Packaging and sustainability: a study of a liquid paperboard pack

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Dissertation presented in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE

in the Department of Chemical Engineering

UNIVERSITY OF CAPE TOWN

May 2013

Declaration

I know the meaning of plagiarism and declare that all the work in the document, save for that which is properly acknowledged using the Harvard convention, is my own.

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Cape Town, May 2013

Abstract

The liquid paperboard (LPB) supply chain converts coated paperboard into single-use beverage cartons. The packaging industry claims to have engaged extensively with matters of sustainability and that it has taken many steps to improve resource efficiency associated with this type of packaging. Yet, the 2011 recycling rate of used beverage cartons (UBCs) in South Africa was 0.9%, implying that significant volumes are going to landfill disposal. UBCs are a source of high quality fully bleached furnish (paper fibres), which are routinely recovered and recycled in many other countries, and this practice has been shown by multiple life cycle assessments (LCAs) to reduce environmental impacts.

The sustainability awareness of different actors in the LPB supply chain was assessed as the first objective, including both South African and international actors in the comparison. Similarities in sustainability reporting were determined by a content analysis of the annual reports supported by two analyses principled on multi-criteria analysis (MCA). The purposively chosen actors in the LPB supply chain were grouped into three namely, *manufacturers*, *organisations* and '*retailers and brand owners'.*

An analysis using the three focal issues of the Nampak 2010 sustainability report, namely *carbon footprint*, *recycling* and *training*, as search terms shows variation in focus amongst manufacturers to be as wide as that in the two other groups though **Stora Enso** (an international manufacturer) is noted as having the having the most similar focus. **PACSA** is the organisation that has the most similar focus to the three Nampak-identified criteria.

The four-criteria principled MCA with *LCA* as the fourth criterion indicates that **Stora Enso** has the most similar focus to that of Nampak; PACSA is the organisation that has the most similar focus to the four criteria and also had the most focus similar focus to Nampak for the single criterion of '*recycling*'.

It is concluded that sustainability awareness in the LPB supply chain is more nuanced in the international companies (based on the date of first responding, word counts in the reports and use of LCA) but is similar between the three company groups in the supply chain.

An LCA is presented in order to investigate whether policy recommendations for further reducing the environmental impacts of LPB use in South Africa would be similar to those in other countries. The LCA uses SimaPro software, ecoinvent databases and the life cycle impact assessment method of CML 2 with the abbreviated functional unit defined as delivering 1 000 litres of milk at the retailer in 2 litre gable-top cartons. A life cycle GWP reduction of 17.4% may be expected for an increase in the recycling rate of UBCs from the current 0.9% to 70% anticipated in the year 2021. A proposed 10% light-weighting of the paper fibres in the carton is shown to have a much lesser reach in reducing the investigated environmental impacts than the high 70 % recycling rate.

The usage of advanced quantitative assessments, in the form of LCA, is thus shown to help direct further efforts to reduce environmental burdens. Refinement with local data sources and impact assessment methods would bring more precision but is unlikely to change the conclusion that the industry could significantly reduce impacts and improve resource efficiency by collecting the UBCs and recycling the fibre.

The recycling of UBCs could utilise the network of the Collect-A-Can metal recover supply chain in order to obtain high recycling rates.

Keywords: Life cycle assessment, multi-criteria analysis, beverage carton, liquid paperboard, supply chain, recycling, light-weighting, carbon footprint, Nampak Ltd.

Dedication

This dissertation is dedicated to my father and mother-in-law:

Desmond (Des) Lindsay Crawcour
1938–2012

Josetta (Josie) Auret Rose (neé Cooper)
1948–2011

Acknowledgements

I am much indebted to my supervisor, Professor Harro von Blottnitz, for his time, enthusiasm towards environmental issues and his generous sharing of his knowledge and insights. He was enthusiastic from the start about my part-time studies and his guidance and sharing have been of tremendous assistance.

Many thanks to Dr Pippa Notten of The Green House for the LCA training and advice. I am also indebted to Pippa for providing a student licence for using SimaPro and ecoinvent.

Thanks to Jen Eidelman of the UCT library staff for her help and guidance in the library. Thanks also to the Nampak Business Information staff for assistance with queries.

Special thanks to previous students of the Greenie group for their easily accessible theses. Thanks to the Greenie group members of '55 in 2010: Ilhaam Dalwai, Jasper Dick, Lesley Sibanda and Caitlin Bergh – it was instructive working in this group. A special thank you to Rethabile Melamu for her generous assistance with SimaPro.

I am thankful to Sveinar Kildal of Elopak (Norway) for his assistance with queries.

I am most grateful to Hazel (neé Black) and Des Crawcour (my Mom and Dad) for believing in me by sponsoring my initial science studies at Wits.

I also thank my husband, Charles Rose, most sincerely for encouraging me to undertake this study and for his support during my studies.

My sister Tracy Profitt – thank you for typing up my first Honours projects, I have never forgotten your generosity.

Thanks are also due to Carol Carr, Mymoena van der Fort and Neli Dili, all of the Chemical Engineering Department at UCT, for assisting me when called upon.

Thanks to all my friends, family and colleagues for their encouragement and advice.

Finally, I wish to thank Nampak Ltd for full sponsorship of my student fees.

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Agenda 21	-	A referendum and schedule for environmental protection, drafted at the United Nations' Earth Summit of 1992 [Accessed 14 May 2013 http://dictionary.reference.com/browse/agenda+21]
Cardinal	-	Of prime importance. [Accessed 14 May 2013 http://dictionary.reference.com/browse/cardinal?s=t] Cardinal numbers (or cardinals) are numbers that say how many of something there are, such as one, two, three, four, five. http://www.mathsisfun.com/definitions/cardinal-number.html
DALY	-	Disability Adjusted Life Years. The sum of years of potential life lost due to premature mortality and the years of productive life lost due to disability. [Accessed 14 May 2013 http://www.who.int/mental_health/management/depression/daly/en/]
GRI Indicators	-	The indicators of the GRI (Global Reporting Initiative) are made up of principals and standards. [Accessed 14 May 2013 https://www.globalreporting.org/reporting/guidelines-online/G3Online/DefiningReportContentQualityAndBoundary/Pages/DefiningReportContent.aspx]
Nominal	-	A number used only as a name, or to identify something (not as an actual value or position) [Accessed 14 May 2013 http://www.mathsisfun.com/definitions/nominal-number.html] e.g. as a 'yes' (equal to 1) and a 'no' (equal to 0) (Spangenberg *et al.,*2002)
Ordinal	-	Ordinal numbers tell the position of something in a list, such as 1st, 2nd, 3rd, 4th, 5th etc. [Accessed 14 May 2013 http://www.mathsisfun.com/definitions/ordinal-number.html]

List of Acronyms and Abbreviations

Al	-	Aluminium
B-BBEE (or BBBEE)	-	Broad-based black economic empowerment
BR	-	Abbreviation for Brazil (in LCA datasets)
c	-	about
CDP	-	Carbon Disclosure Project
CF	-	Carbon footprint
CH	-	Abbreviation for Switzerland (in LCA datasets)
CO_2	-	Carbon dioxide
CR	-	Corporate reporting
CSD	-	Corporate sustainable development
CSMS	-	Corporate Sustainability Management System
CTMP	-	Chemi-thermomechanical pulp
DJSI	-	Dow Jones Sustainability Index
EA	-	Energy/exergy analysis
E&PSE	-	Environmental & Process Systems Engineering
EC	-	Abbreviation for economic (GRI)
ECM	-	Energy Corrected milk
ECR	-	Efficient Consumer Response
EMS	-	Environmental management system
EN	-	Abbreviation for environment (GRI)
EoL	-	End of life
EPR	-	Extended producer responsibility
Eq	-	Equivalent (unit for LCA results)
ESL	-	Extended shelf life
FU	-	Functional unit
G2	-	Generation two of the GRI
G3	-	Generation three of the GRI
GHG	-	Greenhouse gas
GRI	-	Global Reporting Initiative
GT	-	Gable top
GWP	-	Global warming potential
HDPE	-	High-density polyethylene
IPSA	-	Institute of Packaging of South Africa
ISO	-	International Standards Organization
JSE	-	Johannesburg Stock Exchange
JV	-	Joint venture
KPMG	-	Klynveld Peat Marwick Goerdeler (accounting firm)
LA	-	Abbreviation for social (GRI)
LCA	-	Life cycle assessment
LCI	-	Life cycle inventory

LCIA	-	Life cycle impact assessment
LCSP	-	Lowell Center for Sustainable Production
LDPE	-	Low-density polyethylene
LPB	-	Liquid paperboard
MCA	-	Multi-criteria analysis
MCDM/MCDA	-	Multi-criteria decision making/analysis
MFA	-	Material flow analysis
MSW	-	Municipal solid waste
ODP	-	Ozone layer depletion potential
OECD	-	Organization for Economic Cooperation and Development
PACSA	-	Packaging Council of South Africa
PAMSA	-	Paper Manufacturers Association
PCA	-	Plastic Converters Association
PIFSA	-	Printing Industries Federation of South Africa
PRASA	-	Paper Recycling Association of South Africa
PWR	-	Pressurised water reactor
R&D	-	Research & development
RER	-	European average technology (used in the SimaPro software for the LCA)
S	-	System process (used in the SimaPro software for the LCA)
SA	-	South Africa
SFA	-	Substance flow analysis
SOLO	-	Structure of observed learning outcomes
SPA	-	Sustainable Packaging Alliance
SPC	-	Sustainable Packaging Coalition
TAPPSA	-	Technical Association for the Pulp and Paper Industry of South Africa
U	-	Unit process (used in the SimaPro software for the LCA)
UBC	-	Used beverage carton
UCTE	-	Electricity for a selection of countries
US / USA	-	United States of America
V	-	Version of software or database
WBCSD	-	World Business Council on Sustainable Development

CHAPTER 1 INTRODUCTION

The first chapter sets the stage by identifying a gap in the treatment of a specific packaging waste in South Africa, viz. post-consumer liquid paperboard (LPB). Section 1.1 gives a brief overview of this waste in the context of waste management in South Africa. The treatment of this waste in other countries is described and explored in Section 1.1.3. This concern is then related to the broader concept of sustainability in Section 1.2. A problem statement is given in Section 1.3, followed by a statement of objectives for the dissertation (Section 1.4), along with the scope and limitations (Section 1.5). The dissertation has six chapters and the structure and contents are described in Section 1.6. The significance of this dissertation is described in Section 1.7.

1.1 Background

A general overview of municipal solid waste and LPB waste is given in this section.

1.1.1 Environmental concerns: Municipal solid waste

Municipal solid waste (MSW) "is a growing concern on a global level" (Engledow, 2005) and has been a concern for an extended time. It is an issue in most countries due to the cost of removal, health issues for non-removal and shortage of sanitary engineered landfill sites. MSW can be defined by each country in a different manner (OECD, 2008), so care must be taken with the interpretation of data from various countries and it must be noted that waste within a country can vary from the average national figures produced (OECD, 2008).

The values reproduced in Table 1.1 are a guide for introducing the amount of waste produced in different countries. The packaging waste is calculated to be a fraction of the MSW as a guide to obtaining a packaging waste figure and it is calculated to vary from 16.0 to 36.2% (in OECD countries). The packaging waste would be dependent on the socio-economic level of the country and environmental awareness of the citizens of that country.

Discarded packaging is often singled out as an environmental polluter. This happens whether the packaging is discarded into a kerbside collection system or into unsorted MSW. Acknowledging the other wastes of garden refuse, putrescables, e-waste, batteries, fabrics and "other elements" (Trois and Simelane, 2010), it can be seen that putrescables and packaging are regular items in the waste, with the others added after a specific activity such as gardening or tidying. The short life span of packaging (Huang and Ma, 2004) is often noted as being a major contributor to its prevalence in MSW.

Table 1.1: Municipal solid waste (MSW) and packaging waste from various sources

	Municipal waste in 1 000 tons	Calculated % of packaging waste	Year of data	Component as % of packaging waste			
				Paper	**Plastic**	**Glass**	**Metal**
OECD, 2008							
Denmark	3 340	36.2	2003	70.7	13.0	12.9	3.4
Germany	48 430	27.2	2004	52.7	17.1	23.3	6.9
Netherlands	10 160	27.3	2004	52.7	19.8	19.8	7.7
Japan	54 930		2003				
Norway	1 840	32.2	2005	64.0	22.3	7.8	5.9
Sweden	4 170	16.0	2004	68.0	4.3	22.8	4.9
UK	36 120	24.4	2004	42.3	21.0	27.3	9.5
USA	222 860	27.6	2005	57.5	20.1	16.1	6.3
Adapted from Matete and Trois, 2008							
SA affluent				26	45	15	13
SA informal settlements				36	45	10	9

Note: The packaging waste is sorted by four material types; there is no clear indication which country has had recycling taking place prior to the generation of this data. The MSW is from a selection of countries and produced over one year. The table is a summary of various reports (OECD, 2008).

The local packaging industry is under the impression that it contributes "a … small part of the total solid waste stream, 0.2% in South Africa" (IPSA, 2010). However, Sibernagl (2010) reports on a 2007 waste characterisation survey of one landfill in Cape Town (South Africa), in which 50.9% was found to be packaging waste. The IPSA value is a calculation of national waste which includes industrial waste as well as vast quantities of mining residues, formerly not considered waste under South African law. Sibernagl's value of 50.9% is an actual representation of waste in a single municipal landfill site – this figure is the more applicable value when dealing with issues of volume use in a landfill. Industrial waste is often sent to unique disposal sites, and mining residues to facilities such as slimes dams. Both have significant environmental repercussions, but will not be considered further.

Paper-based packaging waste is described by Nahman (2010) as having a 50% recovery rate in South Africa in 2008. The Paper Recycling Association of South Africa (PRASA) reports a 58.64% rate for recovered paper relative to recoverable paper (PRASA, 2011), rising from 57.6% in 2009 via 58.0% in 2010 (PRASA, 2011).

The available plastics recycling rate in South Africa is for all types of plastic and varies from 14.4% in 2000 to 18.0% in 2010 (SAPRO, 2010). These figures are general values and individual polymers may have higher recycling rates. PET recycling stood at 24% of beverage bottles as reported by

PETCO for 2007 (PETCO, 2008) and it reached values of 38% of beverage bottles in 2010 (PETCO, 2010).

The local packaging industry feels that they have worked on “the four Rs” – namely: reduce, reuse, recycle and recover (IPSA, 2010). Standard waste management terminology refers to “3R”, and would consider “recovery” to be integral to “recycling”. The industry argues that society, packaging manufacturers, raw material suppliers, brand owners and retailers each have a specific part to play in “doing things differently” (IPSA, 2010).

1.1.2 LPB packaging waste in South Africa

Used beverage cartons have been collected in some kerbside schemes (e.g. Cape Town since 2007) and are reportedly sent to China for recovery of the components.

A manufacturer formed a partnership with a mill in July 2011 for the recovery of milk and juice cartons through the process of hydropulping (DBR, 2011). The recovery of used beverage cartons (UBCs) is undertaken at the Gayatri Paper Mills in Germiston, Gauteng, South Africa.

Despite the recent developments for collecting the UBCS, the published recycling rates of UBCs in South Africa have been recorded as 0% since 2005 (DEAT, 2005; Engledow 2005) to the present time (PACSA, 2010) with a value of 1.5% of UBCs recorded in the waste at a landfill (Sibernagl, 2010). The low recycling rate is perhaps due to the lack of identification of the UBC once it is in the landfill waste stream.

This low recycling rate of UBCs in South Africa is comparable to the low rate assigned to the USA by Franklin (2006); the USA is given a 5% recycling rate. A higher post-consumer recycling rate of 27% (Franklin Associates, 2006) was obtained in Canada in 2006. In other countries recycling rates as high as 33% are noted in Europe by Tetra Pak (2009) in 2007. China had an approximate recycling rate of 10% for the UBCs supplied by Tetra Pak in 2008. The rates of collection are listed in Table 1.2.

Nahman (2010) discussed the extended producer responsibility (EPR) for packaging waste that is in existence in South Africa. He divides the EPR into voluntary and mandatory cases. The recovery of metal cans in South Africa by Collect-a-Can is often presented as a recycling success, achieving a 67.5% recovery rate of cans in 2008 (Nahman, 2010). At present there is a reported 70% recycling rate for 2010 (Collect-a-Can 2012), with 2008 having the highest collection rate of 72%.

Table 1.2. Rates of collection of used beverage cartons

Author (year)	Year of rate	Country	Rate in %	Description of rate
DEAT	2005	RSA	0	
Engledow, 2005	2005	RSA	0	Collection of used beverage cartons (UBCs)
Franklin, 2006	2006	Canada	27	Post-consumer recycling
Franklin, 2006	2006	USA	5	Post-consumer recycling
Sibernagl, 2010	2007	RSA	1.5	Composites as % of the waste characterisation at Vissershoek
Tetra Pak, 2009	2007	Europe	32	Tetra Pak beverage carton recycle rate
Tetra Pak, 2009	2008	China	c 10	Recycling rate of Tetra Pak beverage cartons
PACSA, 2010	2010	RSA	0	LPB – not yet recycled

The only mandatory EPR in South Africa to date has been for the plastic bag. The reason the government forged ahead with this mandatory EPR was because the thin caliper plastic bag had become the "national flower" as it had little reuse and recovery potential. Regulations were then put in place for a mandatory EPR and this was met with "tensions, debates and responses" as described by Nhamo (2005) in his Nampak-sponsored thesis. He further stated that the industry had suffered job losses at the producers and also in community-based organisations, and he concluded that mandatory regulations are best avoided. That notwithstanding, regulations extending producers' responsibilities are being introduced for a range of waste classes under the National Environmental Management: Waste Act of 2008 (NEM: Waste Act 59 of 2008).

Milk production and distribution in South Africa

South Africa produced approximately 1 100 million litres of white milk in 2007. The proportion of milk that becomes drinking milk is sold in cartons (44%), plastic bottles (40%) and sachets (13%) and a small quantity (about less than 1%) is sold in glass. Foster *et al.* (2006), in the WRAP study of UK milk, state that "about 78% of chilled and ambient liquid milk …is in plastic containers (HDPE and PET) … Glass bottles account for 11% and … cartons for the rest" (11%). Milk sold in South Africa is therefore four times more likely to be sold in a milk carton compared with the UK.

The use of single-use beverage cartons can vary between countries, depending on consumer preference and due to the marketing of a new pack or process.

In South Africa there is no regulation at present regarding the recycling of milk carton packaging.

1.1.3 LPB waste in other countries

As landfill space is limited worldwide, increasing attention is being paid to categories of packaging waste. Used beverage cartons (UBCs) contribute towards filling landfills as the quantities of UBCs produced are high. There has been interest in other countries such as Brazil (Mourad *et al.,* 2008), Germany and Italy in recovering the UBCs from the MSW and recovering the paper fibres, plastic components and in some cases aluminium from the cartons.

In Brazil, the cartons are separated into paper fibres and a polyethylene-aluminium mix that can be separated by plasma technology to generate aluminium, and the plastic is used as fuel (Mourad *et al.,* 2008). The German Papierfabrik Niederauer Muhle recovers the paper fibres from 100 000 tons of UBCs per year (in 2009); however, the polyethylene-aluminium mixture is sent to landfill (Best in Packaging, 2009). The same source advises that there are mills in Finland and Spain that recover the paper fibres from UBCs. Corrugated roof shingles are also produced in Brazil by some 11 operators – the paper is recovered and sold to interested parties – the aluminium and plastic layers are dried and then heat pressed into boards some 7 mm thick. These boards compete with traditional roof tiles on price and comfort factors.

Deniz (2002) describes the shredding of UBCs in Turkey in order to reuse the paper, aluminium and plastic as a material for a plywood–type panel. The process uses two pressing stages and a heating stage to produce Yekpan® panels for furniture (a roofing sheet is pictured in Figure 1.1).

Figure 1.1. A Yekpan roofing sheet made in Turkey from used beverage cartons (UBCs)

In 1999 Nyström (2000) advised that there were an estimated 9 405 tons produced per year of (recycled) “beverage board” under varying commercial names in the following regions: South America (Brazil, Argentina), Africa (Kenya), Asia (China, Pakistan, and Turkey) and Europe (Slovakia). The

Pakistan and Turkey plants are the two that use up to 60% of post-consumer waste – the other sites use at least 99% of post-industrial waste.

The collection of UBCs in the UK is undertaken by consumers who return UBCs to “bring banks”. The three major suppliers in the production of beverage cartons have formed The Alliance for Beverage Cartons and the Environment (ACE UK). UBCs in the UK produced by Tetra Pak, SIG Combibloc and Elopak are able to be deposited into the banks. A fourth supplier (Italpack) does not subscribe to ACE UK but it is likely that the cartons produced by this supplier could end up in the “bring banks”.

1.1.4 LPB waste in the context of sustainability

As discussed in Section 1.1, the South African packaging industry is aware of the concept of sustainability and has taken action by using product design tools, e.g. light-weighting or reduction in the number of materials. The National Environmental Management: Waste Act 59 of 2008 resulted in the government giving authority to the Packaging Council of South Africa (PACSA) to write an Industry Waste Management Plan (Popplewell, 2011). This plan details the collection of paper, metal, glass, PET plastic and other plastic. A material organisation (MO) has been formed “for liquid board packaging under the umbrella of PRASA.” Furthermore, “… Tetra Pak and Gayatri Paper have jointly invested R3 million for the separation of the components of paperboard beverage cartons and certain other paper laminates into recyclable elements” (Popplewell, 2011).

However, in contrast to the regulatory regime applying to the packaging industry in some jurisdictions, prior to 2008 environmental regulations applying to the packaging industry in South Africa were limited to compliance with production site emissions and have since been extended to end-of-life waste management. An optimisation of the environmental considerations of packaging over the product life cycle is not under discussion. In particular, in South Africa there are no publicly accessible studies that deal with the LPB as a packaging material in a cradle-to-grave context.

It is therefore possible to state that there has been little application of Life Cycle Assessment (LCA) as an advanced sustainability assessment tool in the South African packaging industry.

The PACSA waste plan does not mention advanced sustainability assessment tools.

1.2 Introduction to sustainability reporting

The word ‘sustainable’ and ‘sustainability’ are often mentioned in recent annual reports, presentations and used in everyday language. Yet there was a time (noted as before 1991 by Lucena and Schneider, 2008) when engineers received training without reference to sustainability.

Today, engineers receive training in sustainability issues as third-year students (of a four-year course) (Carew and Mitchell, 2002) or even as fourth-year students (Von Blottnitz, 2006). Sibanda *et al* (2011) find evidence through preliminary analysis of feedback from graduated chemical engineers that it would be beneficial to integrate sustainable development into the engineering course from an early point and as a core part of the curriculum.

In South Africa, the King II report of 2002 is a code for corporate governance that encourages companies to publish an annual sustainability report. King II also mentions that the:

> Disclosure of non-financial information should be governed by the principles of reliability, relevance, clarity, comparability, timeliness and verifiability with reference to the Global Reporting Initiative (GRI) Sustainability Reporting Guidelines on economic, environmental and social performance (King II, 2002).

As sustainability reporting evolved over the past decade, how did a company decide what to include, exclude or adapt? A company has to decide which items are relevant to it, its staff and the area it operates in.

The King II report and GRI Guidelines provide information sources that could guide South African companies. In terms of background, it would be useful to know how common sustainability reporting has now become in the South African packaging industry in general, and for LPB suppliers in particular.

1.3 Problem statement

The background to this dissertation, as introduced above, has shown that the packaging industry is well aware of the amount of waste indirectly produced through consumers and in addition to that coming from manufacturers – although in the South African case it is possibly guilty of trying to present itself in a good light by selectively citing waste quantities. The food and beverage industry is crucial for nutrition and the well-being of people. However, with small portion sizes, a decrease in the size of households and single-use packaging, more packaging waste is being produced. The fact that more food and beverages are being preserved is ignored by many critical commentators. Packs are often compared against one another (or the previous pack) and the comparison needs to be undertaken using environmental tools that have relevance and are useful. A best practice at one research site in the packaging industry uses various design and end-of-life scenarios in order to produce the optimal pack for a product (Svanes *et al.,* 2010).

With the imminent changes to the South African packaging legislation, the actors of packaging materials such as LPB need to compare their measurement tools against international best practice. As an example, there have been numerous LCAs published on LPB cartons in other countries that have addressed issues such as the carbon footprint of a carton, the recycling rates and benchmarking against the environmental profile of competing packaging options. All these are rather sophisticated and detailed studies, yet to date the South African packaging industry has no such publicly accessible studies. Against the backdrop of regulatory modernisation in the packaging industry, being driven primarily by end-of-life waste management concerns, this apparent lack of use of a science-based, policy-relevant advanced sustainability assessment tool is the primary concern informing this dissertation.

1.4 Objectives

The dissertation therefore has the following objectives:

- To assess the level of sustainability awareness of a selection of companies active in the supply chain of LPBs in South Africa and to compare this with international best practice
- To investigate whether the use of an LCA for LPB in South Africa would yield policy recommendations (especially for post-consumer recycling) similar to those it yielded in other countries.

This dissertation therefore has two major components: firstly, it compares a selection of companies (in the LPB supply chain) in terms of the focal points in their 2010 sustainability reports. Secondly, it explores the application of LCA to imported liquid paperboard, converted to a beverage milk carton and having end-of-life scenarios as per the current and future proposed South African practices.

1.5 Scope and limitations

Nampak has embraced environmental issues of relevance to the company through the sponsoring of relevant studies. In 2005 Nhamo completed his Nampak-sponsored dissertation on the regulations with regard to plastic (shopping) bags. As per the objectives stated above, the present dissertation (sponsored by Nampak) addresses the sustainability reporting in selected companies in LPB supply chains, and also explores a specific environmental assessment tool for one selected LPB pack.

The researcher is a full-time employee of Nampak Research and Development (Nampak Management Services), registered as a part-time student of the Environmental & Process Systems Engineering Group (E&PSE) within the Department of Chemical Engineering, University of Cape Town.

The LCA study considers a milk pack produced by Nampak and Elopak at the joint venture (JV) named Elopak SA. The other packaging materials (secondary and tertiary) that are used in the supply chain are included as appropriate.

The country-specific datasets needed for the background of a Life Cycle Assessment (LCA) are mostly not available for the South African case. This may limit the precision of the LCA results as it may be necessary to make use of data from other countries when local data are unavailable.

The dairy processor of interest to this dissertation is Woodlands Dairy, situated in Humansdorp in the Eastern Cape. This dairy processes milk and packs it into the selected carton.

The milk carton under study requires refrigeration after packing until consumption, i.e. a chilled distribution chain. The milk is sold in selected retailers' stores.

Litter and the contribution by packaging to this scourge are not under discussion. Furthermore, the study will not be used to compare two similar products. An interpretation of the study's approach and findings for the general public, which would go beyond the stated objectives for this research, would have to be done with appropriate professional care.

The dissertation will not serve as an introduction to LCA as there are numerous guides, standards and books written on the topic. For an introduction to the topic it is recommended that the reader consult Baumann and Tillman (2004).

For this dissertation the references and sources used were mainly in English, unless an English translation was available.

1.6 Dissertation structure

The structure of this dissertation is represented in Figure 1.2.

This chapter (Chapter 1) is an introduction to the dissertation and sets the objectives for the dissertation; it also places the dissertation in context and briefly describes the environmental efforts of the packaging industry. Chapter 2 presents a literature review of sustainability in terms of frameworks and the tools of multi-criteria analysis (MCA) and life cycle assessment (LCA) issues. Chapter 3 starts by outlining the research hypotheses and then describes in detail the methodology that was used for gathering and generating the evidence produced in Chapters 4 and 5, including the MCA of sustainability reports and the LCA of a milk carton.

Chapters 4 and 5 can be read separately and in any order, with Chapter 4 detailing the results of sustainability reporting by the selection of companies involved in the supply chain of LPBs. Chapter 5 deals with the LCI and LCIA results of the selected pack and the possible future means of disposal of the pack in the South African context.

Chapter 6 concludes the dissertation, makes various recommendations and mentions future work.

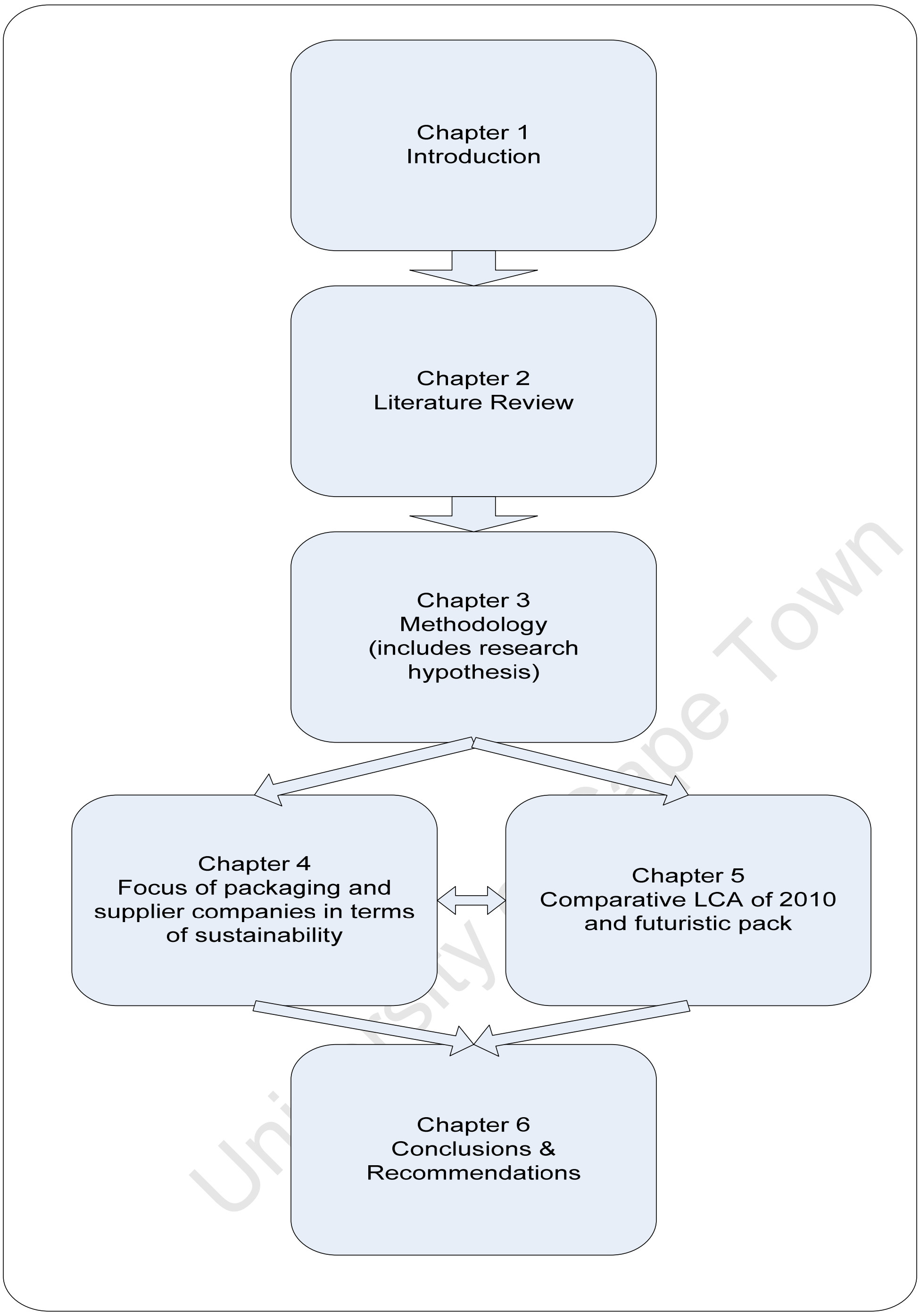

Figure 1.2. The dissertation structure, with a brief description of each chapter

1.7 Significance of this dissertation

This dissertation deals with the liquid paperboard (LPB) supply chain – the first theme uses as a data source the recently published sustainability reports to assess sustainability awareness using the tool of multi-criteria analysis.

This second theme of LCA in the dissertation represents the first sponsored LCA by Nampak Limited (South Africa) and has been compiled by a permanent staff member of Nampak Research and Development (R&D). The dissertation will be the first published LCA that deals with Pure-Pak® cartons in South Africa.

CHAPTER 2 LITERATURE REVIEW

This chapter presents a discussion on the conceptualisation of sustainable development in the packaging industry (Section 2.1), proceeding to a brief discussion of sustainable production and corporate interpretations of sustainability (Section 2.2) in companies. Specific attention is then paid to the analysis of company sustainability reports in section 2.3.

The use of LCA in the packaging industry is reviewed in Section 2.4, identifying outdated criticism of this tool by an important packaging industry body in South Africa, and more relevant critiques of ‘packaging-only’ LCAs. The objectives of LCA studies on packaging systems, the selection of the functional unit, and the availability and choice of LCIA methods are also reviewed. Finally, the literature review introduces liquid paperboard (LPB) packs and discusses the end-of-life recycling rates achieved in various countries.

The chapter concludes with a summary of the literature review (Section 2.5).

2.1 Sustainable development and the packaging industry

> *"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts:*
>
> *the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and*
>
> *the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs."*
>
> (The Brundtland Commission, 1987)

The Brundtland definition is widely regarded as the starting point for a modern definition of sustainability. This definition is of particular relevance to developing countries such as South Africa as there are two distinct groups, namely the rich and poor.

Goodland and Daly (1996) describe the need to separate social, environmental and economic sustainability. The authors clarify those things that “are clearest when kept separate”. They define sustainable development from an “environmental sustainability” vantage point as “universal and non-negotiable”. With these two definitions in mind, the terms “packaging” and “sustainable” will be discussed.

Lewis *et al.* (2010) discuss ‘sustainable packaging’ and base the history of the discussion on the Australian’s Sustainable Packaging Alliance (SPA) and the American Sustainable Packaging Coalition (SPC). The SPC definition is reproduced in Figure 2.1. This definition has eight points which include terms such as recycling, renewable energy resources and contain multiple mentions of the term *life cycle*. Furthermore, the definition mentions clean production and optimisation of materials and energy.

A. Is beneficial, safe & healthy for individuals and communities throughout its life cycle
B. Meets market criteria for performance and cost
C. Is sourced, manufactured, transported, and recycled using renewable energy
D. Optimizes the use of renewable or recycled source materials
E. Is manufactured using clean production technologies and best practices

Figure 2.1. The sustainable packaging definition of the US-based Sustainable Packaging Coalition (SPC) (GreenBlue, 2011)

The SPA definition incorporates the four principles of "effective, efficient, cyclic and clean". Lewis *et al.* (2010) further discuss the Walmart environmental scorecard and note that it is seen as a work in progress and has limitations, such as excluding the effects of primary packaging removed from the retailer's premises. They finally offer a complex definition with four principles, namely "effective (social and economic benefit), efficient (doing more with less), cyclic (optimising recovery) and safe (non-polluting and non-toxic)." The criterion to notice about this definition is that items "must be selected based on the environmental impacts and specific circumstances relating to each product-packaging system".

Robertson (2010) asks the question: "Does it (sustainable packaging) really exist?" He quotes the definition offered by the SPC and proceeds to note that it has been critically reviewed by him as implying "that no packages on the market are sustainable according to this definition". Robertson summarises his article by stating that most consumers believe that sustainable packaging is recyclable packaging and that confusion abounds in the media and among consumers.

According to the PWC (2012), the packaging manufacturers "as a whole have argued that focusing on packaging alone in the sustainability debate is counterproductive and shortsighted". The PWC further state the following:

> It's clear that the debate around what constitutes good or bad packaging has moved on, to the extent that we would argue that 'sustainable packaging', as a term, is no longer relevant. … This means taking into account efficiencies that can be made during the entire life cycle of the product, including a packaging solution that uses the minimum amount of resources and produces the minimum amount of waste, while also protecting the product. And beyond that,

transport and display efficiency, and what happens after the product is used, is also taken into account.

The Efficient Consumer Response (ECR) and European Organization for Packaging and the Environment (EUROPEN, 1999) produced a document to address the issues about ‘sustainable packaging’, in which they prefer to deal with ‘packaging and sustainability’ separately. ECR and EUROPEN addressed the packaging producers and indicated that the term ‘sustainable packaging’ is not correctly understood and should not be used.

‘Packaging and sustainability’ is the preferred term in this dissertation as it keeps the two issues separate but on an equal footing. If it is the case, as Robertson states, that the consumer interprets sustainable packaging as recyclable, then all the other interventions that a pack could undergo are unseen by the consumer.

2.2 Sustainable production and corporate interpretations of sustainability

This section deals with two frameworks that have been proposed by other researchers to guide companies in responding to sustainable development imperative, and also lists various indicators that companies can use for this purpose. The selection of these two frameworks from the numerous selection that is available is undertaken due to previous contact with these frameworks; the limiting factor of two frameworks is due to limited space in the dissertation. Section 2.2.1 describes the two frameworks and they are compared in Section 2.2.2. A selection of indicators is presented in relation to the frameworks in Section 2.2.3.

2.2.1 The two frameworks

The Lowell Center for Sustainable Production (LCSP) framework

The Lowell Center for Sustainable Production is part of the University of Massachusetts, US. Veleva *et al.* (2001) describe the LCSP indicators of sustainable production and define five levels (Figure 2.2) in the framework that companies can achieve. This five-level framework addresses the environmental aspects of sustainable production. The objectives of indicators for firms are as stated:

1. to raise awareness and understanding
2. to inform decision-making
3. to measure progress toward established goals (Veleva *et al.,* 2001).

Each level of the framework is shown in Table 2.1, with examples taken from Veleva *et al.* (2001). The levels are compared in Section 2.2.2 along with the tools that could be used on each level.

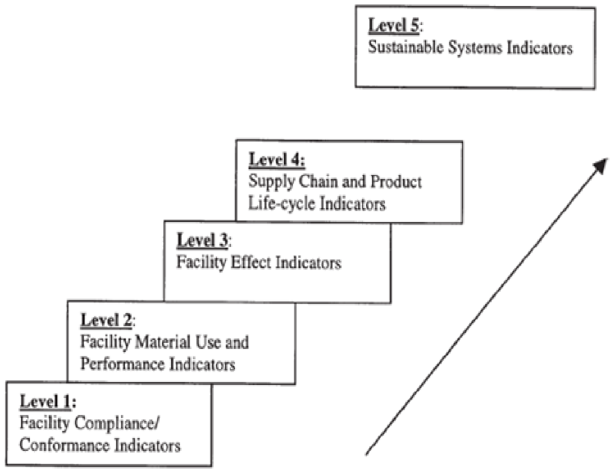

Figure 2.2. The five-level hierarchy of sustainable production (LCSP framework) (Veleva *et al.,* 2001)

Table 2.1. The LCSP framework with examples for each level

Level	LCSP Framework (Veleva *et al.,* 2001)	LCSP Framework (Veleva *et al.,* 2001) examples	Staff training	Highest level of software or equipment required	Level of knowledge
5	Sustainable system indicators	Percentage of total energy used from renewable sources harvested sustainably	Experienced specialists	Advanced technical software, e.g. water recharge	National knowledge
4	Supply chain and life cycle indicators	1. Tons of GHG emissions generated during product transportation (in CO_2 eq) 2. Percentage of products designed to be easily reused or recycled	Specialised scientific or engineering training with other skills, e.g. design, logistics or innovation	Specialised software (environmental & design)	National knowledge
3	Effect indicators	kg of greenhouse gas (GHG) produced per year (in CO_2 eq)	Specialised scientific or engineering training	Specialised software or spreadsheets	Regional knowledge
2	Material use	Tons of sludge generated per kg of product output	Scientific training	Spreadsheets useful	Facility knowledge
1	Compliance	Number or currency value of fines paid	General skills	Not necessary	Facility knowledge

__The Corporate Sustainability Management System (CSMS) of Azapagic (2003)__

Azapagic (2003) describes a five-stage general framework for the management of corporate sustainability (Figure 2.3). This framework is designed to cover all three aspects of sustainability, namely **economic**, **social** and **environmental** (i.e. the triple bottom line (Azapagic Sustainable production and corporate interpretations of sustainability, 2003)).

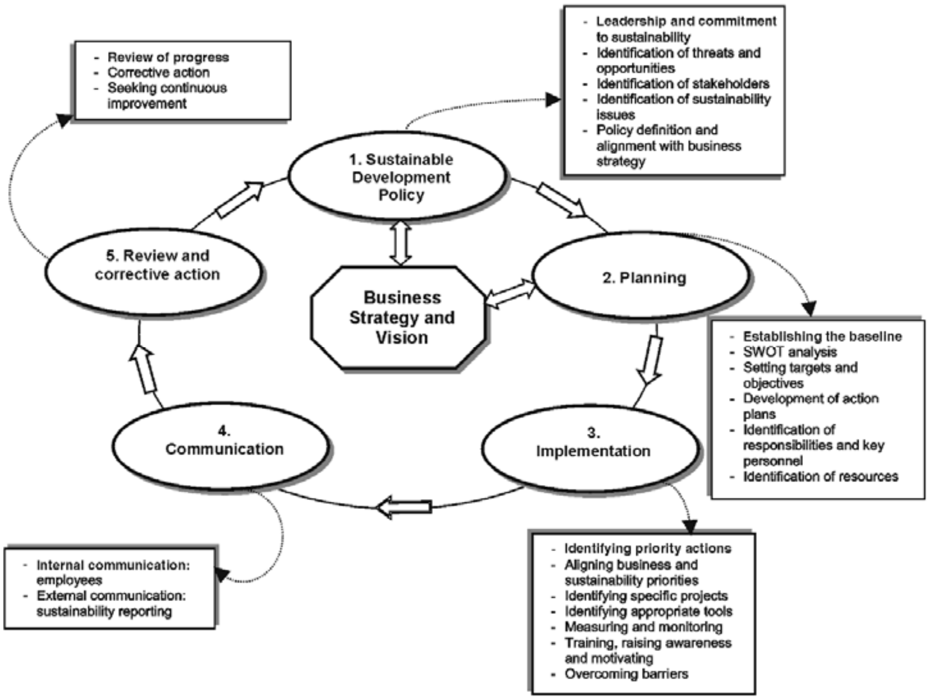

Figure 2.3. The Corporate Sustainability Management System (CSMS) of Azapagic (2003) with five stages

2.2.2 Discussion and comparison of the two frameworks

The LCSP is used as the starting point and is compared with the CSMS framework.

Level 1: Facility compliance/Conformance indicators

This is the starting level and is the minimum level of compliance that the firm (or facility) needs to comply with. Veleva *et al.* (2001) give four examples of indicators, of which the “number or currency value of fines paid” is the selected example. This indicator could be easily determined without the use of any specialised tools, software or knowledge; it would require simply the counting of fines or the summing of the currency value over a specific time period by a staff member with general office skills.

As can be seen from this example for Level 1, the indicator selected can be a count of an event and can be unitless, or it can have a clearly defined unit such as a currency.

The first two stages of the LCSP, namely the 'Sustainable Development Policy', in particular the identification of sustainability issues, and the 'Planning' stage of identifying resources in the CSMS framework (Azapagic, 2003) are equated to Veleva's Level 1.

Level 2: Facility material use and performance

The example selected for analysis on this level is "tons of sludge generated per kg of product output". The example indicator can be measured with the aid of simple analytical equipment such as weighing instruments and uses staff with a level of scientific training.

The use of formal environmental tools as described in Jeswani *et al.* (2010) is in this case matched with the tools of material flow analysis (MFA) and substance flow analysis (SFA). However, this would require the tool to be defined over time.

The stage 3 example from the CSMS framework (Azapagic, 2003) of ''measuring and monitoring'' is equated to the Level 2 of the LCSP framework, though certain items such as identifying appropriate tools could be seen as Level 1 on the LCSP framework.

Level 3: Facility effects

The effect of "GHG produced per year (in kg CO_2 eq)" is selected. This effect requires the use of specialised software and an in-depth study of the facility; it uses staff with a specialised level of training in a scientific or engineering field.

Stage 4 of the CSMS framework (Azapagic, 2003) is "communication" and includes the external communication of sustainability reporting. This output from a facility is deemed to be linked to Level 3 of the LCSP framework. Sustainability reporting by the facility (or parent company) is included as a Level 3 indicator – the reason being that this is the highest of the five levels which reports on a company without the inclusion of the supply chain.

Level 3 could also be matched to the carbon footprint of a facility, provided the scope includes a clearly defined time period.

Level 4: Supply chain and product life cycle

Two examples are used to discuss this level. The first is "GHG emissions generated during product transportation in tons of CO_2 eq" and is a part of a full LCA. This example requires the use of specialised software and an in-depth study of the facility and the supply chain; it uses staff with a specialised level of training in a scientific or engineering field and possibly in the design or logistic fields. The second example of "percentage of products designed to be easily reused or recycled" requires the use of innovative ideas and staff with specialised design skills.

The life cycle assessment tool (Jeswani *et al.,* 2010) is matched with Level 4. This tool is more detailed than the example given by Veleva *et al.* (2001), but the same level of staff, training and software use would be used for such a study.

There are no stages of the CSMS framework (Azapagic, 2003) that are assigned to the Level 4 LCSP framework.

Level 5: Sustainable systems

The example indicator selected is “Percentage of total energy used from renewable sources harvested sustainably” and this requires the use of experienced specialist staff having knowledge of national-level supply chains. This level can also involve advanced technical software used by a small pool of staff.

A tool mentioned by Jeswani *et al.* (2010) is “energy/exergy analysis (EA)”. This bears similarities to the energy concept in Level 5 of the LCSP framework. However, the latter indicates the source and the type of energy (renewable) and gives a value but does not state a minimum level required, e.g. a company could use 5% renewable energy but without a guide to a target, e.g. increasing by x% every y years until a minimum of z% is obtained.

Stage 5 of the CSMS framework (Azapagic, 2003) includes review and continuous improvement and is able to be assigned to Level 5 of the LCSP framework, provided that the systems include this type of looped activity. The feedback loop is not shown in Figure 2.2.

The two frameworks are compared in tabular form in Table 2.

The LCSP framework does not state how many of the level indicators need to be identified, by whom they are identified or what number needs to be undertaken on each level before the firm can claim compliance with the next level. The situation is as stated by Veleva *et al.* (2001):

> A firm can be in full compliance with government requirements but still making little progress in reducing its impacts on global or local sustainability. Additional indicators are needed to examine, for example, the firm’s greenhouse gas emission over time and include estimates of supply chain and product life-cycle contributions.

As already mentioned, the LCSP framework is also a five-step process without any feedback or review as indicated by the single direction of the arrow – this indicates a process that does not have its roots in the ISO standards (Azapagic, 2003).

Table 2.2. The LCSP framework compared with the CSMS framework

Level	The LCSP framework[1]	Stage	The CSMS framework[2]	Example of tool
5	Sustainable system indicators	5	Review and corrective action	Percentage of total energy used from renewable sources harvested sustainably
4	Supply chain and life cycle indicators			Life cycle assessment
3	Effect indicators	4	Communication	Carbon footprint Sustainability reporting
2	Material use	3	Implementation	Tons of sludge generated per kg of product output
1	Compliance	1 & 2	Sustainable Development Policy (1) Planning (2)	Number or currency value of fines paid

Notes:
[1] As per Veleva *et al.* (2001)
[2] As per Azapagic (2003)

In contrast, the framework for Azapagic's (2003) incorporates a review and feedback process in the five-stage flow and she states:

> It is important that sustainable development objectives are clear, concise and, wherever possible, expressed as measurable targets. … Targets also need to be realistic but challenging and related to certain time-scales.

2.2.3 The indicators available to companies

The dissertation is not seeking to design a new tool but to use appropriate indicators in the investigation of the sustainability of the supply chain. Spangenberg *et al.* (2002) define an indicator as something that "ought to build the foundation for improved information and data collection, and enable a comparative … analysis of the state of and progress towards sustainable development".

A company has a large selection of indicators for measuring sustainable development (Spangenberg *et al.,* 2002) and needs to select ideal indicators according to Gatech (2012) which:

1. Are appropriate for the task
2. Are based on readily available, accurate and verifiable data
3. Are easy to apply and evaluate
4. Are simple yet meaningful

5. Allow comparisons with other companies
6. Are politically supported and accepted at different levels
7. Enhance understanding of the context of application
8. Have clear, transparent and standard methodology for data gathering, processing and monitoring.

However, Spangenberg *et al.* (2002) also require the following:

1. Relevant to the main objective of assessing progress towards sustainability
2. Understandable, that is to say, clear, simple and unambiguous
3. Realisable within the capacities …, given logistics, time, technical and other constraints
4. Conceptually well founded
5. Limited in number, remaining open-ended and adaptable to future developments
6. Broad in coverage of Agenda 21 and all aspects of sustainable development
7. Representative of … consensus, to the extent possible
8. Dependent on the data that are readily available or available at reasonable cost to benefit ratio, are adequately documented, of known quality and updated at regular intervals.

Prior to the selection of indicators, the scales need to be discussed and the types need to be clearly documented. The literature discusses three types: *nominal, ordinal* and *cardinal*. Spangenberg *et al.* (2002) state that nominal scales are "inadequate for measuring progress towards sustainability" as the answer is 'yes' or 'no'. However, Perez and Sanchez (2009) used a nominal scale for converting selected GRI data in the sustainability reports of four mining companies in order to undertake an acceptable analysis. This analysis converted the data and "results show that there is a clear evolution in the report's comprehensiveness and depth" (Perez and Sanchez, 2009).

In this context, an analysis of the sustainability reports of various mining companies was undertaken over ten years, i.e. from 1997 to 2006, by Marira and Chipunza (2011). The 2006 reports are considered to be in the early stages of sustainability reporting as once a company reports an item for each of the analysed GRI indicators, then a score of 100 will result. The nominal rating scale is primitive as a comparison of companies all with scores of 100 would be meaningless and an ordinal number for each would be a better fit. Marira and Chipunza (2011) deemed the "yes" and "no" responses suitable for the corporate governance dimensions. The *nominal* values can be used for a rapid analysis for companies that have not yet achieved a "yes" answer for all the rated indicators.

In other analyses of company-produced GRI data, a four-level scale using *ordinal* numbers can be used (Marira and Chipunza, 2011). This gives more insight into the company for the three performance indicators of economic, environmental and social as this scale provides "robust illustrations".

The *cardinal* scale is the third type and provides “quantitative information, referring it to the distance to target” (Spangenberg et al., 2002). An example for country sustainability is “expenditure on R&D as a percentage of GDP (0.4–0.5% for Africa)” (Spangenberg *et al.,* 2002).

Another group of researchers (KLD, 2008) note that it is acceptable if a company references the GRI framework since the GRI has been in existence since 1997 and is therefore seen as an established indicator. The GRI tables provided in company sustainability reports are also seen as a quick tool for analysis and comparison, and can include the triple bottom line, i.e. economic, environmental and social.

2.3 The analysis of company sustainability reports

The analysis of corporate sustainability reports has been ongoing since the 1990s (Perez and Sanchez, 2009). Non-financial company reports can be found by using a combination of keywords, such as sustainability or sustainable, responsibility, environment, society and development (Hubbard, 2009). The term favoured in this dissertation is sustainability reporting.

The literature appears to contain four methods of analysing sustainability reports:

- Discussion
- Content analysis
- Metrics
- Frameworks.

The first method used is a **discussion** of an environmental aspect, although this discussion also mentions metrics such as water footprint. This method was used by Lambooy (2011) to analyse 20 Dutch multinational companies in order to “bear responsibility for their impact on water resources” (Lambooy, 2011).

The method of **content analysis** is used by Hackston and Milne (1996), De Villiers and Lubbe (2001), KLD (2008), Perez and Sanchez (2009) and Marira and Chipunza (2011); this method is reported to be a “favourite approach in social reporting” (Perez and Sanchez, 2009). The selected literature is mostly reviewed by content analysis. The 1992 reports analysed by Hackston and Milne (1996) used a number of sentences dealing with sustainability. Six years later De Villiers and Lubbe (2001) analysed the 1998 reports of 87 companies listed on the JSE using the Hackston and Milne method.

KLD (2008) used five specific questions for a content analysis. The questions are easy to answer and positive responses reveal that a company is aware of sustainability reporting.

Perez and Sanchez (2009) used 62 assessment items of sustainability on four mining companies. For their paper they used a time series of the four mining companies to obtain a clear picture compared with analysing only a single report. The drawback to the method of Perez and Sanchez is that there is a trend among companies for most reports not to contain the additional sustainability items that require “specially trained analysts” for the scoring. However, the companies often report on the GRI third-generation (G3) guidelines (also used by Perez and Sanchez) and this could allow for rapid and accurate analysis.

Another content analysis using the GRI guidelines is the analysis of ten mining companies. This analysis could be undertaken rapidly using selected economic, environmental and social GRI performance items to compare the companies.

With regard to the analysis of metrics, the three pillars of sustainability can be measured in any combination or as a single entity. The reporting of the companies on these metrics enables a company-focused assessment to be done. This method requires companies to report the metrics in a clear, consistent manner for comparison. Two groups of researchers selected this method – the first analysed similar companies in the pulp and paper industry (Mikkilä and Toppinen, 2008) and the other selected 20 German companies (Székely and Knirsch, 2005). While it is possible to list the metrics for companies in different industries, a comparison across industries can lead to less specific conclusions.

A selection of the literature reviewed for sustainability reporting is presented in Table 2.3.

A trend noticed in the comparison of the sustainability reports is that country of origin is used as a comparator – Hackston and Milne (1996), KLD (2008) and Mikkilä and Toppinen (2008) all had a country focus in their analysis, with the earliest study comparing the US, the UK and Australia reporting with the New Zealand reporting. The mention of South Africa as the “leading emerging market country” in terms of sustainability reporting by KLD (2008) is of interest to this dissertation. The country and area focus for the pulp and paper companies (Mikkilä and Toppinen, 2008) is the Nordic countries, the US and Japan.

Quaddus and Siddique (2011) state “that most of the corporate sustainability frameworks use some variations of MCA”. The framework analyses are mostly used by large organisations such as the Dow Jones Sustainability Index (DJSI) and the FTSE4Good index. The indices have become well known and are compiled by groups of specialists. It was not possible to find the use of an MCA by a small team of researchers and this is identified as a gap that could be researched.

Table 2.3. A selection of the literature reviewed for company sustainability (The reports are listed by the year the reports were analysed)

Authors	Year of reports	No. of companies in group	Method used	Country: Focus
Hackston and Milne (1996)	1992	47 in low profile and high profile	Content analysis	New Zealand: Social and environmental disclosure
De Villiers and Lubbe (2001)	1998	20 in energy 67 in other; included Nampak	Not given (identified as content analysis)	*South Africa*: Environmental
Székely and Knirsch (2005)	2000 to 2004	Group of 20	Analysis of social, environmental and economic metrics	German: Best available metrics
Mikkilä and Toppinen (2008)	2005	Group of 10 pulp and paper companies	Metrics for sustainability performance	International: (Nordic countries-US-Japan)
Perez and Sanchez (2009)	1999 to 2006	Time series of four mining companies	Content analysis	UK, France, Mexico and Australia
Hubbard (2009)	2007	10 each in banking, food, oil & gas	Framework	International: Development of disclosure index
KLD (2008)	2007	21 in energy, 28 in materials, 26 in communications	Content analysis by response to five questions	Emerging markets: South Africa is included
Lambooy (2011)	2008	Group of 20	Discussion	Dutch: Water reporting; large world companies: water risk disclosure
Marira and Chipunza (2011)	2009	10 mining companies	Content analysis	South Africa

The five questions used by KLD (2008) are of interest and will be used as a starting point for the sustainability discourse. The questions are:

- Does the company have any public disclosure of sustainability issues?
- Does the company have a separate section of its website and/or annual report addressing sustainability issues?
- Does the company publish a current … (within the last two years) and stand-alone sustainability report?

- Does the company reference the Global Reporting Initiative (GRI) framework for its stand-alone report?
- Does the company report sustainability goals *and* benchmarks? (KLD 2008)

Another point gained from the literature review is that the analysis of a group of companies having an item of commonality is preferred; the companies selected can be based in different countries and a time series can be of benefit in understanding the sustainability reporting of a company.

2.4 Life cycle assessment

Life cycle assessment (LCA) is a four-step tool that is formalised in the ISO 14040 series of standards. The four steps of an LCA are used to describe a cradle-to-grave study of a material, product or service. The goal of the study is described and the scope is defined in the first step. The second step consists of an inventory analysis, followed by the third step which is the elaboration of the life cycle impact assessment. The fourth step is the interpretation of the results. All four steps are iterative in that decisions, data gathering and data analysis can be changed to adapt to the system under study. Figure 2.4 is a diagram of the four-step process; this diagram will be referred to throughout this dissertation.

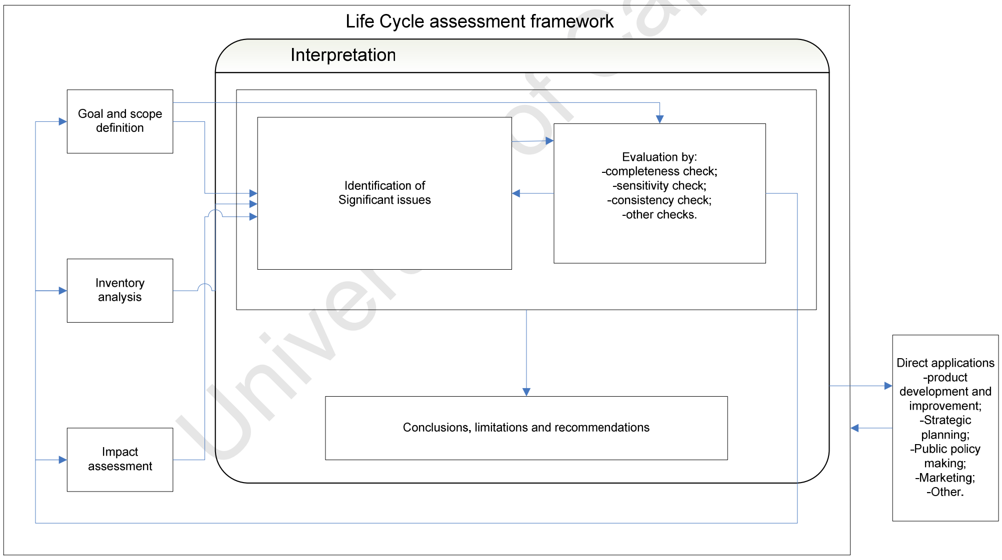

Figure 2.4. The steps of a life cycle assessment (ISO 2006b)

As described by Baumann and Tillmann (2004) in their LCA guidebook, the first recognised LCA was undertaken by the Coca-Cola company in 1969. This confidential study was termed a Resource and Environmental Profile Analysis (REPA) and was used to support the use of plastic bottles for supplying beverages. Prior to the study, Coca-Cola had only used glass bottles.

LCA was formally described in 1992 by the CML/NOH of the Netherlands, then in 1993 by SETAC and the US-EPA. The Nordic countries followed in 1995 (Nord). Denmark's description (EDIP) and the

ISO standards for LCA were both published in 1997 and revised in 2006. At the time of writing of this dissertation, the LCA standard is some 19 years old.

The *International Journal of Life Cycle Assessment (LCA)*, first published in 1996, is dedicated to the topic. There are numerous journals that accept LCA articles for publication; some examples are *Environmental Engineering Science*, *Packaging Technology and Science* and *Science of the Total Environment.*

This section continues with a discussion of relevant LCA studies (Section 2.4.1) then proceeds through to criticisms of packaging LCAs (Section 2.4.2). The objectives of LCA packaging system studies and a review of the functional unit follow in Sections 2.4.3 and 2.4.4 respectively. A discussion of life cycle impact assessment (LCIA) methods follows in Section 2.4.5.

2.4.1 Relevant LCA studies on packaging systems and liquid paperboard

This section discusses the studies that deal with LCA and packaging; a summary of the relevant studies is provided in

Table **2.**

The studies summarised in the table are mostly comparative between two or more beverage packs. The exceptions are those of Mourad *et al.* (2008), IFEU (2010) and Xie *et al.* (2011) as these studies present analyses of improvements to beverage carton life cycles through either recycling or material changes to the pack systems.

Some studies (e.g. Singh *et al.,* 2006) describe themselves as a life cycle inventory (LCI), (though for the cited example the abbreviated title is the “LCA of fresh fruit and vegetable containers”). The reason for this possible discrepancy is that “according to ISO, every LCA must at least include classification and characterisation. If such procedures are not applied … refer to the study as a … LCI” (PRé Consultants, 2008). In many cases authors chose to abide by this rule and refer to their study as a LCI.

Roy *et al.* (2009) reviewed LCAs on food products and included a review of food packaging systems in the academic press; as this study reviewed food product LCAs, these are included in this dissertation. Roy *et al.* (2009) conclude that the use of “lesser amounts of packaging materials without deteriorating the quality of food” would be beneficial, as would recycling and the selection of one material over another.

Pasqualino *et al.* (2011) describe the production and use of various beverage packs in Spain. Two impact categories were used to evaluate the aseptic carton. Three options were noted as the end-of-life scenarios – recycling, landfill or incineration. The Pasqualino *et al.* (2011) study revealed that on the basis of global warming potential it is preferable to recycle, then landfill and lastly incinerate the cartons.

The IFEU study (2010) is more relevant as UHT milk in a SIG Combibloc one litre pack is studied. This review study includes secondary and tertiary packaging. A 36.7% recycling rate is used, together with 35.1% of cartons being landfilled and the remaining cartons (28.2%) incinerated. The study compares two cartons – one having a closure and the other not – though both these cartons had an additional polyamide layer compared with the pack under study. The two cartons compared both have an aluminium layer and closures. This study is unique in that the closure is discussed. It is stated that “overall, the major impact in all examined environmental indicators originates from the production – and in some cases also the recycling – of the primary packaging’s (material) components” (IFEU, 2010).

BIOIS (2010) describes wine packaging in various materials. The study describes the beverage carton with an aluminium foil layer as having a high impact percentage for water consumption, primary energy and human toxicity potential for the packaging production, and low impacts for water consumption, primary energy and photochemical oxidation potential for recycling or disposal.

Mourad *et al.* (2008) stated that "increasing the recycling rate of the Tetra Pak (to a theoretical 70%) enabled a reduction in (48%) GWP giving rise to a total reduction of the energy requirements of the system". This study is for Brazilian conditions and also describes a carton with an aluminium layer; the recycling of the beverage carton is described in this paper in some detail.

Banar and Cokaygil (2008) describe an LCA of the juice beverage carton in Turkey. The system excludes the caps (closures) and includes an aluminium layer. The paper describes the reuse of the used beverage cartons at the Yekplan factory. The aim of the Turkish study was to compare glass bottles and beverage cartons. As it uses a specific example for transporting the cartons and does not use national averages or weighted data, the interpretation is deemed city-specific and the study is of little relevance with regard to the impact indicators.

The relevant beverage carton LCA studies are summarised in Table 2.4.

Table 2.4. A summary of the relevant beverage carton LCA studies

Source (year) Country	Compared packs: product and features	Impact categories	LCIA method (Source of data by country)
Mourad *et al.* (2008) of Brazil	**Beverage carton**: milk in Tetra Paks	Global warming potential	**IPCC 2001**
Banar and Cokaygil (2008) of Turkey	Glass bottle and **beverage carton**: juice	Climate change Ecotoxicity Acidification/eutrophication Fossil fuels	**Eco-Indicator 99**
FKN (2007) Describing the 2004 IFEU & and 2006 IFEU studies (both of Germany)	**Beverage carton** with closures and refillable glass bottle: juice **Beverage cartons** and PET bottles: milk and juice	Global warming potential Terrestrial eutrophication Resource consumption (fossil) Acidification, summer smog Aquatic eutrophication Space requirements (forest) Energy consumption (total)	**Federal Environment Agency** **Federal Environment Agency**
Huang and Ma (2004) of Taiwan	**Two** types of **beverage cartons**, and other materials: beverages	Ozone layer depletion Heavy metals Carcinogenic substances, Summer smog, winter smog, Pesticides Greenhouse effect Acidification and eutrophication	**Eco-Indicator 95** **(BUWAL 250 – Switzerland and** **IDEMAT 96 – Netherlands)**
Bloemhof *et al.* (2001) of the Netherlands	**Beverage carton** and polycarbonate bottle: dairy or soft drinks	Greenhouse effect Smog, Acidification Nitrification Human toxicity	**Not described**
WRAP (2010) of the UK	HDPE bottles; PET bottles; pillow pouches, including serving jug; stand-up pouches; cartons with **screw cap**; and **gable-top cartons**	Abiotic resource depletion Climate change Photo-oxidant formation Acidification Eutrophication Human toxicity Freshwater aquatic ecotoxicity	**CML 2 baseline 2000**
IFEU (2010) Of Western Europe	**Beverage cartons** with aluminium layer	Acidification Climate change Summer smog Eutrophication Human toxicity Fossil resource consumption Use of nature	**CML 2007**
Pasqualino *et al.* (2011) of Spain	HDPE, PET and glass bottles, aluminium can and **aseptic beverage carton**	Global warming potential Cumulative energy demand	**(not stated)**
BIOIS (2010) of Nordic countries	PET, glass bottles, bag in box, stand-up pouch, **beverage carton**	Abiotic resources depletion potential Global warming potential Ozone layer depletion potential	**CML2 spreadsheet 3.3**

Source (year) Country	Compared packs: product and features	Impact categories	LCIA method (Source of data by country)
		Photochemical oxidation potential Air acidification potential Eutrophication potential Human toxicity potential Freshwater aquatic ecotoxicity potential Sedimental ecotoxicity potential Terrestrial ecotoxicity potential Water consumption Primary energy	
Xie *et al.* (2011) of China	**Beverage carton** (with foil) and polyethylene	Carcinogens – respiratory, Respiratory inorganics Climate change Ozone layer depletion Radiation Ecosystem quality Eco-toxicity , Acidification/eutrophication Land use Resources: fossil fuels, minerals	**Eco-Indicator 99**

2.4.2 Critique of packaging LCA

Despite the popularity of LCA for analysing packaging systems, there are often criticisms of the studies. For example:

> It became fashionable in the 1990s to develop LCAs (Life Cycle Analyses) for various types of packaging to assess and compare the total environmental impact of the packaging during the production, of input raw materials and throughout its existence. In the writer's opinion, many of these conclusions lacked credibility as they were subjective and designed to protect the product of the sponsor (IPSA, 2005).

This criticism was levied eight years after the publication of the early ISO standards ISO 14040:1997 and ISO 14041:1998 and the criticism is made by a non-LCA practitioner; the ISO standards were developed specifically to strengthen the credibility of LCAs, by prescribing a rigorous approach and including a peer review process.

Jeswani *et al.* (2010) wanted to expand or broaden LCA as a tool while keeping it simple and realistic to use. These European researchers were also keen for it to be noted that it was important to understand that "there is no 'one-size-fits-all' solution to integrating different LCA-related concepts, methods and models for better sustainability assessment" (Jeswani *et al.,* 2010).

An assessment of three papers (Huang and Ma, 2004; Jewsani *et al.*, 2010 and Svanes *et al.,* 2010) revealed a subtle criticism of LCA – the authors of these papers applied further tools to be used in conjunction with LCA and could have felt that the output of LCAs was too complex or was not linked to a monetary value. Jeswani *et al.* (2010) did, however, acknowledge that LCA has "matured over the past decades".

The applicability of undertaking an LCA on empty packaging was questioned in the mid-1990s and the response was as follows:

> In reaction to a paper in *Environmental Management* in which the sense and sensibility of environmental assessments of packaging were questioned, it is argued that these types of assessments may be very useful, provided the relevant types of questions are posed (Heijungs and Guinée, 1995).

In a recent carbon footprint study of milk and packaging in the Western Cape, it was found that plastic "packaging materials are of low importance – (the) carbon footprint (is) equivalent to about 1.5 tablespoons of the milk inside the bottle" (Notten and Mason-Jones, 2011).

Another outlook on packaging, in this case wine packaging, advised that "it should be kept in mind that in general up to 90% of the environmental impact comes from the product and just 10% from the packaging" (EIPRO in Bio Intelligence Service, 2010).

2.4.3 Objectives of LCA packaging system studies

The most common packaging system LCAs compare two or more options for a similar type of product. Tan and Khoo (2005) compare a corrugated paperboard and an expanded polystyrene pack and are able to decide on the one pack based on the assessed lower environmental burden. They describe LCA as "an important tool to quantify the potential environmental loads during the product's life cycle stages". Singh *et al.* (2006) state that LCA is a "holistic approach to evaluate environmental performance". Most of the studies mention the cradle-to-grave nature of LCA studies.

Bloemhof *et al.* (2001) employed a decision-support model comprising a cost model and an environmental model; this group selected the LCA tool for the environmental model.

Mourad *et al.* (2008) compared a single pack with increased recycling rates of milk cartons to determine the GWP reduction using LCA and were able to calculate that with a 70% recycling rate attained for the milk cartons, a 48% reduction in GWP resulted. Furthermore, Mourad *et al.* determined that the increase in recycling of aluminium and polyethylene "has a smaller effect on GWP reduction".

IFEU (2010) compared two ambient milk packs using LCA. The newly developed pack (cb3 EcoPlus) was determined to be more favourable in seven of the 11 impact categories, with three of the others showing insignificant differences and aquatic eutrophication being more favourable for the established ‘cb3pack’. This study further indicated that landfilling in European countries is the least favourable end-of-life scenario and that recycling and incineration are preferred. The study suggests that the milk pack supplier (SIG Combibloc) and the “company’s LPB suppliers may be one crucial element of a successful strategy for achieving this goal of sourcing this raw material (wood) from forests with state-of-the-art management systems”.

Xie *et al.* (2011) compared two milk packs (of 1 litre and 200 ml) using the same functional unit. They concluded that the multilayer 1 litre pack has minimal recycling of the three layers (paper, aluminium and polyethylene) and that the multilayer pack has a “slightly higher environmental impact than the plastic (polyethylene) one”.

WRAP (2010) undertook an LCA of six types of beverage pack systems, deciding “not to make any direct comparison between the different milk containers studied” (WRAP, 2010). Of main interest to this dissertation is the fact that only two laminate-type milk packs were available with 0% recycled content and that the LCA also included the environmental benefits of 10% light-weighting. The WRAP (2010) study identified the production of the laminate as the “predominant contribution” to the impact categories assessed. Two end-of-life scenarios were discussed – recycling and energy from waste. Neither option was a clear winner in this UK study of milk packs.

End-of life options for beverage cartons (UBCs)

As mentioned in the objectives of LCA studies, there are a few options for the used carton – recycling, incineration (energy from waste), prevention (e.g. light-weighting) and landfilling. As incineration is not an option at the present time in the geographic region of interest, it will not be discussed in depth. Moreover, the fully bleached fibres from UBCs are seen as a valuable recyclable paper grade.

Landfilling

As the milk packs are single-use packs, the potential for these packs to be landfilled is high unless there are options available to the consumer.

Recycling

The packs can be recycled depending on the location and environmental awareness of the consumer. Various municipalities across the globe offer recycling facilities. In South Africa, Engledow advised that the City of Cape Town did not consider laminate milk and juice packaging as recyclable (Engledow, 2005).

Cape Town’s recycling scheme operated by Waste Plan (and sometimes referred to as “Think 2wice”) has detailed milk containers as being recyclable since 2009. The recyclable items are described on a leaflet given to residents in the recycling area. The picture from the leaflet is reproduced in Figure 2.5.

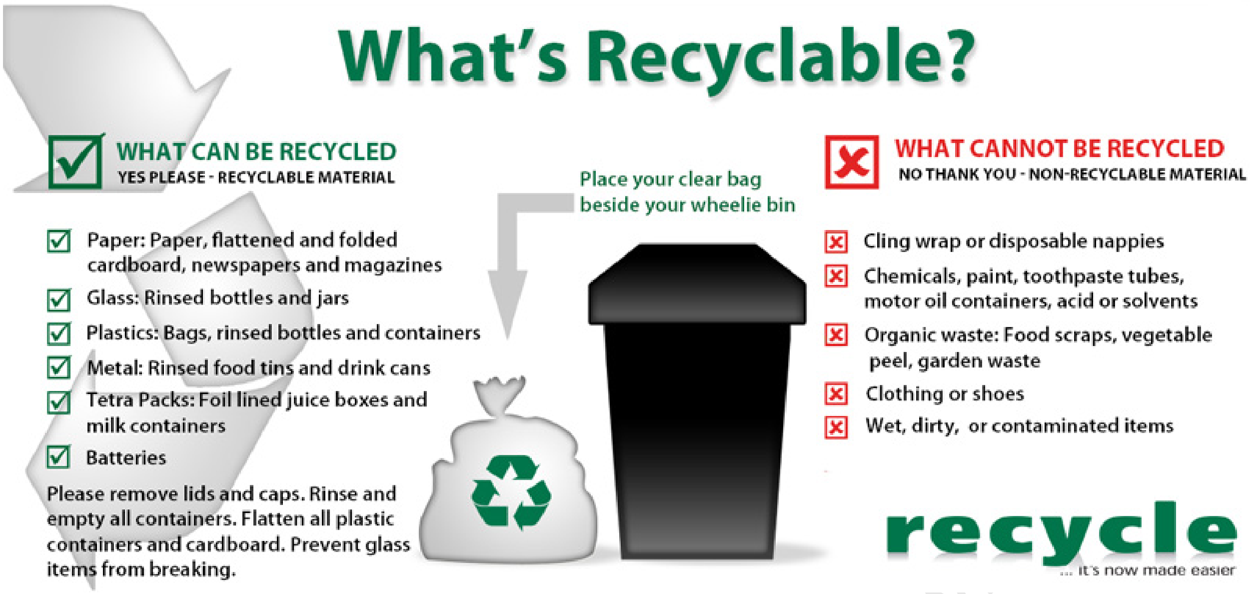

Figure 2.5. The Waste Plan brochure, indicating the items that can and cannot be recycled. Tetra Packs: foil-lined juice boxes and milk containers are noted as 'recyclable material' (Waste Plan, 2009).

Recycling rates of 22% to 36.7% are noted in the recent literature (Table 2.5). WRAP (2010) mentions recycling rates up to 100%, but the report fails to give actual values obtained in the UK.

Table 2.5. Various recycling rates of used beverage cartons

Reference	Country	Year	Recycling rate as %
Mourad *et al.*, 2008	Brazil	2004	22
Banar and Cokaygil, 2008	Turkey	2004	25.9
Mourad *et al.*, 2008	Brazil	2008	30
IFEU, 2010	West European average	2010	36.7

2.4.4 Review of the functional unit (FU)

When undertaking a stand-alone study, the functional unit "is seldom critical" (Baumann and Tillman, 2004). The functional unit should be comparable within the study itself.

The specification of a functional unit is central to an LCA and must be consistent with the objectives of the study. In general, half the studies read use a small size unit and the others use 1 000 L of milk or packaging for 1 000 L of milk. Huang and Ma (2004) dealt with various packaging materials for beverages. As each pack could consist of various materials, the researchers selected "grams of packaging material per liter of beverage" as the functional unit. This unit perhaps suited their comparative study of nine different packs.

In her study of milk production, Eide (2002) selected 1 000 L of drinking milk, i.e. 1 033 kg as the functional unit. This functional unit describes a term in words (e.g. drinking) as perhaps the qualitative differences were unable to be fairly described across all the compared products. Banar and Cokaygil (2008) used the unit of a one litre juice package, which is a smaller functional unit than that used in the Eide study.

Cederberg and Mattson (2002) had the "functional unit (FU) …1000 kg energy corrected milk (ECM) leaving the farm gate. ECM is a correction factor generally used by the dairy industry; it considers both the fat and the protein content of the milk". This FU was noted only once in the literature that was read; perhaps this would be of more benefit to studies that deal with the dairies or the "fill good".

2.4.5 Life cycle impact assessment (LCIA method)

The section discusses how the LCIA step has been undertaken in packaging-related LCA studies and introduces the software used for the analysis.

An overview of LCIA methods

The European LCIA methods group lists seven types – dated from 1999 to 2008. Most of the beverage carton LCAs reviewed used one of these methods, as will be discussed below.

LCIA methods are updated as time permits and as an example the CML method (compiled by staff at the University of Leiden) is discussed. First proposed in October 1992 and updated in 2001, this method can also be adapted in software packages to provide other versions (using various combinations of impact categories) and various normalisations that are normally geographically based.

According to Brent (2003), five LCIA methods are "most commonly used in South Africa" – these are as listed by Brent as: CML, Ecopoints, Eco-Indicator 95 (since superseded) and Eco-Indicator 99, and EPS in 2003. The methods still in use are listed as European in origin. These LCIA methods describe LCAs undertaken over a broad range of industries in South Africa.

Selection and use of LCIA in related LCAs

The mention of LCIA methods in other beverage studies and local LCA studies is now discussed. This discussion will aid with the selection of the LCIA in Section 3.3.4.

Methods recently used for studies on beverage cartons are listed in Table 2.6.

The 11 beverage and three local LCA studies mentioned in Table 2.6, use 18 LCIA methods (as some studies use more than one method). Comparing the number of times a LCIA is used, the following is noted:

- The CML method is used in 6 studies,
- The Eco-Indicator 99 method is used in 3 studies,
- The Federal Environment Agency method and Eco-Indicator 95 are each used in 2 studies and
- The remaining methods are used once each.

The question to delve into is why do the six studies select the CML LCIA – geographically three of the studies are based in Europe (WRAP 2010, IFEU 2010, and BIOIS 2010) and all local (non beverage) LCA studies selected this mid-point method. WRAP (2010) describe the LCA method as the "impact assessment method employed in this study is the problem-oriented approach developed by CML" so clearly they have a problem and that is to compare the example of milk packs in the UK. The goal of the IFEU 2010 study centres around the new SIG packaging and the goal is problem oriented. The BIOIS study compared five alternative wine packs and does not fully explore the reasons for selecting CML – however, the goal uses the word "indicates" which means this is a problem oriented LCA.

Three selected studies (Banar and Cokaygil, 2008, Huang and Ma, 2004 and Xie *et al.,* 2011) selected the end-point method of Eco-Indicator 99. This method measures damage and is perhaps easier to communicate to non-technical LCA audiences such as the Turkish consumer (Banar and Cokaygil, 2008). The Huang and Ma (2004) study required an endpoint approach to feed the results into an analytic hierarchy process (AHP) which required the single type score. Xie *et al. (*2011) note the reason for selecting this method and the reason is taken from the software manual "was used for the impact assessment step, because it is a damage-oriented and endpoint approach proceeding from the identification of areas of concern (damage categories) to determine what causes damage in these areas (PRe Consultants, 2007)".

Table 2.6. Recent LCIA methods for studies on beverage cartons

Source (year) **Country**	**Type of study: Beverage carton or local study**	**LCIA method** **(Source of data by country)**
Mourad *et al.* (2008) of Brazil	**Beverage carton**: milk in Tetra Paks	IPCC 2001
Banar and Cokaygil (2008) of Turkey	Glass bottle and **beverage carton**: juice	Eco-Indicator 99
FKN (2007) Describing the 2004 IFEU & and 2006 IFEU studies (both of Germany)	**Beverage carton** with closures and refillable glass bottle: juice **Beverage cartons** and PET bottles: milk and juice	Federal Environment Agency Federal Environment Agency
Huang and Ma (2004) of Taiwan	**Two** types of **beverage cartons**, and other materials: beverages	Eco-Indicator 95
Bloemhof *et al.* (2001) of the Netherlands	**Beverage carton** and polycarbonate bottle: dairy or soft drinks	Not described
WRAP (2010)	HDPE bottles; PET bottles; pillow pouches, including serving jug; stand-up pouches; cartons with **screw cap**; and **gable-top cartons**	CML 2 baseline 2000
IFEU (2010)	**Beverage cartons** with aluminium layer	CML 2007
Pasqualino *et al.* (2011)	HDPE, PET and glass bottles, aluminium can and **aseptic beverage carton**	(not stated)
BIOIS (2010)	PET bottles, glass bottles, bag in box, stand-up pouch, **Beverage cartons**	CML 2 spreadsheet 3.3
Xie *et al.* (2011)	**Beverage carton** (with foil) and polyethylene	Eco-Indicator 99
Brent (2003)	**Local studies**	CML, Ecopoints, Eco-indicator 95 (since superseded) and Eco-indicator 99 and EPS in 2003
Notten and Mason-Jones (2011)	**Local study**	CML 2 baseline ReCiPe 2008
Ras (2011)	**Local study**	CML 2 baseline

2.5 Final thoughts on the literature review

The literature review on company sustainability reports indicates that sustainability reports are a frequent tool used to analyse companies in specific **industries**. The industries can be diverse and be in banking, mining, listed on a stock exchange or purposefully selected based on a valid commonality. The analyses use **publicly available data** such as annual reports or sections thereof for a study of the industry. The **analysis** can be on content, metrics, discussion or frameworks with the content analysis a quick and reproducible method to obtain comparable data. The study of 47 low and high profile companies by Hackston and Milne (1996) and the 10 mining companies by Marira and Chipunza (2011) for content analysis indicates that this method has been well established and has been used for over 15 years.

The frameworks discussed can be used to guide researchers on the selection of aspects – either environmental (LCSP framework) or all three **aspects of sustainability** (CSMS framework) i.e. the triple bottom line (TBL). The company sustainability can be assessed on environmental, economic or social aspects or using one or a combination of the aspects.

SD Indicators need to have “standard methodology for data gathering, processing and monitoring” and the company response to such indicators can be a source of analysis.

The LCA literature review indicated that the analysis of milk and beverage packs are regularly undertaken in areas such as Europe and are less numerous in developing **countries** such as Brazil, Turkey, China and Taiwan. The **recycling** of UBCs and the resultant environmental benefits are noted in the study of Mourad *et al* (2008) and WRAP (2010). The theoretical reduction of 20 % for climate change is about four times the lowest value in the WRAP (2010) study and about a 2.5 times reduction of the highest value obtained in the Mourad *et al* (2008) study. Increased recycling rates result in reductions of landfill volume and are able to provide a source of recycled bleached papers for other processes.

The WRAP (2010) study further describes the environmental impact of **light-weighting** of the paper fibres in the carton. The numerous unique **disposal** methods of dealing with the UBCs is described and includes incineration (or producing energy from waste), recycling in Sweden (WRAP, 2010) and reuse as roof tiles or other building laminates. The WRAP (2010) gives an equal emphasis towards the carton (without light-weighting) and with the 10% light-weighting, however, as one of the organisations that provided data to the WRAP (2010) study is a LPB converter, the light-weighting could be a valid option in the UK. The light-weighting of cartons in Southern Africa, would require an LPB supplier to provide the material and a feasibility study to determine if the high handling of the supply chain could cope with the light-weighting and hence possibly less sturdy carton.

CHAPTER 3 METHODOLOGY

In line with the objectives (stated in Section 1.3) of this dissertation and building on the conclusions of the literature review, this chapter proceeds to develop hypotheses (Section 3.1), as well as the methods used for the investigations described in Chapters 4 (Section 3.2) and 5 (Section 3.3).

3.1 Development of the hypotheses

The hypotheses are used to propose explanations in relation to each of the objectives as stated in section 1.4.

There is one system under investigation – the liquid paperboard supply chain in South Africa. The following four hypotheses are proposed:

1. There may be differentiated sustainability awareness among manufacturers compared with 'retailers and brand owners' of the South African liquid paperboard supply chain as manufacturers are believed to be responding to environmental claims.
2. The manufacturing companies are more aware of recycling than the 'brand owners and retailers' and organisations, because some manufacturing companies have recycling divisions.
3. A high recycling rate (70%) of used beverage cartons would result in a significant decrease in selected environmental impacts.
4. Key environmental impacts could be decreased more by the use of a high recycling rate of 70% than a further 10 % light-weighting of the paperboard of the beverage carton.

An analysis of the sustainability awareness of a purposeful selection of actors in the LPB supply chain, with the aid of a multi-criteria analysis (MCA) using recent reports, is used to confirm hypotheses 1 and 2. The reports selected are mostly sustainability reports; however, for the two organisations selected, the recently published reports are a textbook and a presentation.

An LCA is used to investigate the change in selected environmental impacts when recycling the beverage carton from the present low value of 1% of the paper fibres up to the anticipated value of 70% and thereby substantiate hypothesis 3.

An LCA is also used to measure the change in selected environmental impacts when considering the comparison of light-weighting versus high recycling rate of the paper fibres of the carton and thereby confirm hypothesis 4. The end-of-life scenarios that could have been selected from the literature review, had some end-of-life options put aside as the technology in southern Africa is not yet in place e.g. production of roof tiles from UBCs. The WRAP (2010) study gave an equivalent emphasis to the light-weighted and the current WRAP cartons.

3.2 Research Methodology for the assessment of sustainability awareness

This section describes the research methodology, research design and data collection used to address the first objective, which is as follows:

> The sustainability reporting of a selection of companies, active in the supply chain of liquid paperboards in South Africa, is compared against the three focal points identified in the 2010 Nampak sustainability report.

This section is also used to substantiate the first and second hypotheses.

3.2.1 Methodology for the analysis of sustainability reporting

The review is divided into the following six sections (see also Chapter 4):

1. The selection of companies[1] and organisations is discussed with a list of the sustainability reports sourced as the data. The selection is visually represented in a supply chain diagram (Figure 3.1).
2. The analysis of the reports is undertaken after reading of the selected reports. The analysis of the year of the first sustainability report of each company is discussed (Section 3.2.4).
3. An overview of the sustainability reports by comparison of report lengths and two SD indicators that the companies report on, is then undertaken (Section 3.2.5).
4. The sustainability reports of Nampak are analysed for general trends, a rating is assigned and the three focal points in the 2010 report are identified. A discussion of the Nampak reports is then undertaken (Section 3.2.6).
5. The Nampak focal points are then searched for in the other selected company reports and an MCA is used to rate all selected companies in terms of the number of the points dealt with (Section 3.2.8).
6. A fourth criterion, the use of an LCA, is then added to the MCA analysis (Section 3.2.9).

The tasks above are linked to the questions that KLD (2008) asked and for clarity these questions and the relevant section in this dissertation are tabulated in Table 3.1.

[1] As noted in Lambooy's article (2011), "all private business entities are referred to as 'companies', noting that these include an array of different legal and operating structures". This definition of companies may be used to include the commercial companies but preference is given to separate the organisations based on the primary data source.

Table 3.1. The five sustainability questions asked by KLD (2008) and the relevant section in this dissertation

The question (KLD, 2008)	Section in this dissertation
Does the company have any public disclosure of sustainability issues?	Section 4.2
Does the company have a separate section of its website and/or annual report addressing sustainability issues?	Section 4.2.1
Does the company publish a current (within the last two years) and stand-alone sustainability report?	Section 4.2.1
Does the company reference the Global Reporting Initiative (GRI) framework for its stand-alone report?	Section 4.2.2
Does the company report sustainability goals *and* benchmarks?	Not analysed

3.2.2 Scope of the six tasks

The scope of the group of tasks covers obtaining credible sustainability data from a selection of at least ten companies and analysing the data. The tools used to analyse the data are the word count and page count of Hackston and Milne (1996) and these data are further analysed using MCA.

It was not the aim of the research to compile or expand on a new sustainability index or ranking system.

3.2.3 Data collection procedure: purposive sampling

Purposeful sampling can be considered a non-representative sample – in that a choice is made in the sampling plan for a particular reason. Representative sampling requires that the sample taken is “a subset of a statistical population that accurately reflects the members of the entire population” (Investopedia, 2011).

The type of purposive sampling used to select the companies is a combination of maximum variation sampling. This type of variation is observed between the actors as each has a different role in the LPB supply chain and it was anticipated that they would react differently to sustainability issues.

In order to reduce the sample size, Creswell describes purposefully selecting participants “that will best help the researcher understand the problem” and he further states that it “does not necessarily suggest random sampling or selection of a large number of participants” (Creswell, 2009).

Actors selected

A small number of actors (organisations and companies) are selected. From one to 2 113 companies are analysed by the authors in the selected papers in the literature review (Chapter 2). The average number of companies analysed is 34 for two authors or, if the noted sub–groups are used, then the number drops to 29 (when the value of 2 113 is excluded). The 11 purposefully selected companies 2 organisations for consideration are seen as a valid number for analysis.

The consumers of the finished goods (beverage cartons) are not included as actors in the supply chain due to lack of available information and due to the cost of implementing such a survey as mentioned by Notten and Mason-Jones (2011) ensures that it is beyond the scope of this work,

Process

The sampling process was undertaken by a single researcher without consultation. The number of companies selected was based on the initial number of ten, with additional companies to be added as necessary.

The purposefully selected companies and their relationship to the sponsor are listed in Table 3.2. The three aspects of relevance to the purposeful sampling are the **actors** – these are all potential or present suppliers of the LPB supply chain – with the **setting** (the 'where') of the research being the international suppliers and customers of the LPB supply chain of South Africa, and the **events** that are analysed being the recent (in 2010) sustainability reports.

The recently published sustainability reports of the 11 selected companies were then sourced. The report of a company is referenced by a year (e.g. 2010), with no attempt made to clarify the month of publication. The sustainability reports are all in English.

Selection of companies

To select the companies, the researcher skimmed through various supplier and competitor companies of the LPB supply chain. One company was rejected as the report was legal and of no relevance to this exercise. Other companies were rejected for reasons such as being similar in nature to another company or difficulty in finding sustainability reports by a particular company. The final choice was **11 companies active in the LPB supply chain** and which had published a recent sustainability report.

Two long-term potential **suppliers** of LPB were also selected (Mondi and Sappi), with Stora Enso, the only current **supplier** of LPB, making up the third supplier. Two **competitors** (SIG Combibloc and Tetra Pak) and two **retailers** active in southern Africa (Spar and Woolworths (South Africa)) and a retailer that has recently acquired shares (Walmart) in the local southern African market were further selected. A product **brand owner** (Danone) was also selected. Although it is the only brand owner, two of the identified retailers also own in-house brands (Woolworths and Spar) and therefore no additional brand owners were added. (Nampak is also a brand owner in the tissue business, though this is not depicted in Figure 3.1 as tissue is not part of the LPB supply chain.) Nampak, Pick n Pay and Woolworths were involved in the plastic bag hearings (Nhamo, 2005) regarding the caliper and print levels of these bags and for this reason the two companies Nampak and Woolworths were chosen for review. Pick n Pay was then excluded from the selection as only three retailers were required to be selected. The selected pack used for the LCA is a Spar branded package, hence the inclusion of Spar as a retailer.

Table 3.2. Selection of 11 companies reviewed in the study and the relationship to the sponsor company

Company abbreviation	Relationship to sponsor company	Abbreviated relationship
Danone	Food and beverage company that operates in South Africa	Brand owner
Elopak	In 2010 had a joint venture (JV) in Isithebe, KwaZulu-Natal, South Africa	LPB converter
SIG Combibloc	Competitor of the joint venture partner	LPB converter
Tetra Pak	Competitor of the joint venture partner	LPB converter
Stora Enso	Supplier of liquid paperboard (LPB)	LPB supplier
Mondi	Local supplier of paper and liners	Paper supplier
Sappi	Local supplier of paper and liners	Paper supplier
Walmart	Retailer with newly acquired shares in South Africa	Retailer
Spar	Local retailer of milk packaging made by Nampak-Elopak	Retailer and brand owner
Woolworths	Woolworths Holdings Limited, a retailer in South Africa	Retailer and brand owner
Nampak	Sponsor company	Sponsor

In grouping the selected companies there are three LPB converters, one LPB supplier, two local paper suppliers, two ‘retailers and brand owners’, one retailer and one brand owner. The sponsor company (which has a joint venture with one of the LPB converters and is also a paper supplier and converter) is also selected, giving a total of 11 companies.

The publicly available company data (sustainability reports or sections) are available on the applicable company website or were accessed through www.CorporateRegister.com. Contact was made with Elopak staff for the annual financial report of Ferd (the parent company) in order to obtain the page length of the report.

Selection of organisations

The following are a selection of organisations that could have an interest in the LPB supply chain in South Africa: the Packaging Council of South Africa (PACSA), Paper Recycling Association of South Africa (PRASA), Plastic Converters Association (PCA), Paper Manufacturers Association (PAMSA), (Nampak, 2009), Institute of Packaging SA (IPSA), Technical Association for the Pulp and Paper Industry South Africa (TAPPSA) and the Plastics Federation of South Africa.

The purposeful selection of two South African **organisations** was the chosen method for increasing the number of companies selected and completing the green supply chain.

The **Institute of Packaging SA** (IPSA) was the first to be chosen as the organisation is active in the training and development of its members. IPSA was “formed in 1970 by 33 members and today represents packaging professionals in South Africa and the rest of Africa” (IPSA, 2011). IPSA offers membership to individuals and companies; individual membership categories are student, member and fellow. IPSA is a “non-profit organisation dedicated to the development of the art and science of packaging in South Africa” (IPSA, 2011). Funds generated by training courses and seminars are used to support IPSA activities.

IPSA produced two textbooks between 2004 and 2011 and the chapter in the 2010 textbook was used as the data source. The recent textbook is available for purchase from IPSA.

The **Packaging Council of South Africa** (PACSA) was the second and final South African organisation chosen as it has been involved in recent national legislation and is willing to share information. PACSA is a voluntary industry body (PACSA, 2011) formed in the mid-1980s.

PACSA has three classes of corporate membership: converters, associates (raw material suppliers) and affiliates (customers and major recyclers). It is a not-for-profit organisation. Sappi and Mondi are associate members of PACSA. Nampak South Africa, SIG Combibloc Obeikan SA (Pty) Ltd and Tetra Pak SA (Pty) Ltd are converter members of PACSA. IPSA and Woolworths are two affiliate members of PACSA.

These two organisations (Table 3.3) will be compared to each other and not with the other companies.

Table 3.3. Selection of organisations reviewed in the study and the relationship to the sponsor company

Organisation abbreviation	Relationship of sponsor company to local organisation	Abbreviated relationship
IPSA	Sponsor is member of Institute of Packaging South Africa (IPSA)	Member
PACSA	Sponsor is converter member of the Packaging Council of South Africa (PACSA)	Converter

The green supply chain

The extended green supply chain diagram (Baumann and Tillman, 2004) in Figure 3.1 links the LPB supplier and converters with the brand owners and retailers. An analysis of the consumers and collection companies (e.g. for recycling) is beyond the scope of this study. The two organisations, namely IPSA and PACSA, are included as two examples of the industries that deal with “re-use, remanufacture and recycling” issues; however, these organisations do not participate in using the recovered paper fibres.

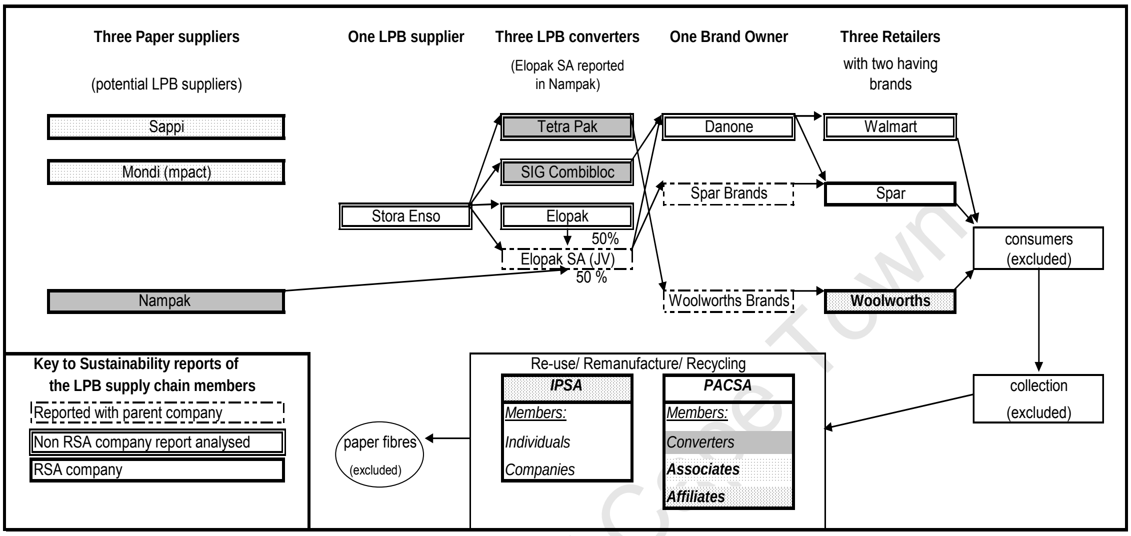

Figure 3.1. The adapted extended green supply chain diagram (Baumann and Tillman, 2004)

The reports

The reports used are summarised in Table 3.4, which also gives the country of the parent company.

Table 3.4. Selected companies with the filename of the recent report and country of origin

Company	Name of recent sustainability report	Country of parent company
Danone	danone_rapport_developpement_durable_2010_en	France
Elopak	Environmental_Report_2010[1]	Norway
SIG Combibloc	Environment_GB[1]	Before 2007: Switzerland 2007+ New Zealand
Tetra Pak	2009TP_Environmental_Social_Report[1]	Switzerland
Stora Enso	Stora_Enso_Sustainability_Report_2010_E_April	Sweden
Mondi	Mondi_SD_Review_FINAL[1]	South Africa
Sappi	FINALSappiSD2010LR[1]	South Africa
Walmart	WMT2010GlobalSustainabilityReport	USA

Company	Name of recent sustainability report	Country of parent company
Spar	SPAR COMMENTARYa[1]	The Netherlands
Woolworths	The_Good_Business_Journey_Report_2010	South Africa
Nampak	Nampak 2010 LOW	South Africa
IPSA	Chapter in book (2010 edition)	South Africa
PACSA	Presentation to IPSA Congress 18 August 2010-Andrew Marthinusen.ppt	South Africa

Note: Tetra Pak published a sustainability report dated 2011. As this company reports every two years, it was decided to use the 2009 report as this would have been the most recent report at the end of 2010.

A document is defined as "data ... that participants have given attention to compiling" (Creswell, 2009). The sustainability reports, textbook chapter and presentation are taken to be the primary data source (Mouton, 2009) and were analysed for sustainability information. All the sources were in existence prior to the start of this study and are noted as being authentic.

3.2.4 Identifying the year of the first sustainability reports for the selected companies

The recent sustainability reports were examined; this translates into skimming, reading and analysing. The data were then "broken up ... into manageable themes" (Mouton, 2009). If the recent report was without a mention of the first year of sustainability reporting, then earlier reports were consulted for each company.

The sustainability events are the year of the Rio Earth Summit (1992) and the King reports (II and III) (2002 and 2009 respectively). The founding of the GRI in 1997, the second generation (G2) in 2002 and the third generation (G3) in 2006 are included. These events are listed in Table 3.5 and were used to place the first published sustainability reports of the selected companies in perspective.

Table 3.5. A timeline of significant sustainability events

Sustainability event	Year
Rio Earth Summit	1992
Founding of GRI	1997
King II	2002
GRI G2	2002
GRI G3	2006
King III	2009

3.2.5 Overview of the sustainability reports and two indices

The reports were analysed for the type of reporting – combined or separate. The number of pages in each of the sustainability and financial reports for the same year for each company were counted using the page count given in the documents. The page count was then used in the following equations:

$$\text{\% Sustainability content in separate reports} = \frac{\text{(Page count in the sustainability report)}}{\text{(Page count in both reports)}} \times 100\%$$

Equation 3.1. The calculation for reporting the sustainability content in separate reports

$$\text{\% Sustainability content in combined reports} = \frac{\text{(Page count in the sustainability section)}}{\text{(Page count in the annual reports)}} \times 100\%$$

Equation 3.2. The calculation for reporting the sustainability content in combined reports

Three companies (Danone, SIG Combibloc and Tetra Pak) and PACSA did not have the corresponding annual report available on the internet and therefore the percentage of sustainability reporting was not calculated. The IPSA textbook (having 749 pages) was used as the complete data source and the 12-page chapter on the *Environment* was assigned to be the sustainability report.

The country of origin of each of the selected companies was also documented.

Two SD indicators were selected and the participation in these by the selected companies was analysed. The recent sustainability reports were the data source. A description of each of the two indices is given.

3.2.6 Methodology for the overview of the Nampak sustainability chapters

The sustainability chapters of the years 2003 to 2010 were the sources of data considered for the Nampak analysis. A previous annual report for the year 2002 was also consulted. The calculation used for the sustainability content in each report is Equation 3.2.

The selection of the three focal points was determined from a page count of relevant items in the 2010 chapter. The page counts of the three highest items (with an exclusion documented) are the three focal points identified for Nampak.

The Nampak Annual Report of 2010 had a high page count for the Global Reporting Initiative (GRI). However, as the GRI is a sustainability tool that encourages participation by all companies, the four pages discussing this topic were put aside.

The rating systems were selected from three sources:

- The GRI single score uses the methodology described by Perez and Sanchez (2009). This score is a percentage and the maximum obtainable score is 100. Values reported are based on the GRI categories, viz. social, economic and environmental.
- The Lowell Center Index is based on the Lowell Center for Sustainable Production's (LCSP) indicator framework (Veleva *et al.,* 2001) – the index has a five-point rating.
- The Skills Development Index is based on the Structure of Observed Learning Outcome (SOLO) taxonomy (Biggs, 1996) to give a five-point (modified to four) rating.

The GRI single score uses the company-provided response to the GRI reporting system for analysis. The maximum number of statements per pillar of the three pillars of sustainability indicators – economic (EC), social (LA) and environmental (EN) – as given by the GRI are 9, 14 and 30 respectively.

The company GRI tables are then consulted and a response to an indicator is given a rating of '1' for the presence of information and '0' for the absence of information. This scale is a nominal scale in that it does not allow for the interpretation of the distance between the responses, i.e. a rating of '1' does not indicate a target reached but can merely be a mention of an indicator (Markam, 2012). However, this rating provides a rapid analysis of provided GRI data and has a benefit. The rating could have been expanded to include a five-point rating from '0' to '4' with an analysis of the company-provided response, but time constraints were a limiting factor; furthermore, this rating is only used for three sustainability reports.

The number of counts per pillar is summed using the nominal rating. The count per pillar is then normalised using the maximum number of statements for the same pillar using Equation 3.3.

$$\text{Normalisation of each GRI pillar } (g_i) = \frac{\text{No. of counts per pillar x 100\%}}{\text{Max no. of statements per pillar}}$$

Equation 3.3. Calculation for the normalised data of each GRI pillar

A single score was obtained using calculation (Equation 3.4) for all three pillars using the equal weighting of 0.333. This single score obtained for each year is used in the discussion (Section 4.3.2).

$$GRI_i = \sum_{i=1}^{3} 0.333 g_i$$

where g_i is the 'normalised data for each criterion', *i* is the criteria of EC, LA and EN indicators, and 0.333 is the equal weighting for each GRI pillar.

Equation 3.4. Single score calculation for the GRI score

The GRI single score can be seen as an isolated score that requires further reading as to the manner in which the value is obtained. Company-provided GRI response tables are used to determine the score. As Nampak reported the GRI tables starting in 2008, this indicates a gap in comparing the reports from 2003 up to 2007. Therefore the two other unrelated rating systems were used to rate all the Nampak sustainability reports from 2003 to 2010.

The five-point system of 'The Lowell Center Index' and the modified four-point system of the 'Skills Development Index' are used to provide an overall rating of the sustainability chapters for each year, with the selection of text given as proof of the rating. The results are likely to have low reproducibility as the method is subjective, undertaken by a single researcher without training in this analysis.

The Skills Development Index is based on the SOLO taxonomy and "provides a systematic way of describing how a learner's performance grows in complexity when mastering many tasks" (Biggs, 1996). This system is then used to imply that the "learner" is Nampak and the rating is based on the overall "answer" or sustainability chapter.

The rating systems used to rate the sustainability reports of Nampak from 2003 to 2010 numerically are listed in Table 3.6.

Table 3.6. Rating systems used to assess the Nampak sustainability reports

Rating	Nominal scale	Lowell Center Index	Skills Development Index
5		Sustainable systems	Relational (modified from extended abstract)
4		Life cycle thinking and or management	Relational
3		Continuous improvement	Multi-structural
2		Performance monitoring & eco-efficiency	Uni-structural
1	Presence of information	Compliance with environmental legislation	Pre-structural
0	Absence of information	No comment	No comment

Notes:

1. The nominal scale uses the methodology described by Perez and Sanchez (2009) to obtain a GRI single score. Values reported are based on the GRI indicators of 'economic', 'social' and 'environmental'.
2. The Lowell Center Index is based on the Lowell Center for Sustainable Production (LCSP) indicator framework (Veleva *et al.,* 2001).
3. The Skills Development Index is based on the SOLO taxonomy (Biggs, 1996).

3.2.7 Selection of tools

The selection of tools in this dissertation was undertaken with reference to the two frameworks. As the time frame of the dissertation is limited, the tools were selected from among those discussed in Section 2.2.3. The tools selected are listed in Table 3.7.

As stated previously in Chapter 1, the dissertation has the following objectives:

- To assess the level of sustainability awareness of a selection of companies active in the supply chain of LPB in South Africa and to compare this with international best practice
- To investigate whether the use of an LCA for LPB in South Africa would yield policy recommendations (especially for post-consumer recycling) similar to those it yielded in other countries, i.e. to further predict the environmental benefits of recycling and light-weighting of components of the paperboard carton.

The tools associated with Level 3 of the LCSP framework require specialised scientific training and either specialised software or spreadsheets, as well as regional knowledge of the environment. The first tool required to assess the level of sustainability awareness of selected companies is an analysis of sustainability reporting of companies active in the LPB supply chain; this tool is MCA.

The second tool selected is LCA. This is deemed to be on Level 4 of the LCSP framework and requires national knowledge and the use of specialised software. This tool is able to give measurable and comparative values to yield policy recommendations (especially for post-consumer recycling) as it did in other countries.

The tools selected for use in the dissertation exclude those associated with Level 1 of the LCSP framework as they require only general skills without software to obtain the data. The tools associated with Level 2 are found to require scientific training with knowledge of general computing software and knowledge of the facility.

Table 3.7. The selected tools and their level in the LCSP and CSMS frameworks

Level	LCSP framework (Veleva *et al.*, 2001)	Stage	CSMS framework (Azapagic, 2003)	Example of tool (as in text)
4	Supply chain and life cycle indicators			Life cycle assessment
3	Effect indicators	4	Communication	Carbon footprint Sustainability report

3.2.8 Multi-criteria analysis (MCA) principled method

The principles of a multi-criteria analysis (MCA) were undertaken on the data. This section describes the MCA-based analysis and the three criteria used in the analysis.

A description of how a MCA is undertaken is given in by Ness *et al.* (2007):

> Multi-Criteria Analysis (MCA) is used for assessments in situations when there are competing evaluation criteria. MCA identifies, in general, goals or objectives and then seeks to spot the trade-offs between them; the ultimate goal is to identify the optimal policy.

MCA is widely used in environmental planning and has numerous documented instances in water planning (Hajkowisz and Collins, 2007); it is noted that the first application of MCA appeared in 1965. The article by Hajkowisz and Collins (2007) cited a few journals that had published MCA articles as follows: *European Journal of Operational Research*, *Agricultural Systems* and *Water Resources Management*. This tool is therefore seen as interdisciplinary as it spans the sciences and humanities.

The sustainability reports used for the analysis of the 11 companies were used as the data sources. A presentation and chapter of a textbook were used for the two organisations. The top three Nampak focus points from the 2010 sustainability report were used as the criteria in the MCA; these three points are as follows:

- **Carbon footprint**, is defined as “the amount of greenhouse gases and specifically carbon dioxide emitted by something (as a person's activities or a product's manufacture and transport) during a given period” (Merriam-Webster, 2013)
- **Recycling**, is defined as “to pass again through a series of changes or treatments as**:** to process (… waste, glass, or cans) in order to regain material for human use” (Merriam-Webster, 2013)
- **Training**, is defined as “the state of being trained” (Merriam-Webster, 2013)

The three terms are seen as general environmental awareness terms and could have been randomly selected from the literature.

A search was done in the data for each of the criteria and each was expanded to include synonyms. The criterion of ‘carbon footprint’ was equated to ‘Danprint’ in the Danone report. Recycling and training – used the addition of wildcard terms or alternate spellings. The term ‘recycling’ was searched for using the term ‘recycl*’ and all words were counted. The term ‘training’ was searched for using the word ‘train*’, noting the context of the word to exclude trains used in transport. The synonym of ‘educat*’ was also searched for. The Find function of Adobe®, Presentations® or MSWord® was used to count the criteria. The IPSA textbook chapter was manually counted for the criteria.

The following methodology was used to convert the criteria word count to a percentage rating:

- A zero count for a term gets a score of ‘0’ (the minimum) – the lowest rating.
- The maximum rating is ‘100’.

- The count of headings or names of companies is dependent on the analysis.
- Percentage scoring only uses whole (or counting) numbers (in order to minimise interpretation).
- Each reference to a search term is seen as positive.

The following equation (Equation 3.5) was used to calculate the percentage value for each of the criteria:

$$\text{Percentage for criterion } (p_i) = \frac{\text{Word count x 100\%}}{\text{Maximum no. of counted words for the same criterion}}$$

Equation 3.5. Calculation of the 'percentage for each criterion' without normalisation

A single score for each company is then calculated using Equation 3.6, i.e. the sum of the percentage for each criterion multiplied by the selected weighting. The equal weighting is assigned a value of 0.333 for each of the three criteria.

$$S_i = \sum_{i=1}^{3} p_i w_i$$

where p_i is the 'percentage for each criterion

and w_i is the weighting as selected

Equation 3.6. Single score calculation using the percentage and weighting

A single score with unequal weighting uses Equation 3.6. The criterion of 'carbon footprint' is assigned the highest weighting of 0.45 as it requires the use of more sophisticated software and data gathering. 'Recycling' is also given a weighting (of 0.33) as it is deemed appropriate and 'training' is given the lowest weighting of 0.22 as it is vague and could describe training and education across many disciplines. Table 3.8 summarises the weightings used for the three criteria.

Table 3.8. The weightings selected for the three-criteria MCA

No. of criteria	**Weighting description**	**Weighting of criteria (**w_i or w_j)		
		Recycling	**Training**	**Carbon footprint**
Three	Equal	0.333	0.333	0.333
Three	Unequal	0.33	0.22	0.45

There was concern that the MCA analysis may be biased as some companies have a high page count for the sustainability report and other companies have a low page count. A normalisation of data based on the search term count as a percentage of the overall word count in the document was thus undertaken. Normalisation took into account whether the search term is one word or a two-word term.

The calculation used for normalisation is as follows:

$$\text{Normalised value} = \frac{\text{(Search term count x no. of words in search term) x 100\%}}{\text{(Total number of words in sustainability report or chapter)}}$$

Equation 3.7. Calculation of the normalised value for the MCA

The normalised values are then used to calculate the rating as follows:

$$\text{Norm. percentage for criteria } (p_j) = \frac{\text{Normalised value x 100\%}}{\text{Maximum no. for the normalised words for the same criterion}}$$

Equation 3.8. Calculation for the 'normalised percentage for each criterion'.

$$Sj = \sum_{k=1}^{3} p_j w_j$$

where p_j is the 'normalised percentage for each criterion'
and w_j is the weighting as selected

Equation 3.9. Single score calculation for normalised values in the MCA

3.2.9 Life cycle assessment (LCA) as the fourth criterion in the MCA

The term 'life cycle assessment' (LCA) or life cycle analysis was used to search through and count the number of occurrences in the recent sustainability reports of the 11 companies and two organisations for use as the fourth criterion in the MCA.

A single score for each company was then calculated using Equation 3.6, i.e. the sum of the percentages for each criterion multiplied by the selected weighting. The first set of weightings for the four criteria were each assigned a value of 0.25.

The single score with unequal weighting uses Equation 3.6. The criterion of 'carbon footprint' was assigned the highest weighting of 0.40 and 'recycling' was assigned a weighting of 0.30, i.e. both values are slightly lower than those assigned for the three-criteria MCA. 'Training' is given the lowest weighting of 0.10 due to the previously mentioned generality of the term. The fourth term, 'life cycle assessment', is given a weighting of 0.20 – this weighting does not indicate that it is less important than the term 'carbon footprint', but it is assigned a lower weighting as few companies use the term. Table 3.9 is a summary of the weightings used for the four-criteria MCA.

Table 3.9. The weightings selected for the four-criteria MCA

No. of criteria	Weighting description	Weighting of criteria (w_j)			
		Recycling	**Training**	**Carbon footprint**	**Life cycle assessment**
Four	Equal	0.25	0.25	0.25	0.25
Four	Unequal	0.30	0.10	0.40	0.20

As previously noted, there is concern that the MCA analysis may be biased for companies having long reports. A normalisation of data based on the word count as a percentage of the overall word count in the document was again calculated using the four criteria. Normalisation took into account whether the search term is one word or a two- or three-word term.

Equation 3.6, Equation 3.7 and Equation 3.8 were used to obtain the values for the normalised equal and non-equal weightings for the four criteria.

A single overall score was then obtained for each company (using Equation 3.9) by multiplying the assigned counts by the weighting and adding up each of the selected number of criteria. This method thus produced a score for all selected companies and organisations in terms of the three most important 2010 sustainability focus points of Nampak.

3.2.10 Concluding remarks on the sustainability awareness methodology

The measurements of sustainability were undertaken using a variety of methods from the general and management sciences. A word count as described by Hackston and Milne (1996) was used in this dissertation with ordinary desktop software that is readily available.

There are various tools available for analysis of sustainability, but the researcher chose to use the recent sustainability reports of 11 companies active in the LPB supply chain as the data source. The two organisations had other data sources used. The top three focus points were determined in the 2010 Nampak sustainability report and these three points were then counted in each of the other 12 reports and recorded for an MCA, i.e. the raw data of recorded counts were converted to a single score for each company. Two weighting choices were made – the first was an equal sharing for all terms and the second was termed an unequal weighting. The tools for the MCA use standard desktop options that are readily available on the average computer.

The tasks undertaken are all related to sustainability aspects of the purposefully selected 11 companies and two organisations. These entities were analysed by a single researcher. The analyses are presented in Chapter 4 of this dissertation.

3.3 Research methodology: Life cycle assessment (LCA)

The LCA tool is a four-step iterative process. This section describes the goal and scope of the study. The inventory analysis, life cycle impact assessment, identification of significant issues and evaluation are discussed in Chapter 5, with the final interpretation of the LCA and MCA are presented in Chapter 6.

3.3.1 Research design

The main objective of the dissertation is to engage with selected actors of the green supply chain for liquid paperboard (LPB). Section 3.2 described the methodology followed for the assessment of sustainability awareness among the actors. The following hypotheses were formulated in Section 3.1 to aid the development of the LCA and are repeated:

- A high recycling rate (70%) of used beverage cartons would result in a significant decrease in selected environmental impacts.
- It is further hypothesised that these selected environmental impacts could be decreased more by the use of 10 % light-weighting of the paperboard of the beverage carton than by a high recycling rate of 70%.

General comments regarding data collection are also given in this section. The LCA was undertaken after a flow chart had been compiled and a model of the product process had been built.

3.3.2 Goal

The goal of the LCA study was to assess the environmental impacts of a South African printed beverage carton that is landfilled as the end-of-life option. The study included the changes to the environmental impacts through the recycling of the paper fibres arising from the paperboard. The study also reports on probable changes to the environmental impacts if the paperboard were to be light-weighted by 10%.

The documentation relates to the present situation, with the reference year set at 2011. The realisation horizon of future years is included with the increase in recycling of the used beverage carton over time. It is anticipated that it will take 10 years to obtain a 70% recycling rate of used beverage cartons. In the year 2021, it is hoped that natural gas would be more readily available (though the cost may make is inaccessible) and that biofuels and biogas would be fuel sources above the 2% level. The study is not comparative between two packaging types and relates only to single-use chilled milk beverage cartons with a pack volume of 2 000 ml (2 litres).

The focus points identified by the sponsor company in its 2010 sustainability report (Section 3.2.6), viz. ‘carbon footprint’ and ‘recycling’ are then explored in the LCA of the LPB pack. The third focus point of ‘training’ is a general term and is not explored in the LCA.

The future scenarios of recycling the used beverage cartons (UBCs) and light-weighting the paperboard are listed in Table, with the anticipated recycling rate given as 20% in 2014 and as 70% in 2021.

Table 3.10. Scenarios under investigation for the LCA of the used beverage carton

Scenario	**Scenario No.**	**Comments**
Present pack: with 0.9% recycling of used cartons	1	**Base case**. Reference year is 2011.
Future 20% recycling of used cartons	2	Anticipated rate in 2014
Future 30% recycling of used cartons	3	
Future 40% recycling of used cartons	4	
Future 50% recycling of used cartons	5	
Future 60% recycling of used cartons	6	
Future 70% recycling of used cartons	7	Anticipated rate in 2021
Future light-weighting of paperboard by 10%; with subsequent change in secondary packaging	8	10% light-weighting of paperboard (WRAP, 2010)

Nampak and its subsidiaries produce the following packs for milk distribution in South Africa: Pure-Pak® cartons with a screw cap (Figure 3.2), Pure-Pak® cartons, HDPE jug bottles and sachets.

This LCA covers the Pure-Pak® carton with a screw cap. The distribution of these cartons is to a retailer (supermarket). The sustainability awareness of the supply chain actors is analysed in Chapter 4. Sections of this distribution system are analysed in the LCA.

The LCA was undertaken in accordance with ISO 14040:2006 and ISO 14044:2006.

Figure 3.2. A printed two litre Pure-Pak® carton showing the gable-top carton style and the white screw cap closure

Audience of the research: Technical packaging

There are various research groups that could have an interest in aspects of the LCA in relation to milk packaging, the South African context, packaging *per se* and the end-of-life scenarios of the study.

LCAs are undertaken at various institutes and universities in South Africa. The University of KwaZulu-Natal, the University of Pretoria, Stellenbosch University and the CSIR have all been involved in LCA studies. There are also numerous international organisations employing LCA practitioners who may be interested in the research presented. In addition, there are various organisations involved in the packaging industry of South Africa.

The customers of the Elopak carton, brand owners, retailers and others in the LPB supply chain could have an interest in the study.

The readers of the study could include literate members of the South African public with an environmental education and/or interest.

3.3.3 Scope

The LCA assessment was a cradle-to-grave study of the packaging material.

The ‘cradle’ was taken to indicate the raw materials used for the production of the polyethylene and paperboard. The ‘grave’ part of the study indicates the end-of-life scenarios that the used beverage carton undergoes at present and the anticipated recycling rates and light-weighting that could be achieved.

3.3.3.1 Functions of the product

According to IPSA (2005), the criteria that packaging needs to satisfy are:

- Protection of the product
- The functions the packaging must serve
- The appearance, including the sales appeal.

The cost

The WRAP (2010) study includes the "preservation, storage and enabling loading and transport". WRAP (2010) further indicates that the pack should provide information and be tamperproof.

The description of the functional unit in the next section includes the protection of the product and its appearance; it also includes the extended shelf life of the product. Although the distribution requirement to use refrigerated vehicles is compulsory, this part of the system is excluded.

The Elocap is a double-tamper evident closure with a twist-off and pull ring to ensure the pack's integrity. The closures are alternatively termed 'screw caps' (Figure 3.3).

Figure 3.3. A picture of the white four-piece closure; the HDPE components are tan-coloured and the LDPE components are white-coloured (Bericap, 2011)

The gable-top carton is made from liquid paperboard, i.e. multi-layers of virgin paperboard extrusion coated with LDPE on both sides, as depicted in Figure 3.4. The LPB is made of predominantly of bleached sulphate pulp and a smaller quantity of chemi-thermomechanical pulp (CTMP). This is the simplest construction and additional layers of material can be added. For example, a polyamide layer or an aluminium foil layer can be added for fruit juice packaging or wine packaging.

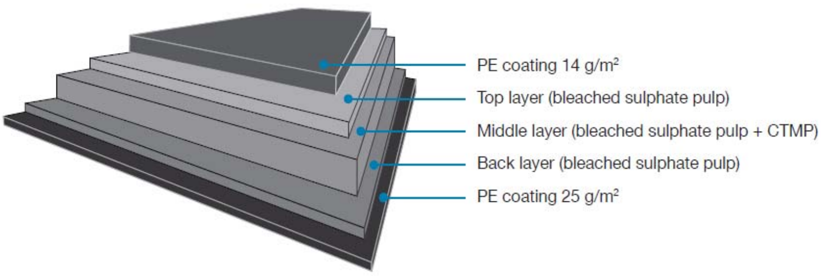

Figure 3.4. Construction of the liquid paperboard material (©Stora Enso 2010a)

3.3.3.2 Functional unit

The literature review on related beverage and milk packaging, as presented in Chapter 2, assisted with defining the functional unit in terms of the packaging and volume of the beverage pack. The functional unit has been selected as follows:

> The packaging system for containing, protecting, storing and transporting 1 000 litres of extended shelf-life pasteurised cow's milk to the retailer in South Africa in 2 litre Pure-Pak® beverage cartons.

The functional unit defined for this study is closely linked to the WRAP (2010) definition of "packaging systems for containing, protecting, storing and transporting 1 000 pints of pasteurised cow's milk to the consumer in the UK".

The two litre milk container is a popular size of milk unit though in South Africa, although this milk volume is often retailed in an HDPE jug bottle.

The reference flow will be 500 two litre Pure-Pak® (gable top) cartons having a sleeve mass of 51.31 g (34.79 g of bleached sulphate pulp and 11.60 g of CTMP with an LDPE coating on both sides of the board of 4.93 g), with a screw cap closure of 1.74 g of LDPE and 1.28 g of HDPE. The weight of the closure components includes masterbatch (white-coloured pigments).

Size and volume

This study describes the results and interpretations for a two litre pack. While other similar packs exist with different volumes and closures, these results cannot be extrapolated to the other packs (WRAP, 2010). Despite this exclusion, and in the limited number of studies available, comparisons are often made between different pack sizes.

3.3.3.3 Purposive selection of the pack for the LCA

Nampak is described as having 110 manufacturing sites (Nampak, 2010) and with numerous products produced at each site; the choice for the selection of a product LCA is wide. A complex study of the market significance (IFEU, 2004) and relevance (UBA-FB, 2000) was not undertaken in selecting the pack. The researcher is aware that the Nampak research centre was involved in two milk pack launches prior to 2009; one of these packs is a complex paper laminate pack – this LPB carton pack was chosen to be suitable for the study.

The pack can be described as a Pure-Pak® milk pack produced by Nampak and Elopak at the premises of the joint venture named Elopak SA.

3.3.3.4 Milk packaging system studied (definition)

The gable-top carton is produced from board obtained from the Swedish mills of Stora Enso. At present for the large-size two litre capacity, there is one board grammage recommended and 100% virgin papers are used for the paperboard. The LDPE used to coat both sides of the paperboard is virgin LDPE extruded plastic. The contamination and migration of unknown chemicals from recycled content into foodstuffs is of concern to the food and beverage industry and the use of recycled materials for direct food contact is seen as unlikely at this point.

The different scenarios for the selected milk pack are tabulated in Table 3.9.

3.3.3.5 System boundaries

The study is a cradle-to-grave study with recycling of the paper fibres of the used beverage cartons into other paper-based packaging. It concerns a single pack (i.e. non-comparative between two packs) of extended shelf-life refrigerated and pasteurised milk.

The milk itself and the production of milk are excluded from all the scenarios. As the sponsor of the research is the producer of the primary packaging and not the food product, the LCA of the empty pack will be of value. The background and foreground data of the LCA study are described in the following paragraph and Figure 3.5.

The boundary of the beverage carton is from the manufacture of the liquid paperboard in Sweden to its disposal in South Africa. The liquid paperboard is manufactured in Sweden and is treated as background data in this LCA model. The closure plastics and ink materials are also treated as background data in this LCA model. The carton is printed and manufactured at Elopak SA and then sent to the dairy for closure application and filling. The closure is produced from raw material purchased either locally or overseas and converted at Nampak Closures, Durban site. The closures are sent separately to the dairy. After filling of the milk cartons, the palletised goods are sent to the retailer for distribution in the trade. The filling, retailing and consumer sections of the supply chain are excluded from this study.

The used beverage cartons (UBCs') can undergo one of three processes: 1) either landfilled with the closures intact, 2) disassembled into components with the film and closures landfilled and the paper fibres recycled or the closures could be recovered incinerated and 3) an unknown small proportion of the cartons are used in crafts and are sought after.

An overview of the boundary of the packaging system is detailed in Figure 3.5.

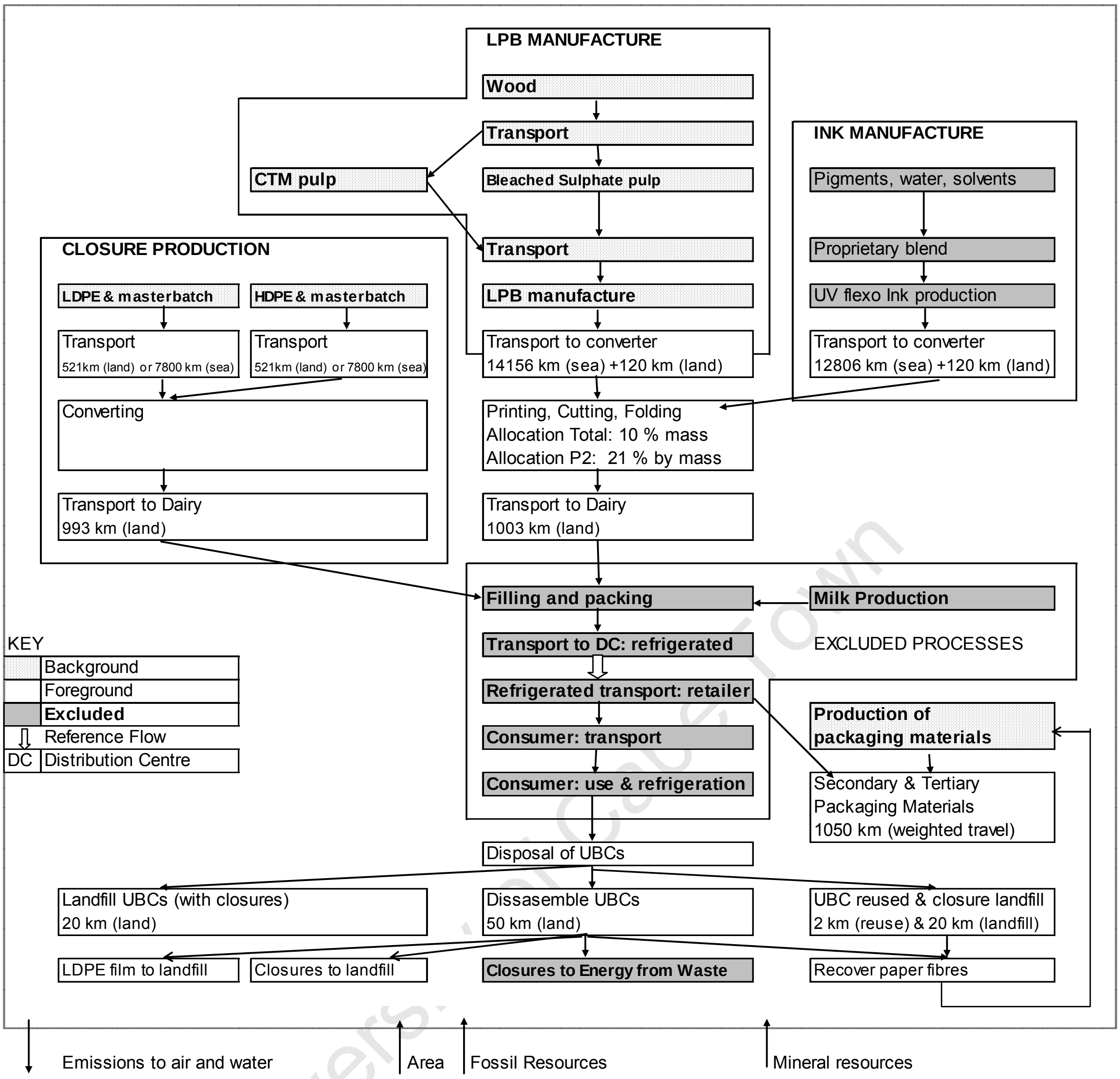

Figure 3.5. Flow chart of the 2 litre Pure-Pak® milk cartons

3.3.3.6 Recycling allocation

There are numerous methods available for allocation in recycling - the **cut-off method** that “assigns load directly caused by a product to that product” (Baumann and Tillman, 2004). The **50/50** method for “degradable materials such as paper and plastics” (Baumann and Tillman,–2004) for open-loop recycling “which divides equally the impacts of recycling between the product being recycled and the product using recyclate” (WRAP, 2010). The **avoided burdens** method with system expansion and **consequential LCAs** are other methods available.

As the main packaging materials of the LPB had 100% **virgin** paper fibres and plastic laminates as the content during the reference time frame of 2011, the method used a **credit** for the paper fibres to reduce the burden in the system.

For the plastic component and the other secondary packaging materials such as corrugated shippers, kraft paper and plastic pallets the 50/50 method could be used. However, as these materials are modelled using general datasets, the cut-off method is also used.

3.3.3.7 Software and computing

The LCA software programme SimaPro v 7.3.0 (PRé Consultants, 2008) was used to model the system for the LCA analysis. A licence for the ecoinvent database v2.0 was also made available.

An HP Compaq nx7010 notebook computer was used to run the models. The computer is the property of the Environmental & Process Systems Engineering (E&PSE) group at UCT.

3.3.3.8 Project implementation

This LCA was undertaken with funding from Nampak Limited in the form of a study loan. The study was started in 2009 as a part-time research project.

The customer champion is Professor Harro von Blottnitz of the Chemical Engineering Department of UCT. Technical assistance was given by Thabi Melamu.

The staff members at Elopak SA, in particular Vasen Pillay, have been generous with the data provided.

3.3.3.9 Exclusions

Although initially planned to include all secondary and tertiary packaging, the following exclusion is noted:

> Plastic pallets are excluded from all calculations; the data was unavailable in the local context and the complexity of modelling the recycling and stock loss was beyond the scope of this study; the wooden pallets are included.

The secondary packaging materials are also noted as being produced and entailing confidential information and therefore average European data are used. Although this could introduce uncertainty, the error in the study is deemed minimal.

According to Brent and Hietkamp (2003) "the impacts associated with the general operation of the [two converters'] "infrastructure, i.e. air conditioning, lighting, on-site transport and fuel, labour impacts, etc. have not been included in the … life cycle inventory". The exclusion of detailed infrastructure is also used in the Nordic Wine LCA and "burdens associated with the running of offices, workshops … are not incorporated in the assessment" (Petrie *et al.,* 2004). The exclusion extends to the "maintenance, production and disposal" (IFEU, 2006) of the infrastructure. The exclusion of the infrastructure is limiting as the site and personnel use resources such as energy, paper and flights, however, the data was unable to be shared.

The capital asset of the printing machine is estimated at 20 t of metal and 3 t of plastics. An estimated 1.068 $x10^{10}$ cartons are produced in an approximate ten-year life span of the machine. For the functional unit this equates to 0.94 g of metal and 0.14 g of plastics. As these input values are low, the printing asset is excluded from the LCA.

The plastic moulding machine for the closures is also excluded from the LCA as it is expected that the large number of closures produced over the life time of the machine will also be high.

The inputs of capital assets (for printing and moulding) are therefore excluded as these flows have a low material input of far less than 1% of the LPB flow, i.e. calculated at 0.0038% for the printing machine.

The following are also excluded – the filling and packaging at the dairy, the fill good (i.e. the chilled milk), point-of-sale cooling and the consumer. The inks manufactured for printing on materials such as LPB and corrugated board are excluded due to the proprietary information used in the manufacture of inks.

3.3.4 Selection of the impact assessment method

A midpoint impact assessment method is required as the endpoint method has more uncertainty than at the midpoint level. The LCIAs available are ReCiPe midpoint and CML 2.

A single score assessment is not required as most stakeholders have a novice LCA ability and the use of a single result for the LCA is deemed less educational to the stakeholders.

The study is not "as complete as possible" (Baumann and Tillman, 2004) in terms of impact categories as the time and budget were limiting factors.

3.3.4.1 Decision on the LCIA method

The literature review on related beverage and milk packaging, as presented in section 2.4.5, detailed some LCIAs used. AS the LCIA of CML2 was selected the most often, at 6 times, this method was also selected for this study.

The LCIA method is fully described as "CML 2 baseline 2000 v2.05 (with World 1995 normalisation weighting)"; the method is abbreviated as CML 2.

The CML 2 life cycle impact assessment method is favoured in other recent beverage carton studies (IFEU, 2010, BIOIS, 2010 and WRAP, 2010) and in local studies (Notten and Mason–Jones, 2011 and Ras, 2011) and is and appropriate LCIA selected for this study as the study is a problem orientated LCA. Other LCIAs (that use the endpoint method) could be used for checking the conformity of the results, e.g. the “Eco-indicator 99”, and one is reported in this study.

3.3.4.2 Number and selection of impact categories

As the life cycle impact assessment method (CML 2) has 12 impact categories, a smaller number of relevant impact categories needed to be selected. This midpoint method is justified as the stakeholders identified are not experts in LCA and the output from a high number of impact categories is deemed to be confusing to the reader.

A list of LPBs and other relevant packaging LCAs was compiled from the literature study. In total 48 studies were analysed in terms of the impact categories selected by the researchers and the results were tabulated. Fourteen impact categories were obtained from the literature study. The total number of times each impact category was used was then summed for the 13 indicators (Table 3.11). The top four categories, namely abiotic resource consumption, climate change (or global warming potential), acidification and eutrophication, were used in this study. The remaining impact categories were not selected for the following reasons:

- The human toxicity and ecotoxicity impacts have no suitable South African and so were not selected.
- Winter smog is relevant in the South African context and is included in the human toxicity impact mentioned above.
- The ozone depletion impacts would require the use of refrigeration and applicable gases. The filled milk pack requires refrigeration, however, this process has been excluded in the study.
- The land use category is minimal with regard to footprints for the manufacturing sites and as the majority of the paper fibres used are produced in Sweden, this impact was set aside.
- Waste – Although this is a relevant impact indicator, it is not available in the shelf-ready CML 2 impacts.
- Water consumption – The water involved is mostly used in Sweden for the production of the majority of the paper fibres and is a background process; secondly, cooling of the injection moulding equipment for the closure production is estimated using German data.

Table 3.11. The total number of times an impact indicator is mentioned in relevant LPB and packaging LCAs (Impacts selected are in bold)

Total count	Impact indicator in relevant LCAs of beverage cartons	Impact indicator in CML 2
45	**Abiotic resource consumption** Energy resource consumption **Cumulated energy**	**Abiotic depletion**
34	**Climate change**	**Global warming (GWP100)**
31	**Acidification**	**Acidification**
31	**Eutrophication**	**Eutrophication**
22	Summer smog	
15	Human toxicity	Human toxicity
13	Land use	Fresh water aquatic ecotoxicity
10	Waste	Marine aquatic ecotoxicity
9	Ozone depletion	Terrestrial ecotoxicity
8	Ecotoxicity	Photochemical oxidation
5	Winter smog	Human toxicity
4	Traffic	
3	Water consumption	Resources
2	Pesticides	Human toxicity and ecotoxicity

3.3.4.3 Comparison of values in the LCA

The comparison of values can become subjective and a well defined, transparent rating is sought. Von Falkenstein *et al.* (2009) in the LCA of beverage cartons describe three comparative values: the first is the much higher value and this relates to all values at least 50% higher, the second is the term “slightly higher” and describes values 10 to 49% higher and lastly the values within 10% of the value are described in the similar range. The comparative values of “slightly higher” are modified in this into the original titled “slightly higher” group of 10 to 29% (i.e. the lower half of values) and a new group of “higher” having the remaining values of 30 to 49%. These comparison values are summarised in Table 3.12.

IFEU (2010) state “that … [in description, comparison and interpretation of results] differences ≤ 10% are considered as insignificant in accordance with the common practice for LCA studies comparing different [product] systems”. This statement compares favourably in that values of 10% are stated as being similar or having insignificant differences.

Table 3.12. Comparison of LCA values used in the dissertation

Comparison of LCA values	Original comparison[a]	Adapted comparison[b]
Much higher	At least 50%	At least 50%
Higher	Not used	30 to 49%
Slightly higher	10.1 to 50%	10.1 to 29%
Similar range	Less than 10.1%	Less than 10.1%

Notes: a. The original comparison is based on Von Falkenstein *et al.* (2009).
b. The adapted comparison is used in this dissertation.

3.3.5 Peer review

The goal (Section 3.3.2) and scope (Section 3.3.3), and the classification and characterisation in Chapter 4 are required to conform to the ISO standard.

The LCA was internally reviewed by the supervisor and by presentation of the data to the members of the E&PSE group at UCT.

The dissertation submitted and dated February 2013 will be reviewed by external examiners and then the comments and corrections will be incorporated into a final document (May 2013).

3.3.6 Concluding remarks on the LCA methodology

The LCA is a high-level tool selected to gain an understanding of the sustainability aspects of the actors in the LPB supply chain. This tool requires either spreadsheets or LCA-specific software depending on the number of processes to be dealt with; the researcher selected LCA-specific software due to its availability and the large number of processes that can be analysed. LCA is also a tool having an international standard and is practised across various disciplines.

3.4 Summary of the methodology used for this dissertation

The chapter began with the development of research hypotheses. The MCA methodology used to assess the sustainability of the LPB supply chain was then described, with the use of sustainability reports as the data set. The results of the MCAs are discussed in Chapter 4.

The chapter proceeded with a discussion of the methodology used for the LCA of an LPB pack and its relation to the goal and scope given in this chapter. The remaining steps of the LCA are presented in Chapter 5. Chapter 6 gives the overall conclusions and recommendations.

CHAPTER 4 SUSTAINABILITY FOCI OF PACKAGING AND SUPPLIER COMPANIES

Chapter 4 gives the results of five of the six tasks described in Section 3.2.1; Section 3.2.3 describes the first task that of the purposeful selection of the 11 companies and two organisations. These tasks were undertaken to assess sustainability awareness in the LPB supply chain. The year the selected companies first produced a sustainability report is reported in Section 4.1, along with an analysis of the recent sustainability report (Section 4.2). The sustainability reports of the sponsor company are analysed in Section 4.3 and the three focus points of the Nampak 2010 report are selected in Section 4.3.3. These three focus points are used to analyse the other suppliers in the LPB supply chain using an MCA (Section 4.4). A fourth criterion is introduced to the MCA in Section 4.5 using the LCA as a term.

The concluding remarks are in Section 4.6 and overall conclusions are given in Chapter 6.

4.1 The first sustainability report of the selected companies

The 11 selected companies produced their first sustainability reports from 1998 to 2006. The SIG Combibloc report of 2004 and the Elopak report of 2005 were taken to be the first report of each company by the researcher. All but one company had published a sustainability report prior to the 2006 movie entitled “An Inconvenient Truth”. The year of the Rio Earth Summit (1992), the King Reports (II and III) and the GRI events are added as placeholders in the sustainability reporting (Table 4.1).

The earliest report was published by the Danone Group (in 1998). The median year of publication was 2003.1, and as Nampak published its first sustainability report in 2003, this indicates that in this group of companies, the sponsor could be seen as an average first-time responder to sustainability reporting.

Danone and Tetra Pak are pre-King II first-time sustainability reporters, with the remaining nine companies reporting post-King II.

Table 4.1. The year of the first sustainability report for the selected companies and the placeholders in sustainability reporting

Company or sustainability placeholder	Sorted year of first sustainability report
Rio Earth Summit	1992
Founding of the GRI	1997
Danone Groupe	1998
Tetra Pak	2000
LCSP Framework	2001
King II	2002
GRI G2	2002
Mondi	2002
Nampak	2003
Sappi	2003
Stora Enso	2003
Woolworths Limited (South Africa)	2003
CSMS framework	2003
SIG Combibloc	2004
Spar (South Africa)	2005
Elopak	2005
Walmart	2006
GRI G3	2006
King III	2009

Note: The LCSP Framework is described in Veleva *et al.,* 2001.
The CSMS framework is described in Azapagic, 2003.

4.2 Overview of the selected sustainability reports

The company reports were analysed as per the methodology described in Section 3.2.1. As mentioned, a general analysis of the type of reporting is done.

The type of corporate responsibility reporting is detailed for each company. The choice is 'separate', 'combined' or 'none'. The corporate summary of the King II Report states that

> "stakeholder reporting requires an integrated approach" (King II).

The King III Report encourages

> "… an integrated report that conveys information about the operations of the company. The report should include sustainability and financial reporting" (SAICA, 2009).

The GRI also encourages integrated thinking as in the following:

"Integrated reporting can show the connectivity between financial and non-financial information and reflects 'integrated thinking' " (GRI, 2012).

Two of the 11 selected companies, namely Spar and Nampak, use integrated reporting.

The number of pages of a sustainability report can be misleading as some reports have pages of pictures with minimal text or even diagrams with a low text level. It also appears that the creative editor can use trends items that can contribute to white space or minimal text.

The industry class on the JSE was described in order to differentiate companies in terms of local or international origin (see Table 4.2). Elopak at 45.2% is noted as having the highest percentage of sustainability in the annual and sustainability reports. Spar is noted as having the lowest sustainability value of 10.6% for a company. IPSA is noted as having a sustainability value of 1.6% which is the lowest measured among the reporting organisations. Four companies were unable to have a value assigned due to non-availability of their annual reports. The four companies selected that are listed on the JSE all had sustainability reports in 2010.

Table 4.2. The selected companies and an analysis of their most recent sustainability report

Company	Type of corporate responsibility	No. of pages	% Sustainability content in reports	Industry class on Johannesburg Stock Exchange	Year of report
Danone	Separate	232	-	Not listed	2010
Elopak (Ferd)	Separate	28/ (28+34)	45.2	Not listed	2010
SIG Combibloc	Separate	16	-	Not listed	2009
Tetra Pak	Separate	52	-	Not listed	2009
Stora Enso	Separate	52/ (52+136)	27.7	Not listed	2010
Mondi	Separate	40/ (40+172)	18.9	Forestry & Paper	2010
Sappi	Separate	48/ (48+204)	19.0	Not listed	2010
Walmart	Separate	47/ (47+107)	30.5	Not listed	2010
Spar (South Africa)	Combined	10/94	10.6	Food and Drug retailer	2010
Woolworths	Separate	65/ (65+186)	25.9	Retailer	2010
Nampak	Combined	28/202	13.9	General Industrials	2010
IPSA	None	12/749	1.6	Not listed	2010
PACSA	None	37	-	Not listed	2010

The number of pages by year, percentage of the sustainability report as part of the company financial and sustainability report, type of reporting (separated or combined), and sorting by first year of reporting are analysed as an introduction to the topic. However, a scientific (mathematical) method of analysis is required.

4.3 Sustainability analysis of Nampak

This section presents an analysis of Nampak sustainability chapters, from 2003 (the year of the first sustainability report) to 2010 (Section 4.3.1). A rating of the Nampak sustainability reports from 2002 to 2010 is discussed using three rating systems (Section 4.3.2).

Three focus points of the recent sustainability report are identified and discussed (Section 4.3.3). This portion of the chapter seeks to determine whether Nampak is increasing its awareness of environmental sustainability, which is assessed using the sustainability chapters as primary data (Section 4.3.4).

4.3.1 The 2003 to the 2010 Nampak Annual Reports

The following general trends, without further analysis, are noted for Nampak in terms of the sustainability chapters:

- A consistent level of GRI reporting as level C (since 2008)
- Participation in the Carbon Disclosure Project (CDP) (since 2008) and full disclosure in 2010
- Reporting on the numbers and percentages of trained staff across various training programmes
- Targets being set for the following year in the 2009 and 2010 reports (except for B-BBEE and staff profile)
- An increase in B-BBEE rating (since 2008)
- A single mention of the JSE SRI index in 2009 and in 2010 a mention of the Ernst & Young Corporate Excellence award.

The following trend is noted and is discussed further:

- An increase in page numbers of the sustainability chapter with each year (except in 2006).

The Nampak reports were summarised for the total number of pages in the sustainability chapters – these varied from 8 to 28 pages (Table 4.3). The highest percentage for the sustainability chapter was 13.9% in 2010; the lowest percentage was 4.7% in 2006 (the first year of reporting has a value of 5.5%). As was to be expected, there was an overall upward trend in terms of the number of pages in the sustainability chapter.

Table 4.3. An analysis of the sustainability chapters of the Nampak annual reports

Nampak Annual Report (combined reporting)	No. of pages in sustainability chapter	No. of pages in annual report	% of report on sustainability
Nampak 2010	28	202	13.9
Nampak 2009	29	212	13.7
Nampak 2008	24	196	12.2
Nampak 2007	15	198	7.6
Nampak 2006	8	172	4.7
Nampak 2005	11	171	6.4
Nampak 2004	9	143	6.3
Nampak 2003	8	146	5.5
Nampak 2002	0	113	0

4.3.2 Rating of the Nampak sustainability chapters

The Nampak sustainability chapters were analysed in order to gain an insight into the changes over the eight years of combined reporting (2003 to 2010). The selection of the data, rating systems used and tables will now be discussed.

The output of the analysis is a rating for each of the three systems for each year (Table 4.4). These values are tabulated with text from the rating system (Table 3.5).

The rating systems are diverse: the GRI single score is derived from company-provided data, whereas the Lowell Centre Index and the Skills Development Index are rated by an individual.

Rating of reports using the GRI single score

The starting GRI single score is 48% in 2008. The 2007 score is unavailable as the score requires company-published GRI tables and these were not given in 2007. The value of 48% indicates the start of GRI reporting in the sustainability chapter and as such is taken as the initial increase. A 7% increase to 55% for 2009 is the next recorded change and in 2010 the score remains the same at 55%.

Nampak had a 14% increase in reporting sustainability issues from 2008 to 2010 when using the GRI single score.

Table 4.4. An analysis of the sponsor's company sustainability reports using three different indices

Nampak Annual Report	GRI Single score (GRI_i)	Lowell Center Index	Skills Development Index
Nampak 2010	55	Life cycle thinking and/or management (4)	Relational (4)
Nampak 2009	55	Life cycle thinking and/ or management (4)	Relational (4)
Nampak 2008	48	Continuous improvement (3)	Relational (4)
Nampak 2007		Compliance with environmental legislation (1)	Multi-structural (3)
Nampak 2006		Compliance with environmental legislation (1)	Multi-structural (3)
Nampak 2005		Compliance with environmental legislation (1)	Multi-structural (3)
Nampak 2004		Compliance with environmental legislation (1)	Multi-structural (3)
Nampak 2003		None (0)	Uni-structural (2)

Notes:

1. The GRI single score uses the nominal scale (described in Chapter 3) and the methodology described by Perez and Sanchez (2009). Values reported are based on the GRI indicators of 'social', 'economic' and 'environmental'.
2. The Lowell Center Index is based on the Lowell Center for Sustainable Production (LCSP) indicator framework (Veleva *et al.,* 2001).
3. The Skills Development Index is based on the SOLO taxonomy (Biggs, 1996).

As Nampak currently has a rating of 55% out of a total of 100%, the company is reporting slightly above the mid-point level on the scale and has the ability to improve this score by reporting on more GRI issues. The improvement in the score could have resulted from increased awareness and reporting on each of the three items; the environmental contribution to the overall value has the lowest value for each of the three years and focusing on reporting on these issues in the future could be beneficial.

A limitation of this rating system is that once the company reports on all the selected GRI indicators, a score of 100% is achieved. Thereafter further increases in sustainability reporting cannot be compared using the nominal scale. It is therefore suggested that the nominal scale be used until a score of above 90% is achieved and then an ordinal scale (with a four-point system) be used to assess sustainability.

Rating of reports using the Lowell Centre Index

The Nampak sustainability chapters of 2003 to 2010 are given ratings of 0 to 4 on the five-point system. A single score of 0 is obtained in 2003 as there was no mention of compliance with legislation, only that "governments around the world are introducing legislation to set recycling targets" (Nampak, 2003).

The four years from 2004 to 2007 obtained a score of 1 owing to compliance with shopping bag environmental legislation ("Shopping bag sales, which fell substantially in the previous year as a result of legislation" (Nampak, 2004)), ensuring a rating of 1 for 2004. Compliance with the removal of asbestos from the working environment ("we conducted inspections of all our factory buildings and commenced a phased replacement or encapsulation of asbestos building materials" (Nampak, 2005)) ensured that 2005 is rated 1. "Our safety, health and environment committees are responsible for identifying any emissions or waste disposal practices that do not conform to acceptable standards. We have a formalised environmental policy which is aligned to ISO 14000" (Nampak, 2006) is the text selected to give a rating of 1 in 2006. The text "all major new projects, major additions and extensions undertaken in the group are preceded by full environmental impact assessments" (Nampak, 2007) gives a rating of 1 for 2007.

The following year's sustainability chapter (namely 2008) is assigned a score of 3, i.e. continuous improvement. In general, the following points are noted: a contact name is provided for further information; 2009 targets are reported in 2008; stakeholders are identified; GRI reporting is documented for the first time; and there is continuity through the mention of the previous report and that "Nampak is committed to complying with the law in all of its operations and beyond to minimise its risks and impacts by developing robust and documented systems to measure, monitor and communicate its environmental performance both within its operations and to the broader community" (Nampak, 2008).

The two most recent years (2009 and 2010) both score 4 for the life cycle approach based on "the second approach is a life cycle assessment process which establishes the carbon emissions of packaging products from resource usage (cradle) to the customers' premises (gate) (Nampak, 2009 and 2010).

Rating of reports using the Skills Development Index

The Nampak sustainability chapters of 2003 to 2010 are given ratings of 2 to 4 on the modified four-point index. The lowest score of 2 (uni-structural) is obtained in 2003 for the initial report which was a structured report.

The years 2004 to 2007 obtain a score of 3 (multi-structural) as in these reports there is overall reporting on each item with the reports "treated independently and additively" (Biggs, 1996).

The years 2008 to 2010 obtain the highest score on the system as these three years show an overall integrated approach with a contact name provided for further information, targets reported for the next year, stakeholders being identified and GRI reporting noted. It is felt that the reports met the need to be “integrated into a coherent whole” (Biggs, 1996).

The Lowell Centre Index and the Skills Development Index ratings indicate that Nampak has had four increases in sustainability reporting – in the years 2003 (the initial report), 2004 (the next year), 2008 (after four years on the same level) and 2009 (for only the Lowell Centre Index).

Increase in the Nampak sustainability reports as per the three rating systems

The GRI single score method is an easy method that requires minimal training to obtain rapid and valid scores for companies scoring under 100% on the selected GRI categories. The method can be extended to include an ordinal scale using all GRI categories. In contrast, the other two rating systems are subjective and could depend on the researcher.

The GRI single score rating (while only reporting for 2008 to 2010) shows agreement with the Lowell Centre Index in that there is an increase noted in 2009. An increase is noted in both the Lowell Centre Index and the Skills Development Index in 2004 and 2008.

It is noted that using three dissimilar rating systems, Nampak sustainability chapters have had three increases in content, with the fourth increase attributed to 2003 (i.e. the initial report).

4.3.3 Three focus points identified in the Nampak 2010 Annual Report

The Nampak 2010 sustainability report is analysed in terms of the number of pages devoted to a topic and the following three are given the highest number of pages:

- Recycling (3.8 pages)
- Skills development and training (3.2 pages)
- Carbon footprint (including Carbon Disclosure Project) (2.6 pages).

The discussion on **recycling** of the four main material types appears to be a repeat from previous annual reports with the paragraph on paper having a high word repetition, i.e. new data included the three changes in year and a new recycling rate. Recycling is a Level 2 tool in the five-level LCSP framework (Veleva *et al.,* 2001).

The socio-economic concern of **skills development and training** received significant attention in the sustainability report; this is justified in terms of the historic background of the home country of the company, i.e. South Africa. It was noted that of all the training mentioned, none was documented as dealing exclusively with environmental or sustainability training.

Training is also identified as a Stage 3 tool in the CSMS framework (Azapagic, 2003) (this is equated to a Level 2 tool in the five-level LCSP framework (Veleva *et al.,* 2001)).

The **carbon footprint** data have been included for all the South African Nampak sites, and Nampak is a contributor to the Carbon Disclosure Project (CDP) to which it has been contributing since 2008, although the values were only made public in 2010.

Carbon footprint is identified as a Level 3 tool in the five-level LCSP framework (Veleva *et al.,* 2001) (Section 2.2.2). Carbon footprint is the highest-level tool identified in the top three focus points of the Nampak 2010 sustainability report.

4.3.4 Discussion of the Nampak sustainability chapters

Nampak gives attention to three aspects in the 2010 sustainability report – recycling, skills development and training, and carbon footprint (including the Carbon Disclosure Project). These items include a single tool (i.e. 'carbon footprint'), another less well-defined tool ('recycling') and 'training' (which is a general term).

Nampak has become aware of the need to report on sustainability issues since the first sustainability chapter was published in the 2003 Annual Report. The company had four increases in sustainability reporting – in 2003 (the initial report), 2004, 2008 and 2009 (as determined using two rating systems).

Based on the following observations, Nampak can be described as a cautious responder to sustainability:

- The sustainability chapter in the first report of 2003 is 8 pages long, or 5.5% of the annual report, and has since increased to 29 pages (2009) or 13.9% (2010). This indicates that information is provided, but it is kept concise for a company with over 100 sites.
- The first sustainability chapter was published in 2003 a year after the King II Report.
- The first GRI reporting is undertaken in 2008 using after the third generation (G3); this is two years after the G3 was introduced.
- Nampak sustainability reports are slightly repetitive in content, with a low increase of new content each year.

4.4 Similarity of the sustainability focus of Nampak and LPB supply chain members

This section quantifies the similarity of focus in sustainability reporting of the selected companies in the LPB supply chain, by rating them relative to the focus of the Nampak 2010 report. An MCA of the data is undertaken. The discussion of the results takes into account the relationship of the companies to Nampak.

4.4.1 Results of the three-criteria MCA

The single score for each company is determined using the following four conditions:

- The Nampak-identified focus terms (with synonyms as identified in Section 4.3.3) with equal weighting as follows:
    - Equal to 0.333
    - Unequal.
- The same three focus terms (also with synonyms) with a word count normalisation and then with equal weighting as follows:
    - Equal to 0.333
    - Unequal.

The number of words counted in the 2010 sustainability reports is summarised in the Table 4.8. It is noted that Elopak has the fifth-lowest count and Danone, with 65 287 words, has the highest count. Nampak has the sixth-highest word count.

There are four results columns for the MCA analysis (Table 4.5) and these are described for Nampak and the companies with the highest and lowest single scores and organisation with the highest score:

1) The single scores attained on the percentage word count with the unequal and equal weightings are from a low value of 10 for Elopak to the highest score of 85 for Danone. The single score has a range of 75.
    a. When the equal weighting is used, Nampak has a single score of 39 and is third highest. When the unequal weighting is used, Nampak has a single score of 38 (i.e. joint third highest in the group of 13).
    b. When the equal weighting is used, both organisations have a single score of 13. When the unequal weighting is used, IPSA has the slightly higher single score of 14.
2) The single score attained on the normalised values indicates that with the unequal and equal weightings, a low value of 9 is obtained for Mondi and the highest single score is for Stora Enso (with a value of 62 for the equal weighting) and 68 for PACSA for the unequal weighting.
    a. When the equal weighting is used, Nampak has a single score of 45 and is rated fourth. When the unequal weighting is used, Nampak has a single score of 42 (i.e. fourth in the group of 13).
    b. When the equal weighting is used, PACSA has the higher single score of 60. When the unequal weighting is used, PACSA has the higher single score of 68.

Comparing the results, the values obtained with the word count normalised for the report length, with the unequal weighting, is seen as the reasonable option. The unequal weighting separates the three focus points and places more emphasis on the environmental tool of carbon footprint, ensuring that the general term ‘training’ is given less emphasis. The normalisation for report length is reasonable as the longer reports can theoretically cover more items in more detail and could have higher single scores.

Table 4.5. The results for the three-criteria MCA for the companies and local organisations

Company	Word count of report	Single score			
		Without normalisation	Normalised	Without normalisation	Normalised
Danone	65 287	85	36	85	36
Elopak	7 225	10	19	10	22
SIG Combibloc	3 592	17	40	17	41
Tetra Pak	12 686	29	30	27	24
Stora Enso	12 600	36	62	38	66
Mondi	72 719	27	9	26	9
Sappi	23 702	32	33	31	32
Walmart	18 665	29	31	27	28
Spar	4 756	13	49	12	40
Woolworths	23 827	49	30	50	32
Nampak	12 692	39	45	38	42
Average single score		**33**	**35**	**33**	**34**
Local Organisation	**Word count of report**	**Without normalisation**	**Normalised**	**Without normalisation**	**Normalised**
IPSA	3 590	13	41	14	49
PACSA	2 124	13	60	13	68
No. of focus criteria		**Three**	**Three**	**Three**	**Three**
Weighting:	*Recycling*	*0.33*	*0.33*	*0.33*	*0.33*
	Training	*0.33*	*0.33*	*0.22*	*0.22*
	Carbon footprint	*0.33*	*0.33*	*0.45*	*0.45*
Description of weighting		*Equal*	*Equal*	*Unequal*	*Unequal*

The tables of counts for each of the three criteria (and the fourth) are in appendix Table A4.1 to Table A4.3.

4.4.2 Grouping of the companies and organisations using the single scores obtained from the three-criteria MCA

Comparing the reasonable selection of normalised report length and unequal weighting, the companies are sorted into four groups as per the single score obtained on the MCA (as per Table 4.6):

1. Stora Enso (a manufacturer) is noted as having a single score above that of Nampak, i.e. as having an increased focus compared with the Nampak-identified criteria.
2. Spar (a retailer and brand owner) and SIG Combibloc (a manufacturer) have single scores that indicate a similar focus to that of Nampak, with the single scores in the range of 40–49.
3. The brand owner (Danone), the retailers Woolworths and Walmart, and Sappi (a manufacturer) have less focus on the Nampak issues (with single scores in the range of 28–36).
4. Three additional manufacturers (Elopak, Tetra Pak and Mondi) are noted as having the least focus on the Nampak issues, with low single scores of 9–24.
5. Comparing the organisations - PACSA has an increased focus on the Nampak selected criteria and IPSA has the lower focus of the two organisations.

Table 4.6. Grouping of the companies and local organisations in terms of the three-criteria MCA single score

Company	Relationship in supply chain	Single score grouping
Stora Enso	Manufacturer	66–68
Spar	Retailer & brand owner	40–49
Nampak	Manufacturer	
SIG Combibloc	Manufacturer	
Danone	Brand owner	
Woolworths	Retailer & brand owner	28–36
Sappi	Manufacturer	
Walmart	Retailer	
Elopak	Manufacturer	9–24
Tetra Pak	Manufacturer	
Mondi	Manufacturer	
Organisation	**Relationship in supply chain**	**Single score grouping**
PACSA	*Organisation*	60
IPSA	*Organisation*	41

4.4.3 Discussion of the three-criteria MCA

The use of normalised counts with unequal weightings has been selected for the three-criteria MCA. The companies are grouped into manufacturers and 'retailer and brand owners' (Table 4.6) with the organisations treated separately in order to relate to the hypothesis.

The sponsor company (a manufacturer) had the three search terms as the focus in 2010 and this company is expected to be placed higher than its fourth place in the selected MCA analysis. However, the other selected companies also mention the same three terms and this could be due to the influence that the supply chain has on the flow of information between companies.

Comparing the manufacturers to the other two groups, it is noted that these companies are more numerous in the purposefully selected list of companies. The manufacturers are noted as having members in each of the four bands of Table 4.6. However, a larger proportion of the manufacturers are in the group with the lower single scores. The 'retailer and brand owners' are found in the middle two groups.

The two companies with the most focus to the Nampak-identified criteria are Stora Enso (a manufacturer) and Spar (a retailer and brand owner). The lowest band has three manufacturers placed within – two carton producers (Elopak and Tetra Pak) and a local paper manufacturer (Mondi).

PACSA has more focus to the Nampak-identified criteria and is known to be more active in recycling and dealing with environmental issues.

4.4.4 Discussion of the single criterion of recycling

The two companies with the most focus on the single criterion of 'recycling' for the three-criteria MCA with a normalised value are SIG Combibloc with a value of 1.00 and Nampak with the next most focussed value of 0.50.

PACSA (the organisation) has the most focus on the single criterion of 'recycling' for the three-criteria MCA with a normalised value of 1.22, and IPSA a value of 0.67.

The values calculated for the companies are separated into three bands (Table 4.7) with a separate grouping for the organisations and the following are noted:

a. Spar and Woolworths (both 'retailers and brand owners') have similar normalised values
b. Walmart and Danone have lower normalised values
c. The manufacturers are represented in each of the four groups. However, manufacturers have the top two normalised values for 'recycling'.
d. The two organisations both have high normalised values for the criterion of 'recycling'

Table 4.7. The normalised values for the criterion of 'recycling'

Company	Relationship in supply chain	Normalised value
SIG Combibloc	Manufacturer	
Nampak	Manufacturer	0.5–1.00
Tetra Pak	Manufacturer	0.18–0.40
Spar	Retailer and brand owner	
Woolworths	Retailer and brand owner	
Stora Enso	Manufacturer	
Elopak	Manufacturer	
Walmart	Retailer	
Sappi	Manufacturer	0.03–0.10
Danone	Brand owner	
Mondi	Manufacturer	
Organisation	**Relationship in supply chain**	**Normalised value**
PACSA	*Organisation*	1.22
IPSA	*Organisation*	0.67

4.5 The criterion of LCA in a four-term MCA

The advanced environmental assessment tool selected for further study in Section 3.4 of this dissertation is life cycle analysis (LCA). LCA is selected as the fourth criterion in the MCA using the selected sustainability reports of the 11 companies and the data sources of the two organisations.

4.5.1 Results of the four-criteria MCA

The single score for each company is determined, for the four-criteria MCA, using the following two conditions:

- The four criteria, including LCA (all with synonyms as identified in Section 4.3.3), with unequal weighting.
- The same four focus criteria (also with synonyms) with a word count normalisation and then with unequal weighting.

The results of the MCA with the four criteria, including LCA, are presented in Table 4.8.

Table 4.8. The results for the four-criteria MCA (the fourth criterion is the term 'LCA')

Company		Word count of report	Single score Percentage normalised	Percentage normalised
Danone		65 287	27	27
Elopak		7 225	16	21
SIG Combibloc		3 592	55	55
Tetra Pak		12 686	26	19
Stora Enso		12 600	51	57
Mondi		72 719	7	6
Sappi		23 702	25	24
Walmart		18 665	23	20
Spar		4 756	37	26
Woolworths		23 827	23	26
Nampak		12 692	34	32
Average single score			**29**	**28**
Local organisation				
IPSA		3 590	31	44
PACSA		2 124	45	61
No. of focus criteria			**Four**	**Four**
Weighting:	*Recycling*		*0.25*	*0.30*
	Training		*0.25*	*0.10*
	Carbon footprint		*0.25*	*0.40*
	LCA		*0.25*	*0.20*
Description of weighting			*Equal*	*Unequal*

There are two sets of results for the four-criteria MCA analysis and both are described for Nampak and the companies and organisation with the highest and lowest single scores:

The rating attained on normalised values indicates that with both weightings a low focus to the four criteria of 6 to 7 is obtained for Mondi and the highest focus is for SIG Combibloc (with a value of 55 for both weightings). When using both weightings the organisation with the most focus to the four criteria is PACSA.

When the equal weighting is used, Nampak has a single value above the average of 34 (i.e. fifth highest in the group of 11) and with the unequal weighting used, Nampak has a slightly lower single score of 32 and remains at the same level.

The single score obtained with the unequal weighting (and normalised for word count) in the four-criteria MCA is seen as the reasonable option. The unequal weighting places an emphasis on the environmental tool of ‘carbon footprint’ and ensures that the tool of LCA is given half as much emphasis with the general term ‘training’ given less focus, as in the three-criteria MCA.

4.5.2 Grouping the companies using the single scores obtained from the four-criteria MCA

Comparing the reasonable selection of normalised report length and unequal weighting, the companies are sorted into three bands and a separate band for the organisations for the single scores obtained on the four-criteria MCA (as per Table 4.9):

1. The two manufacturers (Stora Enso and SIG Combibloc) have high single scores in the range of 55–57, indicating an increased focus to the four criteria.
2. Nampak, the brand owner (Danone), the retailers Woolworths and Spar, and Sappi (a manufacturer) have less focus to the four criteria, with single scores of 24–32.
3. Three manufacturers (Elopak, Tetra Pak and Mondi) and Walmart (a retailer) are noted as having the least focus to the four criteria, with low single scores of 6–21.
4. PACSA had the most focus on the four criteria compared to IPSA.

The manufacturers are noted as having members in all three ranges when the single score value of the four-criteria MCA are artificially placed in three company sorted bands (Table 4.9); with three of the manufacturers in the band with the lower single scores. The ‘retailer and brand owners’ are found in the middle range of values.

Table 4.9. Grouping of the companies in terms of the four-criteria MCA single scores

Company	Relationship in supply chain	Single score grouping
Stora Enso	Manufacturer	55–57
SIG Combibloc	Manufacturer	
Nampak	Sponsor	24–32
Danone	Brand owner	
Spar	Retailer and brand owner	
Woolworths	Retailer and brand owner	
Sappi	Manufacturer	
Elopak	Manufacturer	6–21
Walmart	Retailer	
Tetra Pak	Manufacturer	
Mondi	Manufacturer	
Organisation	**Relationship in supply chain**	**Single score grouping**
PACSA	*Organisation*	61
IPSA	*Organisation*	44

4.5.3 Discussion of the four-criteria MCA

The four companies that included the term 'LCA' in their selected sustainability reports had short or medium-length sustainability reports. Of more consequence is the fact that all four companies are LPB converters and suppliers, i.e. are manufacturers in the supply chain. The retailers, brand owners and paper producers (also a manufacturer) did not mention LCA in the selected sustainability reports.

The four companies with a positive LCA term in the four-criteria MCA are rated in the following order (with the single score in brackets):

Stora Enso (57) > SIG Combibloc (55) >> Elopak (21) > Tetra Pak (19)

Elopak had been acknowledged in 2010 as one of the sponsors for the wine beverage carton LCA undertaken by BIOIS (2010). Despite this, the normalised percentage value in the 2010 sustainability report for the term 'LCA' is 8 (i.e. in the lowest group), which could indicate the separation of the technical report writers from the sustainability report writers.

A single beverage carton producer (Tetra Pak) has previously published LCAs on the various packs – from 1995 until recently. Stora Enso was involved in a study on beverage cartons in 2009 (Von Falkenstein *et al.,* 2009). SIG Combibloc has recently (IFEU, 2010) published LCAs that are readily available on the internet.

While some of these studies may be confidential but mentioned in other sources, there appears to be a lack of reference to the recent LCA studies in the analysed sustainability reports. It could be that the companies separate the technical publications from the sustainability reports or that the sustainability reports of 2010 reflect a lag in the technical reports from that year. Five published articles are noted as being produced in 2009 and 2010 – two of the five are sponsored exclusively by Tetra Pak and one by SIG Combibloc. Tetra Pak sponsored another two articles in conjunction with two other companies, namely Elopak and Stora Enso. The order of the four companies (for published articles in 2009 and 2010 as per Table 4.1) can be given briefly as:

Tetra Pak (2 articles and 2 co-sponsored) > SIG Combibloc (1 article) > Stora Enso = Elopak (co-sponsored one each).

Using the LCA articles of 2009 and 2010 as a source compared with the term 'LCA' in the sustainability reports, Tetra Pak is noted as having the two (i.e. the most) articles and sponsorship of articles published. SIG Combibloc has one published article. Stora Enso and Elopak have an equal number co-sponsored with one each. This indicates that there is either a lag in reporting the LCAs in the sustainability report or there is minimal connection between the two reports. The other item not explored is the number of articles that could have been written and were not traced due to language or confidentiality issues. The published studies are summarised in Table 4.10.

As previously mentioned, the integration of sustainability and financial reports is required by King III and the GRI – this integration could enhance certain selected companies' LCA scores in future MCA analyses.

Table 4.10. LCA studies published in 2009 and 2010 to coincide with the sustainability reports of the selected companies

Source	**Year**	**Country/ Countries**	**Company**	**Compared packs:** product and features
WRAP	2010	UK	Tetra Pak	Cartons with **screw cap**; and **gable-top cartons**
IFEU	2010	Germany	SIG Combibloc	**Beverage cartons**: milk
Bio Intelligence Service	2010	Nordic	Elopak, Tetra Pak, (Smurfit Kappa)	**Beverage cartons:** wine
Jesle, Eriksson and Einarson	2009	Nordic	Tetra Pak	**Beverage cartons**
Von Falkenstein *et al.*	2009	Focus on Europe – includes others	Tetra Pak, Stora Enso	**Beverage cartons:** milk, juice and wine

4.6 Concluding comments

The chapter presented the assessment of sustainability reporting in the selected LPB supply chain. It is noted that the earliest sustainability report was by the **Danone Group** in 1998. The companies were divided according to the first year of sustainability reporting into a group of pre-King II reporters and a group of post-King II reporters. The two companies that reported pre-King II were both international companies – Danone Group and Tetra Pak – with the brand owner first reporting in 1998 and the manufacturer in 2000. The remaining companies reported post-King II, with five companies first reporting within two years of King II. Walmart responded the latest in the selected group of companies by producing its first sustainability report in 2006.

Elopak has the highest % sustainability content in the analysed in the selected recent (2010) sustainability reports.

The analysis of the sustainability reporting of Nampak is dealt with in a separate section (4.3) which sought to gain insight into whether Nampak has increased its sustainability awareness since first reporting. All sustainability chapters up to 2010 were analysed for general trends such as page content devoted to sustainability. The first Nampak sustainability chapter of 2003 indicates that in this group of companies, the sponsor could be seen as an **average** responder to sustainability reporting.

The Nampak chapters were rated using three systems:- the Lowell Centre Index, the Skills development index and the GRI single score. This revealed four increases in sustainability reporting – the start in 2003, then increases in 2004, 2008 and 2009; each of the increases, from 2004 to 2009, is confirmed by at least two of the three rating systems. The GRI single score content of the three Nampak chapters and the 2010 chapter had as the highest score 55 (out of 100); Nampak is therefore reporting slightly **above the mid-point level on sustainability** issues when assessed on this method.

The sustainability report page count as a percentage of the number of pages in the annual reports was calculated for the selected companies for 2010 and **Elopak** was found to have the highest percentage of 45.2%. Stora Enso had a value 27.7% and Walmart 30.5% for the sustainability page count in 2010. The five companies that had the lowest measurable sustainability page count in the 2010 reports were all local companies. The average page count for these five local companies was 17.7%. Nampak (at 13.9%) is therefore reporting **slightly below** the local average sustainability page count. The average page count in 2010 for the non-local companies was 34.5%. Although the number of pages devoted to sustainability reporting by the local companies is lower, this does not necessarily indicate the actual value of the content or text and so an analysis using MCA principles is undertaken.

The three top **focus points** of the Nampak 2010 sustainability report were used as criteria in an MCA. The data sources are the 11 company sustainability reports and a chapter and presentation (the latter two analysed separately). The MCAs were undertaken using the data as is and using normalised data (for report length). The normalised data takes into account the length of the report analysed. The length of the different company sustainability reports varied from 1 755 words to 72 719 words, with the long report being over 40 times longer than the shortest report. Two weightings were used in the analysis – an even weighting for each of the three terms and an unequal weighting. The normalised word count and unequal weighting were used to provide a valid MCA.

The normalised single score with unequal weighting for the three-criteria MCA is deemed the most appropriate and indicates **Stora Enso** has the most similar focus in the sustainability report compared to the Nampak-identified criteria.

A focus point of interest to this dissertation, namely LCA, was then used as the fourth criterion in a MCA using the same data sources. The normalised single score with unequal weighting for the four-criteria MCA identifies **Stora Enso** as the organisation with the most similar focus using the three Nampak-identified terms and the term ‘LCA’.

A comparison of the term LCA in the sustainability reports to the published LCAs was undertaken – it was noted that there could be a lag between publishing and mention in the sustainability report. The overall conclusions on the companies' sustainability awareness are presented in Chapter 6.

CHAPTER 5 COMPARATIVE LCA OF 2011 AND FUTURISTIC PACK SYSTEMS

This chapter compares the LPB system with future recycling scenarios of improved recycling and light-weighting, presenting the inventory analysis and the life cycle impact assessment and interpreting results.

The inventory analysis is described in Section 5.1. The four selected impact analyses are described in Section 5.2 and the LCA interpretation is given in Section 5.3.

Two items are dealt with in the interpretation of the LCA (the fourth and final step), namely the identification of significant issues and the evaluation. Concluding comments are given in Section 5.4 and the overall conclusions are in Chapter 6. The steps discussed in this chapter can be viewed in Figure 2.4.

5.1 The inventory analysis

The inventory analysis describes the foreground and selected background processes. The processes used in the software are presented and changes are also documented in this section. The quality of the data in each process is described. The datasets used in the study are tabulated together in Table A5.1 (Appendix) for ease of reference; when the dataset is referred to in the text a general description will be given.

5.1.1 The milk packaging system studied

The gable-top liquid paperboard carton and white closure are pictured in Figures 3.2 and 3.3 in Chapter 3. The datasets for the study are in Table A5.1 (in the Appendix).

A field visit to the Isithebe site is the source of the primary packaging materials, pallet configuration and secondary and tertiary packaging materials. This visit was undertaken over two days and with access granted to spreadsheets and information. The material composition of the milk system is divided into the primary packaging materials (Table 5.1) and the pallet configuration which involves the secondary and tertiary packaging materials (Table 5.2).

Table 5.1. The primary packaging materials used in the model for the base case and for the functional unit (FU) of 1 000 litres distributed to the retailer

At	To	No. of units	*LPB*	*HDPE*	*LDPE*
			Mass in kg for the FU		
Manufacturer	Manufacturing site	563	28.888	0.721	0.979
	Shipping loss at manufacturer	19	*0.975*	*0.024*	*0.033*
Manufacturing site	Dairy	544	27.913	0.696	0.946
	Dairy manufacturing loss at the Manufacturing site	*19*	*0.975*	*0.024*	*0.033*
Dairy	Retailer	525	26.938	0.672	0.913
	Dairy loss in the dairy	*25*	*1.283*	*0.032*	*0.043*
Retailer		500	25.655	0.640	0.870
End of life	About 0.9% recycling of paper	4	0.205	0	0
	About 99.1% landfill	496	25.450	0.640	0.870

Note: The data was sourced during a site visit.

Table 5.2. Pallet configuration for the closures and milk cartons

	Shipper and pallet configuration	
Item	**Closures**	**Unfilled milk cartons**
Item per corrugated shipper	3 000	
Item per kraft wrap		200
No. per layer	6	4
Layers per Euro pallet	3	4
Items per pallet	54 000	3 200
No. of FUs per pallet	108	6.4
	Mass of individual items of secondary and tertiary packaging (g)	
Corrugated shipper	416.4	
Kraft wrap		79.3
Euro pallet	20 000	20 000
	Mass of secondary and tertiary packaging per pallet (g)	
Corrugated shipper	7 495.2	
Kraft wrap		1268.8
Euro pallet	20 000	20 000
Shrink film – LDPE	645	670
	Mass of secondary and tertiary packaging per FU (g)	
Corrugated shipper	69.4	
Kraft wrap		198.25
Euro pallet	185.2	3 125
Shrink film - LDPE	6.0	104.7
No. of reuses of Euro pallet	20	20

Note: The data was sourced during a site visit.

The Huang and Ma (2004) and Pasqualino *et al* (2011) studies give a breakdown of a single unit of the packaging material to be used as the functional unit or for analysis in the interpretation section and this is done for this study in Table 5.3. The selected 2 L pack has a mass of 29.704 g of packaging per litre. Huang and Ma (2004) had a value of 40.09 g/L for a LPB of an unstated volume and Pasqualino *et al* (2011) a value of 35.2 g/L for a 1.5 L carton.

Table 5.3. Mass of packaging for the milk pack

Pack	Size in litres	Mass	Mass (g/L)
Elopak carton (with closure)	2	59.407 g	29.704
Item	**No. of items**	**Mass**	**Mass (g/L)**
Cartons in FU (at the retailer)	1 000	27.165 kg	27.165
Cartons and closures at manufacturer	1 126	30.588 kg	27.165

5.1.2 Production of the flat folded beverage cartons

The production of liquid paperboard (LPB) is taken to be representative of average European mill data. The production of paper, bleaching, extrusion coating and internal wastewater treatment is included in the process. The energy requirements are included in the process data. The LPB datasets are used as background. LPB is available as three options in the databases (an option in the Buwal 250 library (from one Swedish factory dated 1994) and an ecoinvent process of production of liquid paperboard containers that mentions the use of inks, glue and aluminium foil).

The ecoinvent process is used in all calculations – the selected option does not state the grammage of board produced, however, the board composition is 60% hardwood fibres, 33% softwood fibres and 7% unknown (Hischier, 2007). The actual board composition (Figure 3.4) reflects that bleached sulphate pulp is the predominant type. In Sweden in 2001 (Hischier, 2007), the bleached sulphate pulp production figure reflects that 19% is hardwood and 81% is softwood; the model using this dataset could require adaptation, which was not undertaken, or is a limitation.

The actual grammage of the paperboard is 370 g/m^2. It is manufactured in Sweden from bleached sulphate pulp and chemi-thermomechanical pulp (CTMP) (Stora Enso, 2010a). The fibres are 100% virgin (i.e. have no recycled content). The coatings on the paperboard are virgin low-density polyethylene (LDPE) suitable for direct contact with food.

The LPB is transported to South Africa for printing, creasing, cutting and sealing at the Elopak SA site in Isithebe (KwaZulu-Natal). LPG and a South African electricity mix are the energy inputs used to convert the cartons into flat folded beverage cartons.

Mass allocation at the printer is used to differentiate the selected pack from the others produced at the site. A value of 2.1% of the total energy amount of the Isithebe site is assigned to this pack – this equates to the sum of 10% (mass/mass) of total product from this paper machine and 21% (mass/mass) of the production of the specific printing machine used (one of two machines). The low percentage value is included for building of a complete model.

Harding and Melamu (2009) and Eskom (2010) data are used to produce an RSA electricity mix (Appendix Table A5.2). The energy is coal intensive at the time of this dissertation.

Biogenic carbon

One approach for dealing with biogenic carbon in LCA is to exclude the absorption and release of this cycled CO_2 from the climate change impact calculations (WRAP, 2010). This study has taken the approach of the WRAP (2010) study in that the biogenic carbon is ignored as there is “no long term storage of carbon” in the LCA study.

5.1.3 Manufacture of the closures

Two grades of plastic are used in the manufacture of the closures (note the older data of ETH has been used, this was due to the dataset been dated in the software as 1996 and the as the others were undated it was erroneously thought that this would be the better dataset):

- High-density polyethylene (HDPE) – to make the lid and security ring,
- Low-density polyethylene (LDPE) – to make the neck and pull tab

The white masterbatch is not accounted for, despite the fact that both polymers require it.

As with most large manufacturers, polymer is purchased from various suppliers both locally and overseas. In order not to breach confidentiality, the model used the 1992 German dataset, namely the ETH datasets for respective polymer types and all quantities. While 1992 data has been used for the plastic components, it is likely that the impact categories could underestimate the local affects as for example the electricity used in some of the local plastic suppliers sites would be carbon intensive. The transport of the polymer is allocated as half from a local South African supplier and the remaining half from the European supplier.

The production of polymers uses the polymers, energy sources from electricity and LPG, transport of the materials to the plant and secondary packaging materials such as corrugated board and pallets to complete the background data of this study. The polymers are converted to closures at the Nampak Closure site in Durban. Mass-based allocation is used to assign energy, i.e. electricity and LPG, to the manufacture of the closures. Plant data was unable to be sourced and compared against the datasets.

5.1.4 Secondary and tertiary packaging materials

As listed in Table 5.2, the following secondary and tertiary packaging materials are used:

- Corrugated board
- Kraft paper
- Stretch film (made from LDPE)
- Wooden pallets

The datasets used for these packaging materials are described in Table A5.1 (in the Appendix).

5.1.4.1 Corrugated board

The corrugated board is used to pack the produced closures and is modelled using data from six corrugated board producers.

5.1.4.2 Kraft paper (unbleached paper)

The kraft paper is used to wrap the flat folded beverage cartons. As data on the unbleached kraft paper produced at Sappi Mandeni is unavailable, the dataset used data from one European and one Finnish database (hence average European data).

5.1.4.3 Stretch film (LDPE)

Stretch film made from LDPE is used to wrap a pallet of goods. The raw materials are used without any conversion to the film. An ETH dataset is used and it is a German dataset from 1992.

5.1.4.4 Wooden pallets

Wooden pallets are used for storing and transporting of goods. The wooden pallets have a long life-span and in the absence of local data, the German source is used for the transport of the products.

5.1.5 Transport

Transport distances

The geographic location of the study starts with the sourcing of the liquid paperboard in Sweden, the inks from Belgium and the plastics from Europe and South Africa; transport of the secondary and tertiary packaging materials to and within South Africa as per the simulated actual situation for local packaging materials is accounted for.

The transport of items has been taken as a single one-way trip. It is assumed that the full truck is used on this one-way trip, i.e. a 100% volume or payload is used. The road and ocean transport distances are given in the flow chart in the scope (Section 3.3.3) and are shown in Table 5.4.

An estimated value of 20 km by truck to sanitary landfill is conservative for South African conditions. It is likely that with the present landfills filling, that the new landfills are situated further from the cities, however, a value was estimated and a total weighted distance (such as used for the forthcoming retail distance in Table 5.5) could have been more accurate.

The nautical miles are obtained using the values given on the Searate website (2011). For example, the sea distance from Sweden to South Africa is 7 644 nautical miles, which equates to 14 156 km (Searate, 2011) using a conversion of 1 nautical mile = 1.852 km. These distances are based on an expected port of departure with a known port of entry. However, weather could affect use of the anticipated ports and the distances could be affected by distances of up to 200 km.

Table 5.4. Transport distances used in the model

From site	To site	Transport type	% of material sourced	Distance in km
LPB manufacturer	LPB printer	Sea	100	14 156
LPB manufacturer	LPB printer	Land	100	120
LDPE & HDPE manufacturer	Closure converter	Sea	50	7 800
LDPE & HDPE manufacturer	Closure converter	Land	50	521
Ink manufacturer	LPB printer	Sea	100	12 806
Ink manufacturer	LPB printer	Land	100	120
Closure converter	Dairy	Land	100	993
Printed carton blanks	Dairy	Land	100	1 003
Filled milk cartons & secondary & tertiary packaging material)	Consumers	Land	100	1 050
Consumer	Sanitary landfill	Land	100	20
Consumer	Disassembly	Land	Up to 70	50
Consumer	UBC reuse	Land	< 1	2

The transport of goods by sea usually excludes transport on land from the manufacturing site to the outward port. The distances between the land sites were obtained using Google Maps and are deemed to be accurate to within 10 km. A map of the country is reproduced in Figure 5.1 in order to provide a visual guide to the country.

Figure 5.1. Map of South Africa showing the larger cities (www.places.co.za) and ports

Filled milk cartons are transported to various cities in South Africa. As an example, the distance from the Woodlands Dairy, situated in Humansdorp in the Eastern Cape, to Johannesburg in Gauteng province is 1 145 km and it is estimated that 65% of the population of South Africa live in Gauteng. Five distribution centres in South Africa are listed along with the estimated population in each area; the percentage population is equated to the percentage use of the filled milk cartons. A weighted retail distance of 1 050 km is calculated from the five distribution centres to the estimated population serviced (Table 5.5).

Table 5.5. Average retail transport distance for the distribution of the filled milk cartons

Humansdorp	Value	Distance	Weighting % of estimated population serviced	Weighted distance
To Cape Town	667	km	5	33
To Durban	993	km	25	248
To Johannesburg	1145	km	65	744
To Bloemfontein	748	km	3	22
To Port Elizabeth	85.3	km	2	2
			Total retail weighted distance	**1 050**

Transport by truck (lorry)

The information that was required in Table 5.6 such as 'yearly performance in km' and 'length of roads' is difficult to source and varied between the different carriers. Therefore the two truck sizes selected for use in the model, used general datasets as the "transport required an easy application" (Frischnecht *et al*, 2005).

Table 5.6. Data required on the trucks for the preparation of a road dataset

	Truck Size		Source of data
	3.5-7.5 t	**16-32 t**	
Lifespan tyre set (km)	45000	75000	Spielmann *et al* 2007
Tyre weight (kg)	8	47.5	Spielmann *et al* 2007
Emission standard	EURO3	EURO3	Spielmann *et al* 2007
Power (kW)	Not known	Not known	Spielmann *et al* 2007
No. of tyres per vehicle	4	6	Spielmann *et al* 2007
Fuel consumption factor	Not known	Not known	Spielmann *et al* 2007
Ratio vkm/tkm	Not known	Not known	Spielmann and Scholz, 2004
Average load in t	Not known	Not known	Spielmann and Scholz, 2004
Yearly km performance	Not known	Not known	Spielmann and Scholz, 2004
Vehicle Lifetime transport performance (km)	Not known	Not known	Spielmann and Scholz, 2004
Length of roads (km)	Not known	Not known	Spielmann and Scholz, 2004
Net vehicle weight (kg)	Not known	Not known	Spielmann and Scholz, 2004

The two truck sizes used in the model are described as:

- The adapted ecoinvent dataset "Transport, lorry 16-32t, EURO3/RER U" is used for all processes except end-of-life, adapted for local fuel conditions as mentioned in the paragraph below; Euro 3 indicates vehicles manufactured after 2000 and having defined emissions.
- The adapted ecoinvent dataset "Transport, lorry 3.5-7.5t, EURO3/RER U" is used for end-of-life operations (smaller truck size).

The Euro 3 standard is selected as the "most conservative, i.e. highest GHG emitting, level available in *ecoinvent*" (Vossberg, 2012). The truck has **average loading** (or 50 %) documented for the ecoinvent dataset (Frischknecht *et al*, 2005**)**.

The major difference to the dataset is that the local (South African) transport in the model uses a South African diesel mix (Appendix 5.2b). The South African diesel mix is described by Stephenson *et al.* (2010) and "consists of 65 vol% refined crude oil and 35 vol% synthetic fuel, with 15 vol% being produced by Sasol's coal to liquid … plant in Secunda and 20 vol% from the gas to liquid … plant operated by PetroSA company in Mossel Bay".

Table 5.7. Climate change calculations for the South African diesel fuel for both truck sizes

Europe:	**Original Fuel composition %**	**kg CO_2 eq/kg fuel**	**Mass of fuel in kg/km**		**Carbon dioxide (fossil) in kg for the emission to air for the operation of the EURO 3 truck for 1 km**	
			For 3.5-7.5t	**For 16-32 t**	**For 3.5-7.5t**	**For 16-32 t**
Diesel, low-sulphur, at regional storage/RER U (original)	100	3.163	0.14338	0.21035	0.4535	0.6653
South Africa (ZA):	**South African Fuel composition %**	**kg CO_2 eq/kg fuel**	**Mass of fuel in kg/km**		**Calculation of the South African adapted Carbon dioxide (fossil) in kg for the emission to air for the operation of the EURO 3 truck for 1 km**	
			For 3.5-7.5t	**For 16-32 t**	**For 3.5-7.5t**	**For 16-32 t**
Diesel, low-sulphur, at regional storage/RER U	65	3.163	0.0932	0.13673	0.296	0.432
Sasol	20	*6.4*	0.02868	0.04207	0.185	0.269
PetroSA	15	*5*	0.00215	0.03155	0.108	0.158
TOTAL	**100**	**4.1**	**0.14303**	**0.21035**	**0.589**	**0.859**

Note: The mass of fuel used is as per TREMOVE (2007). The additional CO_2 value assumed at a value of 6.4 t CO_2 eq/t fuel. (Sasol 2010) and 5 t CO_2 eq/t fuel for PetroSA (estimated value) (2011).

The South African diesel mix changes the emitted value of carbon dioxide to the modified value of 0.859 kg CO_2 eq/km from 0.6653 kg CO_2 eq/km for the air emissions for the process "Operation, lorry 16–32t, EURO3/RER U" and to 0.589 kg CO_2 eq/km from 0.4535 kg CO_2 eq/km for the process "Operation, lorry 3.5–7.5t, EURO3/RER U" (Table 5.7). The South African diesel mix has a calculated value of 4.086 kg CO_2 eq/kg fuel.

Transport by ocean

Oceanic transport is used to transport materials to South Africa – the dataset sets the exit port as the Netherlands (Europe). The "Transport, transoceanic freight ship/OCE" is used as dataset and describes the "operation of vessel; production of vessel; construction and land use of port; operation, maintenance and disposal of port" (SimaPro, 2011). The fuel used is heavy fuel engine technology (HFE), steam turbine and diesel engines (SimaPro, 2011).

5.1.6 End of life of the components

The routine option for the UBC is landfilling in South Africa. Incineration is not an option available for post-consumer waste at present. Recycling of the UBCs is an option that is being explored as the virgin fibres of the carton can be used as a high quality furnish in the production of tissue products and liners for corrugated boxes. The plastic components of the UBCs are at present unlikely to be recycled above levels of 5%.

Landfilling of damaged wooden pallets is minimal (estimated at 5%) as the pallets are repaired or the wood can be used for heating and furniture manufacture. Damaged plastic pallets can be shredded, and the plastic reused to make new pallets. They can also be used for building and the landfill rate is estimated at 2%. Corrugated boxes and kraft wrap have a high recycle rate as cash is paid to the collector and the rate to landfill is estimated at 2%.

Other secondary packaging materials such as the shrink wrap are landfilled at an estimated 80% rate. However, there are individual processors that downcycle the polymer into plastic planks and bin liners.

The waste management processes assessed are the current practice of landfilling (without methane collection) and recycling of the paper fibres from the liquid paperboard carton (Table 5.8). A municipal landfill dataset for Switzerland is selected for the used beverage cartons (UBCs); however, this system includes landfill gas (i.e. methane) collection which is not routinely undertaken in South Africa, although a number of landfill sites in Durban and Gauteng have installed such systems. A South African-specific landfill option is unavailable in life cycle databases and development thereof extends beyond the scope of this project.

The selection of the Swiss landfill dataset – with methane capture - will ensure that this study will have a lower GHG emissions and this will be included in the discussion.

The recovery of paper fibres is obtained after removal of the extruded LDPE layers from the paperboard. As the printing is undertaken on the outer LDPE layer, the paper fibres do not require de-inking. The LDPE and HDPE plastics are modelled as landfill and incineration was not explored. The packaging disposal conditions used in the model are summarised in Table 5.8.

Table 5.8. End-of-life of the LPB components used in the model

Material	Landfilling	Recycling
Used beverage cartons (UBCs)	Modelled as the combined disposal to landfill (Swiss)	Only the virgin paper layers were considered in the scenarios; Production of recycled paper (without de-inking) was the avoided load.
Closure	Modelled as the combined disposal to landfill (Swiss)	Not undertaken in this dissertation.
LDPE printed film	Modelled as the combined disposal to landfill (Swiss)	Not undertaken in this dissertation.

Note: Table adapted from Pasqualino *et al.,* 2011.

5.1.7 Excluded data

As mentioned in Section 3.3.3.9, the following are excluded – ink manufacture for all printing on LPB and corrugated cartons, filling and packaging at the dairy, the fill good (i.e. the chilled milk), point-of-sale cooling, the consumer and all associated activities.

The lack of proprietary data on the LPB ink manufacture meant that the printing process is excluded. The transport of the inks from Belgium to South Africa is, however, included.

The production of energy from waste, when the waste is closures, and other secondary and tertiary packaging is at present a less-than-usual option in South Africa and these processes are excluded.

The use of plastic pallets during the process of converting LPB to flat folded cartons is not included in any of the calculations due to the limited availability and trustworthiness of the data.

5.1.8 Data quality assessment

Specific data

The specific data on the production of the flat folded beverage cartons and closures is confidential to Nampak. Similar process datasets have been used, although the datasets are European. Staff members at Nampak are not trained in LCA and requests for information are not always answered in full or in a formal written manner. Nampak-provided data are therefore questionable and have not been used; instead generic data have been used.

The collection of primary data at the closure site has the fore mentioned problems and generic data has also been used. This has allowed the distribution of the study to a wider audience but the quality of the data is not company specific.

The materials loss is taken at 5% for all processes except the LPB conversion (3.5% is used). These figures are approximate values.

Generic data

The assessment of data for "completeness and precision" (WRAP, 2010) in datasets is beyond the means of this project. However, the majority (>90%) of the data used are from ecoinvent processes which are "peer-reviewed databases and so are considered to be of acceptable completeness and precision" (WRAP, 2010).

The age of the datasets (Table A5.1 in the Appendix) is either 1992 to the 2010 adapted dataset for electricity or is unknown. Had a choice been available or the date more clearly indicated then more recent datasets would have been selected. This is considered by WRAP (2010) to be "a common problem when conducting LCAs" but as WRAP states, the generation of own datasets is "time-consuming and resource intense".

5.2 Life cycle impact assessment

The life cycle impact assessment (LCIA) is the third stage in an LCA. The impact analyses selected (as discussed in Section 3.3.4) are recapitulated. The results for each impact analysis are then given (Sections 5.2.1 to 5.2.4). Thereafter the base case scenario is compared with the proposed recycling scenario (Section 5.2.5) and with a light-weighted pack (Section 5.2.6).

CML2, the LCIA that was selected, has ten impact categories. As discussed in Chapter 2, four impact categories out of the ten were selected for use in this study. These categories are global warming, eutrophication, acidification and abiotic depletion. It is noted that all four have different units (Table 5.9) which neatly separates each impact category and prevents them from being combined into a single score.

Table 5.9. Impact categories selected with the region influence, time frame and the units given

Impact category available in CML 2 baseline 2000 v2.05	Units	Phenomenon	Time frame
Global warming (GWP100)	kg CO_2 eq	Global	100 years
Eutrophication	kg PO_4^{3-} eq	Regional	10 years
Acidification	kg SO_2 eq	Regional	10 years
Abiotic depletion	kg Antimony (Sb) eq	Global	

The geographical system boundary is linked to the impact categories selected. The global warming potential and abiotic depletion are global phenomena; the two other impact categories, i.e. eutrophication and acidification, are regional phenomena.

5.2.1 Climate change

The published global warming potential or GWP (i.e. carbon footprint (CF)) for packing 1 000 litres of a beverage in a similar carton is between 58 and 74 kg CO_2 eq (Pasqualino *et al.,* 2011; WRAP, 2010; Mourad *et al,.* 2008; IFEU, 2010). This value rises to 110 kg CO_2 eq for plastic bottles in South Africa (Notten and Mason-Jones, 2011) and to 139 kg CO_2 eq for foil-lined cartons (BIOIS, 2010). A low value of 31 to 37 kg CO_2 eq was obtained by two carton producers (Elopak, 2009 and Tetra Pak, 2010b) for the same functional unit (FU) of 1 000 litres.

The carbon footprint can be used as a data check to assess whether the output of the LCA is of the correct order of magnitude. The value of 92.7 kg CO_2 eq for the FU is higher than the literature published values of 58 to 74 kg CO_2 eq of the studies by Pasqualino *et al.* (2011), WRAP (2010), Mourad *et al.* (2008) and IFEU (2010). This could be due to the different geography – the WRAP study was undertaken in the UK and Mourad *et al.*'s study in Brazil.

The adapted Von Falkenstein comparison indicates that the carbon footprint for foil-lined cartons is higher at 136 kg CO_2 eq for the same FU. The low values of 31 and 37 kg CO_2 eq for the two producers of cartons includes are both used in the non-peer-reviewed studies (Elopak, 2009 and Tetra Pak, 2010b).

The highest single contributing factor to the CF is a value of 23.9 kg CO_2 eq for the disposal of paper fibres into a landfill site – this value could increase with the use of a South African landfill model (the Swiss dataset with methane capture was used in the model). The next significant value is 17.7 kg CO_2 eq (Table 5.10) due to the production of LPB in Sweden. The use of 16–32 t trucks gives a combined value of 9.8 kg CO_2 eq. The generation of electricity from coal gives a high value of 8.6 kg CO_2 eq. A value of 8.0 kg CO_2 eq is contributed by the recycling of corrugated board.

A value of 4.5 kg CO_2 eq is contributed to the GWP by the transport of the LPB and polymers from Europe to South Africa. Values of 5.3 kg CO_2 eq for LDPE polymer (including the value used for shrink film) and 1.8 kg CO_2 eq for HDPE are contributed by the closure raw materials. The remaining processes contribute 13.1 kg CO_2 eq. The process contributions to CF are summarised in Table 5.10.

Table 5.10. Process contribution to GWP for scenarios in kg CO_2 eq

Process	**Base case in kg CO_2 eq**	**% Contribution**
Total of all processes	92.7	
Remaining processes	13.1	14
Disposal Paper, 11.2% water to sanitary landfill/CH S	23.9	26
Liquid packaging board (LPB), at plant/RER S	17.7	19
Adapted operation, truck 16–32t, EURO3/RER U	9.8	11
Electricity from coal in ZA	8.6	9
Corrugated board, recycling fibre, single wall, at plant/CH S	8.0	9
LDPE ETH S (polymer for closures)	5.3	6
Transport, transoceanic freight ship/OCE S	4.5	5
HDPE ETH S (polymer for closures)	1.8	2

5.2.2 Eutrophication

The eutrophication impact for packing 1 000 litres of a beverage in a similar carton is noted to have four groups of values. The low values obtained in the literature of 0.016 to 0.024 kg PO_4^{3-} eq in the separate aquatic and terrestrial values in an IFEU (2004) study are for 1 litre and 1.5 litre cartons. Two other studies, WRAP (2010) and IFEU (2006), give similar values of 0.031 to 0.038 kg PO_4^{3-} eq respectively. Values of 0.074 to 0.110 kg PO_4^{3-} eq were obtained in the Nordic (BIOIS, 2010) and French (BIOIS, 2008) studies. This dissertation obtained a higher value of 0.173 kg PO_4^{3-} eq; this value is the highest compared with the literature values.

The highest single contributing factor to the eutrophication impact is a value of 0.082 kg PO_4^{3-} eq (Table 5.11) due to the disposal of paper in a sanitary landfill. A value of 0.025 kg PO_4^{3-} eq is attributable to the production of LPB in Sweden and a value of 0.021 kg PO_4^{3-} eq to the disposal of packaging cardboard in a sanitary landfill. The use of 16–32 t trucks gives a combined value of 0.008 kg PO_4^{3-} eq.

A value of 0.008 kg PO_4^{3-} eq is contributed to the eutrophication impact by the transport of the LPB and polymers from Europe to South Africa. A value of 0.008 kg PO_4^{3-} eq is contributed by the disposal of plastics to sanitary landfill. The recycling of corrugated board gives a value of 0.007 kg PO_4^{3-} eq. The electricity generated from coal gives a high value of 0.004 kg PO_4^{3-} eq. The remaining processes contribute 0.010 kg PO_4^{3-} eq.

Table 5.11. Process contribution to eutrophication for scenarios in kg PO_4^{3-} eq

Process	Base case in kg PO_4^{3-} eq	% Contribution
Total of all processes	0.173	
Remaining processes	0.010	6
Disposal, paper, 11.2% water, to sanitary landfill/CH S	0.082	47
Liquid packaging board, at plant/RER S	0.025	14
Disposal, packaging cardboard, 19.6% water, to sanitary landfill/CH S	0.021	12
Adapted operation, truck 16–32t, EURO3/RER U	0.008	5
Transport, transoceanic freight ship/OCE S	0.008	5
Disposal, plastics, mixture, 15.3% water, to sanitary landfill/CH S	0.008	5
Corrugated board, recycling fibre, single wall, at plant/CH S	0.007	4
Electricity generated from coal in ZA	0.004	2

5.2.3 Acidification

The acidification impact for packing 1 000 litres of beverage in a similar carton is noted to have four groups of values. The lowest value obtained in the literature is 0.200 kg SO_2 eq (WRAP, 2010). Three other IFEU studies (2004, 2006 and 2010) give four values between 0.256 to 0.295 kg SO_2 eq respectively. A value of 0.421 kg SO_2 eq was obtained in this dissertation for the base case which, together with the value of 0.424 kg SO_2 eq for the 1 L Tetra Brik carton of the French study (BIOIS, 2008), falls in the third group of results. The highest values found in the literature study are values of 0.504 and 0.527 kg SO_2 eq in the BIOIS (2010) and Tetra Gemina (BIOIS, 2008) studies respectively.

The adapted Von Falkenstein comparison indicates that one acidification value is slightly lower (IFEU, 2004) and two are slightly higher, namely the Tetra Brik carton in BIOIS (2008) and BIOIS (2010). The majority of the values obtained in the literature are lower in comparison (WRAP, 2010; IFEU, 2006; IFEU, 2010; IFEU, 2004), with just one being higher (BIOIS, 2008).

The highest single contributing factor to the acidification impact is a value of 0.098 kg SO_2 eq (Table 5.12) due to the transport of the LPB and polymers from Europe to South Africa. A high value of 0.096 kg SO_2 eq is due to the production of LPB in Sweden. The electricity generated from coal gives a high value of 0.081 kg SO_2 eq. The use of 16–32 t trucks gives a combined value of 0.033 kg SO_2 eq. Values of 0.047 kg SO_2 eq for LDPE and 0.016 kg SO_2 eq for HDPE are contributed by the closure raw materials and LDPE shrink film. A value of 0.019 kg SO_2 eq is contributed by the recycling of corrugated board. The remaining processes contribute 0.031 kg SO_2 eq.

Table 5.12. Process contribution to acidification for scenarios in kg SO_2 eq

Process	Base case in kg SO_2 eq	% Contribution
Total of all processes	0.421	
Remaining processes	0.031	7
Transport, transoceanic freight ship/OCE S	0.098	23
Liquid packaging board, at plant/RER S	0.096	23
Electricity generated from coal ZA	0.081	19
LDPE ETH S	0.047	11
Adapted operation, truck 16–32t, EURO3/RER U	0.033	8
Corrugated board, recycling fibre, single wall, at plant/CH S	0.019	5
HDPE ETH S	0.016	4

5.2.4 Abiotic depletion

The acidification impact for packing 1 000 litres of a beverage in a similar carton is noted to have three groups of values. The lowest value is obtained in this dissertation, i.e. 0.471 kg Sb eq. Two studies, the WRAP (2010) and the Tetra Brik carton in BIOIS (2008), give values of 0.561 and 0.615 kg Sb eq respectively. The remaining two studies, the Tetra Gemina in BIOIS (2008) and the BIOIS (2010), give values of 0.816 to 0.920 kg Sb eq respectively.

The adapted Von Falkenstein comparison indicates that one abiotic depletion value is slightly higher (WRAP, 2010) at 22%, another still higher (the Tetra Brik study (BIOIS, 2008)) at 34% and two much higher, namely the Tetra Gemina study (BIOIS, 2008) at 0.816 kg Sb eq and the BIOIS (2010) study, which is 100% higher.

The highest single contributing factor to the abiotic depletion impact is a value of 0.123 kg Sb eq (Table 5.13) due to the production of LPB in Sweden. A value of 0.058 kg Sb eq is contributed by the recycling of corrugated board. Values of 0.072 kg Sb eq for LDPE and 0.027 kg Sb eq for HDPE are contributed by the closure raw materials and shrink film. The generation of electricity from coal (open-cast mine) has a value of 0.037 kg Sb eq.

The value of 0.030 kg Sb eq is due to the transport of the LPB and polymers from Europe to South Africa. A value of 0.027 kg Sb eq is also attributed to polymers for the stretch film. LPG and coal each contribute 0.021 kg Sb eq and crude oil has three fields totalling 0.042 kg Sb eq. The remaining processes contribute 0.040 kg Sb eq.

Table 5.13. Process contribution to abiotic depletion for scenarios in kg Sb eq

Process	Base case in kg Sb eq	% Contribution
Total of all processes	0.471	
Remaining processes	0.040	8
Liquid packaging board, at plant/RER S	0.123	26
LDPE ETH S	0.072	15
Corrugated board, recycling fibre, single wall, at plant/CH S	0.058	12
Coal from underground mine ZA U	0.037	8
Transport, transoceanic freight ship/OCE S	0.030	6
HDPE ETH S	0.027	6
LPG I	0.021	4
Coal from open-cast mine U	0.021	4
Crude oil, at production onshore/RAF U	0.018	4
Crude oil, at production onshore/RME U	0.013	3
Crude oil, at production/NG U	0.011	2

5.2.5 Present process and recycling of paper fibres

The present process (base case or scenario 1) is assigned a recycling rate of 0.9% for the paper fibres in the UBC. The recycling ratio is given a rate of 20% in scenario 2, with a linear increase of 10% for each scenario through to 70% for scenario 7. The changes in each impact indicator are discussed by comparing the base case and the highest anticipated rate (70%) and are summarised in Table 5.14.

The Mourad *et al* (2008) study describes the use of the beverage content with the post consumption packages (or UBCs) being sent to one of two options – either landfill with the second option as paper recycling with subsequent aluminium and plastic recycling. The recycled paper fibres are depicted as being used in the beverage carton, however, in this study the beverage carton is made from virgin fibres and the fibres are more likely to be used in the production of secondary packaging materials such as the kraft wrapper or corrugated shipper. As Mourad *et al* (2008) have recycled the paper fibres into the beverage production, and have used the **recycling content** approach.

The WRAP (2010) study describes the recycling as using the "**avoided burdens** approach, the environmental impacts of producing the avoided material are credited to the product sent to recycling".

Global warming potential

A value of 92.7 kg CO_2 eq is obtained for the cartons in this study, with the present low level of 0.9% recycling using the model described. The recycling of paper fibres from 0.9 to 70% gives a GWP reduction of 16.0 kg CO_2 eq; this equates to a 17.3% reduction (Figure 5.3). This reduction indicates a slightly higher difference between the base case and the recycling rate of 70%. Mourad *et al.* (2008) found a higher reduction of 48% when increasing the recycling rate from 2% to 70% in Brazil.

The results for the increase in recycling (Figure 5.2) are further analysed and it is noted that the percentage GWP reductions found when the WRAP study (2010) and this study are compared are more comparable than those found when the Brazilian (Mourad *et al.,* 2008) study and this study are compared.

The use of a Swiss landfill will cause a lower GHG value for high landfilling rates of the cartons i.e. low recycling rates, and when the high recycling rates are used, the cartons are diverted from the landfill and there is a minimisation to this limitation. The actual GHG attributed at low and high recycling rates is not quantified.

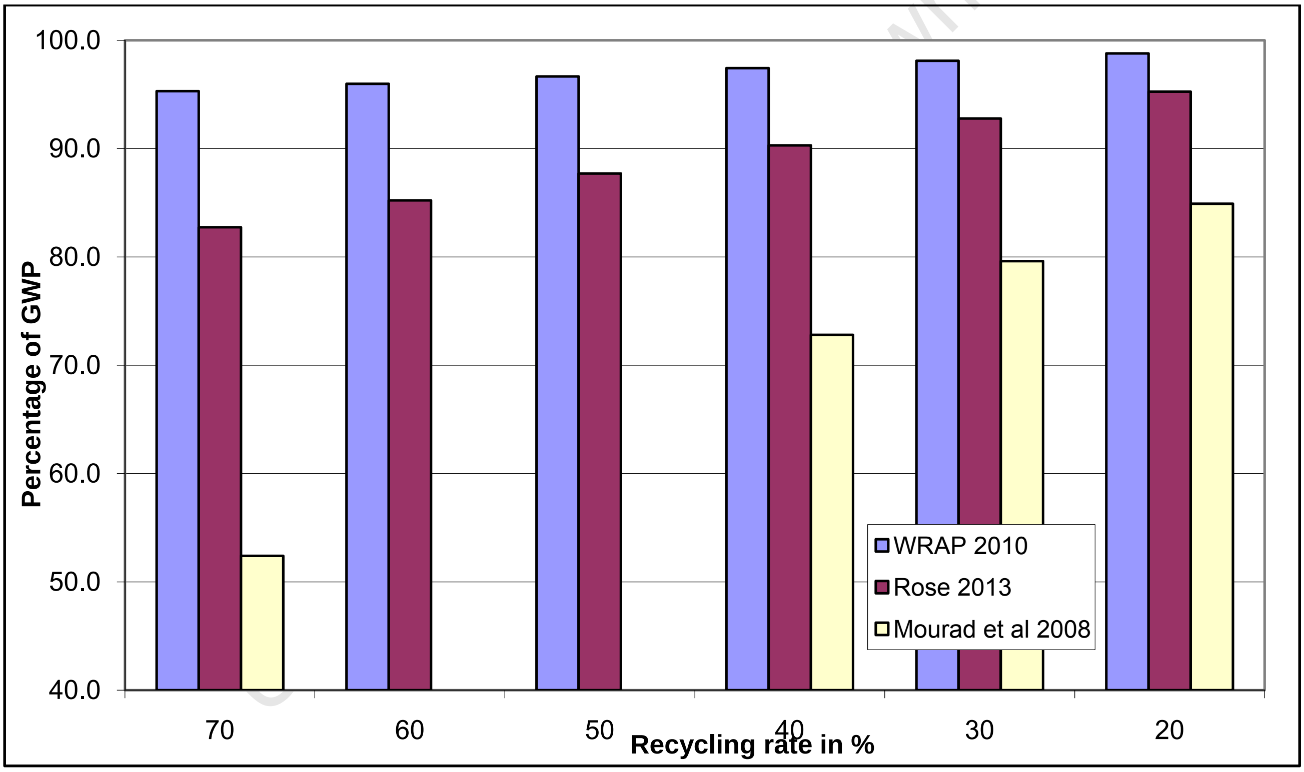

Figure 5.2. Evaluation of GWP reductions due to recycling and comparison with two other studies

Eutrophication

A value of 0.173 kg PO_4^{3-} eq is obtained for the cartons in this study with the present low level of 0.9% recycling using the model described. The recycling of paper fibres from 0.9 to 70% gives a reduced eutrophication impact of 0.008 kg PO_4^{3-} eq; this equates to a 4.6% reduction. This reduction is the lowest one for the four impacts. The difference is less than 10% and the value is therefore similar to that of the base case.

Acidification

The recycling of paper fibres from 0.9 to 70% gives a reduced acidification impact of 0.027 kg SO_2 eq this equates to a 6.4% reduction. This reduction indicates a difference of less than 10% and the value is therefore similar to that of the base case.

Abiotic depletion

The recycling of paper fibres from 0.9 to 70% gives a reduced abiotic depletion impact of 0.120 kg Sb eq this equates to a 25.3% reduction. This reduction indicates a high difference between the base case and the recycling of 70% of the paper fibres.

Table 5.14. Summary of the results obtained for 70% recycling of the paper fibres

Impact	Value	Decrease in value for 70% recycling	% decrease
GWP in kg CO_2 eq	92.7	16.0	17.3
Eutrophication in kg PO_4^{3-} eq	0.173	0.008	4.6
Acidification in kg SO_2 eq	0.421	0.027	6.4
Abiotic depletion in kg Sb	0.475	0.120	25.3

5.2.6 Comparison of the 10% light-weighted paperboard with the high recycling rate

Light-weighting of the paperboard is taken to result in a reduction of 10% of the paper fibres. A summary of the values compared with the WRAP study (2010) is given in Table 5.15. The WRAP study undertook a similar comparison and hence with adjustment of the figures to the same functional unit, one impact could be compared.

Light-weighting of 10% of the paperboard in the LPB results in a **3.2%** decrease in the GWP impact. WRAP (2010) found a **4.6%** decrease in GWP for 10% light-weighting of the carton in the UK. The reduction percentage obtained in this dissertation for light-weighting is therefore slightly lower than that found in the WRAP study. The WRAP (2010) study had similar percentage value reductions for 70% recycling and 10% light-weighting. The Elopak study has a twofold reduction for light-weighting compared to high recycling.

Table 5.15. Summary of the results and comparison with those of the WRAP study (2010)

Impact	**Value**	**% decrease for light-weighting**	**% decrease for 70% recycling rate**	**WRAP (2010)**	**% decrease for light-weighting (given)**	**% decrease for 70% recycling rate***
GWP in kg CO_2 eq	92.7	3.2	17.3	60.0	4.6	4.8
Eutrophication in kg PO_4^{3-} eq	0.173	3.5	4.6	0.031	7.8	
Acidification in kg SO_2 eq	0.421	3.1	6.4	0.200	5.3	
Abiotic depletion in kg Sb	0.475	2.7	25.3	0.561	2.1	

Note: The values for the WRAP study (2010) have been adjusted for a functional unit of 1 000 litres. * indicates a calculated value from the WRAP (2010) study. The WRAP (2010) study uses the data for the gable-top cartons.

The remaining three impact indicators are unable to be compared to the WRAP study.

Light-weighting of 10% of the paperboard in the LPB results in a **3.5%** decrease in eutrophication. WRAP (2010) found a **7.8%** decrease in eutrophication for 10% light-weighting of carton in the UK. This indicates a double the difference between the findings of the two studies. Both values could be noted to be in a similar range to the original scenario and are not seen as highly significant.

Light-weighting of 10% of the paperboard in the LPB results in a **3.1%** decrease in acidification. WRAP (2010) found a **5.3%** decrease in eutrophication for 10% light-weighting of carton in the UK. The WRAP (2010) study had a slightly higher reduction, however, the reductions for both studies are considered to be similar for the potential of reducing acidification.

Light-weighting of 10% of the paperboard in the LPB results in a **2.7%** decrease in abiotic depletion. WRAP (2010) found a **2.1%** decrease in abiotic depletion for 10% light-weighting of carton in the UK. The two results are therefore similar for the potential of abiotic depletion.

Table A5.4 (in the Appendix) has values used for the current case, 70% recycling rate and 10% light-weighting scenario.

5.3 Identification of significant processes for the pack and checks

The multi-part fourth stage of the LCA is discussed in this section. LCA interpretation is the "analysing and presenting of the results" (Baumann and Tillman, 2004). The first item is the identification of significant issues in the base case scenario of the beverage carton in its life journey from Sweden to

South Africa (Section 5.3.1). The second section (5.3.2) discusses the evaluation of the interpretation through the use of sensitivity checks. The consistency check is briefly discussed in Section 5.3.3.

5.3.1 Identification of significant issues of the base case

The issues identified in each impact indicator are tabulated in Table 5.16 in an artificial order with the 19 process items sorted on the basis of the number of times each appears under an impact indicator.

Three items are contributors to all four impact indicators, namely (1) LPB production, (2) recycling of corrugated board and (3) transport of the LPB and polymers from Europe to South Africa.

The transport of goods (using a 16–32 t truck) and the generation of electricity from coal (in ZA) are both contributors to the three impacts of GWP, eutrophication and acidification. The two polymers for closure production are contributors to the three impacts of GWP, acidification and abiotic depletion.

The other single contributors to the impacts are as follows:

- Remaining GWP processes, which account for 14.1% of the GWP impact
- "Paper disposal to landfill", which contributes 25.8% of the GWP impact
- "Paper disposal to landfill", which contributes 47.4% to the eutrophication impact
- "Cardboard disposal to landfill", which contributes 12.1% to the eutrophication impact
- "South African underground coal", which contributes 7.9% to the abiotic depletion impact.

The other contributors to single impact categories have values of less than 6% of the impact indicator. The use of the Swiss landfill dataset, will have an underreporting on the amount of GHG and the impact of GWP could be higher than the calculated 25.8%, though the amount is not quantified.

Table 5.16. Identification of significant issues affecting the base case with a functional unit of 1 000 L

Process	**GWP**	**% GWP**	**Eutrophi-cation**	**% Eutrophi-cation**	**Acidifica-tion**	**% Acidifica-tion**	**Abiotic depletion**	**% Abiotic depletion**
	Base case in kg CO_2 eq	**% of total**	**Base case in kg PO_4^{3-} eq**	**% of total**	**Base case in kg SO_2 eq**	**% of total**	**Base case in kg Sb eq**	**% of total**
Total of all processes	92.7		0.173		0.421		0.471	
Remaining processes	13.1	14.1	0.010	5.8	0.031	7.4	0.040	8.5
Liquid packaging board, at plant/RER S	17.7	19.1	0.025	14.5	0.096	22.8	0.123	26.1
Corrugated board, recycling fibre, single wall, at plant/CH S	8.0	8.6	0.007	4.0	0.019	4.5	0.058	12.3
Transport, transoceanic freight ship/OCE S	4.5	4.9	0.008	4.6	0.098	23.3	0.030	6.4
Adapted operation, truck 16–32t, EURO3/RER U	9.8	10.6	0.008	4.6	0.033	7.8		
Electricity generated from coal in ZA	8.6	9.3	0.004	2.3	0.081	19.2		
LDPE ETH S (polymer for closures)	5.3	5.7			0.047	11.2	0.072	15.3
HDPE ETH S (polymer for closures)	1.8	1.9			0.016	3.8	0.027	5.7
Disposal, paper, 11.2% water, to sanitary landfill/ CH S	23.9	25.8	0.082	47.4				
Disposal, packaging cardboard, 19.6% water, to sanitary landfill/CH S			0.021	12.1				
Disposal, plastics, mixture, 15.3% water, to sanitary			0.008	4.6				

Process	GWP	% GWP	Eutrophi-cation	% Eutrophi-cation	Acidifica-tion	% Acidifica-tion	Abiotic depletion	% Abiotic depletion
landfill/CH S								
Coal from underground mine ZA U							0.037	7.9
LPG I							0.021	4.5
Coal from open-cast mine U							0.021	4.5
Crude oil, at production onshore/RAF U							0.018	3.8
Crude oil, at production onshore/RME U							0.013	2.8
Crude oil, at production/NG U							0.011	2.3

5.3.2 Sensitivity check

The evaluation checks of an LCA are used to indicate that the modelling assumptions have been successfully incorporated. This dissertation equated the carbon footprint with the GWP results in Section 5.2.1 to check the magnitude of the results. The use of checks can also be seen as evaluation of the "robustness of the results" (Baumann and Tillman, 2004). The data in Table 5.16 can be used to select different datasets for impact categories that have a high value.

The first major assumption in the model is the choice of the **dataset for LPB manufacture** – an alternative database is used and the model is run using the same assumptions. The output for the base case using the ecoinvent LPB is 95.3 kg CO_2 eq compared with the Buwal 250 LPB value of 84.2 kg CO_2 eq. The lower value obtained with the Buwal 250 process could be due to the fact that the data are from one Swedish factory from 1994 whereas the ecoinvent process uses average European data of an unknown date.

The eutrophication, acidification and abiotic depletion impacts have similar values when the base case scenarios are compared using CML 2 and the two LPB datasets of ecoinvent and Buwal 250 (Table 5.17).

Table 5.17. The differences obtained between the base case and the results using the two datasets of LPB and CML 2 as the LCIA

Impact category	Unit	Base case LPB in ecoinvent	Base case LPB in Buwal 250
Global warming (GWP100)	kg CO_2 eq	92.7	85.0
Eutrophication	kg PO_4^{3-} eq	0.173	0.181
Acidification	kg SO_2 eq	0.421	0.429
Abiotic depletion	kg Sb eq	0.475	0.416

Another sensitivity test undertaken is the assumption that CML 2 is the most applicable life cycle impact assessment method. The "IPCC 2007 GWP 100a" **impact assessment method** was selected and run with the same model and data. The output for the base case using the impact assessment method of IPCC is 96.0 kg CO_2 eq compared with output from the IPCC method inherent in CML as the CF (GWP) value is 92.7 kg CO_2 eq; this difference is seen as less than 10.1% and is similar in value when using two different life cycle impact assessment midpoint methods.

The endpoint model of EcoIndicator 99 was then selected with the default Hierarchist version (and average weighting set of "A") and a value of 1.885×10^{-5} DALY was obtained for the climate change impact. Using De Schryver *et al.* (2008) the overall damage factor of 2.0×10^{-6} DALY/kg CO_2 eq a climate change value of 9.4 kg CO_2 is obtained. This value is approximately one tenth of the CML2 method and is consistent with the fact that "current LCA methodologies contain several limitations in addressing the influence of GHG emissions at the endpoint level" (De Schryver, 2010).

5.3.3 Consistency check

A consistency check of the data was undertaken during the preparation stage. The data have been discussed and an appropriate choice was made. An example of this is the transport processes – all selected processes used Euro 3 processes and one of two size truck sizes was selected.

5.4 Concluding comments

The materials and processes involved in the beverage LCA were described in Section 5.1. The values for the base case for the four impact categories of GWP, eutrophication, acidification and abiotic depletion were reported on in Section 5.2. The data were interpreted in Section 5.3, with the inclusion of various checks.

The LCA results compared favourably with those of the similar study by WRAP (2010) with regard to the GWP at the lower recycling rates of 30 and 40%. However, at the recycling rate of 70% the WRAP study had a reduction of 4.7% (noted as being in a similar range to the compared WRAP value); this study has a 17.4% reduction (noted as being slightly lower) compared to the value of 92.7 kg CO_2. The limitation to the GWP is that the Swiss landfill dataset (with methane capture) is used to model this study and there is therefore a reduction of methane emissions for landfilled cartons.

The findings of the study in the dissertation did not compare favourably with the much lower GWP reductions found by Mourad *et al.* (2008). The reason proposed for this is "methane exhibited the greatest mass reduction among the greenhouse emissions, … as a result of anaerobic degradation in landfills" Mourad *et al.* (2008).

The LCA is "part of a toolbox" (Guinée *et al.,* 2001) and this study was able to model results similar to those of beverage carton studies such as WRAP (2010) and Mourad *et al.* (2008). The LCA model reflected a single-use South African beverage pack (modelled using European data) that was compared with the present 2011 pack and two options – recycling up to the highest anticipated level of 70% and 10% light-weighting of the paperboard. As the results are not **aggregated** (that is condensed into one overall value as in the MCA), it is not possible to compare the single score for the two options and thereby rate high recycling or light-weighting as the preferred option. However, it is possible to evaluate the options using the reductions obtained and knowledge of the LPB supply chain.

The reductions to the four impacts for 10% light-weighting of the paper fibres gave values of 2.7–3.5%. All four reductions can therefore be noted as having **similar values** to the base case. For the high recycling impacts, the reductions varied from a low 4.6% (for eutrophication) and 6.4% for acidification to the two values having above 10% reductions i.e. showing less similarity in results i.e. 17.3% for GWP and the **high** 25.3% **reduction** in abiotic depletion for the high recycling rate.

The decision to have mid-point life cycle impact assessments and not utilise a single end-point value is seen as beneficial in terms of more educating, however, it is required that the two options be compared. Based on the higher reductions obtained for two impacts, and within the limitations of this study, the preferred option for the environmental impacts assessed is the **high recycling rate**. Furthermore, based on the practicality of requiring an international supplier to light-weight the LPB or the recycling of cartons in a country with recycling supply chains, the option to recycle is deemed the more feasible.

CHAPTER 6 CONCLUSIONS AND RECOMMENDATIONS

The final chapter ties the conclusions from the sustainability awareness analysis (in Chapter 4) and from the product LCA (of Chapter 5) together by referring to the two objectives and four original hypotheses and assessing whether these can now be evaluated. Section 6.1 reviews how the objectives of the dissertation were met. The overall conclusions from the study regarding sustainability awareness and the LCA are discussed in Section 6.2. Section 6.3 concludes the dissertation with further recommendations for the LPB actors in the supply chain and for tasks connected with sustainability research.

6.1 Objectives

The following objectives were proposed in Section 1.4:

- To assess the level of sustainability awareness of a selection of companies active in the supply chain of LPB in South Africa and to compare this with international best practice
- To investigate whether the use of an LCA for liquid paperboard in South Africa would yield policy recommendations (especially for post-consumer recycling) similar to those it yielded in other countries.

The objectives were used to guide the research, to extract relevant conclusions and findings from the literature, to select appropriate companies and organisations for study, and to select the two tools used in this dissertation, namely a content analysis of sustainability reports using the principles of multi-criteria analysis (MCA) and a life cycle analysis (LCA).

6.1.1 Conclusions acquired from the literature

The following conclusions and findings were obtained from the literature:

- Similar past research had been reported for the **industry** of beverage packaging and milk packs in particular;
- Sustainability awareness in the industry can be analysed using **content analysis** and the tool of **MCA;**
- For the **LCA**, the literature encouraged the LCIA method of CML2;
- The WRAP (2010) study differentiated two scenarios from the base case – a high **recycling** rate of 70% and 10% **light-weighting** of paper fibres.

6.1.2 Purposeful selection of actors in the LPB supply chain

In all, 13 actors were selected for this study. Eleven companies active in the LPB supply chain were purposefully selected. Four of the companies, namely Stora Enso, Elopak, Tetra Pak and SIG Combibloc, have recently published articles on LCAs and were noted as being necessary for selection. The remaining 7 companies are active in the LPB supply chain and are also necessary for selection.

The two organisations selected were deemed to complete the supply chain and had 3 converters, 2 associate and 2 affiliate members among the 11 companies.

6.1.3 Analysis of sustainability awareness

The recent sustainability reports of the purposeful selection of the actors in the LPB supply chain were obtained and used as a data source for sustainability awareness. An analysis of the reports was undertaken in terms of the year of the first sustainability report, the length of the recent (and analysed) report and the reporting by the companies to two SD indicators.

Further analysis was undertaken on the reports up to 2010 for the Nampak (a manufacturer) and three ratings of the reports were undertaken. The selection of the three top focus points in the sustainability chapter of Nampak's 2010 Annual Report were then used to obtain counts in the reports of the selected actors and a word count of each sustainability report was undertaken as part of the MCA.

The options generated for the three-criteria MCA were non-normalised and normalised, each with unequal and equal weighting. It was decided that the most applicable option for comparing the 11 companies and two organisations active in the LPB supply chain was the selection of results normalised for report length and with unequal weighting for the three selected search terms.

The options generated for the four-criteria MCA were normalised, with both unequal and equal weighting. The most applicable option for comparing the 11 companies and two organisations active in the LPB supply chain was decided as having unequal weighting for the four search terms with the fourth term being LCA.

The analysis of the sustainability reports and the MCA on the focal points allowed comparisons and similarities between the three groups of companies to be assessed.

6.1.4 LCA of the Elopak

As regards the second objective, LCA was used to compare the current system, the increase in post-consumer recycling rate from the present rates up to 70% and the light-weighting of the paperboard by 10%. Four impact categories were considered and the results are without aggregation into a single score.

The waste of LPB (i.e. UBCs) arises from a number of suppliers, converters and brand owners in South Africa. The waste can also include frozen dinner cartons. There are two options discussed in this dissertation that can reduce the quantity of waste: recycling of the paper fibres and light-weighting of the paper fibres. The option of generating energy from waste is not considered for the UBCs as the fully bleached virgin fibres are seen as a valuable recyclable paper grade.

6.2 Evaluation of the hypotheses and conclusions

The evaluation of the four hypotheses is undertaken in Section 6.2.1 and then the conclusions to the sustainability awareness theme are in section 6.2.2. Section 6.2.3 contains the conclusions to the LCA.

6.2.1 Evaluation of the four hypotheses

The *first hypothesis* was based on the findings from the literature review and suggested that the members of the supply chain for LPB would have different sustainability awareness that is dependent on the role the company has in the supply chain.

1. *There may be differentiated sustainability awareness among manufacturers compared with 'retailers and brand owners' of the South African liquid paperboard supply chain as manufacturers are believed to be responding to environmental claims.*

The 2010 focus points (identified in Section 4.3.3) of the manufacturing company Nampak (the sponsor) were quantitatively compared to those of the other companies in the LPB supply chain in Sections 4.4 and 4.5.

The results of the MCA which investigated the validity of this hypothesis are contained in Sections 4.4.3 and 4.5.3. When comparing the normalised three-criteria MCA, it is noted that the manufacturers in the LPB supply chain, were found in all the bands of single scores but were prominent in the lower band. **Stora Enso** a manufacturer is noted as having the highest focus to the selected three search terms. As it was expected that the 'retailer and brand owners' would have been the companies to have featured in the lower band, the hypothesis is thus rejected for the three-criteria MCA.

However, the four-criteria MCA was also to be used for validating this hypothesis as this includes the additional term of 'LCA' which is a high level tool in environmental awareness. When comparing the normalised four-criteria MCA, it is noted that the organisations have more a similar focus with **PACSA** having the highest focus to the selected four search terms. The numerous group of manufacturers of the LPB supply chain, were found in the top and lower two groups. It was expected that the 'retailers and brand owners' would have been the companies to have featured in the lower band. The hypothesis is **rejected** for both the three-criteria and four-criteria MCA.

The *second hypothesis* expands on the concern of excessive waste generation by comparing the MCA value obtained for the term ‘recycling’. The comparison for recycling is between manufacturers and the other group of companies (brand owners and retailers).

2. *The manufacturing companies are more aware of recycling than the ‘brand owners and retailers’ and organisations, because some manufacturing companies have recycling divisions.*

The single criterion of ‘recycling’ was extracted from the interim data of the three-term MCA (using normalised report lengths) in Section 4.4.4. The data indicate that PACSA has the most focus on the single criterion of ‘recycling’ for the three-criteria MCA and IPSA the other organisation also has a high value. SIG Combibloc and Nampak also have high values for the term ‘recycling’. The hypothesis is thus **rejected** by the results of this analysis.

The *third hypothesis* defines recycling rates up to 70% for an LPB beverage product and aims to measure the reduced environmental impact that would result from a high recycling rate. This hypothesis is explored through the use of an LCA. The results are discussed in Section 5.3.5.

3. *A high recycling rate (70%) of used beverage cartons would result in a significant decrease in important environmental impacts.*

It was noted that there were significant decreases for the two impact indicators of abiotic depletion and GWP. A reduction of 17.3% is obtained for GWP and 25.3% for the abiotic impact at the high recycling rate of 70%. The hypothesis is therefore **accepted** as two impacts did have a reduction.

The *fourth and final hypothesis* explores a further environmental concept of reduced consumption and is termed ‘light-weighting’ (of the LPB). This concept would also reduce landfill volume and is generally regarded as beneficial. The results are discussed in Section 5.2.6.

4. Key environmental impacts could be decreased more by the use of a high recycling rate of 70% than a further 10 % light-weighting of the paperboard of the beverage carton.

For the purpose of selecting between the high recycling rate of 70% and 10% light-weighting, the levels of reductions are compared directly. The high recycling rate gave a higher reduction in GWP (by over five times) and the abiotic depletion had nearly ten times the reduction of the 10% light-weighting option. The hypothesis is therefore substantiated and is accepted.

6.2.2 Overall conclusions on the sustainability awareness of LPB supply chain actors

From the analysis of the recent (2010) sustainability reports of a purposeful selection of companies and organisations, the following findings are noted:

- The **Danone Groupe** (an international brand owner) was the first responder to publish a sustainability report in 1998 i.e. pre- King II
- **Elopak** (an international manufacturer) had the highest percentage of sustainability reporting in the recent reports that also had the annual reports available
- **Woolworths** (a 'retailer and brand owner') had the highest percentage of sustainability reporting in the local recent reports
- **Stora Enso** (an international manufacturer) has the most similar focus to the Nampak identified terms (i.e. the three-criteria and four-criteria MCA) and has had the most published LCAs over the time frame of 2009 and 2010
- The local organisation **PACSA**, has a high focus to the normalised word content for 'recycling' and also has most similar focus to the Nampak identified terms (i.e. the three-criteria and four-criteria MCA)
- **Tetra pak** (an international manufacturer) had the most published LCAs (in the English language) over the time frame of 2009 and 2010.

The statements above lead to the conclusion that the 6 companies all have strong sustainability awareness in the LPB supply chain, however, one group (e.g. the manufacturers) cannot be seen as being more aware than the other 2 groups. The remaining 6 companies and IPSA may not have excelled at the analysed items but are responding to other issues.

It is noted that the Danone Groupe (an international company) was the **earliest responder** to sustainability reporting, it is an international company that is also a late responder in the actors i.e. Walmart. The international companies have a high content on sustainability in the annual reports compared to the local companies.

From the MCA it was concluded that the two organisations (IPSA and PACSA) had a similar focus on the three Nampak-identified issues. The LPB supplier (Stora Enso) had a high focus on the three issues. The LPB converters and paper suppliers (Nampak, Elopak, SIG Combibloc, Tetra Pak, Mondi and Sappi) had less focus on the three issues and in this group Nampak had the most focus on the three issues. Of the 'retailers and brand owners', Spar had the most similar focus to the three Nampak-identified issues. This could indicate that there exists networks and contact between the different actors e.g. the Executive Director of PACSA was a director of Nampak before November 2005 (Nampak, 2005).

The use of LPB as a beverage pack can be linked to the mention of LCAs in the LPB converters' reports – since Coca Cola's first use of an LCA in the late 1960s, this tool has been widely used in the beverage industry. The term 'LCA' was then used as a fourth term in another MCA (also using the normalised data and with a different unequal weighting). The most noticeable change for the four-criteria MCA was that SIG Combibloc had more focus on the four issues and Spar had less focus.

Four of the selected companies reported on LCAs during 2009 and 2010. It is noted that there could be a lag between undertaking and reporting on the LCAs in the sustainability chapter, or the technical and sustainability reports may have minimal linking of content.

The four companies that included the term ‘LCA’ in the selected sustainability reports (i.e. Stora Enso, SIG Combibloc, Elopak and Tetra Pak) are all LPB converters or suppliers i.e. all manufacturers and are all international companies. This could indicate that the local companies and ‘retailers and brand owners’ need to focus on publicly reporting LCAs in the future.

The terms ‘carbon footprint of a carton’, the ‘recycling rates’, the determination of ‘LCAs on a pack’ and benchmarking against the environmental profile of competing packaging options are taken to be a selection of **international best practices**. The analysis of the sustainability awareness of the actors were assessed for the response to the CDP (i.e. a carbon footprint of the site and/or products) and used the terms ‘recycling’, ‘carbon footprint’ and ‘LCA’ in an MCA along with the local term of ‘training’. The local and international companies have therefore been assessed on these best international practices using the terms for analysis in the sustainability reports.

The Nampak identified focal issues can be noted as having equivalence – especially with the term of ‘carbon footprint’ - to the international best practices.

6.2.3 Overall conclusions from the beverage packaging LCA

The conclusions from the beverage packaging LCA are given for the system studied and within the limitations of the study.

The study examined the use of LPB produced in Sweden and polymers (for the closures) produced in Europe and South Africa and the transport of the goods to and within South Africa for conversion to printed carton blanks and closures (screw caps). The datasets used are mostly European and as the LPB and half the plastic polymer are produced in Europe, the datasets are applicable, but it is expected that the use of South African datasets could lead to more accuracy in the results.

The study used four impact categories from the European CML 2 life cycle impact assessment (LCIA) method (carbon footprint or global warming potential (GWP), eutrophication, acidification and abiotic depletion). The beverage carton base study determined that the disposal of paper is the dominant contributor to both GWP and eutrophication and for acidification it is transoceanic transport and the production of the LPB is the dominant contributor for abiotic depletion.

The study revealed that a 25.4% decrease could be obtained for abiotic depletion if the paper is recycled at the high rate of 70% - although paper is made from a biotic resource, abiotic resources are used in the harvesting of wood, the production of pulp and paper with the plastic polymer requiring the use of oil for production and other abiotic sources for conversion to the plastic polymer. A 17.4% reduction for GWP when recycling 70% of the paper fibres was obtained. Compared to the WRAP (2010) study which reported a reduction of 4.6 % going from 0% to 70% a much higher potential for carbon footprint reduction is thus noted in the South African study as the WRAP study used the avoided burden approach and this study credited the recycled fibres to secondary and tertiary packaging materials. The limitation to this study is that the GWP is reduced (by an unknown amount) due to the use of a Swiss landfill model having methane capture – this is more prominent at low recycling rates. The acidification and eutrophication impact indicators showed reductions of less than 10% for the recycling of 70% of the paper fibres.

The other scenario change is the possibility of light-weighting the paper fibre component of the LPB by 10%. The highest measured reduction for this scenario is 3.5% for eutrophication, and the second highest is a 3.2% reduction for GWP; these two reductions were noted as being significantly higher than in other studies and in this scenario acidification has a 3.1% reduction and abiotic depletion has a 2.7% reduction when compared with the base case.

The 30 kg of LPB used in the provision of the functional unit (packing of 1 000 litres of milk into 2 litre portions) results in a GWP of 92 kg CO_2 eq. The production, transport processes and disposal of the LPB all contribute significantly to this value. However, it should be borne in mind that the overall carbon footprint of 1 000 litres of fat and protein corrected milk in the Western Cape would be of the order of 1 933 to 2 680 kg CO_2 eq (Notten and Mason-Jones, 2011). Packaging thus contributes a small proportion to the carbon footprint of this product, and inferior packaging resulting in product loss would thus also significantly increase the product environmental burdens.

As mentioned the LPB is made in Sweden and the end-of-life of the cartons would be in South Africa. Together with the knowledge that Nampak has a share in the Collect-A-Can recycling supply chain, it would be a reasonable to surmise that the achievement of high recycling rates for the UBCs would be more achievable in the short term. The recovery of the fibres from the collected cartons could be achieved through cooperation with the Gauteng based mill or utilisation as a high quality fibre source for the Nampak Corrugated Rosslyn plant.

This would indicate that increasing the recycling rates of the cartons would be a favourable option for Nampak as a high quality fibre source could be made available for direct use.

The 2nd objective of this dissertation is to assess whether similar policy recommendations, especially regarding post-consumer recycling, would be arrived at based on the conclusions of the LCA. As the LCA only investigated two options – increase in recycling and 10 % light-weighting – the other end-of-life options for UBCs should be investigated if they are feasible to undertake e.g. making roof laminates. It is, however clear that a high recycling rate of the UBCs would significantly reduce the environmental burden and decrease landfill volume.

6.3 Recommendations

The following recommendations are made and could produce more information on the topics dealt with in this dissertation.

6.3.1 Recommendations for sustainability awareness research

Based on the conclusions, and without further analysis of data, the recommendations for sustainability awareness in the LPB supply chain are firstly to ensure that the Sustainability Managers of the companies are aware that the sustainability reports are analysed as a data source and that the data needs to be accessible, editable and clearly include any sustainability reporting schemes and indices that the company participates in. For the local companies this includes the recommendation to increase the sustainability content in the reports.

A recommendation to companies is to state the focal issues of sustainability for the company up front and clearly emphasise these issue; this would allow quicker analyses.

It is recommended that the technical and corporate sustainability reports of some companies are linked in the future and additionally that there is more reference to technical reports in languages other than the reporting language.

6.3.2 Recommendations for LCA of liquid paperboard packaging

The LCA presented here could be made more precise by using LCA databases specific to the country and company. It is recommended that databases be compiled for waste processes, transport and production specific to South Africa in order to aid future modelling work. The inclusion of emissions from specific sites, obtained from accurate measurements, would be of assistance. The study could be further extended to include characterisation factors for South African-specific derived life cycle impact assessment methods.

As the manufacture of the LPB and the transport thereof from Sweden to South Africa are noticeable contributors to all four of the selected impacts, it would be of interest to explore a theoretical LCA with the option of LPB produced in South Africa.

The quantity of beverages sold in milk cartons, should also be quantified alongside the use of other beverage packs as a noted significant landfill reduction with high recycling of beverage cartons could be negligible compared to say the volume of plastic bottle that are landfilled.

The use of uncertainty could be included in the data – this would assist with accurately comparing data of similar values.

The collection of the cartons could be better modelled if the process was undertaken and data collected for the purposes of LCA.

6.3.3 Overall recommendations for LPB actors

As the LCA presented in this dissertation has confirmed that recycling of the paper fibre contained in used beverage packs could significantly reduce resource consumption and carbon footprint associated with this type of packaging as used in South Africa, the major recommendation to actors in the LPB supply chain is to focus environmental improvement activities on this aspect, setting a high recycling target.

At the same time, LPB actors should note the conclusion that losses of the product due to inferior packaging would also increase environmental burdens very significantly, and should thus record and quantify such losses explicitly with the aim of reducing them.

The future company sustainability reports could also be analysed for quality (Hubbard, 2009), such as stating targets, applying for external assurance of the sustainability report or sections thereof by a recognised provider and reporting of detailed information such as a list of sites with ISO 14001 and other accreditations.

Tetra Pak has succeeded in having their pack mentioned by name on the Cape Town Waste Plan of recyclable goods, however, the similar Elopak beverage cartons and other brands are not reflected as recyclable goods. It would be advisable to have the general public and waste collectors identify with the Elopak brand and become aware of the other option for the carton other than landfilling.

As Nampak has had success with the Collect-a-Can recycling operation achieving collection rates of 69% (Nampak, 2010) it could be advisable to use sections of this supply chain to collect the cartons as a source of high quality paper fibre or reuse the cartons for secondary building materials.

The recycling rates of the Elopak branded cartons are at present low (under 1% in 2011) in South Africa, however, there are recyclers and pulping facilities in a few provinces that could utilise this source of high quality once-used paper fibres. The recommendation is to recycle the cartons at present. Incineration could be explored, however, this may utilise the plastic components, but it would destroy the valuable source of high quality fibres found in the paperboard of the cartons.

The use of the cartons as a secondary building material could be explored more fully.

References

AccountAbility. 2007. AccountAbility Rating™ 2007: An Analysis of the Financial Mail Top 51 Companies of South Africa. Online: http://www.unisa.ac.za/contents/colleges/col_econ_man_science/ccc/docs/Accountability%20Rating%202007%20Report.pdf

Azapagic, A. 2003. Systems approach to corporate sustainability: A general management framework. *Transactions of the IChem E*: 81(B): 303–316.

Banar, M. and Cokaygil, Z. 2008. A comparative life cycle analysis of two different juice packages. *Environmental Engineering Science*. **25**(4): 549–555.

Baumann, H. and Tillman, A. 2004. *Hitch Hiker's guide to LCA: An orientation in life cycle assessment methodology and application.* Lund, Sweden: Studentlitteratur.

Bericap. 2011. Products: Carton Packaging Milk. Online: http://www.bericap.com/index.php?id=130&L=0%252&L=0%252 [Accessed 9 January 2012].

Best in Packaging. 2009. Online: http://bestinpackaging.com/2009/12/13/brazil%E2%80%99s-small-scale-business-model-for-recycling-post-consumer-tetra-paks/ [Accessed 11 January 2012].

Biggs, J. 1996. Biggs' structure of the observed learning outcome (SOLO) taxonomy. The University of Queensland, Australia. Online: http://creative.canberra.edu.au/groupwork/documents/Biggs_Solo.pdf [Accessed 5 September 2011].

Bio Intelligence Service S.A.S. (BIOIS). 2010. Nordic Life Cycle Assessment Wine Package Study. Final report – ISO compliant. Online: http://www.tetrapakprotects.se/Documents/LCA%20Nordic%20Wine%20comparative_August_10_with%20final%20statement.pdf [Accessed 27 December 2011].

Bio Intelligence Service S.A.S. (BIOIS). 2008. Analyse du cycle de vie des emballages de Tetra Pak. Rapport Final. Online: http://www.tetrapak.com/fr/SiteCollectionDocuments/Analyse_du_Cycle_de_Vie_ACV/tba_edge/Rapport%20BIO%20IS%20-%20Tetra%20Pak%20ACV%20du%20TBA%20Edge%20-mars11.pdf

Bloemhof, J., Van Nunen, J., Vroom, J., Van der Linden, A. and Kraal, A. 2001. One- and two-way packaging in the dairy sector. ERIM Report Series, Reference Number ERS-2001-58-LIS. Online: http://www.erim.eur.nl [Accessed 24 April 2009].

Brent, A. 2003. A proposed lifecycle impact assessment framework for South Africa from available environmental data. *South African Journal of Science.* 99(3 & 4): 115–122.

Brent, A. and Hietkamp, S. 2003. Comparative evaluation of life cycle impact assessment methods with a South African Casestudy. *International Journal of Life Cycle Analysis.* **8**(1): 27–38.

Brent, A., Rohwer, M., Freidrich, E. and Von Blottnitz, H. 2002. Status of life cycle assessment and engineering research in South Africa. *International Journal of Life Cycle Assessment.,* **7**(3):167–1721.

Brundtland Commission. 1987. Our Common Future, Report of the World Commission on Environment and Development, World Commission on Environment and Development, 1987. Published as Annex to General Assembly document A/42/427, Development and International Co-operation: Environment August 2, 1987. Retrieved, 2007.11.14

Carew, A.L. and Mitchell, C.A. 2002. Characterizing undergraduate engineering students' understanding of sustainability. *European Journal of Engineering Education*., **27**(4): 349–361. DOI: 10.1080/0304379021016665 7.

Cederberg, C. and Mattsson, B. 2000. Life cycle assessment of milk production — A comparison of conventional and organic farming. *Journal of Cleaner Production.,* **8**: 49–60.

Collect-a-Can. 2011. Collect-a-Can – Our Achievements. Online: http://www.collectacan.co.za [Accessed 6 January 2012].

Creswell, J.W. 2009. *Research design: Qualitative, quantitative and mixed method approaches*. London: Sage.

Danone. 2010. Sustainability Report. Online: http://www.danone.com/images/pdf/danone_uk_24mai.pdf [Accessed 30 September 2011]. (originally named "danone_rapport_developpement_durable_2010_en.pdf").

De Schryver, A. M. *et al.* (2008) In Jolliet, O. 2009. Air conditioning: reducing mortality in extreme heat conditions or ...Increasing human health impacts through smog and global warming. [Accessed 14 May 2013 http://www.lcacenter.org/LCA9/presentations/201.pdf]

De Schryver, A.M. 2010. Value choices in life cycle impact assessment. PhD thesis. Radboud University, Nijmegen.

De Villiers, C.J. and Lubbe, D.S. 2001. Industry differences in respect of corporate environmental reporting in South Africa: A research note. *Meditari Accountancy Research.,* **9**: 81–91.

Deniz, D. 2002. Sustainability and environmental issues in industrial product design. Master of Industrial Design dissertation, Izmir Institute of Technology, Izmir, Turkey. Online: http://library.iyte.edu.tr/tezler/master/endustriurunleritasarimi/T000136.pdf [Accessed 11 January 2012].

Department of Environmental Affairs and Tourism (DEAT, South Africa). 2005. Working with Waste Series. Online: http://www.sawic.org.za/documents/232.pdf [Accessed April 2011].

Detzel, A. Wellenreuther, F., Krüger, M. and Mönckert, J. 2009. LCA of beverage cartons and plastic bottles in Spain. In Von Falkenstein, E., Detzel, A. and Wellenreuther, F. Meta analysis: LCA study on beverage cartons and alternative packaging. Heidelberg, Germany: IFEU GmbH.

Digital Media Group Plc (DBR). 2011. Tetra Pack signs deal with South African paper mill to recycle beverage cartons. Online:[http://packaging.drinks-business-review.com/news/tetra-pack-signs-deal-with-south-african-paper-mill-to-recycle-beverage-cartons-050711 [Accessed 5 July 2011].

Efficient Consumer Response (ECR) and European Organization for Packaging and the Environment (EUROPEN). 2009. Packaging in the sustainability agenda: A guide for corporate decision makers. Joint publication of ECR Europe, Belgium [www.ecrnet.org] and The European Organization for Packaging and the Environment (EUROPEN) aisbl, Belgium [www.europen.be].

Eide, M.H. 2002. Life cycle assessment (LCA) of industrial milk production. *International Journal of Life Cycle Assessment.,* 7-(2):115–126.

Elopak AS. 2009. LCA[1].pdf (Category #2 –Life Cycle Assessment (LCA). Online: http://www.elopak.com [Accessed 16 February 2009].

Elopak AS. 2010. Environmental Status Report 2010. Online: http://www.elopak.com/language=en/10196 (File "Environmental_Report_2010[1].pdf". [Accessed 28 September 2011].

Engledow, S. 2005. The strategic assessment of a curbside recycling initiative in Cape Town as a tool for integrated waste management. MA thesis, University of Cape Town. Online: http://www.sustainabilityinstitute.net/component/search/sally%20ann/?ordering=&searchphrase=all [Accessed 16 November 2009].

Environmental Impacts of Products (EIPRO). 2006. Analysis of the life cycle environmental impacts related to the final consumption of the EU25. In Bio Intelligence Service, 2010. Nordic Life Cycle Assessment Wine Package Study, Final Report – ISO compliant. Online: http://www.tetrapakprotects.se/Documents/LCA%20Nordic%20Wine%20comparative_August_10_with%20final%20statement.pdf [Accessed 27 December 2011].

Eskom. 2010. Eskom Integrated Report 2010. Online: http://financialresults.co.za/2010/eskom_ar2010/downloads/eskom_ar2010.pdf [Accessed 27 February 2012].

Efficient Consumer Response (ECR) and European Organization for Packaging and the Environment (EUROPEN). 1999. Use of life cycle assessment (LCA) as a policy tool in the field of sustainable packaging waste management. Online: http://www.europen.be/download_protected_file.php?file=48 [Accessed 13 February 2012].

Ferd. 2010. Annual Report 2010. Online: http://www.e-magin.se/v5/viewer/files/viewer_s.aspx?gKey=pn4tcjdg&gInitPage=1] www.ferd.com [Accessed 7 October 2011].

FKN. 2007. FKN – Life Cycle Assessment, Beverage cartons under test. Online: http://www.sig.biz/site/media/pdf/environment/life_cycle_assessment/FKN_LCA_Beverage_Cartons_under_test.pdf [Accessed 16 February 2009].

Foster, C., Green, K., Bleda, M., Dewick, P., Evans, B, Flynn, A, and Mylan, J. 2006. *Environmental impacts of food production and consumption: A report to the Department for Environment, Food and Rural Affairs.* Defra, London: Manchester Business School. Online: http://www.ifr.ac.uk/waste/Reports/DEFRA-Environmental%20Impacts%20of%20Food%20Production%20%20Consumption.pdf [Accessed 10 April 2012].

Franklin Associates. 2006. Life Cycle Inventory of container systems for wine. Final report prepared for Tetra Pak, Inc. Online: http://www.tetrapak.com/se/Documents/WineContainers_report%5B1%5D.pdf [Accessed 18 February 2011].

Frischknecht,R., Jungbluth, N., Althaus, H.-J., Doka, G., Dones, R., Heck, T., Hellweg, S., Hischier, R., Nemecek, T., Rebitzer, G., Spielmann, M. 2005. The ecoinvent Database: Overview and Methodological Framework. *Int J LCA* **10** (1) 3. DOI: http://dx.doi.org/10.1065/lca2004.10.181.1.

Frischknecht, R., Jungbluth, N., Althaus, H.-J., Doka, G., Heck, T., Hellweg, S., Hischier, R., Nemecek, T., Rebitzer, G., Speilmann, M. and Wernet, G. 2007. Overview and methodology. EcoInvent Report No. 1- Dübendorf, Swiss Centre for Life Cycle Inventories.

Gatech. 2012. Environmental Metrics & Indicators. Online: http://www.srl.gatech.edu/education/ME4171/IndicatorsMetrics.ppt [Acessed 12 Nov 2012].

Gjølberg, M. 2009. Measuring the immeasurable? Constructing an index of CSR practices and CSR performance in 20 countries. *Scandinavian Journal of Management.*, **25**: 10–22.

Global Reporting Initiative (GRI). 2012. Integrated reporting. Online: https://www.globalreporting.org/information/current-priorities/integrated-reporting/Pages/default.aspx [Accessed 19 February 2012].

Goodland, R., and Daly, H. 1996. Environmental sustainability: Universal and non-negotiable. *Ecological Applications,* **6**(4): 1002–1017.

GreenBlue. 2011. Definition of sustainable packaging. Version 2.0, August 2011. Online: http://sustainablepackaging.org/uploads/Documents/Definition%20of%20Sustainable%20Packaging.pdf [Accessed 25 November 2011].

Guinée, J.B. (Final editor), Gorrée, M., Heijungs, R., Huppes, G., Kleijn, R., de Koning, A., van Oers, L., Wegener Sleeswijk, A., Suh, S., Udo de Haes, H. A., de Bruijn, H., van Duin, R., Huijbregts, M.A.J., Lindeijer, E., Roorda, A.A.H. and Weidema, B.P. 2001. Life Cycle Assessment: An operational guide to the ISO standards. Part 3: Scientific background. Den Haag and Leiden, The Netherlands: Ministry of Housing, Spatial Planning and Environment (VROM) and Centre of Environmental Science (CML). Online: http://www.leidenuniv.nl/cml/ssp/projects/lca2/html [Accessed 20 March 2012].

Hackston, D. and Milne, M.J. 1996. Some determinants of social and environmental disclosures in New Zealand companies. *Accounting, Auditing & Accountability Journal*, **9**(1): 77–108.

Hajkowisz, S. and Collins, K. 2007. A review of multiple criteria analysis for water resource planning and management. *Water Resources Management,* **21**:1553–1566. DOI 10.1007/s11269-006-9112-5.

Harding, K. And Melamu, R. 2009. *Harding and Melamu_2009_Electricity LCA-ZA*. [Excel Spreadsheet], Cape Town: University of Cape Town.

Heijungs, R. and Guinée, J. 1995. On the usefulness of Life Cycle Assessment of packaging. *Environmental Management.* **19** (5): 665–668.

Hischier, R. 2007 Life Cycle Invetories of Packagings and Graphical Papers. Ecoinvent Report No. 11, Swiss Centre for Life Cycle Inventories, Dübenford.

Huang, C. and Ma, H. 2004. A multidimensional environmental evaluation of packaging materials. *Science of the Total Environment.* **324**(1–3): 161–172.

Hubbard, G. 2009. Unsustainable reporting. CorporateRegister.com. Paper presented to the CR Debates, The Royal Institution of Great Britain, London.

Institut für Energieund Umweltforschung (IFEU). 2004. Life Cycle Analysis beverage cartons for juice in Germany. In FKN, 2007. FKN – Life Cycle Assessment, Beverage cartons under test. Online: http://www.sig.biz/site/media/pdf/environment/life_cycle_assessment/FKN_LCA_Beverage_Cartons_under_test.pdf [Accessed 16 February 2009].

Institut für Energieund Umweltforschung (IFEU). 2004. Life Cycle Analysis beverage cartons for juice in Germany, Excerpt from the study. [Accessed]

Institut für Energieund Umweltforschung (IFEU). 2006. Comparative LCA of beverage cartons and PET one-way bottles. Wiesbaden, Germany. In Von Falkenstein, E., Detzel, A. and

Wellenreuther, F. 2009. Meta analysis: LCA study on beverage cartons and alternative packaging. Heidelberg: IFEU GmbH.

Institut für Energieund Umweltforschung (IFEU). 2010. Comparative Life Cycle Assessment of beverage cartons Cb3 and Cb3 Ecoplus for UHT milk. Heidelberg: IFEU GmbH.

Institute of Packaging of South Africa (IPSA). 2005. *A Handbook of Packaging Technology,* Pinegowrie, South Africa: IPSA.

Institute of Packaging of South Africa (IPSA). 2010. *A Handbook of Packaging Technology,* Pinegowrie, South Africa: IPSA.

Institute of Packaging of South Africa (IPSA). 2011. Online: www.ipsa.org.za [Accessed 10 October 2011].

International Organization for Standardization (ISO). 2006a. *ISO 14040: Environmental management – Life Cycle Assessment – principles and framework.* Geneva: International Organization for Standardization.

International Organization for Standardization (ISO). 2006b. *ISO 14044: Environmental management – Life Cycle Assessment – Requirements and guidelines.* Geneva: International Organization for Standardization.

Investopedia. 2011. Glossary. Online: http://www.investopedia.com/terms/r/representative-sample.asp#ixzz1rASY8xEz [Accessed 5 April 2012].

Jelse, K., Eriksson, E. and Einarson, E. 2009. Life Cycle Assessment of consumer packaging for liquid food. Stockholm, Sweden: Swedish Environmental Research Institute.

Jeswani, H.K., Azapagic, A., Schepelmann, P. Ritthoff, M. 2010. Options for broadening and deepening the LCA approaches. *Journal of Cleaner Production.,* **18**(2):120–127.

King II. 2002. King II Report on Governance in South Africa. Online: http://www.sustainabilitysa.org/sustainabilityreporting/StandardsandGuidelines/KingReportsonCorporateGovernance.aspx [Accessed 23 December 2011].

KLD Research and Analyticals (KLD). 2008. Sustainability reporting in emerging markets: An analysis of the sustainability reporting in selected sectors of seven emerging market countries. Online: http://www.socialinvest.org [Accessed 11 March 2012].

KPMG. 2008. KPMG International Survey of Corporate Responsibility Reporting 2008. Online: http://www.kpmg.com [Accessed 6 July 2011].

Lambooy, T. 2011. Corporate social responsibility: Sustainable water use. *Journal of Cleaner Production*. **19**: 852–866.

Lewis, H., Fitzpatrick, L., Verghese, K., Sonneveld, K. and Jordon, R. 2007. Sustainable packaging redefined. Draft. Online: http://www.sustainablepack.org/database/files/newsfiles/Sustainable%20Packaging%20Redefined%20Nov%20%202007.pdf [Accessed 17 April 2010].

Lucena and Schneider. 2008. Engineers, development, and engineering education: From national to sustainable community development. *European Journal of Engineering Education.,* **33** (3):, 247–257.

Marira, T. and Chipunza, C. 2011. Corporate governance, corporate social responsibility and sustainability: Comparing corporate priorities within the South African mining industry. *Journal of Human Ecology*, **35**(2): 95–111.

Markam, S. 2012. Scaling. Online: http://www.csse.monash.edu.au/~smarkham/resources/scaling.htm [Accessed 16 November 2012].

Merriam-Webster. 2013. Dictionary. http://www.merriam-webster.com/dictionary/carbon%20footprint [Accessed 13 May 2013]

Matete, N. and Trois, C. 2008. Towards zero waste in emerging countries – A South African experience. *Waste Management,* **28**: 1480–1492.

Mikkilä, M. and Toppinen, A. 2008. Corporate responsibility reporting by large pulp and paper companies. *Forest Policy and Economics*, **10**: 500–506.

Mondi Group (Mondi). 2010. Sustainable development review. Taking stock of our sustainability footprint. Online: http://www.mondigroup.com/desktopdefault.aspx/tabid-2065 Mondi_SD_Review_FINAL[1].pdf [Accessed 15 April 2011].

Mourad, A. L., Garcia, E.E.C., Vilela, G.B. and Von Zuben, F. 2008. Environmental effects from a recycling rate increase of cardboard of aseptic packaging system for milk using Life Cycle Approach. *International Journal of Life Cycle Assessment,* **13**(2): 140–146.

Mouton, J. 2009. *How to succeed in your master's & doctoral studies*. Pretoria: Van Schaik.

Nahman, A. 2010. Extended producer responsibility for packaging waste in South Africa: Current approaches and lessons learned. *Resources, Conservation and Recycling*, **54**(3): 155–162.

Nampak Limited. 2003. Annual Report 2003. It's all part of the package! Online: http://www.nampak.com/DynamicData/AnnualReport/Archive/Nampak_AR_2003.pdf [Accessed 21 April 2011].

Nampak Limited. 2004. Annual Report 2004. Packaging solutions. Online: http://www.nampak.com/DynamicData/AnnualReport/Archive/Nampak_AR_2004.pdf [Accessed 21 April 2011].

Nampak Limited. 2005. Annual Report 2005. Online: http://www.nampak.com/DynamicData/AnnualReport/Archive/Nampak_AR_2005.pdf [Accessed 21 April 2011].

Nampak Limited. 2006. Annual Report 2006. Online: http://www.nampak.com/DynamicData/AnnualReport/Archive/Nampak_AR_2006.pdf [Accessed 21 April 2011].

Nampak Limited. 2007. Annual report 2007. Online: http://www.nampak.com/DynamicData/AnnualReport/Archive/Nampak_AR_2007.pdf [Accessed 21 April 2011].

Nampak Limited. 2008. Annual Report 2008. Beyond the blue. Online: http://www.nampak.com/DynamicData/AnnualReport/Archive/Nampak_AR_2008.pdf [Accessed 21 April 2011].

Nampak Limited. 2009. Annual Report 2009. Online: http://www.nampak.com/DynamicData/AnnualReport/Archive/2009_Complete_Annual_Report.pdf [Accessed 21 April 2011].

Nampak Limited. 2010. Annual Report 2010. Online: http://www.nampak.com/DynamicData/AnnualReport/Archive/Nampak%202010%20LOW.pdf [Accessed 21 April 2011].

Ness, B., Urbel-Piirsalu, E., Anderberg, S. and Olsson, L. 2007. Categorising tools for sustainability assessment. *Ecological Economics*, **60**: 498–508.

Nhamo, G. 2005. Environmental processes surrounding South Africa's plastic bag regulations: Tensions, debates and responses in waste product regulation. PhD Thesis, University of Rhodes, Grahamstown, South Africa.

Notten, P. and Mason-Jones, K. 2011. Life Cycle Assessment of milk production in the Western Cape. The Green House. Online: http://assets.wwfza.panda.org.wwf-web-1 [Accessed 29 February 2012].

Nyström, T. 2000. Production of panel board – A world overview. Online: http://www.kuruc.sk/storage/file/press [Accessed 11 January 2012].

OECD. 2008. OECD Environmental data. Compendium 2006–2008. Waste. Online: http://www.oecd.org/dataoecd/22/58/41878186.pdf [Accessed 17 April 2010].

Packaging Council of South Africa (PACSA). 2010a. Presentation to IPSA Congress 18 August 2010 by Andrew Marthinusen. Online: http://www.pacsa.co.za/pictures/pdfs/Presentation%20to%20IPSA%20Congress%2018%20August%202010-Andrew%20Marthinusen.ppt [Accessed 9 November 2011].

Packaging Council of South Africa (PACSA). 2010b. Presentation at meeting on the establishment of a Recycling Industry Body (RIB). Online: http://www.pacsa.co.za/index.php?option=com_content&view=article&id=21&Itemid=19 [Accessed 30 December 2011].

Packaging Council of South Africa (PACSA). 2011. Welcome to PACSA. Online: www.pacsa.co.za [Accessed 20 December 2011].

Paper Recycling Association of South Africa (PRASA). 2011. PRASA statistics. Online: http://www.prasa.co.za [Accessed 5 Jan 2012].

Pasqualino, J., Meneses, M. and Castells, F. 2011. The carbon footprint and energy consumption of beverage packaging selection and disposal. *Journal of Food Engineering.* **103**: 357–365.

Perez, F. and Sanchez, L.E. 2009. Assessing the evolution of sustainability reporting in the mining sector. *Environmental Management*, **43**(6): 949–961.

PET Recycling Company (Pty) Ltd (PETCO). 2008. PETCO: 2007 review of activities. Online: http://www.petco.co.za [Accessed 6 January 2012].

PET Recycling Company (Pty) Ltd (PETCO). 2010. PETCO: 2010 review of activities. Online: http://www.petco.co.za [Accessed 6 January 2012].

Petrie, J., Basson, L., Notten, P. and Stewart, M. 2004. Multi-Criteria Decision Analysis: The case of power generation in South Africa. In Azapagic, A., Perdan, S. and Clift, R. (Eds) 2004. *Sustainable Development in Practice*. UK: Wiley.

Places. 2011. Map of South Africa. Online: www.places.co.za [Accessed 14 November 2011].

Popplewell, N. 2011. PACSA proposes industry plan. *Packaging Review.,* Nov/Dec 2011. Online: www.packagingreview.co.za

PRé Consultants. 2008. Introduction to LCA with SimaPro. 7 February 2008. Version 4.2. Amersfoort, The Netherlands.

PRé Consultants. 2009. ReCiPe 2008: A Life Cycle Impact Assessment method which comprises harmonised category indicators at the midpoint and the endpoint level. 1st edition. Amersfoort, The Netherlands.

PWC. 2012. Sustainable Packaging: Myth or Reality? Online: www.pwc.co.uk [Accessed 26 September 2012].

Quaddus, M.A. and Siddique, M.A.B. 2011. *Handbook of corporate sustainability: Frameworks, Strategies and Tools*. Edward Elgar Publisher.

Ras, C. 2011. An industrial ecology approach to salt-related environmental sustainability issues in a large industrial complex. MSc dissertation, University of Cape Town, Cape Town.

Robèrt, K. 2000. Tools and concepts for sustainable development. How do they relate to a general framework for sustainable development, and to each other? *Journal of Cleaner Production.,* **8**(3):243-254.

Robertson, G.L. 2010. Sustainable packaging: Does it really exist? Online: http://www.worldfoodscience.com/cms/?id=1005168 [Accessed 17 April 2010].

Roy, P., Nei, D., Orikasa, T. *et al*. 2009. A review of Life Cycle Assessment (LCA) on some food products. *Journal of Food Engineering.* **90**(1):1-10.

Sappi Corporate Affairs. 2010. Annual Report 2010. Online: http://sappi.investoreports.com/sappi_sdr_2010/downloads/sappi_sdr_2010.pdf [Accessed 20 September 2011].

SAPRO. 2010. Snippets. Online: http://www.plastics.info.co.za/downloads/RecyclingSnippets [Accessed 21 October 2011].

Sasol 2010. Annual Review and Summarised Financial Information 2010. Online: http://www.sasol.com/sasol_internet/frontend/navigation.jsp;jsessionid=WUH5WO0WZD1WPG5N4EZSFEQ?navid=19300002&rootid=3 [Accessed 15 March 2012].

Searates. 2012. Online: [http://www.searates.com/reference/portdistance/?country1=155&fcity1=518&country2=121&fcity2=19958&speed=14 [Accessed 4 January 2012].

Sibanda, L. Case, J. And Von Blottnitz, H. 2011. Sustainable development as a threshold concept in engineering education. Paper read at the SA Society of Engineering Education, Wallenburg Centre, Stellenbosch, August 2011. Online: http://www.sasee.org.za/wp-content/uploads/2012/02/Proceedings-of-the-1st-Biennial-SASEE-Conference.pdf.

Sibernagl, P. 2010. What's the composition of your domestic waste stream? Is there value in recycling? In Emory, R. (Ed.). *The Waste Revolution Hand Book South Africa Volume 1: The Guide to Sustainable Waste Management*. Cape Town: Alive2green. pp. 137-141.

SIG Combibloc. 2010. Our carton packs: Ecologically advantageous. Online: http://www.sig.ch/site/media/pdf/karton/environment_04_09/Environment_GB.pdf [Accessed 15 April 2011]. (Original title "Environment_GB[1].pdf").

Singh, S., Chonhenchob, V. and Singh, J. 2006. Life Cycle Inventory and analysis of re-usable plastic containers and display-ready corrugated containers used for packaging fresh fruits and vegetables. *Packaging Technology and Science.* **19**: 279-293.

South Africa (Republic). 2008. *National Environmental Management: Waste Act 62 of 2008.* Pretoria: Government Printer. Online: www.info.gov.za/view/DownloadFileAction?id=94444 [Accessed 11 December 2011].

South African Institute of Chartered Accountants (SAICA). 2009. Summary of report on governance for South Africa – 2009 (King III). King Committee on Governance. Rev 0. Online: http://www.saica.co.za [Accessed 23 December 2011].

Spangenberg, J.H., Pfahl, S. And Deller, K. 2002. Towards indicators for institutional sustainability: Lessons from an analysis of Agenda 21. *Ecological Indicators*.**2**: 61–77.

Spar Group Limited. 2010. 2010 Annual Report. Online: http://www.spar.co.za/getattachment/86b02ac3-1e91-4450-ad08-acbbaffdf401/00000000-0000-0000-0000-000000000000-(1).aspx Filename "SPAR COMMENTARYa[1].pdf. [Accessed 15 April 2011].

Spielmann, M. and Scholz, R.W. 2004. Life Cycle Inventories of Transport Services: Background Data for Freight Transport. Int J LCA. DOI: http://dx.doi.org/10.1065/lca2004.10.181.10. 2004.

Spielmann, M., Bauer, C., Dones, R., Tuchschmid, M. 2007. Transport Services. Ecoinvent report No. 14. Swiss Centre for Life Cycle Inventories, Dübendorf.

Stephenson, A.L., von Blottnitz, H., Brent, A.C., Dennis, J.S. and Scott, S.A. 2010. Global Warming Potential and Fossil-Energy Requirements of Biodiesel Production Scenarios in South Africa. Energy Fuels 2010, 24, 2489–2499: DOI:10.1021/ef100051g.

Stora Enso. 2010a. Review, global responsibility, sustainability report 2010. Online: http://www.storaenso.com/media-centre/publications/annual-report/older-annual-reports/Pages/older-annual-reports.aspx Filename: "Stora_Enso_Sustainability_Report_2010_E_April.pdf" [Accessed 21 April 2011].

Stora Enso. 2010b. Specifications for Natura 2PE Board, issued 02.2010. Online: http://www.storaenso.com/products/packaging/Documents/natura-2pe-board_eng.pdf [Accessed 7 June 2011.

Svanes, E., Vold, M., Moller, H., Pettersen, M.K., Larsen, H. and Hanssen, I.J. 2010. Sustainable packaging design: A holistic methodology for packaging design. *Packaging Technology and Science.* DOI: 10.1002/pts.887.

Székely, F. And Knirsch, M. 2005. Responsible leadership and corporate social responsibility:Metrics for sustainable performance. *European Management Journal.* **23**(6): 628–647. DOI:10.1016/j.emj.2005.10.009.

Tan, R.B.H. and Khoo, H.H. 2005. Life Cycle Assessment of EPS and CPB inserts: Design considerations and end-of-life scenarios. *Journal of Environmental Management.* **74**(3):195-205.

Tetra Pak. 2009. Environmental and social report 2009. Online: http://www.corporateregister.com/a10723/27042-09Co-7923306G2676563076R-GI.pdf [Original file accessed 15 April 2011].

Tetra Pak. 2010a. Corporate presentation 2009/2010. Online: http://www.tetrapak.com/about_tetra_pak/brochures/pages/results.aspx [Accessed 28 September 2011].

Tetra Pak. 2010b. Indicative CO_2 profile of Tetra Rex base 2000 ml. Version 2.0 2010-02-03. Online: www.tetrapak.com [Accessed 15 April 2011].

TREMOVE, 2007. TREMOVE database version 2.5. Transport & Mobility Leuven. http://www.tremove.org/documentation/ [Accessed 14 May 2012].

Trois, C. and Simelane, O.T. 2010. Implementing separate waste collection and mechanical biological waste treatment in South Africa: A comparison with Austria and England. *Waste Management*. DOI:10.1016/j.wasman.2009.12.020.

Umweltbundesamt GmbH (Federal Environment Agency) (UBA-FB). 2000. Ökobilanz für Getränkerverpackungen II. (Life Cycle Assessment for Drinks Packaging Systems II: Summary. Online: http://www.tetrapak.com/se/Documents/UBA_II_part_1_english_summary[1].pdf [Accessed 13 February 2012].

Veleva, V., Hart, M., Greiner, T. and Crumbley, C. 2001. Indicators of sustainable production. *Journal of Cleaner Production*. **9**(5): 447-452. DOI: 10.1016/S0959-6526(01)00004-X.

Von Blottnitz, H. 2006. Promoting active learning in sustainable development: Experiences from a 4th year chemical engineering course. *Journal of Cleaner Production*, **14**(9-11): 916-923.

Von Falkenstein, E., Detzel, A. and Wellenreuther, F. 2009. Meta analysis: LCA study on beverage cartons and alternative packaging. Heidelberg: IFEU GmbH.

Vossberg, C. 2012. A life cycle-based energy and greenhouse gas emission assessment of C&D waste and container glass recycling in the City of Cape Town. MEng dissertation, University of Cape Town, Cape Town.

Walmart. 2010. Global sustainability report. 2010 Progress update. Online: http://az204696.vo.msecnd.net/download/1106/2010-global-responsibility-report_129823709422550601.pdf [Accessed 21 Apr 2011]. Original filename "WMT2010GlobalSustainabilityReport.pdf".

Waste & Resources Action Programme (WRAP). 2010. Life Cycle Assessment of example packaging systems for milk. Final report. Online: http://www.wrap.org.uk/downloads/Final_Report_Retail_2010.e167aed5.8405.pdf [Accessed 28 December 2011].

Waste-Plan. 2009. What can and can't be recycled. Online: http://www.wasteplan.co.za/Recyclables.pdf [Accessed June 2010].

Woolworths Limited. 2010. The Good Business Journey. Report 2010. Online: http://www.woolworthsholdings.co.za/investor/gbj/2010/downloads/The_Good_Business_Journey_Report_2010.pdf [Accessed 15 April 2011].

Xie, M. Li, L., Qiao, Q., Sun, Q.and Sun, T. 2011. A comparative study on milk packaging using life cycle assessment: from PA-PE-Al laminate and polyethylene in China. Journal of Cleaner Production 19 (2011): 2100-2106.

Software

Adobe Reader, 2009. Versions 9.1.0 and 9.1.1.

EcoInvent database V2.0 [Database]. Switzerland: www.ecoinvent.ch

Microsoft Corporation, Microsoft® Office *Excel 2007* with add-in. 2007

Microsoft Corporation, Microsoft® Office *Excel 2003* with add-in. 2003.

Microsoft Corporation, Microsoft® Office *Excel 2002* with add-in. 2001.

Microsoft Corporation, Microsoft® Office *Word 2007* with add-in. 2007.

Microsoft Corporation, Microsoft® Office *Word 2003* with add-in. 2003.

Microsoft Corporation. Microsoft® Office PowerPoint® 2007. 2006.

SimaPro 7 (V 7.3.0). 2011. [Software]. Netherlands: PRé Consultants bv.

Appendices

Table A4.1. The word count for the 11 companies and 2 organisations

	Word count			
Company	**Recycling**	**Training**	**Carbon footprint**	**Life cycle assessment**
Danone	43	130	39	0
Elopak	16	1	3	1
SIG Combibloc	36	2	1	6
Tetra Pak	51	28	0	3
Stora Enso	35	31	15	4
Mondi	21	40	9	0
Sappi	24	43	12	0
Walmart	33	37	6	0
Spar	18	18	1	0
Woolworths	77	24	11	0
Nampak	64	29	5	0
Organisation	**Recycling**	**Training**	**Carbon footprint**	**Life cycle assessment**
IPSA	24	0	3	0
PACSA	26	0	2	0

Table A4.2. The normalised values for the 11 companies and two organisations

	Normalised value (as per Equation 3.7)			
Company	**Recycling**	**Training**	**Carbon footprint**	**Life cycle assessment**
Danone	0.07	0.20	0.12	0
Elopak	0.22	0.01	0.08	0.04
SIG Combibloc	1.00	0.06	0.06	0.50
Tetra Pak	0.40	0.22	---	0.07
Stora Enso	0.28	0.25	**0.24**	0.10
Mondi	0.03	0.06	0.02	0
Sappi	0.10	0.18	0.10	0
Walmart	0.18	0.20	0.06	0
Spar	0.38	**0.38**	0.04	0
Woolworths	0.32	0.10	0.09	0

Nampak	0.50	0.23	0.08	0
Organisation	**Recycling**	**Training**	**Carbon footprint**	**Life cycle assessment**
IPSA	0.67	–-	0.17	0
PACSA	**1.22**	—	0.19	0

Table A4.3. The normalised percentages for the 11 companies and 2 organisations

	Normalised percentage (as per Equation 3.8)			
Company	**Recycling**	**Training**	**Carbon footprint**	**Life cycle assessment**
Danone	5	52	50	0
Elopak	18	4	35	8
SIG Combibloc	82	15	23	100
Tetra Pak	33	58	–-	14
Stora Enso	23	65	99	19
Mondi	2	14	10	0
Sappi	8	48	42	0
Walmart	14	52	27	0
Spar	31	100	18	0
Woolworths	26	27	38	0
Nampak	41	60	33	0
Organisation	**Recycling**	**Training**	**Carbon footprint**	**Life cycle assessment**
IPSA	55	–-	70	0
PACSA	100	–	78	0

Table A5.1 Datasets used in the study

Item	Geography	Year	Technology	Reference
Liquid paperboard (LPB)	Europe	1998 - 2001	Average technology	Hischier, 2007 and ecoinvent
Liquid paperboard (LPB)	Sweden	1993-1994	One mill	Buwal 250
LDPE for closures and stretch film	German	1992	Average technology	ETH
HDPE for closures	German	1992	Average technology	ETH
Kraft paper	European and Finnish	1998 - 2002	Average technology	Hischier, 2007 and ecoinvent
Corrugated board	European	2006	Average technology	FEFCO *et al* 2006
Wooden pallet	German	unknown	Average technology	
Transport, lorry (16-32 t and 3.5-7.5 t)	Switzerland (adapted for South African fuel)	2005	Average vehicle operation	TREMOVE (2007) and ecoinvent
Transport by ocean freighter	Global	1991-2002	Heavy Fuel Energy based steam turbine and diesel engines	CORINAIR (2002) and ecoinvent
LPG	Not given	Before 2001	Not known	IDEMAT 2001
Electricity Mix ZA	South Africa	2009-2010	Average technology	Harding and Melamu (2009) and Eskom (2010)
Landfill	Switzerland	1995	22 % disposal in a landfill	BUWAL 250
Paper recycling	European	Unknown	Average technology	Ecoinvent

Table A5.2. Eskom data used for the RSA electricity mix (Eskom, 2010)

Source	Percentage (%)	Process in SimaPro	Comment and year of data
Carbon-based:			

Coal-fired power plant	89.0	Electricity from coal (Harding and Melamu, 2009); 60 % coal from underground South Africa (U) ; 40% from an open-cast mine (U)	Local data 2009; Coal South Africa (original German source – undated); open-cast mine, source of data not given.
Non carbon-based:			
Nuclear	4.9	Electricity, nuclear, at power plant/UCTE U	Swiss nuclear mix with 90 % PWR (Koeberg is 100 % PWR);19951999
Hydropower (reservoir power plant)	4.87	Electricity, hydropower, at reservoir power plant/BR U	Brazilian dams (non-European) (undated)
Hydropower (pumped storage plant)	1.2	Electricity, hydropower, at pumped storage power plant/CH U	Swiss data -undated
Natural gas (turbine)	0.03	Natural gas, burned in gas turbine/CH U	Mid-1990s data

Table A5.3. Comparison of impact assessment values when using two datasets for plastic polymers

Impact category in CML 2	Units	Values obtained for base case		
		ETH dataset	Ecoinvent dataset	% Difference
Global warming (GWP100)	kg CO_2 eq	92.7	91.2	1.6
Eutrophication	kg PO_4^{3-} eq	0.173	0.172	0.6
Acidification	kg SO_2 eq	0.421	0.388	7.8
Abiotic depletion	kg Antimony (Sb) eq	0.475	0.470	1.1

Table A5.4. Values used for three of the scenarios in SimaPro

Scenario	***Current***	***70 % recycling***	***10 % lightweighting***	***Units***
Life Cycle				
Jun assembly Milk carton at retailer	1	1		piece
Jun assembly Milk carton at retailer LW			1	piece
Paper recycling	-0.251217	-19.5391	-0.2387	kg
Jun Disposal Scenario	1	1		
Jun Disposal Scenario LW			1	
Jun assembly Milk carton at retailer and LW				
Assembly beverage carton (Woodlands Dairy)	1	1	1	p
Was transport lorry 16-32t EURO 3	29.30865	29.30865	27.84285	tkm
Jun Disposal Scenario and LW				
Jun Assembly Milk carton at retailer and LW	1	1	1	p
Landfill/CH S	100%	100%	100%	
Assembly beverage carton (Woodlands Dairy) and LW				
Closures for beverage carton (NP Closures)	1.642	1.642	1.642	kg
Printed carton blanks(at Elopak)	27.913	27.913	26.517	kg
Corrugated board, recycling fibre, single wall	7.98	7.98	7.98	kg
EUR-flat pallet	4.17E-02	4.17E-02	4.17E-02	p

LDPE ETH S	0.625	0.625	0.625	kg
Was transport lorry 16-32t EURO 3	1.6305	1.6305	1.6305	tkm
Was transport lorry 16-32t EURO 3	29.59	29.59	27.98	tkm
Was transport lorry 16-32t EURO 3	0.1667	0.1667	0.1667	tkm
Was transport lorry 16-32t EURO 3	0.005	0.005	0.005	tkm
Was transport lorry 16-32t EURO 3	0.075	0.075	0.075	tkm
Closures for beverage carton (NP Closures)				
HDPE ETH S	0.721	0.721	0.721	kg
Was transport lorry 16-32t EURO 3	0.0181	0.0181	0.0181	tkm
Transport oceanic freighter OCE S	2.8119	2.8119	2.8119	tkm
LDPE ETH S	0.979	0.979	0.979	kg
Was transport lorry 16-32t EURO 3	0.024475	0.024475	0.024475	tkm
Transport oceanic freighter OCE S	3.8181	3.8181	3.8181	tkm
Was transport lorry 16-32t EURO 3	0.18782	0.18782	0.18782	tkm
Was transport lorry 16-32t EURO 3	0.255	0.255	0.255	tkm
LDPE ETH S	0.006	0.006	0.006	kg
EUR-flat pallet	4.63E-04	4.63E-04	4.63E-04	p
Corrugated board	0.0694	0.0694	0.0694	kg
Was transport lorry 16-32t EURO 3	0.00006	0.00006	0.00006	tkm
Was transport lorry 16-32t EURO 3	0.00000463	0.00000463	0.00000463	tkm
Was transport lorry 16-32t EURO 3	0.00347	0.00347	0.00347	tkm
LPG	1	1	1	kg
Electricity mix ZA	6	6	6	kWhr
Waste to recycling	0.084	0.084	0.084	kg
Swiss waste treatment PE	0.057	0.057	0.057	kg
Printed carton blanks(at Elopak) end June				
Liquid Packaging board	28.888	28.888	27.444	kg
Was transport lorry 16-32t EURO 3	3.46656	3.46656	3.293232	tkm
Transport oceanic freighter OCE S	408.938528	408.938528	388.4916016	tkm
Kraft paper unbleached at plant RER S	0.1485	0.1485	0.1485	kg
EUR flat pallet	7.81E-03	7.81E-03	7.81E-03	p

LDPE ETH S	0.105	0.105	0.105	kg
Was transport lorry 16-32t EURO 3	0.001188	0.001188	0.001188	tkm
Was transport lorry 16-32t EURO 3	9.37E-04	9.37E-04	9.37E-04	tkm
Was transport lorry 16-32t EURO 3	0.0126	0.0126	0.0126	tkm
Paper recycling no deinking at plant RER S	0.008775	0.008775	0.000833545	kg
Kraft paper unbleached at plant RER S	0	0	0	kg
electricity Mix ZA	2	2	1.9	kWh
LPG 1	0.011	0.011	0.01	kg
Waste to recycling	0.975	0.975	0.926	kg