that uses the waste material as a raw material. This has made a significant impact on the waste going to landfill and this has a net effect of reducing greenhouse gas emissions from the company.
- Coal ash from the production process is now used as a building raw material by the community in which the company operates.

- The use of chlorine-free bleaching processes has reduced the company's toxic emissions and has also resulted in savings as the new chemicals have fewer implications in terms of treatment after use.
- Investment in new machinery has enabled the company to reduce the cost of production in the long term through becoming more self-sufficient for energy and simultaneously decreasing their carbon emissions by reducing their reliance on fossil fuels.

It was apparent that Company X is engaged in a continuous effort to improve the environmental performance of their business. Furthermore, they are a profitable international business which suggests that economic sustainability is not neglected.

The company has engaged in positive interactions with many of its stakeholders. The pressure that the export market puts on the company to have sustainable operations and products has resulted in them being more conscious of this aspect. Their green image should have a positive impact on their economic performance through the interaction with their customers. The company has also developed positive relationships with communities surrounding their operations, who might otherwise have a negative impact on the performance of the supply chain. At the same time, some of these interactions have improved the performance of the company. Apart from the valorisation of waste through community schemes which reduce environmental impacts, employees are drawn from these communities and the company therefore contributes to the alleviation of poverty. However, analysis suggested that most suppliers engaged by the company are larger companies and in the case of chemical suppliers, these are located far from the company's operations. Global sourcing is likely to contribute to the company's carbon footprint. Nonetheless suppliers are ISO 14001 compliant and hence have been monitored for green practices. Supplier development of local, small enterprises, engaging them on development and training for example, could make a positive impact on the company's environmental performance.

The company complies with a range of government regulations and this stakeholder plays an important role in ensuring that the company maintains a green supply chain. As an energy and water-intensive industry and one that produces large amounts of wastes to landfill, water bodies and in the form of air emissions, Company X must continually improve its operations to meet its environmental obligations. Its certification by voluntary bodies such as the FSC and ISO indicates a positive attitude to these requirements.

While the participants confirmed that they were familiar with lean principles, lean does not appear to have been comprehensively implemented although some important aspects have been introduced, such as multi-disciplinary teams with team-based problem solving, and visual displays which help employees to understand processes (aspects of TQM). There were no indications of a holistic lean-green approach.

The conceptual framework suggests that a change towards green practices has a direct impact on the firm's environmental sustainability and that lean practices can also make a contribution in this regard. However, because the two paradigms seemed to be operating separately some benefits that the literature highlighted have not been realised. Some participants commented that green is still fairly new and they are still gaining an understanding of the philosophy. From the findings, it seems that return on investment from the green investments has not yet been fully realised. Some economic benefits are likely to be recognised in the long-term as mentioned in the literature. Integrating the two paradigms will be beneficial as the returns on lean investments are often realised quickly and this will then provide some compensation for green costs. There are other green practices to be considered that may require less investment such as biological effluent treatment and the use of the water pinch analysis method to reduce water requirements.

Lean practices which were highlighted in the literature might be useful for the company. Challenges with implementing lean are not unusual in a process industry, but there is evidence that there are potential benefits for the environmental performance of companies of this type.

6.3 Recommendations

The company is continuously engaged in process improvement and techniques such as water pinch analysis and bioremediation of waste may offer further gains in sustainability. However, the literature on lean and green systems would suggest that instead of looking at the two paradigms separately, lean practices may make a further contribution to greening of the supply chain and that a Green Lean approach might deliver greater benefits.

6.3.1 Sustainable value stream mapping (SusVSM)

The five principles of value stream mapping may be adapted as follows to incorporate sustainability:

1. Identify a stable value stream

2. Identify the flow of value and its environmental aspects and impacts
3. Measure value stream environmental impacts and the use of natural resources
4. Identify alternatives to impact reduction and resource productivity
5. Pursue perfection with continuous improvement

This will result in a sustainable value stream map which will not merely focus on eliminating waste for more productivity (economic benefit) but also on more productivity with minimal impact on the environment (environment benefit). Company X could profit from this approach as this will impact their performance environmentally and economically. It will enable them to identify the main problem areas in their processes and procedures and could involve their MDT teams (quality circle). Where practices that can improve productivity and reduce environmental impact can be identified these employees can contribute to their implementation and possibly start a virtuous cycle as the teams pursue perfection with the Kaizen (continuous improvement) approach.

The company could use guidelines such as the EPA *Lean and Green Toolkit* (EPA: 2007) to identify wastes during the SusVSM process. This document suggests using environmental metrics when implementing lean, to ensure complementarity between lean and green practices.

Literature suggests that VSM with a focus on the environment plays an important role in the identification of opportunities for sustainability improvements in a company. SusVSM can act as an enabler for achieving greater cooperation in the design and development of new, more environmentally sustainable products, as well as the management of the end-of-life of the product.

6.3.2 Stakeholder collaboration and supply chain integration

From the framework adopted by the researcher, it was suggested that stakeholders play a significant role in supporting sustainable business development and it was evident from the empirical research that this is the case for Company X. Participants highlighted the need for more collaboration with suppliers and customers. They stressed that more can be done should both sides be focused on sustainability rather than profitability. It is recommended that the company develop a transparent value chain with information sharing capability, and that they promote collaboration with their supply chain partners for waste reduction and environmental preservation.

Secondly the framework also shows that to achieve more from lean and green there should be more supplier development. Participants highlighted that they have relationships with suppliers which are more financially focused. This could be the reason why there are almost no recommendations from suppliers on improvements to reduce waste. The literature states that lean and green rely on close collaboration with supply chain partners. Collaboration enables information and best practice sharing across the chain and serves the goal of an integrated supply chain. This opens opportunities for further waste reduction and the extension of the scope of benefits beyond the focal company.

6.3.3 5Ss

Most companies, regardless of their production process, benefit from this ‘housekeeping’ system. It is often introduced as an early stage of the lean journey and requires employees to create a clean, orderly working environment. The hardest of the 5 principles is often to Sustain the systems which have been put in place, so that if lean has yet to become an established part of the way the company operates, and even if the 5Ss have been tried before, it is worth revisiting this technique.

6.3.4 Total productive maintenance (TPM)

With enormous investments in machinery, the pulp and paper industry cannot afford to have down-time with machine breakdowns. TPM strives to minimise these problems, as well as those of slow setups, poor product during start-ups due to machine malfunction and less than optimal machine speeds. The principle of autonomous maintenance by employees involved in the process can contribute to better management of the plant as well as greater employee satisfaction.

TPM reduces environmental impacts by ensuring that energy used is channelled into value added products rather than defective output and machines that function at sub-optimal levels. Maintenance reduces spills and environmental contamination from end-of-pipe pollution control that is not functioning (e.g. effluent treatment plants).

The research findings and literature highlight that a lean environment serves as a catalyst to facilitate green implementation. Lean and green complement each other in the three main principles of waste reduction, reducing waste at source and the involvement of people. In conclusion, more can still be done if concerted efforts are made within the industry’s value chain, making the integrated green-lean model a part of the organisation’s culture instead of

implementing the practices of these two paradigms in isolation. There is a need for more training within the organisation that focuses on employees' orientation towards this way of approaching their work.

6.4 Limitations

The study is exploratory research and used a case study approach and hence it was limited to one organisation. Therefore, the information cannot be generalised to all companies operating in the same industry. More research should be conducted to be able to apply the findings to other companies.

Furthermore, not much research has been conducted on the research problem area, in relation to the paper industry. As a result, the researcher was limited in the journal articles and other sources of information that were used for secondary data and these did not always cover exactly what the researcher was looking for.

Due to time and travel constraints the researcher could not go to the company's other plants which are widely dispersed in the South Africa to get more information from other participants that are employed there. This delimits the researcher's results to two plants where the research participants were situated. Only heads of departments were selected to be a part of the interviews which then excluded the other employees that are not in senior management.

Some participants highlighted that they are still exploring the practice of green supply chain and training employees. Thus, while conducting primary research the researcher might not have obtained the same amount of information that could be obtained should the same issue be raised years later.

6.5 Future research

- The opportunity to access other companies in the industry will give the future researcher more information and allow more general conclusions to be drawn.
- Research into other practices that can be used to improve the environmental sustainability of pulp and paper industry is appropriate in the scientific and engineering fields.
- A lean and green model that can be applied in all industries and regarded as a theory or management philosophy has yet to be developed.

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APPENDICES

Appendix A: Interview Guide: Operations Department

- 1. Plantations are reported to have a substantial impact on ecosystems. Since most of your wood is derived from plantations, what measures have been taken to reduce the impact that plantations have on the environment?**
- 2. You have adopted the use of bagasse as a substitute for trees in making paper at the Stranger Mill. How has that proved to be efficient is there a possibility in the long-term to make that the raw material instead of trees?**
- 3. What are the most hazardous types of waste that typically are produced and how are these wastes managed?**
- 4. Substantial amounts of solid wastes are sent to landfill. How have you managed them to reduce these additions to landfill and the resultant greenhouse gas emissions?**
- 5. Lignin is one of the main wastes that end up in wastewater. What have you done to reduce the levels of lignin discharged to wastewater?**
- 6. How much impact has the adopting of TCF and ECF processes made on reducing impact of the bleaching process?**
- 7. What chemicals have you managed to recover from the chemical recovery process?**
- 8. After multiple recycling of the water from dyeing, how have you managed to dispose the wastewater?**
- 9. What (BAT) Best Alternative Techniques/Technologies have you adopted?**
- 10. What biological methods have you used to degrade waste products?**

- 11. Lean and green are regarded as recent, modern technologies. Have you found these practices contribute to increased efficiencies?**

- 12. The pulp and paper industry is regarded very resource intensive, especially with regard to energy and water. How have you managed to keep the levels minimal? Do lean practices contribute to addressing this issue?**

- 13. Black liquor has been used as an alternative for energy production at the Saiccor mill. Is there a possibility of using the black liquor as a source of energy?**

Appendix B: Interview Guide: Logistics Department

- 1. What have you done to reduce emissions such as exhaust fumes and pollution such as oil spills when transporting?**
- 2. In what ways do you strive to make your vehicles more environmentally friendly and what have been the cost and other implications of these initiatives?**
- 3. Have you considered other means of transportation such as rail to reduce emissions?**
- 4. Due to the high risk of theft in the country, what measures have been put in place to monitor your trucks *en route* to deliver raw materials or final product?**
- 5. Lean philosophy supports just-in-time delivery. To what extent does putting this theory into practice impact the firm's carbon footprint and how is this impact managed?**
- 6. In an effort to reduce transportation costs, what measures have been put in place, be it with third-party distributors or own fleet? How does the use of 3PLs influence the firm's overall compliance with targets?**
- 7. How are the reverse logistics and waste material management aspects of the business managed?**

Appendix C: Interview Guide: Procurement Department

- 1. What supplier selection criteria do you use to ensure that all suppliers are compliant with firms and general industry standards?**
- 2. Are your supplier selection criteria weighted to reflect the environmental practices of suppliers?**
- 3. If yes, how have you ensured that all suppliers supply you with environmentally friendly materials consistently?**
- 4. To what extent have green conscious suppliers contributed to reducing the environmental impact of the firm and what effect has this had on costs?**
- 5. What percentage of raw materials is derived from BBBEE suppliers?**
- 6. How do you ensure that suppliers remain abreast of changes and comply with them? Do you have regular supplier development training in place?**
- 7. The chain-of-custody is a process that ensures that everyone in paper making tier is using environmental sound materials. What processes, methods and technologies do you have in place to ensure that this is achieved?**
- 8. What role do your stakeholders play to achieve sustainable business development?**

Appendix D: Interview Guide: Environment Department

- 1. Please may you outline all the laws and regulations you are aware of that you have to adhere to.**
- 2. What oversight measures have been put in place to ensure that your processes and activities remain in line with the laws and regulations?**
- 3. What has the environment department discovered or learnt that has contributed to reducing environmental impact?**
- 4. Is there room for improvements to reduce the environmental impact of the company? Is it possible to achieve zero waste and zero harm in the long-term?**
- 5. Has the implementation of green practices has any other positive outcomes in terms of economic and social factors?**
- 6. If the two practices (lean and green) are implemented together, do you consider that this creates synergies that enable them to better achieve their full potential? If not what's your thought on the two?**
- 7. What are your thoughts on the carbon tax policy?**
- 8. How has all this impacted the company's triple bottom line?**

Appendix E: Interview Guide Transcripts

Logistics- Interview guide

Q1: What have you done to reduce emissions such as exhaust fumes and pollution such as oil spills when transporting?

In efforts to reduce carbon footprint from the firm's fleet performance by standard vehicles (PBS) were introduced – responsiveness to technology advancements. Net effect of that is they carry higher pay loads hence, eliminating too many trucks consequently reducing carbon emissions

Q2: In what ways do you strive to make your vehicles more environmentally friendly and what have been the cost and other implications of these initiatives?

All our owned vehicles including the contracted to Sappi vehicles all have to be credited with the road traffic management system which is a self-audit process. In terms of the efficiencies a lot of time in driver training to ensure that lowest consumption is achieved.

Q3: Have you considered other means of transportation such as rail to reduce emissions?

The firm uses a combination of both road and rail, it makes sense to use rail on the longer leads and we use road where there is no rail sidings.

Q4: Due to the high risk of theft in the country, what measures have been put in place to monitor your trucks *en route* to deliver raw materials or final product?

The entire fleet have an on-board computers that monitor payload and where the vehicles are on a 24 hour basis.

Q5: Lean philosophy supports just-in-time delivery. To what extend does putting this theory into practice impact the firm's carbon footprint and how is this impact managed?

Supply of materials is based on production targets not digital volume to avoid waste of resources in inventory, hence this impacts the carbon foot-print. Also the environmental ly friendly fleet reduces foot-print.

Q6: In an effort to reduce transportation costs, what measures have been put in place, be it with third-party distributors or own fleet? How does the use of 3PLs influence the firm's overall compliance with targets?

Third party holders they hold for us. Time is spent in R&D in terms of the truck configurations trying to make the trucks as light as possible so that they carry the maximum payload on the various leads that are run. The firm also strives to bring the latest engines from Europe which are far more efficient and environmentally friendly.

Q7: How are the reverse logistics and waste material management aspects of the business managed?

In terms of timber site we do a lot of back hauls ensuring the trucks are full on both legs. *Not much detail could be provided for other sections as participant is more focused on the logistics of fibre (raw material).*

Procurement- Interview guides

Q1: What supplier selection criteria do you use to ensure that all suppliers are compliant with firms and general industry standards?

From a supplier selection criteria obviously the first thing is been in the industry we have what is called OEM (Original Equipment Manufacturer). Most of the equipment we buy OEM can and do supply the spare parts when and if required so. The selection criteria stipulates what it is that the firm needs and guarantee of the equipment that they supply, the BEE status, letter of good standing from whichever municipality; the trade permits the tax clearance certificate; all those type of things come into play from a procurement perspective to make sure we are dealing with a reputable company. Obviously we are looking for sustainability as well so sustainability factors are considered to.

Q2: Are your supplier selection criteria weighted to reflect the environmental practices of suppliers?

Evaluation of suppliers from a SHEQ perspective not just from environment perspective but from a total SHEQ aspect to look at all factors that involve costs and sustainability.

Q3: If yes, how have you ensured that all suppliers supply you with environmentally friendly materials consistently?

Again it is the vendor assessments. Constant site visits to potential and current suppliers to conduct on site audits.

Q4: To what extent have green conscious suppliers contributed to reducing the environmental impact of the firm and what effect has this had on costs?

Unfortunately, what is happening at the moment is we would like to get green conscious companies that are involved in what we are doing especially from a waste perspective. But at this point in time people that are interested in recycling waste are interested in profiting. In the sense that they would want a raw material for free if I could call it and then sell it at a massive profit. I do not know whether their green conscious from an environment perspective or green conscious from a dollar perspective. Lack of competition in the waste industry hence, making it difficult to achieve total waste elimination and sustainability. Not having enough suppliers within the firm's geographical location, resulting to the need to transport waste from one province to another which does not make sense from a financial perspective. Lack of knowledge sharing to improve on waste handling considering that suppliers in the waste management industry have more experience with different types of waste but they merely focus on getting as much waste as possible to make profits.

Q5: What percentage of raw materials is derived from BBBEE suppliers?

Unfortunately I do not have the figures on what that is but I think one of our only or our biggest BBBEE suppliers will be from the timber side but I cannot tell what the actual percentage is I do not have that information. However its mostly the timber the rest of our raw materials is mostly chemicals which get imported from overseas due to no access locally like caustic soda, and enzyme powder, sodium chloride all of those which originate from Saudi Arabia and Canada and in China so it's mostly imported from there.

Q6: How do you ensure that suppliers remain abreast of changes and comply with them? Do you have regular supplier development training in place?

We do not do supplier training or development training for the suppliers again our suppliers we rely on the fact that they are the subject matter experts if you want to call it that from whatever it is that they supply to us. We do outsource a lot of our engineering functions to get more ideas on our function.

Q7: The chain-of-custody is a process that ensures that everyone in paper making tier is using environmental sound materials. What processes, methods and technologies do you have in place to ensure that this is achieved?

The one thing that we do comply with is Forest Stewardship Council. Again it goes back to the vendors and goes back to doing these vendor assessments to make sure they are doing what their supposed to do. One of the requirements just to go back to your very first question which was the selection criteria is because we are ISO credited company we require our suppliers to

be ISO certified as well. What we look at from a chemical supplier perspective and timber perspective as well for that matter is mostly from a quality perspective we need certain parameters to be met before we can utilise the product. One of those quality parameters or one of those parameters is only if you can only verify that if you do a vendor assessment on the site if their doing what their supposed to be doing from an environment perspective. Once the product gets to us it is mainly the physical quality of the chemical that we can verify and they give us a certificate of analysis based on what they give us. All of that gets recorded but it is not going to play in or give you any information on the environmental perspective on how they actually managed to make the product. Just on that for us it is very important to make sure they are complaint because with the chemicals that we get in for example sulphuric acid its malt and sulphur all those things are potentially hazardous if not treated correctly so we do take it very seriously when we do the vendor assessments to make sure that suppliers from their side are doing what they should be doing from an environmental perspective.

Q8: What role do your stakeholders play to achieve sustainable business development?

When you say stakeholders you mean everybody right? Yes! If we start with I'm going to start from the end of the line. Customer focus is key without customers we have no reason to be in business our customers like I said 98% of our products get exported. Therefore we are under very stringent quality parameters, very stringent contractual obligations towards our customers with regards to our quality specifications. They have now gone as far as obviously us been ISO certified is not good enough for them anymore over and above that we are ISO certified they now want us to make sure our suppliers are ISO certified make sure our suppliers are environmentally friendly etc. That is also part of the reason why we are doing these vendor assessments and checks on suppliers to make sure that we can satisfy our customers. We are sitting in the middle at the moment and our biggest driver from our sustainability perspective is to keep the customer happy. It is now been driven from European perspective the focus is on the complete supply chain and themselves they have pressure from a supply chain perspective so we have to play our part to make sure things are happening from our side. I personally think that is a very good thing it is not only forcing us but also forcing our supplier to do what they need to do. From a supplier perspective it goes to the supplier selection criteria obviously we have to make sure they are complying and they are capable of sustaining their business.

Environment- Interview guides

Q1: Please may you outline all the laws and regulations you are aware of that you have to adhere to.

From an environmental and systems perspective and our certification we have a full legal register I think it is about 28 acts of regulations we have a system so there is no way I can just outline them from my head but you know the Water Act, Forestry Act, NEMA even for fertilisers we are fully complaint with the law. Every six months we have a legal review by an external expert, we also have external audits every year so legal issues are very important and we are extremely diligent about it. If you want we could take you through the register but that is likely to take us the whole day but we have a fully documented procedure so everybody whatever they do knows that it is complaint with the law and all the different regulations.

Q2: What oversight measures have been put in place to ensure that your processes and activities remain in line with the laws and regulations?

There are a number of checks and balances, we have fully documented management system it gets checked. We then have internal audits so all our operations get audited regularly internally according to a set audit check sheet (TQM tool). It is like a culture. The second line we normally have an external legal review once a year so that they check our procedures to check that we are correct. Then we have external audits from our certified body the FSC and the FSC principle one: you have to be fully compliant on all legal requirements of the country so external audits will audit us on that. So there are quite a lot of checks.

Q3: What has the environment department discovered or learnt that has contributed to reducing environmental impact?

All procedures have risk checks. I can give you many examples the risk of using too much water - the trees using too much water we understand were the trees should be planted. What we have done is we have delineated all our wetlands and our streams and rivers so that the trees get withdrawn, we have removed them from such areas so that their not in the bottom of valleys sucking too much water, so we plant them in the right place. We also chose which species to plant and where to, one way we have reduced our environmental impact. Another one huge impact we would say the impact of roads on water quality, because our roads are gravel so if you have too much gravel running off the roads into the streams we get dirty water.

**Q4: Is there room for improvements to reduce the environmental impact of the company?
Is it possible to achieve zero waste and zero harm in the long-term?**

I mean there is always room for improvement I mean it is the cost benefit there is a whole lot of issues at stake hence there is always room for improvement. This also comes with investments in technology that will improve on efficiency especially the operations side of the business. The forestry side not much environmental impact however, for the waste the forestry side exerts there are measures in place and there is training for employees to ensure that close to zero waste is achieved. However any business in operation cannot achieve waste every activity impacts the environment negatively, although it differs the amount of waste.

Q5: Has the implementation of green practices has any other positive outcome in terms of economic and social factors?

Look sustainable management is very important and sustainable management balances your environmental impact your social impact and economic impact. There has been a lot of positive benefit from green practices it is all tied up into sustainability our plantations are healthier there is a lot of biodiversity out there, there are benefits. Cost savings – cost is a huge issue, the world is driven by cost savings part of your sustainable future is to control costs and history about our company we have had to go through quite a bit of change over the past five years to really change our processes and change our products and save a lot of costs. If competing internationally costs are huge. Environmental activities have not brought any savings it is probably striking a balance and if we were ruthless the company could ignore the environment but paying to rectify would have cost the company more, so being sustainable at no savings in the meantime will be better.

Q6: If the two practices (lean and green) are implemented together, do you consider that this creates synergies that enable them to better achieve their full potential? If not what's your thought on the two?

While it is all part of efficiency and part of sustainability costs you have got to maximise your social benefits maximise your economic benefits and minimise your environmental negative impacts or maximise your environmental positive impacts, so you have to integrate you cannot look at the things separately. Sustainability modern day thinks it is new, but sustainability has been there since the beginning those companies that are not sustainable go out of business. A lot of these things are reactive we would like to think we are proactive but one is really just reacting to the economic conditions the environmental conditions one lives in and the social climate one lives in so you would like to be proactive but they kind of dictate what happens. A good example will be in this country this whole employment, we know one of the biggest risk factor in Southern Africa is unemployment which means we are not getting out of poverty but

we know the employment costs increases the machine becomes cheaper we cannot become uncompetitive and yet fed the need of the country by employing hundreds of people so you that is the climate we leave in and one has to balance the two. Lean is cost cutting green is you know you can't do one without the other.

Q7: What are your thoughts on the carbon tax policy?

I do not know much about the carbon tax policy and the intricacies of how it is going to work. I think a lot of things are driven on costs. From the bigger picture sustainability from human kind to change things we certainly crossed climate boundary with CO2 content of the atmosphere so we got to do something as a nation and as human beings and if we are going to keep temperatures from not going above or two degrees normal there's got be something drastic to be done. So the carbon tax is a very good way of changing people and money does count and if it's going to be very expensive. However I'm very cynical about us as a society actually wanting to change the government on cutting the carbon. I mean if there are very serious, there is hundreds of things to be done quite simply, for instance why don't we have cycle tracks why, isn't it much easier to go around without burning petrol why don't we have solar geysers on our roofs, there is no will by government to actually implement things that will work. As long as that money drives the right behaviour it's fine. However it is a cynical thing a company or industry can't just change if you are carbon heavy it's difficult to just suddenly change the process there are billions invested. So if that carbon tax and the money that tax raises is used to drive the right behaviour make it easy for the everyday person then I will be right behind it. The technicalities of it are quiet complex like legislation it can get bagged down in certain things that drive the wrong behaviour or you have the wrong outcomes rather than the right outcomes. For a forestry perspective we are carbon neutral or even maybe absorb we sequester carbon. We have to do something otherwise we will experience more climate change issues.

Q8: How has all this impacted the company's triple bottom line?

Certainly our firm we have managed to strike a balance we are certified and all our operations are certified to the FSC which is internationally recognised. The social side is acceptable which means that we get recognition for the work we have done. We have gone further than just FSC we have quite a lot of environmental programs that are well recognised our steward program; setting up nature reserves; 30% of our land is used for conservation so there is a lot of good things from the environmental side. This then has a ripple effect on the economic side of business.

Operations- Interview guides

Q1: Plantations are reported to have a substantial impact on ecosystems. Since most of your wood is derived from plantations, what measures have been taken to reduce the impact that plantations have on the environment?

You know what it is a common misconception if I can call it from an environmental perspective about plantations. Although the trees obviously need water to grow there is no artificial watering taking place everything is all natural water from rainfall and whatever that they rely on. Secondly if you look at it trees give us oxygen so the benefit from the generation of the oxygen helps reducing the CO2 far more beneficial than the water that the trees consume. From that perspective we also do plant a lot of trees than harvest every year so it is a misconception that we are harming the ecosystem. Also the land is allocated for the trees and it's been like that for many years we don't cut down indigenous forest it's all plantations tree farming if you want to call it that. From my perspective we are benefiting the ecosystem instead of harming it.

Q2: You have adopted the use of bagasse as a substitute for trees in making paper at the Stranger Mill. How has that proved to be efficient is there a possibility in the long-term to make that the raw material instead of trees?

The use of bagasse was obviously started with the start of the Stranger Mill factory way back because of the proximity to the sugar mill that was close by. Bagasse is a relatively versatile raw material in that sense that it can both be used for your high end paper your very glossy magazines, secondly it can be used as far down the paper chain as tissue paper so it is a very versatile product. The problem with bagasse is the supply and there is always off season when they don't actually harvest sugar cane so you don't have your consistent supply, unlike the timber it's all year round so that's the only main issue with the bagasse. Also if you look at the raw material of bagasse the majority of your sugar cane farms is under artificial watering with regards to sprinkling systems to make sure that the crop grows so from an environmental perspective they are putting a strain on the environment.

Q3: What are the most hazardous types of waste that typically are produced and how are these wastes managed?

We have some chemicals that we use to do analysis and some of these chemicals contain heavy metal such as mercury and lead in it which is a very big NO! NO! What happens with these used chemicals is they are not exposed to the environment at all once they have been used

beyond the useable expect of a chemical it gets sealed up in a container which is all sealed up in a bigger container sealed up and that is tightly packed and that is then sent to a class 1 hazardous landfill site. As you might know substances like mercury cannot be destroyed in the sense that it will eventually end up in your ground water if you don't take care of it, so that's why these chemicals especially heavy metals are packed and treated with the utmost of care and sealed off to stay in the container forever.

Q4: Substantial amounts of solid wastes are sent to landfill. How have you managed them to reduce these additions to landfill and the resultant greenhouse gas emissions?

From a solid waste perspective for example one of our main wastes that we do generate is coal ash from our coal boilers. What we have done there is we have managed to get a licence and still in processing of applying a licence or helping the people apply for it for what we refer to as the Umkomaas Block Makers Association. We supply the ash to these guys to make building blocks so they can build houses and whatever else building construction they may need they by diverting what could have gone to landfill into a useable product. One of the other wastes is some of our timber when it comes in it still has some remains of bark on it what we do is that it gets used in compost which ends up in people's gardens. Although technically its landfill but it helps people grow their plants in gardens.

Q5: Lignin is one of the main wastes that end up in wastewater. What have you done to reduce the levels of lignin discharged to wastewater?

We have two separate processes in our factory the one is the magnesium recovery process and the other one is calcium cooking process. Now from calcium cooking process perspective what happens from the liquor there that contains the lignin is sent to our neighbour a company which we have a 50/50 partnership with called X. They actually evaporate the moist off, that lignin is actually sold as a product it ends up as a binding material when they build roads and all sorts of other stuff it's a versatile product. I can say there is very little lignin which ends up in the waste water because these guys are trying to recover as much as they can so that's their raw material.

Q6: How much impact has the adopting of TCF and ECF processes made on reducing impact of the bleaching process?

We went total chlorine free probably about 24 years ago when we completely stopped using chlorine as one of our bleaching chemicals that was due to customer demand perspective. I don't know if you are aware 98% of what we make is exported. So from a customer perspective

European customers obviously demand the highest standard and from an environmental perspective they demand absolute commitment from our side to make sure they buy our product. What we have done is the chlorine used to be the first stage of the bleaching process we substituted with chlorine dioxide which is made from sodium dioxide which is elemental free. Although its chlorine dioxide there is no chlorine in there so it hasn't changed our process it actually turned out to be a more efficient bleaching chemical than what chlorine used to be.

Q7: What chemicals have you managed to recover from the chemical recovery process?

I mentioned earlier that we have two cooking process the magnesium cooking process and calcium cooking process. From the magnesium cooking process we use magnesium oxide powder now this goes through the process it gets evaporated after cooking that liquor gets fired in the boiler and we actually recover that powder up to 98% of what we put in and then reused, so that's from our chemical recovery process.

Q8: After multiple recycling of the water from dyeing, how have you managed to dispose the wastewater?

From our side we don't deal with dyeing of the water in the sense of the wood. The Stranger mill works with the recycled material we work with virgin fibre so we don't have recycled material coming through. Stranger Mill participants were not accessible.

Q9: What (BAT) Best Alternative Techniques/Technologies have you adopted?

The most recent thing we have done from an energy perspective is we have installed two brand new condensing turbines. In order to generate electricity we are at this point about 60% self-sufficient from an electricity perspective and only about 40% of our requirements are supplied from Eskom the rest we generate ourselves.

Q10: What biological methods have you used to degrade waste products?

We don't use biological methods or anything to degrade the waste. No process is in place.

Q11: Lean and green are regarded as recent, modern technologies. Have you found these practices contribute to increased efficiencies?

From a lean perspective yes, for a couple of years now we have been running with the lean motto or trying to run with the lean motto, and one of the things we have adopted is what we refer to as MDT (Multi Discipline Team). The process areas are broken down into production and engineering function with all key decision makers sitting on a daily basis going through the previous problems and whatever was done to resolve it how to go forward just to make sure

everyone is on board or aware of what the current status of specific plants and of the factory and how they impact on that. We've got information displays from not just a process but also how the process impacts on the factory as a whole and what we found is that a lot more interest from the individuals and the realisation that their contributions matter in the biggest couple of things. From a lean perspective that has actually made a difference to get the people to do what they actually need to do to help the process. There are definitely synergies (lean & green) there but the only problem there with the green philosophy is it's relatively new and we are very much in the process of trying to implement and from an environmental perspective it's easy to see the benefit what it's supposed to be but it's not that easy to get that thinking across to someone that has been in the plant for so many years. We have adopted the lean and we are taking all employees through this process and we are taking them through this green philosophy and try to get them to understand the benefits not just for us but for future generations too.

Q12: The pulp and paper industry is regarded very resource intensive, especially with regard to energy and water. How have you managed to keep the levels minimal? Do lean practices contribute to addressing this issue?

For paper making or pulp making its very energy intensive like I said what we have done to help we have our condensing turbines to generate our electricity to help ourselves. From a water perspective we went through a very big exercise when we did our last major factory upgrade. This was to identify every single water user in the factory and we were putting measuring instrumentation to make sure that we checking what's coming into the factory. From a lean perspective what we have determined is we have gone through the process to determine the best efficiency for each individual plant. We are now in a position where we are actually monitoring and we can monitor each individual user to make sure that they comply with the requirement and if they don't what is their reason for exceeding their limit. So it's all about monitoring and making sure the guys stay within their working parameters.

Q13: Black liquor has been used as an alternative for energy production at the Saiccor mill. Is there a possibility of using the black liquor as a source of energy?

Do you mean a source of energy somewhere else? Because we already use it as a source of energy and that is the actual fill for the recovery boiler. While basically all that comes from the cooking process we reuse as a fuel source for the recovery broilers. So if you say is there a possibility of using black liquor as a source of energy not for anybody else because we use what we can for ourselves so it's not like we can export it somewhere. Black liquor originates because of the cooking of timber process during the cooking process the lignin comes out and

that lignin is what gives it a characteristic black colour that's why they call it black liquor it's because of the lignin that it contains that fill. So if you have to have a process that extracts the lignin from timber to have black liquor it won't be worth it the energy and time invested.

Appendix F: Informed Consent Form

UNIVERSITY OF KWAZULU-NATAL
School of Management, IT and Governance

Dear Respondent,

M Com Research Project

Researcher: Ms. Nyasha E Munemo (081 216 5045) Email: eugenia.munemo@gmail.com

Supervisor: Dr. RH Salisbury (033 260 5458) Email: salisbury@ukzn.ac.za

Research Office: Humanities & Social Science Research Ethics Administration, Govan Mbeki
Building Westville Campus, Tel 031 260 8350 Email: hssreclclms@ukzn.ac.za

I, Nyasha E Munemo am a Master of Commerce student in the School of Management, IT and Governance, at the University of KwaZulu-Natal. You are invited to participate in a research project entitled *Integrating lean and green operations initiatives in the pulp and paper industry*.

The aim of this study is to: gain an insight into whether lean and green operations have a positive influence on cost savings and preservation of the environment.

Your participation in this project is voluntary. You may refuse to participate or withdraw from the project at any time with no negative consequence. There will be no monetary gain from participating in this research project. Confidentiality and anonymity of records will be maintained by the researcher and the School of Management, IT and Governance, UKZN. All collected data will be used solely for research purposes and will be destroyed after 5 years.

This study has been ethically reviewed and approved by the UKZN Humanities and Social Sciences Research Ethics Committee (approval number HSS/0146/017M).

The interview should take about 30-40 minutes to complete. Thank you for your time.

Sincerely

Investigator's signature _____ Date _____

This page is to be retained by participant

UNIVERSITY OF KWAZULU-NATAL
School of Management, IT and Governance

M Com Research Project

Researcher: Ms. Nyasha E Munemo (081 216 5045) Email: eugenia.munemo@gmail.com

Supervisor: Dr. RH Salisbury (033 260 5458) Email: salisbury@ukzn.ac.za

Research Office: Humanities & Social Science Research Ethics Administration, Govan Mbeki
Building Westville Campus, Tel 031 260 8350 Email: hssreclclms@ukzn.ac.za

CONSENT

I _____ (full names of participant) hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project. I understand that I am at liberty to withdraw from the project at any time, should I so desire.

Additional consent, where applicable

I hereby provide consent to:

Audio-record my interview

YES / NO

Signature of Participant

Date

This page is to be retained by researcher

Appendix G: Ethical Clearance



24 November 2017

Ms Nyasha Eugenia Munemo (211532128)
School of Management, IT & Governance
Pietermaritzburg Campus

Dear Ms Munemo,

Protocol reference number: HSS/0146/017M

New Project Title: Challenges in green supply chain management in the pulp and paper industry: A KwaZulu-Natal case study

Approval notification – Amendment Application

This letter serves to notify you that your application for an amendment dated 20 November 2017 has now been granted Full Approval as follows:

- Change in Title

Any alterations to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study must be reviewed and approved through an amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number. PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

Best wishes for the successful completion of your research protocol.

Yours faithfully



Dr Shenuka Singh (Chair)
Humanities & Social Sciences Research Ethics Committee

/pm

Cc Supervisor: Dr RH Salisbury
Cc Academic Leader Research: Professor Debbie Vigar-Ellis
Cc School Administrator: Ms Debbie Cunyngame

Humanities & Social Sciences Research Ethics Committee

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