EVALUATING POST-CONSUMER METAL PACKAGING RECOVERY SYSTEMS IN SOUTH AFRICA

by

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APPROVED FOR EXAMINATION

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Kishan Singh

01 July 2024

DEDICATION

This dissertation is dedicated to all those in my personal and professional life, who have been supportive and encouraging, during my studies for my degree in the Doctor of Philosophy Management Sciences in Business Administration.

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ABSTRACT

This thesis evaluated the post-consumer metal packaging recovery systems in South Africa (SA) against the backdrop of existing environmental management legislation and international best practices. It also examined the factors influencing the recovery of post-consumer metal packaging in SA, aligning with the recent Extended Producer Responsibility (EPR) obligations, circular economy principles and sustainable development theory.

The SA packaging industry generates approximately 3.5 million tons of packaging annually, representing an economic value of approximately R100 billion, contributing 1.5% to the SA national Gross Domestic Product (GDP) in 2022. The metal packaging segment, valued at R7.8 billion, exerts a substantial influence on the overall packaging value in South Africa's packaging industry.

In accordance with the compliance regulations set by the Department of Forestry, Fisheries and Environment (DFFE) in South Africa, the metal packaging industry is required to submit annual reports on the recovery of post-consumer metal packaging. These reports must demonstrate a year-on-year post-consumer metal packaging recovery growth of 2%, starting from the 2022 baseline target of 59% and continuing to 67% by 2026.

The actual post-consumer metal packaging recovery was reported as 53.5% for the year 2022, indicating a gap of 5.5% from the target. Given the projection of metal packaging placed on the SA market, against the projected post-consumer recovery rate, this gap is expected to widen to 9.19% by 2024.

The study therefore aimed to propose a model that will improve the recovery and recycling rates, as well as the data reporting integrity, of post-consumer metal packaging in SA, enhancing the metal packaging circular economy, aligning with global sustainable development principles and South African legislation.

This study explored, through a systematic literature review (SLR), the global best practices relating to post-consumer metal packaging recovery, considering the current challenges on metal recovery, coupled with an understanding of the local converter/brand-owner and metal recycler commitment to metal recovery and recycling in SA.

The SLR was complemented with two qualitative surveys to determine the foundational elements of the proposed model. The SLR adopted rigorous search criteria, and restricted the research to the past eight years, to maintain technical relevance, thus ensuring that the latest technology and business knowledge is addressed. The qualitative research, built upon the SLR findings, deployed two sets of open-ended questionnaires that were used to interview key converter/brand-owners and metal recyclers in South Africa, capturing responses through focused, semi structured discussions. The findings of this study indicate that SA is not aligned with global best practices with respect to post-consumer metal packaging recovery.

The researcher proposed a robust post-consumer metal packaging recovery model for South Africa, leveraging Industry 4.0 technology, design for recycling (D4R) principles, synchronised deposit return systems (DRS), supported by unmanned aerial vehicles (UAV), to sustainably increase post-consumer metal packaging recovery volumes. This model, in alignment with international best practices, provides accurate and reliable data to illustrate the circular economy (CE) of metal, aiming to improve the recovery of metal packaging in SA, supporting the EPR compliance obligations and sustainability development principles within SA.

The recommendations derived from this research could have broader applications in other packaging substrates, both domestically and internationally, if they are adapted to the specific context of the respective industries.

Keywords

Sustainable development, circular economy, industry 4.0, extended producer responsibility, post-consumer metal packaging recovery, metal recycling, deposit return schemes, waste to energy.

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LIST OF ABBREVIATIONS AND ACRONYMS

3R	Reduce, Re-use, Recycle
4IR	Fourth Industrial Revolution
5IR	Fifth Industrial Revolution
6R	Reduce, Re-use, Recycle, Recover, Redesign, Remanufacture
AGM	Annual General Meeting
AMS	Automatic Material Separation
ANNEX SL	Annexure Statutory Limits
ARO	African Reclaimers Association
BBBEE	Broad-Based Black Economic Empowerment
BBC	Buy Back Centre
BMi	Business Management insight
BOPP	Biaxially Orientated Polypropylene
CE	Circular Economy
CGCSA	Consumer Goods Council of SA
CIPC	Companies and Intellectual Property Commission
Co	Cobalt
CO_2	Carbon di-oxide
COVID-19	Corona Virus Disease of 2019
Cr	Chromium
CSIR	Council for Scientific and Industrial Research
CSR	Corporate Social Responsibility
D4R	Design for Recycling
DfD	Design for Disassembly
DFFE	Department of Environment, Forestry and Fisheries

DNA	Deoxy-riboNucleic Acid
DRS	Deposit Return Scheme
e	Estimated
EAF	Electric Arc Furnace
EDS	Electrodynamic sorting
EMS	Environmental Management System
EOL	End of Life
EPR	Extended Producer Responsibility
EU	European Union
f	Forecast
GDP	Gross Domestic Product
GE	Green Economy
GG	Government gazette
GHG	Greenhouse Gas
GS1	Global Standards 1
GTFP	Green Total Factor Productivity
HLS	High Level Structure
IIoT	Industrial Internet of Things
IoT	Internet of Things
IPSA	Institute of Packaging SA
IR	Industrial Revolution
ISO	International Organisation for Standardisation
IT	Information Technology
kg	Kilograms
KPI	Key Performance Index
LCA	Life Cycle Assessment

LIBS	Laser Induced Breakdown Spectroscopy
M	Manufacture
MetPac-SA	Metal Packaging South Africa
MIBA	Municipal Incinerated Bottom Ash
MIS	Magnetic Induction Spectroscopy
Mn	Manganese
Mo	Molybdenum
MRA	Metal Recycler Association
MRF	Material Recovery Facility
Nb	Niobium
NDP	National Development Plan
NEMWA	National Environment Management: Waste Act
NGO	Non-Government Organisation
Ni	Nickel
NVivo	Qualitative analysis software
NWMS	National Waste Management Strategy
NWMS	The National Waste Management Strategy
^{o}C	Degree Celsius
PACE	Platform for Accelerating the Circular Economy
para	Paragraph
PCR	Post Consumer Re-grind
PETCO	Polyethylene terephthalate Company
PM	Pre-Manufacture
POLYCO	Polyolefin Company
POPIA	Protection of Personal Information Act
PP PRO Alliance	Paper and Packaging Producer Responsibility Organisation Alliance

PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analysis
PRO	Producer Responsibility Organisation
PSA	Packaging South Africa
PU	Post-Use
R&D	Research and Development
ReSOLVE	Regenerate, Share, Optimise, Loop, Virtualise, Exchange
S@S	Separation at Source
S18	Section 18 of NEMWA
SA	South Africa
SALGA	South African Local Government Association
SAWPA	South African Waste Picker Association
SCM	Supply Chain Management
SD	Sustainable Development
SDG	Sustainable Development Goal
SLR	Systematic Literature Review
SMB	Sustainable Business Model
SRI	Social Responsibility Index
TBL	Triple Bottom Line
U	Use
UAV	Unmanned Aerial Vehicle
UK	United Kingdom
UN	United Nations
UNEP	United Nation’s Environment Programme
V	Vanadium
VOC	Volatile Organic Compound

WCED	World Commission on Environment and Development
WEEE	Waste of Electrical and Electronic Equipment
WEF	World Economic Forum
WFD	Waste Framework Directive
WtE	Waste to Energy
WTP	Willingness to Pay
www	world wide web
ZAR	Zuid Afrikaanse Rand

CHAPTER ONE
INTRODUCTION BACKGROUND AND CURRENT SCENARIO

1.1 Introduction

This study explored the challenges in post-consumer metal packaging recovery systems in South Africa (SA), against current legislation and global best practices, and reviewed the contributing factors that influence post-consumer metal packaging recovery in SA, in alignment with sustainable development theory. Post-consumer packaging refers to packaging that becomes unwanted after the contents have been used by the consumer.

This introductory chapter presents the study context, which provides the background to the research. The chapter presents the research problem, the research justification, the research aim, objectives and questions and outlines the research methodology for the study.

This chapter also highlights the significance of the study, the delimitations and limitations of the study, the conceptual and empirical frameworks, the ethical protocols and concludes with an outline of the rest of the chapters comprising this thesis.

1.2 Context of the study

This study is located within the South African (SA) packaging industry, with a specific focus on post-consumer metal packaging recovery and re-use. Annual post-consumer metal packaging recovery is the ratio of the tonnage of post-consumer metal packaging recovered after use, against the tonnage of metal packaging placed in the economy in that year (South Africa. Department of Forestry, Fisheries and Environment 2020: 10).

This study, through the lens of the SA packaging industry, was aimed at understanding current post-consumer metal packaging recovery systems, as well as the barriers to higher post-consumer metal packaging recovery rates in SA, against the backdrop of social, economic, and legislative challenges prevalent in SA.

A detailed view into the size, scale, economic value, employment potential, business complexity as well as the challenges and opportunities within the SA packaging industry and its supply chain infrastructure is presented in Chapter Two. However, some pertinent facts are presented here as introductory insights.

The total volume of combined aluminium and steel packaging, placed within the SA economy in 2022 was reported as 184 000 tons, and this represented an annualised value of R7.8 billion (Braithwaite and Musingadi 2023: 23). The recovery of post-consumer aluminium and steel packaging was reported at 53.5% in 2022 (Braithwaite and Musingadi 2023: 10).

1.3 Research problem

Since the Department of Forestry, Fisheries and Environment (DFFE) gazetted the Extended Producer Responsibility (EPR) legislation on 05 November 2021, the SA packaging industry was obliged to demonstrate year-on-year improvement in post-consumer packaging material recovery and re-use (Packaging SA 2023: para. 1 line 2; Modise 2023: 1).

The DFFE target for post-consumer metal packaging recovery was 59% in 2022, incrementally increasing to 67% in 2026 (South Africa. Department of Forestry, Fisheries and Environment 2023: 14). For context, the DFFE target of 59%, in 2022, was below the 2021 European benchmark of 78.5% (Rivers 2023:1). The researcher notes that the SA metal packaging recovery rate was significantly below the European benchmark.

The actual post-consumer metal packaging recovery was reported as 53.48% or 98 403 tons recovered against 184 000 tons that were placed on the SA market in the year 2022, indicating a gap of 5.52% from the DFFE target (Braithwaite and Musingadi 2023: 10). Given the projection of metal packaging placed on the SA market against the post-consumer recovery rate, this gap will widen to reach 9.19% by 2024 (Braithwaite and Musingadi 2023: 10; South Africa. Department of Forestry, Fisheries and Environment 2023: 14). Failure to achieve the DFFE metal recovery targets could result in penalties being imposed by the DFFE, on the SA metal packaging industry, to the extent of business closure (South Africa. Department of Forestry, Fisheries and Environment 2023: 11).

The researcher notes that, given the current post-consumer metal packaging recovery systems in SA, the DFFE metal packaging recovery targets will not be achieved, unless robust metal packaging recovery interventions are introduced to close the projected gap of 9.19%. This research problem is further discussed and well-illustrated in Chapter Two.

1.4 Research justification

The current SA post-consumer metal packaging recovery practice is largely dependent on unemployed, informal waste pickers across the country, and this renders the practice unsustainable (Council for Scientific and Industrial Research 2017: 26). Hence, it can be seen from the preceding statement that the metal packaging industry is benefitting largely from the use of unemployed, informal waste-pickers for post-consumer metal packaging recovery and could therefore be viewed as negligent in terms of its social responsibility.

Despite the intrinsic value of metal, underpinned by high recyclability without any loss of properties, as posited by Deshwal and Panjagari (2020: 2377), the post-consumer recovery of metal packaging in SA, over the past 20 years, has plateaued with little or no future growth anticipated (Braithwaite, Groenewaldt, Kruger, Padgett, Scholtz, and Smith 2021: 10).

Chapter Two will illustrate the South African post-consumer metal packaging recovery data, spanning from 2020 ‘actual’ to the projected figures for 2024. It will also highlight the significant 9.19% disparity between the actual recovery statistics and the gazetted DFFE target.

Therefore, the researcher notes that, to meet the DFFE post-consumer metal packaging recovery targets, an effective post-consumer metal packaging recovery model is required to increase the recovery and re-use of metal packaging, creating a circular economy, aligned with global best practices.

1.5 Aim of the study

The study aimed to propose a model that will improve the recovery and recycling rates, as well as the data reporting integrity, of post-consumer metal packaging in SA, enhancing the metal packaging circular economy, aligning with global sustainable development principles and South African legislation.

1.6 Objectives of the study

The research objectives of this study were:

i. To ascertain the global best practices with respect to post-consumer metal packaging recovery models by conducting a systematic literature review.
ii. To evaluate the current South African post-consumer metal packaging recovery model against global best practice models by deploying two qualitative surveys.
iii. To determine the reliability of the current South African post-consumer metal packaging data acquisition and reporting systems by deploying two qualitative surveys.
iv. To determine the converter/brand-owner commitment to post consumer metal packaging recovery within SA by deploying two qualitative surveys.
v. To develop a sustainable model for the post-consumer metal packaging recovery system in SA, that supports job creation and transformation.

1.7 Research questions

The research questions that emanated from the aim of the study were:

i. What are the global best practices relating to post-consumer metal packaging recovery?
ii. How effective is the post-consumer metal packaging recovery model in SA?
iii. How accurate and reliable are the South African post-consumer metal packaging data acquisition and reporting systems?
iv. To what extent are the South African metal packaging value chain stakeholders committed to post-consumer metal packaging recovery?

v. How can re-modelling the post-consumer metal packaging recovery system support job creation and transformation?

1.8 Theoretical framework

The relationships of the theoretical aspects that governed the conceptual framework that was used in the study are illustrated in figure 1.1.

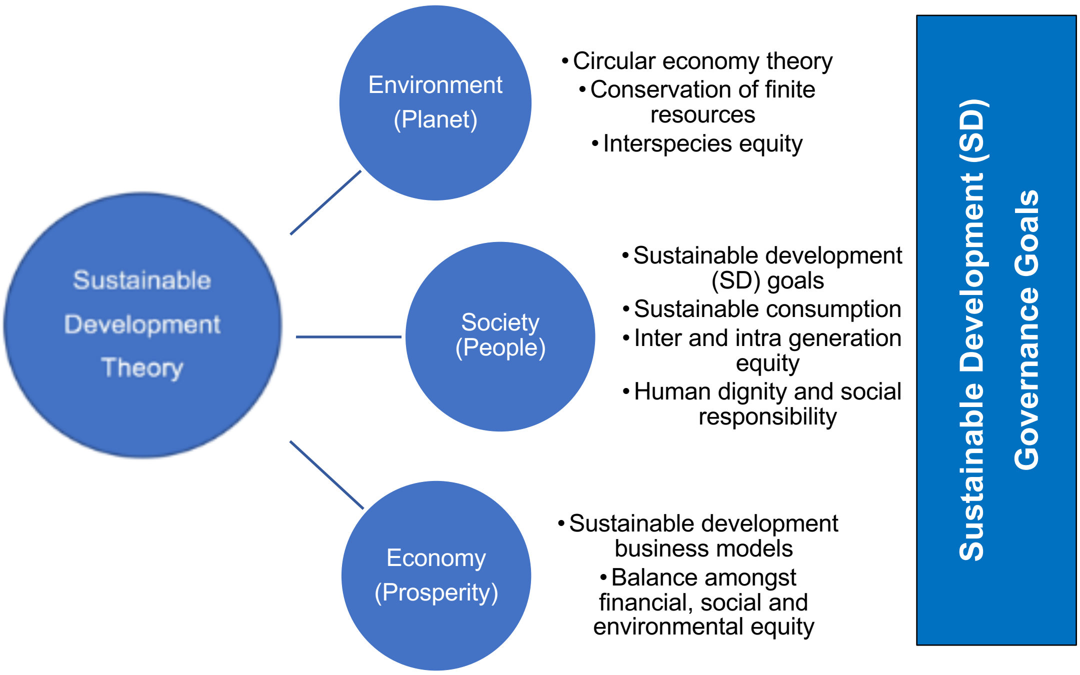

Figure 1.1: Theoretical framework

Source: Adapted from Shi, Han, Yang and Gao (2019: 9).

The study was underpinned by sustainable development (SD) theory as propounded by Shi, Han, Yang and Gao (2019: 9), reinforcing the need for a triple bottom line approach that is driven and guided by overarching sustainable development governance goals.

1.9 Conceptual framework

The conceptual framework that informed the study is shown in figure 1.2. This framework introduced the relationships of the various packaging value chain stakeholders, the pressure points as a result of the Extended Producer Responsibility (EPR), embedded in Section 18 of the National Environment Management: Waste Act (NEMWA), Act 59 of 2008, the pivotal role of the Producer Responsibility Organisation (PRO) and the anticipated sustainable development outcome, as discussed in the legal framework study of EPR by the World Wildlife Fund (Coleman 2019: 13).

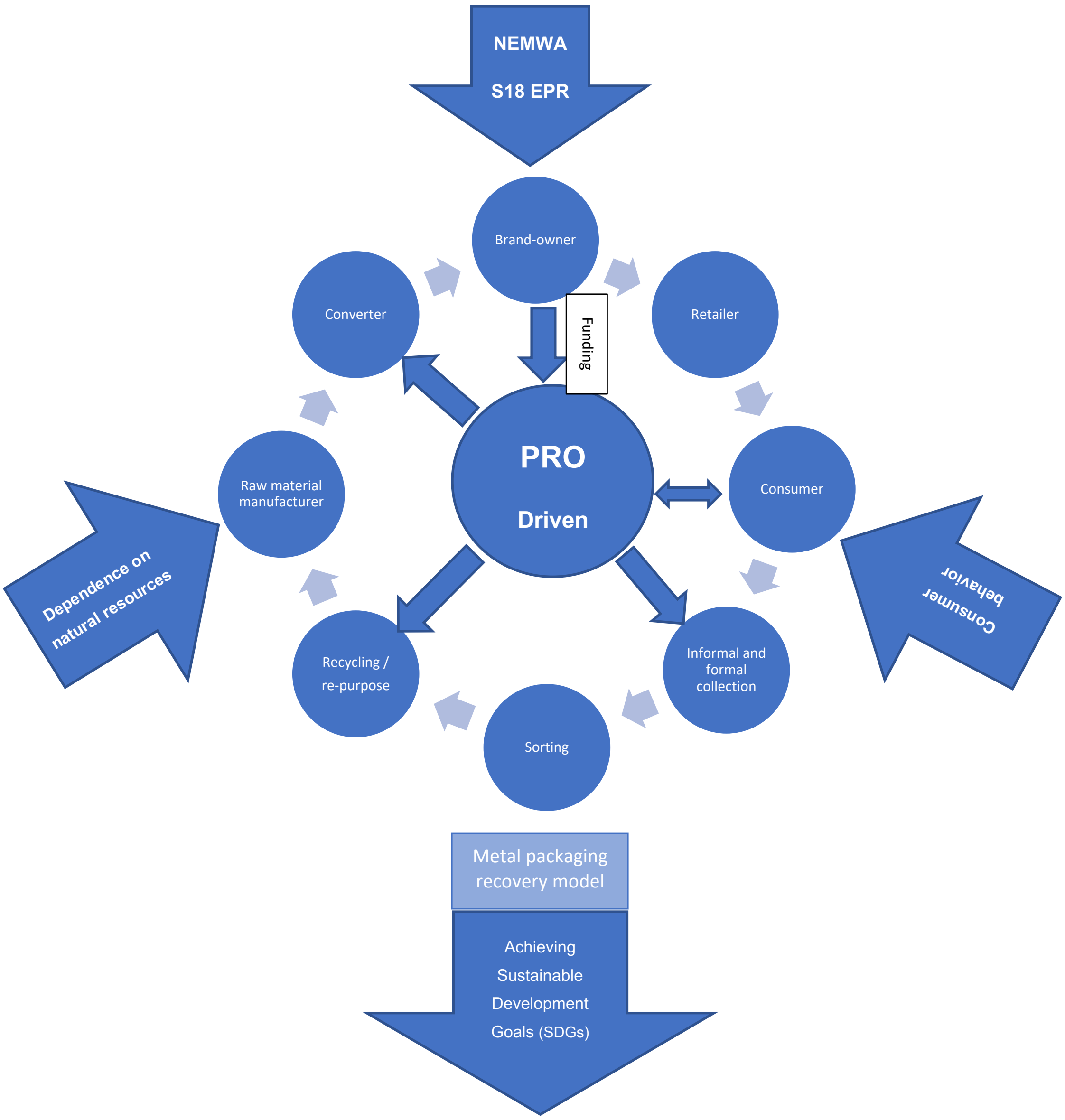

Figure 1.2: Conceptual framework

Source: Researcher's own construction

The study determined the sustainable development goal commitment of the various stakeholders of the packaging value circle, as depicted in the conceptual framework in figure 1.2, as well as the roles of the formal and informal post-consumer packaging recovery systems that support post-consumer metal packaging recovery, in alignment with sustainable development goals.

1.10 Research methodology

This study was founded upon the pragmatism philosophy and deployed a combination of a systematic literature review, coupled with qualitative survey data from brand-owners, as well as metal recyclers, that was analysed and interpreted to develop a post-consumer recovery model to achieve the DFFE metal packaging recovery targets as articulated in Government Gazette (GG) 48527 (South Africa. Department of Forestry, Fisheries and Environment 2023: 14).

Pragmatism, as a research paradigm, avoids engaging with controversial metaphysical concepts like truth and reality. Instead, it acknowledges the possibility of one or multiple realities that are subject to empirical investigation (Kaushik and Walsh 2019: 255). Scholars following the pragmatist approach assert the existence of an objective reality independent of human experience; nevertheless, they emphasise that this reality is intricately connected to the environment and can only be apprehended through human experiences (Kaushik and Walsh 2019: 255).

1.10.1 Research design

Research design is a vital element of a study and must be seen as the planned structure of research and as the substratum that holds all the elements in a research project together (Akhtar 2016: 68).

The research design process, Akhtar (2016: 70), can be staged as follows:

i. Defining the problem to be studied;
ii. Framing research design;
iii. Planning a sample (probability or non-probability, or combination of the two);

iv. Collecting the data;
v. Analysing the data (editing, coding, processing, tailgating) and
vi. Preparing the report.

The types of research designs vary depending on the nature of the study and the expected outcome of the study. The following figure 1.3 reflects the typical research design types.

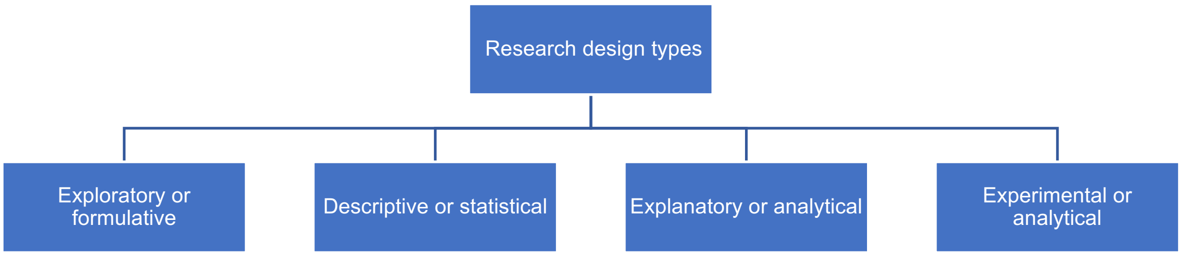

Figure 1.3: Research design types
Source: Akhtar (2016: 73)

This study deployed an exploratory research design as this is the primary stage of research and the purpose of this research was to achieve new insights into post-consumer metal packaging recovery and re-use in South Africa. Exploratory studies are usually more appropriate in cases where there is little research knowledge available on the subject matter (Akhtar 2016: 73).

1.10.2 Research approach

The study adopted an SLR, supported by two independent qualitative surveys exploiting a cross-sectional research approach through the metal packaging converter/brand-owner and the metal recycling sectors in SA.

1.10.2.1 Systematic literature review

This study deployed a systematic literature review to ascertain the global best practices with respect to post-consumer metal packaging recovery models currently in use. In the works of Kraus, Breier and Dasí-Rodríguez (2020:1023), it is noted that systematic literature review (SLR) is a popular research methodology for reviewing historically published literature, to bring the field closer together and to derive logical and significant patterns to develop new or extended theory. A systematic literature review attempts to answer a specific research question, Kraus, Breier and Dasí-Rodríguez (2020:1033), and, in the context of this study, the research question is:

> *"What are the global best practices relating to post consumer metal packaging recovery?"*

The systematic literature review was driven by the above research question and therefore generated data and trends that were used in the interpretation and analysis of the study to contribute to the development of a business model for effective post-consumer metal packaging recovery and recycling. Search protocols were informed by specific key words and key phrases that triggered search results for a comparable objective analysis. Selected databases were targeted to ensure a cross spectrum field of research. Research criteria included country specific producer responsibility organisation activities, post-consumer metal recovery trends, extended producer responsibility fees, statutory and regulatory impositions, and governmental interventions. Search screening deployed journal article titles, abstracts, as well as full texts, and the research timeframe was aligned predominantly to the past six years of study, ensuring relevance, thereby avoiding excessively outdated information.

Recurring themes and subthemes were analysed to ascertain underlying global trends relating to post-consumer metal packaging recovery. Nowell, Norris, White and Moules (2017: 8) posited that a theme is defined as *"an abstract entity that brings meaning and identity to a recurrent experience and its variant manifestations and, as such, a theme captures and unifies the nature or basis of the experience into a meaningful whole."*

1.10.2.2 Qualitative analyses

The results of the systematic literature review were supported by two further qualitative surveys to generate views and responses across critical stakeholders within the metal packaging value chain in South Africa, in response to the study objectives and research questions.

The qualitative research method involved the collection of response information through interviews and observations (Sekaran and Bougie 2016: 409). Two sets of open-ended interview questions were used for the qualitative research to obtain the following information in pursuit of fulfilling the research objectives:

i. Converter/brand-owner views on post-consumer metal packaging recovery, including data accuracy and system reliability, metal packaging triple bottom line, sustainable development and

ii. Metal recycler views on practical metal recovery systems, and reporting, as well as their commitment to the metal circular economy and sustainable development philosophies.

Qualitative analysis credibility must be demonstrated through validity and reliability, as posited by Spiers, Morse, Olson, Mayan and Barrett (2018: 2), supported by Bazeley (2013: 32). The analysis and interpretation techniques, deployed in this study, guided by qualitative research methods, aligned with the principles of validity and reliability, demonstrating credibility. Themes and subthemes arising out of such interviews were also identified and analysed, using descriptive analyses to identify trends.

1.10.3 Population

According to the minutes of Metal Packaging SA's 2023 Annual General Meeting (AGM), the estimated population of metal converter/brand-owners in SA was 80 in 2023 (Board Committee 2023:1).

The number of metal recyclers that are members of the Metal Recyclers Association (MRA) in SA is 131, and these members collectively recycle approximately 70% of the total metal recycled in SA (Starkey 2023:1). In addition, the Get Metal Group, not a member of MRA, represents approximately 10% of the total metal recycled in SA (Nadar 2023: 5).

The researcher notes that this brings the population representation of this study up to 80% of the metal recycled in SA.

1.10.4 Sampling

For qualitative studies, a minimum of 18-20 interviews is recommended for comparative and saturation adequacy (Given 2008: 195; Leavy 2017: 77). Therefore, a sample size of 18 interviews for each of the two qualitative studies, a total of 36 interviews, stratified across the main provinces of South Africa, was considered satisfactory and manageable, given the time frame and available budget.

The two qualitative studies generated responses that were collected through personal interviews. Such interviews were conducted with key converters/brand-owners and metal recyclers within the South African packaging industry to determine the levels of commitment to post-consumer metal packaging recovery and recycling, supporting sustainable development principles.

Industry experts, academic experts, and a statistician in the field of qualitative analyses validated the researcher's analysis, interpretation and results arising out of this study.

1.11 Significance of this study

This study was undertaken to ensure that the SA metal packaging industry is geared to address the forthcoming DFFE packaging legislative requirements. The study therefore explored the socio-economic and environmental needs and challenges of the SA packaging industry, the current DFFE metal packaging recovery targets, the global best practices relating to post-consumer metal packaging recovery, and the commitment of the South African metal packaging industry to achieve the DFFE targets.

The study consequently served to propose a resilient business model for post-consumer metal packaging recovery, accurate and reliable data reporting, as well as the recycling of post-consumer metal packaging in SA, to enable greater circularity of metal, aligning with SA legislation and the following United Nation's Sustainable Development Goals (SDGs):

i. SDG1 – No poverty;
ii. SDG3 – Good health and well-being;
iii. SDG4 – Quality education;
iv. SDG8 – Decent work and economic growth and

v. SDG13 – Climate action.

This study, through the propagation of a metal packaging circular economy, will result in job creation, entrepreneurship, Broad-based Black Economic Empowerment (BBBEE), and transformation in SA.

This business model may then be adopted by the South African metal packaging industry to enhance the current post-consumer metal packaging recovery and recycling, so that the value of the research output can be realised within the South African economy, while aligning with the above SDGs.

1.12 Delimitations of the study

Delimitations are the boundaries or parameters set by the researcher to intentionally narrow the scope of the study (Creswell and Creswell 2018: 180).

This study is restricted to the circularity of the metal packaging value chain within the SA packaging industry. Thus, this study encompassed the SA legislative inputs, the various stakeholders within the metal packaging value chain, the metal packaging PRO and its EPR strategy, as well as the roles and demands of the consumer, to propose a resilient business model that will enhance the recovery and recycling of post-consumer metal packaging.

MetPacSA reported that in 2023, the estimated population of metal packaging converter/brand-owners in SA was approximately 80 (Board Committee 2023:1). At that time, MetPacSA accounted for 67 converter/brand-owners, representing more than 82% of the annual metal packaging tonnage placed in the country (Board committee 2023: 1). Hence, as the focus is on the MetPacSA membership's target population, this study excludes metal packaging stakeholders who account for less than 20% of the total annual metal packaging tonnage placed in the South African economy, because this sector is deemed minor. Consequently, the research will concentrate on the significant 80% of annual metal packaging tonnage in South Africa, recognised as the critical mass.

Also excluded from the study are all non-packaging metals that are recovered and recycled in SA as this does not constitute an *"identified product"* as defined by the

Department of Forestry, Fisheries and the Environment (DFFE), (South Africa. Department of Forestry, Fisheries and Environment 2020: 6).

The study does not directly focus on packaging business strategy, market shares or capital funding although, given the business improvements resulting from this study, such areas will be influenced indirectly. This study does not directly consider the socio-political scenarios within SA, although, given the business improvements resulting from this study, such areas will be influenced indirectly.

1.13 Limitations

Limitations are the shortcomings or weaknesses in a research study that may impact the validity and generalisability of the outcome (Creswell and Creswell 2018: 262).

The limitation in this study was setting up the interviews with the targeted stakeholders because of their tight schedules.

The performance statistics of the packaging industry discussed in this thesis pertain to data up until the conclusion of 2022. Performance statistics for the year 2023 will only become accessible in June 2024.

The outcome of this study is applicable to the metal packaging sector of the SA packaging industry. Recommendations arising from this study may also be applicable to other packaging substrates both locally and globally, provided that the recommendations are contextualised within the specific industry.

While the topic of this research can be generalised across the packaging substrates prevalent in South Africa, this research focused primarily on the recovery and circular economy of post-consumer metal packaging in South Africa.

1.14 Ethical consideration

This research was subjected to approval by the DUT Institutional Research Ethics Committee, prior to the commencement of the empirical phase of the study. The details relating to ethical considerations are presented in Chapter Four, Research Methodology.

The ethical aspect of the study preserved the identity of the participants. Participation in this study was voluntary, and all information collected during the research project is confidential. The data collected was used primarily for academic purposes, but a copy of the thesis will be available to the SA packaging industry for the application of the recommendations.

1.15 Structure of the thesis

Chapter One introduces the topic, addresses the aim and objectives of the research, discusses the problem statement, the research methodology, the conceptual and theoretical frameworks, the delimitations and limitations of the study, and concludes with the benefits of the study.

Chapter Two provides the literature review, contextualising the SA packaging industry, demonstrating the economic influence of the packaging industry on the SA GDP, and presents the split of the packaging industry substrates, by value and volume. The current challenges and opportunities, because of legislation related to Section 18 of National Environmental Management Waste Act (NEMWA), is unpacked and discussed against the topography of the SA packaging industry.

Chapter Three presents the theoretical and empirical literature review of the environmental impact of the industrial revolutions since the 1760s, the consequential drive for sustainable development and circular economies, the value of recovery and re-use of metal packaging and the alternative applications of recovered metal packaging. This chapter also explores sustainability development theories, carbon footprint impact, the functions of PROs, EPR, material recoveries, global legislation versus SA legislation, 6R’s, waste to energy, packaging designed for sustainability and concludes with a short discussion on Unmanned Aerial Vehicles (UAV’s) as a possible mechanism to recover packaging from remote, rural locations.

Chapter Four addresses the research methodology, covering the research aim and objectives, the research paradigm, the research design, the research approach and sampling plans, the logic behind the research instruments, the data analysis techniques, data triangulation, research validity and trustworthiness. The chapter concludes with a discussion on the limitations and ethical considerations of the research.

Chapter Five focuses on the Systematic Literature Review (SLR) of global benchmarks of the best practices related to post-consumer metal packaging recovery and provided an objective view of practical successes achieved by other countries, with the view of adapting such models in SA. This chapter delves into global metal recovery systems, and explores practical models of metal packaging recovery, in support of circular economies. References to prior research, academic papers and textbooks formed the basis for this discussion. A total of 26 SLR themes were identified from the data, and these were reconciled with the five research questions.

Chapter Six addresses the qualitative analyses, reviewing research instruments, the participant's biographical data, the response data analysis and interpretation. The chapter identifies the themes and subthemes that arose from the qualitative analyses and presents the findings of the qualitative research.

Chapter Seven presents the summary of findings, and recommendations, and proposes a logical business model for effective post-consumer metal packaging recovery, benchmarked against global best practices, aligning with the expectations of current South African EPR legislation, supporting the principles of sustainable development. The chapter provides a well-considered conclusion to the research and includes a thorough financial costing of the proposed post-consumer metal packaging recovery model.

1.16 Conclusion

This chapter provided the context of this study, the aim and objectives of this study, as well as the empirical and conceptual framework underpinning this study. This chapter also presented the research methodology framework, highlighting the research questions and outlined the delimitations as well as the limitations of the research study. Additionally, the benefit to the SA metal packaging industry, relating to this study was pointed out, and it was clarified that the recommendations arising out of this study may be extrapolated to other industries locally and globally, within context.

The following chapter contextualises the South African packaging industry against the backdrop of the recent South African EPR legislation, providing an appreciation of the challenges facing the industry.

CHAPTER TWO
CONTEXTUALISING THE PACKAGING INDUSTRY IN SOUTH AFRICA

2.1 Introduction

This chapter reviews the current landscape of the South African packaging industry and its contribution to the South African economy. A detailed examination of the SA packaging industry's background will contribute context and magnitude to this research. It is essential to highlight that the packaging statistical reference materials used in this chapter were drawn mainly from SA-specific packaging statistical reports, journals and publications, across the last five years, reflecting a limited number of research authors on the subject of South African packaging statistics, due to the specialised nature of the SA packaging sector.

This chapter presents a comprehensive perspective on the dimensions, magnitude, economic significance, employment prospects, business intricacies, as well as the obstacles and prospects inherent in the SA packaging industry and its multiple supply chain networks.

2.2 The SA packaging sector context

To provide context for the South African (SA) packaging sector, table 2.1 below, illustrates the total value (in ZAR) and volume (in tonnage) of the South African packaging gross domestic product (GDP) in 2022.

Table 2.1 reflects the split contribution of the different mainstream packaging material substrates to the SA packaging economy, factoring in imports and exports, in 2022.

Table 2.1: Tonnage and rand value of packaging material substrates

Packaging substrate	Tonnage (000s)	% Volume split	R Million	% Value split
Glass	1 140	32.1%	11 635	11.7%
Metal	184	5.2%	7 794	7.9%
Paper	1 213	34.1%	35 626	35.9%
Plastic	876	24.7%	43 460	43.8%
Other packaging	141	4.0%	751	0.8%
Total	**3 554**	**100%**	**99 266**	**100%**

Source: Adapted from Braithwaite and Musingadi (2023: 6)

Table 2.1 illustrates that in 2022, the South African packaging industry, with a combined volume of approximately 3.5 million tonnes, accounted for a total value of R99 266 million (R99.27 billion).

In comparison to the SA national GDP, it can be concluded that the SA packaging sector contributed 1.5% to the SA national GDP of R 6 628 billion, (Trading Economics 2023: 2).

The metal packaging sector of the mainstream packaging substrates account for approximately 184 000 tons of the overall packaging volume in SA, representing a significant R7. 8 billion, equivalent of 0.2% of the SA national GDP, clearly demonstrating the context of the study (Trading Economics 2023: 2).

The year-on-year packaging volume growth from 2017 to 2018 was 1.6% and the total year-on-year package value growth, from 2017 to 2018 was 7.7%, and although the volume and value growth from 2018 to 2019 remained largely unchanged from the previous year, the industry indicated a significant drop in volume and value in 2020 (Braithwaite, Groenewaldt, Kruger, Padgett, Scholtz and Smith 2021: 6). This is due to the trade restrictions imposed by the COVID-19 lockdown in 2020 (Braithwaite *et al.* 2021: 20).

2.3 Trends in the South African packaging sector

Figure 2.1 illustrates the percentage change in volume, by packaging substrate, from 2020 to 2021.

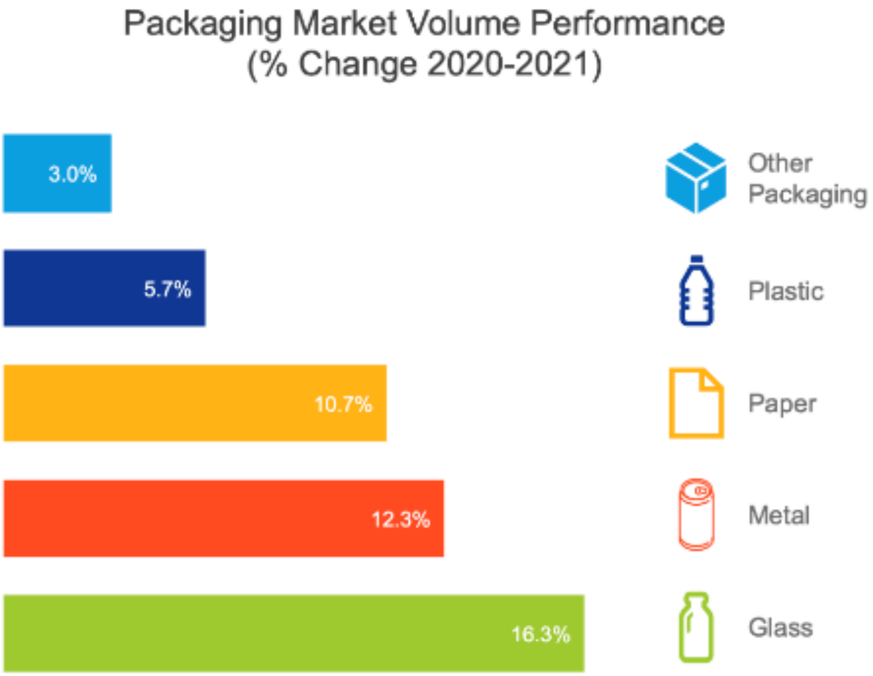

Figure 2.1: Percentage change in volume, by packaging substrate, 2020 to 2021
Source: Adapted from Braithwaite and Musingadi (2022: 8)

According to the 2022 South African packaging statistics report by Braithwaite and Musingadi (2022: 6), the following points are relevant with respect to figure 2.1:

i. In 2021, the glass packaging sector demonstrated a 16.3% year-on-year volume growth, the highest growth rate of the substrates, because it had the most volume to recover after alcohol sales bans affected this sector during the COVID-19 pandemic, and the metal packaging sector showed the second highest year-on-year growth of 12.3%, signalling the South African market's preference for this substrate, given its ease of post-consumer recovery and re-utilisation and
ii. In 2021, the metal packaging industry experienced a 12.3% increase in volume, primarily propelled by elevated demand for beverage cans, including stable food cans and other metal packaging, while the 61.7% rise in value was attributed to significant raw material price surges, limiting margin expansion across the raw material and converter sectors due to challenges in passing these increases along the value chain.

Further reflections by Braithwaite and Musingadi (2023: 10) in their 2023 South African packaging statistics report are as follows:

i. Metal crowns and closures reflected an averaged volume shift relative to the other metal categories, increasing by 6.6% in 2021, with a drop of 5.5% expected in 2022, as drums lost volumes in 2022. Some volume growth will be retained by the ongoing demand for wine and spirits closures in the beverages sector;
ii. The metal industry decreased by 0.7% in volume and increased by 3.9% in value terms in 2022. The metal market volume declines were driven by supply constraints in the drum sector, balanced by conservative sales in the cans sector, as the food services sector continued to recover, alcoholic as well as non-alcoholic beverages benefited. Some of the production, however, is now in stock leading to an expected more subdued market in the coming year;
iii. Metal drums and pails showed a volume drop of 10.0%, hampered by supply constraints and price increases. Exports into the rest of Africa are an important part of the market and these exports remain lower than historical levels and
iv. Metal crowns and closures reflected a volume decline of 1.6% relative to a value decline of 3.5%, with the decline minimised by increases in the glass category that buoyed up the closure sales. Minor growth of 0.9% is expected for 2023, with modest growth in the medium term. Much of the volume growth will be obtained by the ongoing demand for wine and spirits closures in the beverages sector.

Table 2.2 indicates the per capita consumption of packaging in SA (Cowling 2023: 1).

Table 2.2: Per capita consumption of packaging in SA.

Year	Packaging volume ('000 tons)	SA population (million)	kg per capita consumption
2012	3 146	52.51	59.9
2013	3 208	53.31	60.2
2014	3 213	54.15	59.3
2015	3 317	55.01	60.3
2016	3 356	55.91	60.0
2017	3 385	56.52	59.9
2018	3 439	57.20	60.1
2019	3 447	58.79	58.6
2020	3 182	59.60	53.4
2021	3 538	60.14	58.9
2022	3 554	62.03	57.3

Source: Adapted from Cowling (2023: 1)

The per capita consumption of packaging, on average, is calculated at 58.9 kg, and has remained stable over the past 11 years, except for 2020, and this decline was because of trade restrictions imposed by the COVID-19 lockdown in that year, as reported by Braithwaite *et al.* (2022: 77), indicating that the packaging industry has generally been stable, in support of SA's supply chain requirements.

Figure 2.2 illustrates the SA packaging market growth trend from 2012, estimated to 2023.

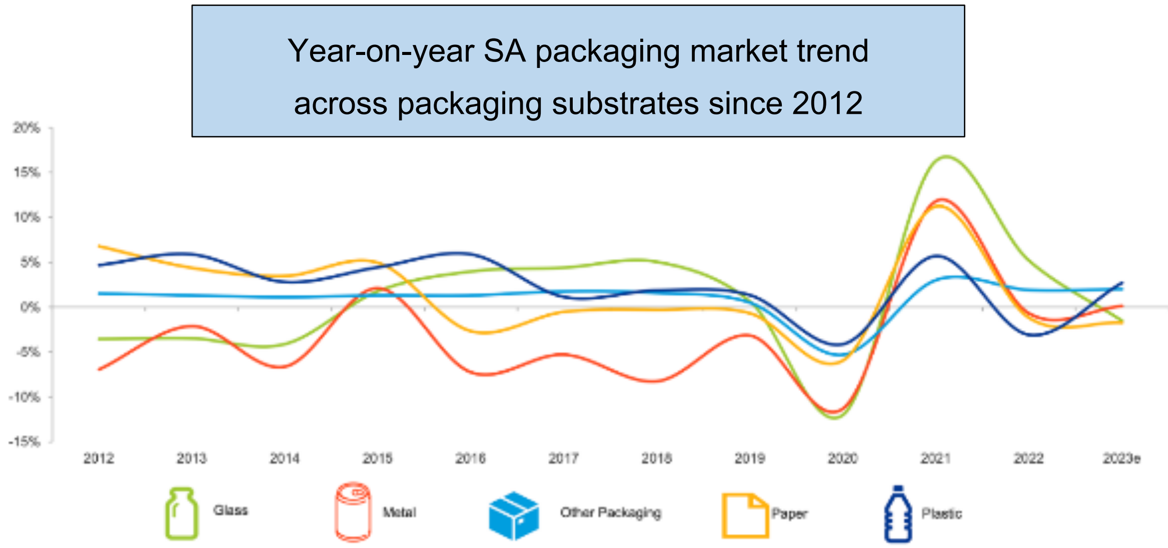

Figure 2.2: Year-on-year SA packaging market trend
Source: Adapted from Braithwaite and Musingadi (2023: 8)

Figure 2.2 depicts slow, but steady growth rates of glass, metal, paper, and plastic packaging in SA, across the past 10 years, estimated to 2023, except for 2020, where all substrates demonstrated a negative growth because of the COVID-19 lockdown impact (Braithwaite and Musingadi 2023: 8).

The researcher summarises that the significantly economical patterns identified in the South African packaging industry, and more broadly, in the South African economy, highlight the socio-economic and socio-political challenges confronting the packaging sector in the aftermath of the substantial negative effects of COVID-19. Table 2.1 indicates that the 184 000 tons of metal packaging placed in the South African economy in 2022, poses a significant challenge with respect to post-consumer metal packaging collection, recovery, and recycling.

Hence, the researcher concludes that:

i. the design, development, and implementation of a robust, sustainable, post-consumer metal packaging recovery model is necessary;
ii. challenges associated with such a recovery model will impact various stakeholders in the South African metal packaging value chains and

iii. these stakeholders encompass suppliers of packaging raw materials, packaging converters or manufacturers, packaging brand-owners, and the retail sector, as elaborated upon in the subsequent discussion.

2.4 Packaging raw material suppliers

Packaging raw material suppliers are pivotal in the supply chain, providing essential materials like paper, plastic, metal, and glass.

The key South African packaging raw material suppliers are listed in table 2.3.

Table 2.3: South African packaging raw material suppliers.

No.	Raw material supplier	Product
1	Arcelor Mital South Africa	Steel and tinplate
2	The Hulamin Group	Aluminium
3	KAP International Holdings	Industrial chemicals and polymers
4	The Mpact Group	Paper and board
5	The Sappi Group	Fine paper
6	Sasol Base Chemicals	Base polymers and resins

Source: Researcher's own compilation

Table 2.3 reflects a list of the raw material packaging suppliers in SA, that are critical partners and sources for obtaining essential materials in the packaging industry.

2.5 Packaging manufacturers / converters

Within the global packaging industry, the term converter is synonymous with manufacturer, these are entities that transform raw materials into consumer and industrial packaging (Board Committee 2023: 5).

The main stakeholders within the manufacturing / converter sector are shown in table 2.4.

Table 2.4: SA packaging manufacturers / convertors.

No.	Packaging convertor	Packaging converted
1	Alpla Packaging (Boxmore)	Beverage, closures, pharmaceutical packaging
2	Astrapak RPC	Flexible polymers, multilayer films
3	Bowler Metcalf	Rigid plastic packaging tubes for personal care and pharmaceutical products
4	Cansmart	Tinplate food cans for meat, vegetables, and fruit
5	Cipapak	Vinyl cling film and expanded polystyrene
6	Consol Ltd	Glass packaging for food and beverage, household, and pharmaceutical products.
7	Constantia Flexibles	Monolayer and composite films for confectionery, snacks, general food, beverages, pharmaceutical and personal care products,
8	Corruseal	Corrugated packaging
9	Nampak	Diversified tinplate food cans, tinplate and aluminium aerosols, beverage cans, rigid plastic
10	Greif South Africa	Metal cans, 210 drums
11	Golden Era	Beverage cans, food cans, folding cartons
12	GZI Cans	Aluminium beverage cans
13	Huhtamaki	Packaging for food, beverage, or personal and home care products
14	MPact	Paper manufacturing and paper converting, polyethylene terephthalate (PET) pre-forms bottles jars and closures
15	Packsolve	Collapsible 210 drums
16	Polyoak	Rigid plastic packaging and closures for dairy, beverage, food, industrial products
17	Shave and Gibson	Paperboard packaging, folding cartons, Visiboxes, corrugated packaging
18	Tetrapak	Packaging for dairy products, beverages, ice cream, cheese, vegetables, pet food and multilayer laminates
19	Transpaco	Cores and tubes, paperboard packaging, folding cartons, refuse bags, flexible packaging, and specialised films
20	Verigreen	Flexible refuse bags
21	Winhold	Flexible plastic film

Source: Adapted from Braithwaite et al. (2021: 82)

Table 2.4 reflects a list of the packaging manufacturers/converters in SA, who are the critical partners and sources for obtaining packaging, manufactured to bespoke specification for specific applications in the packaging industry.

2.6 South African brand-owners

Brand-owners are individuals or entities that own and control a specific brand or trademark, managing the brand's strategic direction, marketing, and overall identity (Board Committee 2023: 5).

Table 2.5 presents a researcher compiled list of key players in the brand-owner sector, including, but not limited, to the prominent names.

Table 2.5: Predominant brand-owners in South Africa.

No.	Brand-owner	Product/s
1	ABinBev (SAB)	Alcoholic beverages
2	Adcock Ingram	Flexible polymers
3	AMKA	Personal care, pharmaceutical, health and beauty
4	Appletiser	Beverage
5	BP	Fuel and lubricants
6	Cadbury	Chocolates and related
7	Caltex	Fuel and lubricants
8	Ceres/Pioneer foods	Fruit juices
9	Coca Cola	Soft drinks
10	Diageo	Alcoholic beverages
11	Distell	Alcoholic beverages
12	Dulux	Glass
13	Dursots	Food cans
14	Engen	Flexible polymers
15	Giants Canning	Canned Food
16	Halewood International	Wines and spirits

17	Heineken	Alcoholic beverages
18	Heinz	Canned Food
19	Indigo Brands AVI Group	Personal care, aluminium aerosols, beauty products
20	Kansai Plascon	Household and industry paints
21	Meatco	Meat and related
22	Medal Paints	Household and industry paints
23	Nestle	Baby food, chocolate and milk products
24	Oceana Group (Luckystar)	Canned products
25	Pioneer Foods	Aluminium beverage cans
26	RCL Foods	Poultry
27	Reckitt Benkiser	Household
28	Red Bull	Energy drinks
29	Revlon	Personal care, beauty
30	Rhodes Group	Food cans
31	Rolfe Laboratories	Aerosols
32	Tiger Brands	Personal care, household
33	Total	Fuel and lubricants
35	SC Johnson	Personal care, household
35	Shell	Fuel and lubricants
36	Unilever	Personal care, household

Source: Researcher's own compilation

The researcher notes that table 2.5 reflects a list of key brand-owners, providing valuable insights into the major entities or individuals that control and shape the market landscape. This list helps stakeholders, investors, and industry observers understand the key players in various sectors, their market influence, and the diversity of brands they manage.

2.7 The South African retail sector

Table 2.6 illustrates the researcher's compilation of prominent retailers in South Africa.

Table 2.6: SA retail sector

No.	Retailer	Product range
1	Boxer Group	General consumer goods
2	Clicks	Beauty and household
3	Mass Cash	Bulk and consumer goods
4	MassMart	Larger items consumer goods
5	Metro Cash & Carry	General consumer goods
6	Mr Price Group	Aerosols, general metal packaging
7	Pick and Pay	Household consumer goods
8	Truworths	Aerosols, general metal packaging
9	Shoprite Checkers	Household consumer goods
10	Spar Group	Household consumer goods
11	Woolworths	Aerosols, general metal packaging

Source: Researcher's own construction

The researcher summarises that the SA packaging industry is extremely dependent on the complex interconnections amongst the raw material suppliers, converters, brand owners and retail groups within the multiple SA packaging supply chains. This is essential both downstream and upstream to facilitate the effective flow of packaged products as well as the related information, ultimately meeting the needs of the South African consumer. These are the key stakeholders that will need to be considered in the design and development of a post-consumer metal packaging recovery model.

The following discussion will present a view into the statistics related to the SA packaging industry.

2.8 The packaging industry and the SA economy

The bar chart shown in figure 2.3 demonstrates the growth trajectory of the SA packaging sector, from 2012 to 2022, with the positive, upward trend interrupted only in 2020, due to the depressed economy as a result of the COVID-19 trade restrictions. This data clearly illustrates the year-on-year growth of the packaging industry, and therefore the anticipated financial support to the SA economy regarding transformation and job creation, as explained in the Council for Scientific and Industrial Research (2017: i) report.

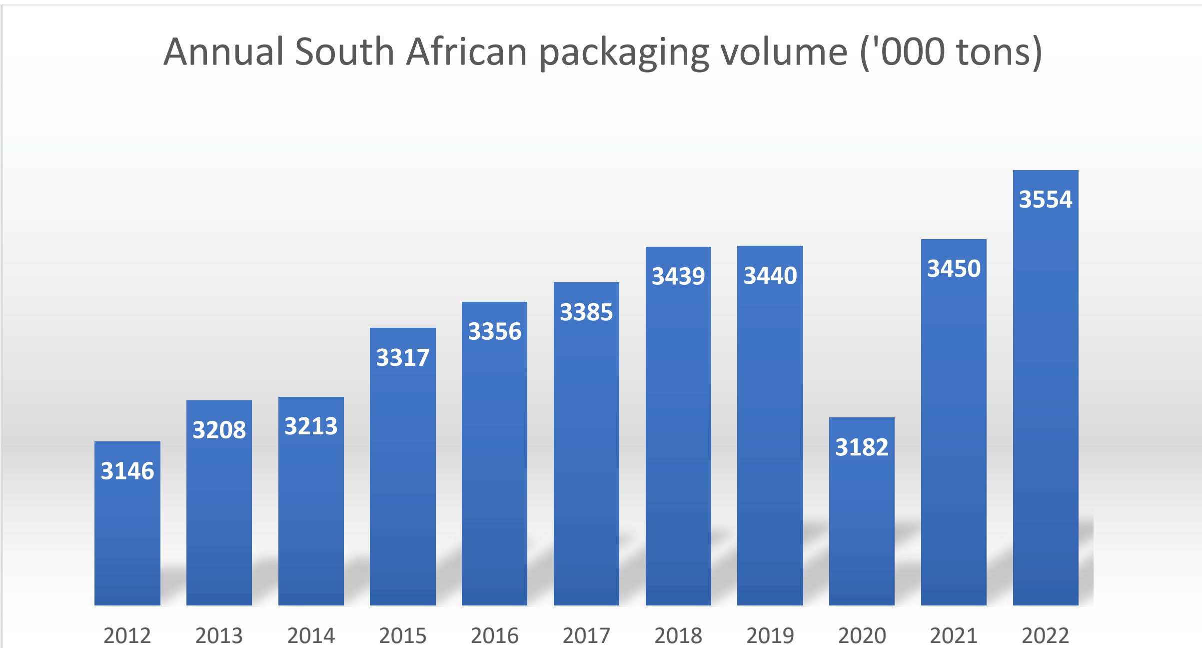

Figure 2.3: Growth of the SA packaging industry.

Source: Adapted from Braithwaite et al. (2021: 6) and Braithwaite and Musingadi (2023: 6)

The researcher points out that the packaging volume will increase year-on-year, given the historical trend, coupled with the rising population in SA, shown in table 2.2.

This implies that the post-consumer packaging recovery system infrastructure will need to be enhanced, enabling increased handling of packaging volume.

Figure 2.4 illustrates the SA GDP trend, in R trillion since 2007.

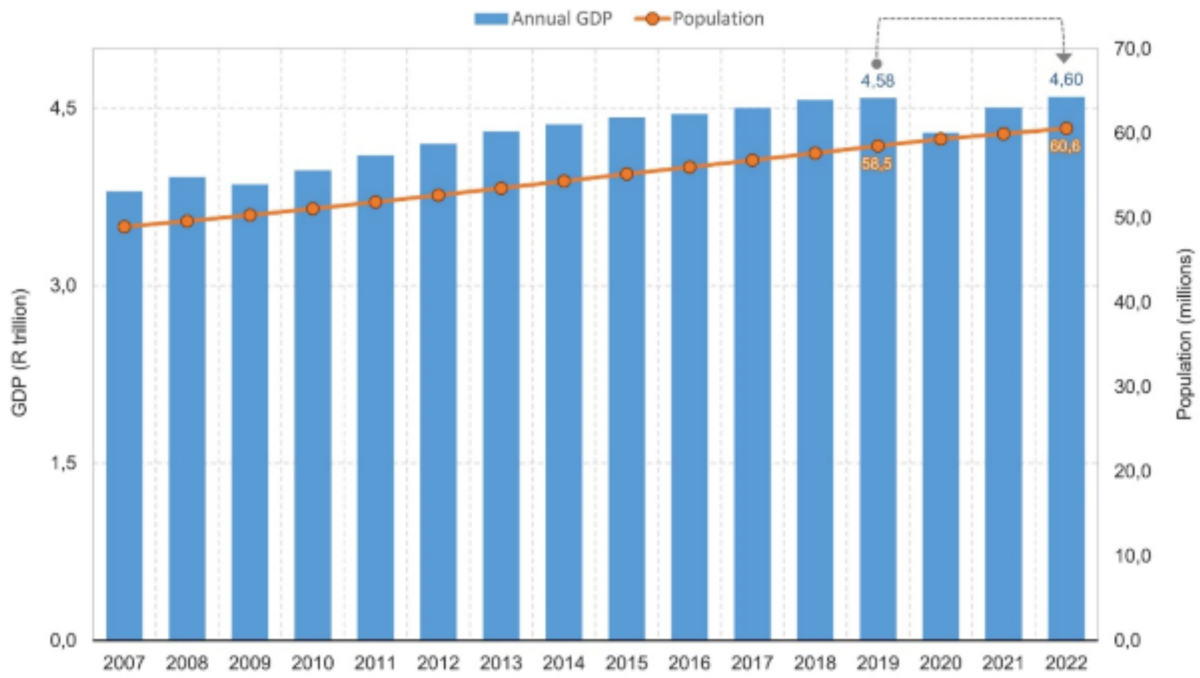

Figure 2.4: SA GDP trend

Source: Adapted from Matsika (2023: 1)

The SA total GDP contracted from R4.58 trillion in 2019 to R4.28 trillion in 2020, due the restricted commercial activity in SA, as a result of COVID-19, nothwithstanding, the SA total GDP in 2022 was measured at R4.60 trillion, according to The Financial Gazette (Matsika 2023: 1).

The researcher notes that it is imperative that the SA packaging industry remains competitive and profitable, to be able to contribute to the SA GDP through the generation of packaging that is critical to the supply chains that service the country's economy.

This suggests that improvements to the post-consumer packaging recovery system infrastructure will be necessary to sustain and support the anticipated growth of the SA packaging industry.

The relationship between the South African packaging GDP and South African total GDP, from 2015 to 2022, is shown in figure 2.5.

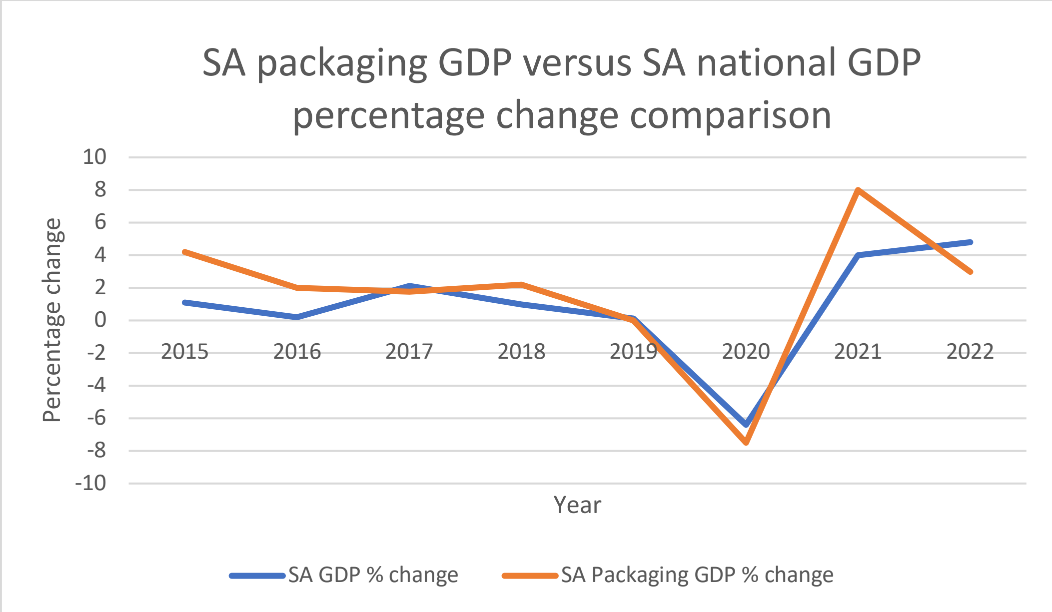

Figure 2.5: Correlation between year-on-year changes in SA packaging GDP and SA economic GDP
Source: Adapted from Tinga (2019: 31); Braithwaite and Musingadi (2023: 14)

Figure 2.5 illustrates the relationship of the SA packaging GDP with the overall SA national GDP. The graphical trends show that there is a positive correlation between the South African GDP and the South African packaging GDP, as reported by Tinga (2019: 31), and it is therefore noteworthy that the SA packaging GDP is a strong indicator of the strength of the SA economy.

The researcher summarises that the preceding discussion has provided a comprehensive overview of the South African packaging industry and its contribution to the country's economy. This contextualisation offers insight into the packaging sector's size, scope, prevailing trends in South Africa, employment prospects, and the intricate nature of its supply chains. The sustainability of South Africa's GDP hinges on the strength of the country's packaging industry. This is because efficient packaging is essential for the transportation of products across supply chains and eventual sales.

The forthcoming discussion will probe the present business trends, as well as the legislative hurdles and opportunities, confronting the packaging industry in South Africa, and the industry's responses to these challenges.

2.9 Business trends within the South African packaging sector

2.9.1 General trends

According to Braithwaite and Musingadi (2023: 27), the most prominent trends noted in the South African packaging industry in 2022 were as follows:

i. Beverage cans have now been fully converted to aluminium from the original steel cans;
ii. Steel demand for pails and food cans continues to be supplied through imports as the local raw material supplier closed the flat steel production lines;
iii. Metal beverage packaging demand has seen an upward trend as restaurant dining, and impulse buying, started to reclaim their place in consumer spending patterns. Nonetheless, recovery remains conservative as overall disposable income is still under pressure;
iv. The recent Russia-Ukraine war has affected steel and aluminium supply into SA in 2022, but supply of these materials is expected to recover into 2024 and
v. Loadshedding remains a significant contributor to uneconomical production, and the foreseeable future is not expected to ease this situation.

2.9.2 Packaging industry challenges

Table 2.7 reflects points that are pertinent to the recent challenges facing the packaging industry in SA.

Table 2.7: SA Packaging industry challenges

No	Challenges	Citation
1	The South African economy was negatively impacted upon by the 2021 mid-year riots in KwaZulu-Natal and Gauteng, affecting local industries. It will take many years to fully recover from the damage to the economy, infrastructure and the losses experienced by the remaining operating businesses. The multiple lockdowns resulted in significant emotional stress for South Africans to the extent that low productivity and job losses became a reality, consequently compromising the packaging industry.	Africanews (2021:1)

2	The unemployment rate in South Africa increased from 2021 to 2022 and measured 31.9% in quarter two of 2023, indicating an instability within the service and manufacturing sectors	Trading Economics (2023: 1)
3	The 2022 international conflict between Russia and Ukraine has hindered South Africa's economic progress, with the negative repercussions extending to the energy sector, given Russia's involvement in the natural gas market, and compounded by the widespread decline in supplies of fertiliser ingredients, maize, and wheat on a global scale.	Braithwaite and Musingadi (2023: 29)
4	The current Israel-Palestine conflict will impact the SA economy, because of the consequential increased crude oil price.	Watson (2023: 1)
5	The packaging industry, due to the recent EPR legislation, will be paying EPR fees based on tonnage of packaging placed in the South African economy. Brand-owners must select materials and design packaging that facilitate easier recovery and recycling, reducing their EPR liability; this is referred to as an “eco-modulated” approach to EPR fee determination.	Modise (2023: 1)

Source: Researcher’s own construction

The researcher notes that business trading conditions through and post the COVID-19 pandemic, and more recently, through the Russia-Ukraine and Israel-Palestine wars, have been extremely difficult, yet the packaging industry continued to demonstrate resilience, supporting supply chains, ensuring that lifestyles of South Africans were not overly compromised, simultaneously contributing to the SA GDP.

The following discussion now moves to the SA legislation around extended producer responsibility.

2.10 National Environmental Management: Waste Act 59 of 2008 (NEMWA)

In 2017, the Department of Forestry, Fisheries, and the Environment (DFFE) enforced Section 28 (duty of care) of the National Environmental Management: Waste Act (NEMWA), as discussed by Muller (2020: 206), which necessitated the prevention of environmental pollution, in general, within South Africa. In May 2021, the DFFE enforced Section 18 of NEMWA, which related to the EPR of the SA packaging industry (Modise 2023: 1). Section 28 and Section 18 of NEMWA require the packaging industry, as brand-owners and producers of packaging, to take responsibility for post-consumer packaging recovery and re-utilisation, as stated by Muller (2020: 206), to reduce packaging pollution in parks, gardens, streets, rivers, oceans, and landfill sites. This is achievable by setting up Material Recovery Facilities (MRF's) and creating business infrastructures to support the recovery and recycling of post-consumer packaging throughout South Africa (Muller 2020: 206). Recovered post-consumer packaging materials and energy are then re-introduced into the manufacturing operations to re-manufacture products in support of circular economies and sustainable development principles (Didenko, Klochkov and Skripnuk 2018: 2).

2.11 EPR legislation

According to Howells (2022: 1), the rise in consumerism in SA, coupled with the adoption of convenient lifestyles, has resulted in numerous environmental challenges, such as:

i. resource depletion;
ii. limited knowledge and awareness of adverse environmental impacts;
iii. high waste generation, as well as irresponsible waste disposal;
iv. higher energy consumption;
v. pollution;
vi. loss of biodiversity and
vii. negative climate change

Consequently, DFFE gazetted the EPR legislation in SA, and it became mandatory for any producer (converter/brand-owner) to register as a member of a DFFE approved EPR scheme (Packaging SA 2023: para. 1 line 3). Alternatively, a producer (converter/brand-owner) may have set up or created its own EPR scheme by no later than 05 November 2021 (Packaging SA 2023: para. 1 line 3).

On 05 May 2021, the final EPR legislation, aligning with Section 18 of NEMWA, was published by the SA DFFE and all producers (converters/brand-owners) in SA had six months to register with the DFFE before the deadline of 05 November 2021 (Packaging SA 2023: para. 1 line 2; Modise 2023: 1).

EPR is a regulatory approach that transfers the obligation of the recovery of post-consumer packaging materials, from the government to the producers of packaging materials (Gadnis 2023: 1). These producers, such as packaging converters, brand-owners, and retailers, are subsequently tasked with overseeing the entire lifecycle of their packaging, encompassing activities like collection, recycling, waste management, and appropriate disposal (Gadnis 2023: 1).

2.12 Producer Responsibility Organisations (PROs)

This legislative pressure resulted in the creation of substrate-specific, non-profit, packaging PROs, funded by members that operate within the PROs specific packaging stream value chains, and act to satisfy the EPR compliance obligations of the EPR legislation (Packaging SA 2023: para. 2 line 2).

As per the new EPR legislation in SA, all producers of packaging, where the production volume exceeds 10 tons per annum, are considered *"obliged industries"* and are therefore required to join an existing PRO or develop an individual EPR scheme for their products (South Africa. Department of Forestry, Fisheries and Environment 2020: 7).

Packaging SA is an umbrella body in SA that represents packaging converters, brand-owners, PROs and related interested parties (Packaging SA 2023: para. 1 line 4). A list of the existing PROs who are members of Packaging SA is provided in a discussion on the roles and obligations of PROs later in this chapter.

The formation of packaging material specific PROs resulted in a focused effort at managing post-consumer packaging recovery and material recycling within South Africa (Muller 2020: 209). The PROs in SA are actively being driven by the respective sectors of the packaging industry in SA and are responsible for the maximum post-consumer recovery and re-utilisation of specific packaging materials in SA (Muller 2020: 209). The materials may be re-utilised within its original manufacturing paths, or the materials may be utilised in alternative manufacturing paths, but ultimately the goal is to divert these used packaging materials from landfill sites, as explained in 2017 by the Council for Scientific and Industrial Research (2017: 9).

Poorly designed packaging contributes to the escalation of waste and litter, leading to a rapid depletion of landfill space across SA, and, to address this problem, the South African government has implemented an EPR system as a mechanism to better manage adverse environmental impact, supported by PROs (Howells 2022: 1).

The implementation of EPR regulations in SA, and the resulting formation of PROs mark a significant stride toward achieving a circular economy, as producers are now held accountable for managing their waste, alleviating the burden of collection and disposal costs that were previously shouldered by the general public (Howells 2022: 1).

According to Rapson and Novotny (2021: 1), the EPR regulations introduced in SA are expected, through PROs, to drive the circular economy agenda, however the following are implementation challenges:

i. Converters and brand-owners are required to define their respective roles and determine whether either or both entities fall under the category of "producers" for compliance with the EPR frameworks;
ii. The provision in EPR regulations permits a retrospective application of the regulations, encompassing both past and existing waste streams, making it crucial to determine whether the enforcement of this law also applies retrospectively to administrative obligations, an example is the EPR fees;
iii. The downstream responsibilities placed on producers and PROs entail the possibility of encountering additional licensing requirements, which may be unforeseen or unintended, and
iv. Licensing pre-requisites necessitate EPR schemes to include provisions for the re-use, recycling, and recovery for beneficial use of specified products and their associated waste streams.

However, the National Environmental Management: Waste Act 59 of 2008, along with its 2013 list of waste management activities, mandates obtaining a waste management license for re-use, recycling, or recovery activities concerning substantial volumes of general or hazardous waste (Rapson and Novotny 2021: 1). This could pose implications for significant producers or PROs subject to regulation under the EPR regulations and sector notices, and, as of now, the packaging industry has not addressed these potential ramifications (Rapson and Novotny 2021: 1).

The following discussion now moves to the scope of work and legislative obligations of the PROs in SA.

2.13 Compliance obligations of the PRO

According to Muller (2020: 209), the PROs, outlined in table 2.8, are responsible for, amongst other responsibilities, close municipal engagement for increased post-consumer material recovery and the establishment of packaging recovery infrastructures across key regions in South Africa.

Muller (2020: 209), further explains that these entities have been working in recent years to introduce and sustain circular economy models within the South African packaging industry, focusing on material suppliers, converters, brand-owners, retailers, informal waste pickers, buy-back centers, recyclers and foundries, and consumer purchase decisions. These PROs operate under the umbrella of Packaging South Africa (PSA), an organisation representing the entire packaging industry in South Africa (Packaging SA 2023: para. 1 line 4).

Table 2.8: A list of SA packaging PROs that are registered with DFFE.

No.	PRO logo	PRO name	Packaging substrate
1		MetPac-SA	Aluminium and steel
2		Petco	Rigid polyethylene terephthalate
3		Polyco	Rigid and flexible polyolefins
4		FibreCircle	Paper, board and corrugated
5		The Glass Recycling Company	Glass
6		EPR Waste Association SA	EPR waste, electronic waste
7		Circular Energy	Electronic, electrical waste

Source: Adapted from Muller (2020: 209)

The EPR scheme addressed in the Government Gazette 43879, defines the total statutory obligations of a PRO, and the following are some of the essential obligations (South Africa. Department of Forestry, Fisheries and Environment 2020: 7):

i. compliance with EPR legislation;
ii. material data management and reporting to DFFE on the following:
    a. percentage of packaging material recovered annually;
    b. percentage recycled;
    c. recycled content;

d. waste to energy;
e. data source verification reports;
f. internal audit reports and
g. EPR fee calculation.

iii. waste minimisation or waste avoidance;
iv. municipality engagement for packaging recovery infrastructure development;
v. increasing the demand for recyclables;
vi. conducting packaging material flow analyses and Life Cycle Assessment (LCA) and
vii. paying a waste picker service fee for identified product.

The preceding discussion provided a brief insight into the compliance obligations of the PROs and the next section will outline the significant interested parties within the SA packaging industry.

2.14 Interested parties of the SA packaging industry

2.14.1 The Paper and Packaging PRO Alliance

To address the common challenges that PROs face as a result of S18 of NEMWA and the related EPR gazettes defining the legislative obligations of a PRO, a collective decision was taken by the PROs as shown earlier in table 2.8 to work together and reap the benefit of collective effort and economies of scale; hence, the Paper and Packaging PRO Alliance, a non-profit organisation, was created (Modise 2023: 1; Packaging SA 2023: para. 1 line 4).

The purpose of the Paper and Packaging PRO Alliance is to achieve consensus on EPR messaging and to become, ultimately, an implementation body for those areas as defined in the regulations that require multi-material collaboration (Modise 2023: 1).

The Paper and Packaging PRO Alliance works closely with the Minister of the DFFE, through the Director General of DFFE and the Deputy Director General of DFFE, on matters pertaining to national and provincial sustainability development requirements, such as (Modise 2023: 1):

i. the development of standardised Key Performance Indices (KPI's), measurement and reporting methodology for the paper and packaging industry;
ii. the execution of national awareness-raising campaigns with agreed messaging on EPR and promotion of recycling;
iii. the facilitation and engagement with municipalities across SA, including the South African Local Government Association (SALGA) and other relevant bodies;
iv. the facilitation of a collaborative approach to explore separation-@-source (S@S) opportunities, the use of existing post-consumer packaging material collection infrastructure, and, where necessary, to establish additional support infrastructure and
v. collaboration with waste picker representative bodies to define mechanisms that will enable the payment of an agreed waste picker service fee to waste-pickers that are registered on the national waste picker database, who collect and sell to buy back centres, packaging material that is *"identified as acceptable"* by the EPR gazettes.

The Paper and Packaging PRO Alliance is operated through a formal memorandum of interest and is funded through annual subscriptions paid by PRO members and membership is open to all paper and packaging PROs in SA (Modise 2023: 1; Packaging SA 2023: para. 1 line 4).

2.14.2 Metal Packaging SA (MetPac-SA)

According to the minutes of MetPac-SA's fourth Annual General Meeting (AGM) held on 31 August 2023, MetPac-SA is a PRO registered with the DFFE, and the EPR registration number is 19/7/5/P/PRO/20210720/005 (Board Committee 2023:1).

MetPac-SA is a registered non-profit company as defined in Section 21 of the Companies Act No. 71 of 2008, with a Companies and Intellectual Property Commission (CIPC) registration number of 2017/216419/08 (Board Committee 2023:1).

MetPac-SA represents the metal packaging value chain in SA, servicing 67 packaging members comprising of raw material suppliers, converters, brand-owners, and retailers, by defining the specific metal material flow paths, and reporting to DFFE, on the post-consumer metal packaging collection and recycling, including import/export of metal packaging, as well as waste to energy (Board Committee 2023:1).

According to MetPac-SA's fourth AGM minutes, the primary objectives of the organisation are to (Board Committee 2023:1):

i. operate as the appointed PRO on behalf of its members, by taking on part of its member's EPR related obligations, thereby ensuring its member's EPR compliance;
ii. promote and improve waste-management and recycling and re-use of metal packaging on an industry-wide basis;
iii. be acceptable in form and operation to the relevant stakeholders, including the Government of the Republic of SA and the metal industry;
iv. be self-regulating and self-funding;
v. prepare common messages and create communication programmes on behalf of members, for a wide range of stakeholders;
vi. develop sustainable use of metal packaging by members;
vii. cooperate with other organisations with similar objectives;
viii. maintain a database of members and other relevant statistics; and
ix. be environmentally sustainable.

Through the Paper and Packaging PRO Alliance, MetPac-SA works closely with other packaging PROs in SA to promote a collective, synergistic, EPR strategy in alignment with South African sustainable development principles (Modise 2023: 1).

2.14.3 The Consumer Goods Council of South Africa (CGCSA)

GS1 South Africa, trading as the Consumer Goods Council of South Africa (CGCSA), is a consumer-centric organisation, with a membership base of 9000 businesses within the manufacturing, retail, and services sectors in SA (Zinhle 2023: 1).

CGCSA is dedicated to its core objective of transforming into the leading platform in the consumer goods industry, focusing on advocacy, collaboration, and the advancement of best practices in South Africa and throughout the African continent (Zinhle 2023: 1).

According to Zinhle (2023: 1), the CGCSA adds value to its members by offering a variety of services, such as:

i. Advocating, lobbying, engaging, and collaborating on industry-related issues that are non-competitive;
ii. Sharing standards for best practices;
iii. Offering targeted regulatory and advisory services;
iv. Granting access to a hub of valuable industry insights and
v. Ensuring alignment with both global Sustainable Development Goals (SDGs) and the National Development Plan (NDP).

The CGCSA has registered, as a packaging substrate PRO with the DFFE, and is now able to attract members within the packaging value chain, and report to the DFFE on recovery rates, recycling rates, import and export tonnages of the consolidated material of its members (Burger 2023: 1).

Given that both MetPac-SA and CGCSA will be competing for membership in the metal packaging sector, the researcher is of the opinion that the entry of CGCSA into the EPR arena may result in conflict that may be counterproductive to the SA EPR goals.

2.14.4 The Institute of Packaging SA (IPSA)

IPSA, established in 1970, operates as a non-profit entity, to serve the interests of the South African packaging industry, and its primary objectives include the following (Muller 2023: 1):

i. promoting elevated standards and professionalism within the packaging sector;
ii. fostering networking and educational opportunities;
iii. advocating the recognition of packaging as a bona fide profession;
iv. organising key programs and events aimed at advancing these goals, such as the prestigious IPSA Gold Pack Awards that recognise innovative and creative sustainable development driven packaging, serving both as an educational tool and a means to encourage careers in packaging;
v. providing packaging technology education and training in SA and
vi. hosting seminars, webinars, and conferences developed to highlight and discuss the most critical issues facing the industry.

The next section provides an insight into the packaging material recovery statistics and projections to 2024.

2.15 The research dilemma - post-consumer packaging material recovery in SA

The data in table 2.9 demonstrates actual post-consumer metal packaging material recovery statistics from 2020 to 2022, estimated for 2023, and forecast to 2024.

Table 2.9: Post-consumer metal packaging recovery statistics

Metal packaging in SA	2020	2021	2022	2023 estimated	2024 forecast
Tons placed in the market	152 391	180 165	184 000	183 046	186 920
Post-consumer recovery in tons	100 349	111 036	98 403	96 986	98 712
DFFE Target in tons	Not available	Not available	108 560	111 658	115 890
Post-consumer recovery rate%	65.85%	61.63%	53.48%	52.98%	52.81%
DFFE Target	Not available	Not available	59.00%	61.00%	62.00%
Gap	Not applicable	Not applicable	5.52%	8.02%	**9.19%**

Source: Adapted from Braithwaite and Musingadi (2023: 10) and (South Africa. Department of Environmental, Forestry and Fisheries 2023: 14)

Table 2.9 illustrates post-consumer metal packaging recovery rates that are falling short of the DFFE targets, therefore, the metal packaging industry will need aggressive interventions to meet the DFFE targets over the next three years.

Also, it must be noted that the SA metal packaging industry post-consumer recovery rate in 2021, reflected as 61.63% in table 2.9, is below the 2021 European benchmark of 78.5% (Rivers 2023:1).

Therefore, the SA metal packaging industry will need to demonstrate greater levels of post-consumer metal packaging recovery by aligning with global best practices, maximising the recovery and re-use of metal packaging.

Figure 2.6 illustrates the diverging trends of metal packaging volumes placed onto the South African market, the post-consumer metal packaging recovery rates, and the DFFE metal packaging recovery targets, projected to 2024.

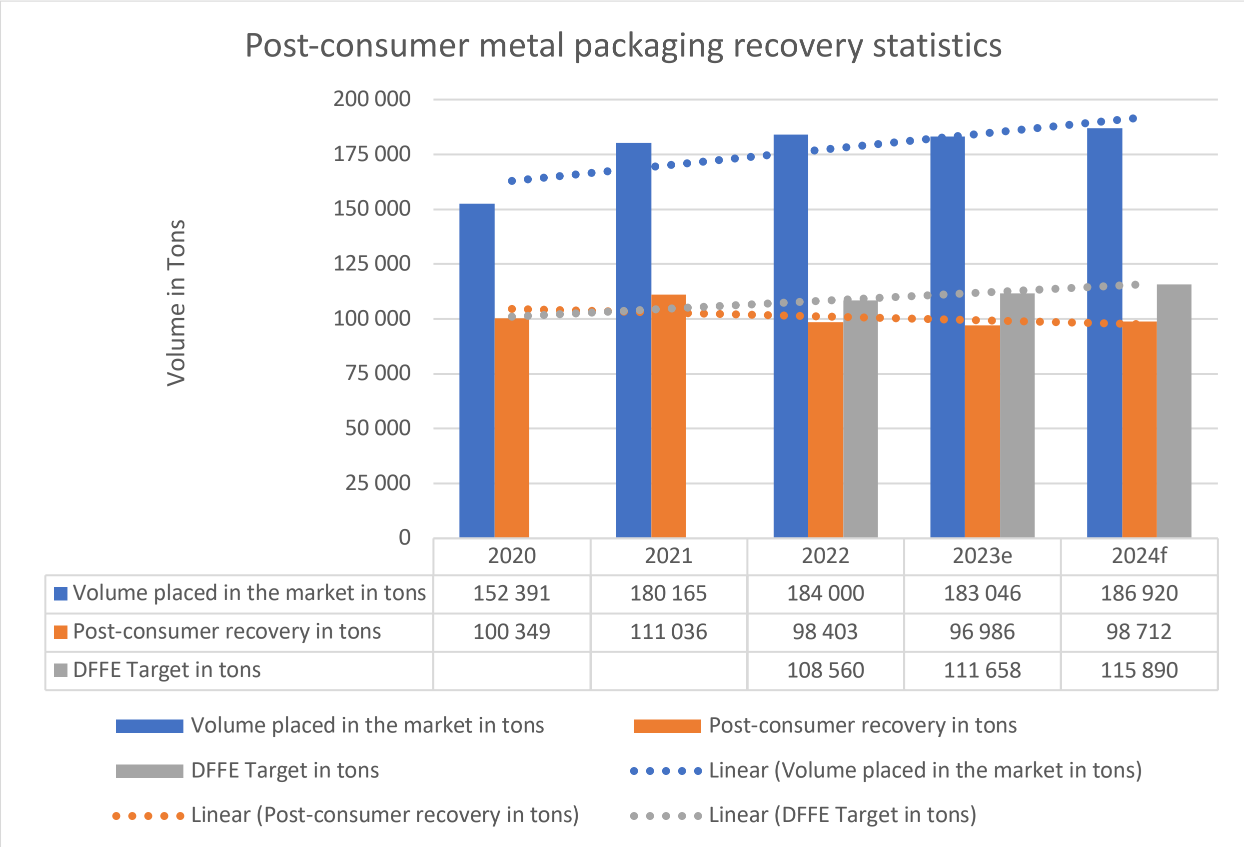

Figure 2.6: Post-consumer metal packaging recovery

Source: Brathwaite and Musingadi (2023: 10) and (South Africa. Department of Environmental, Forestry and Fisheries 2023: 14).

The researcher points out that the extrapolated trendlines, as shown in figure 2.6, indicate that the anticipated post-consumer metal packaging recovery rate is reflecting a declining trend and will be significantly divergent from the projected metal packaging volume growth by 2024.

Also, it must be pointed out that the recovery rate trend is divergent from the DFFE yearly targets as set out in Government Gazette 48527 and this gap is expected to widen to 9.19% by 2024, as reflected in table 2.9.

The researcher sumarises that, given the above scenario, it is clear that the current metal packaging recovery system is inadequate and needs to be stimulated to increase metal packaging recovery. Therefore, a post-consumer metal packaging recovery model that incentivises recovery, simultaneously enabling transformation and job creation in SA, is required to enhance the current levels of metal packaging recovery, to close the 9.19% gap. Such a model will also improve human dignity and social aspects that are lacking in the current, informal system that exploits unemployed waste pickers.

2.16 SA economic value and job creation potential due to circular economies

Increasing the diversion of packaging away from landfill sites, into reuse, recycling, and recovery, will unlock waste packaging into a circular economy, and such a circular economy philosophy will create new jobs, as well as new businesses, or will increase employment in existing businesses (Godfrey 2021: 1).

Table 2.9, reflecting metal packaging material recovery rates, forecast to 2024, projects a decrease in post-consumer recovery to 2024 (Braithwaite and Musingadi 2022: 10).

This then indicates that there is an opportunity for job creation in this sector of the SA economy, given the need to increase recovery rates against the DFFE targets. (Council for Scientific and Industrial Research 2017: i). It is estimated that every 2 million tons of recovered packaging material would generate an additional R712.5 million of economic value that could be unlocked, upstream of recyclers, while a further R2.53 billion of economic value could be unlocked downstream of recyclers feeding into manufacturing industries (Council for Scientific and Industrial Research 2017: i).

While employment statistics for the packaging sector in SA are estimates, it is expected that the above post-consumer packaging recovery and recycling within the packaging recycling sector, could unlock an estimated 1 015 to 1 990 new direct jobs into the SA packaging recycling sector, an additional 1 523 to 2 984 indirect jobs, and 1 776 to 3 482 induced jobs (Council for Scientific and Industrial Research 2017: 26).

2.17 The role of the waste picker in South Africa

In order to attain the South African sustainable development goals related to promoting a workforce better equipped to embrace sustainable practices and contribute to the achievement of sustainable development objectives, it is essential to reassess existing value chains, envision job tasks with integrated sustainability, recognise skill requirements, strategise skills development, and offer opportunities for workers to acquire or enhance technical, vocational, and entrepreneurial skills for green jobs and enterprises (Ramsarup and Ward 2017: 11).

In SA, informal waste pickers play a crucial role in the recycling economy, accounting for approximately 51% of the total paper and packaging waste collected in the country, and they have been actively involved in waste and recycling for over three decades, predating the earliest voluntary paper and packaging EPR schemes (Godfrey 2021: 1). Nevertheless, these voluntary schemes have played a vital role in expanding and growing South Africa's recycling economy. In many developing countries, recycling activities are predominantly undertaken by the informal sector, which serves as the backbone of waste management; however, these informal recycling groups face constant vulnerability due to the potential privatisation of waste management services or the prohibition of informal scavenging (Hajar, Moqbel, Al-Qaraleh and Alhawarat 2021: 02).

The two prominent waste picker representative bodies in SA are:

i. *African Reclaimers Organisation (ARO):* A 5500 membership-based democratic organisation of waste pickers, working in landfills, residential, urban, and rural areas, is responsible for collecting, sorting and selling recyclable materials in SA. ARO represents and defends the interests of waste pickers, ensuring that the waste picker’s human and social dignity is upheld within SA society (Mannan 2023: 1) and

ii. *South African Waste Pickers Association (SAWPA):* SAWPA, a 7500 membership-based democratic organisation, in partnership with the environmental justice organisation groundwork, has supported the cause of waste pickers, and is now recognised by the national government through the National Waste Management Strategy (NWMS) and Waste Pickers Integration Guidelines (Mononga 2023: 1). Municipalities are mandated to register waste pickers within their jurisdiction and formulate plans to collaborate with them, thereby creating a conducive environment for their livelihoods to flourish, simultaneously acknowledging their lawful and ethical contributions in providing services to citizens and addressing climate change impacts (Mononga 2023: 1).

It is estimated that there are more than 215 000 informal waste pickers operating in SA, collecting packaging and other materials, exchanging this for cash at buy back centres across SA (Banda 2022: 1). Hence, approximately 202 000 waste-pickers across SA are not yet registered formally as waste pickers and cannot enjoy a waste picker service fee that has been gazetted as an obligation of the PROs in SA.

The researcher suggests that both ARO and SAWPA, as waste picker representative organisations, present an opportunity to engage with the wider waste picker network in SA, as long as these organisations increase their presence and, consequent waste picker membership.

2.18 Packaging material recovery and recycling in SA

Figure 2.7 depicts the post-consumer packaging pathways in SA.

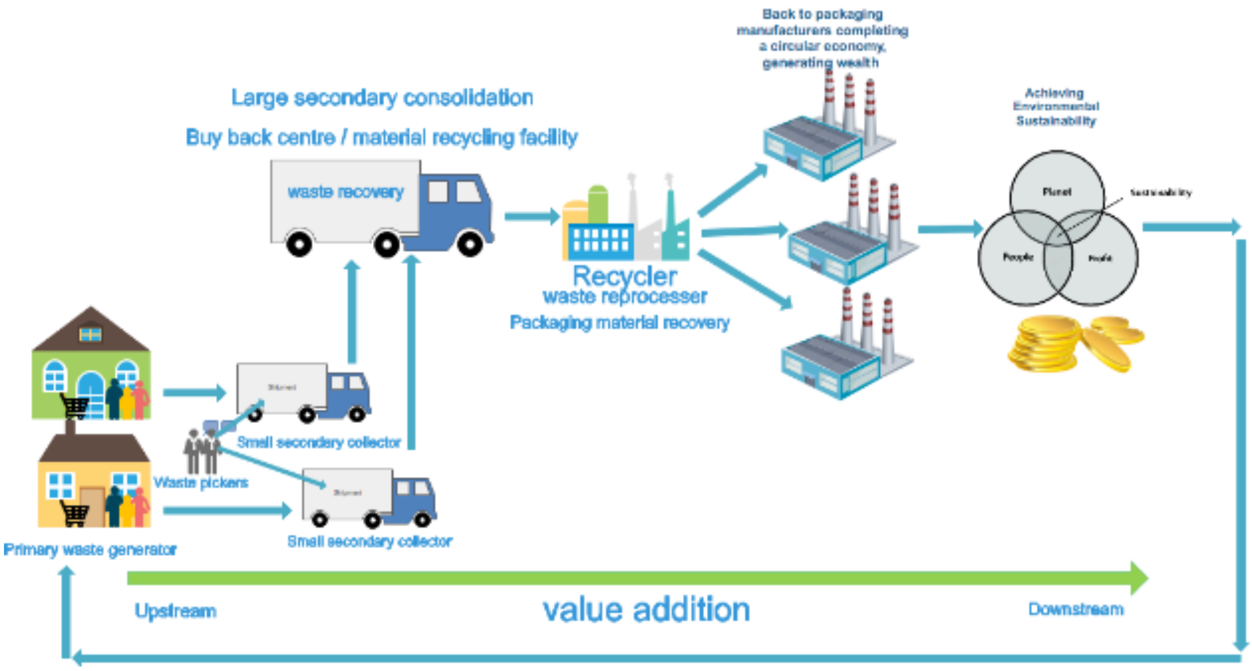

Figure 2.7: Packaging material recovery and recycling in SA.
Source: Adapted from the Council for Scientific and Industrial Research (2017: 9)

The researcher sums up that figure 2.7 illustrates a circular economy where metal packaging, post-consumer, is collected largely by informal waste pickers, sold to secondary collectors, and buy-back centres, then moved to recyclers where metal is re-melted at operations that deploy gas or electrically powered furnaces, returning the metal back into ingots, ready for the packaging converter to then re-use in a cyclical pattern. A model that can enhance this metal recovery system will result in greater circularity of metal in SA.

2.19 Conclusion

The SA packaging industry reflects a dynamic landscape shaped by various factors. Examining packaging statistics reveals a sector marked by growth and evolving consumer preferences, prompting businesses to adapt to shifting trends. However, alongside opportunities come challenges, with issues such as sustainability and environmental impact driving the need for enhanced recovery systems.

This chapter provided insights into various aspects of the South African packaging industry, including its size, scale, economic significance, employment prospects, complexity, challenges, and opportunities. The review indicates a notable correlation between the packaging GDP and the overall South African national GDP. Consequently, the South African packaging sector emerges as a substantial contributor to the country's GDP, thereby playing a crucial role in the broader South African economy.

The introduction of EPR legislation in 2021 indicates a pivotal shift towards a more sustainable approach, compelling industry players to take greater responsibility for the lifecycle of their products. This legislative framework not only addresses environmental concerns but also encourages innovation in packaging design and materials, nurturing a more economic, social, and eco-friendly packaging industry.

The role of waste pickers in the packaging ecosystem cannot be overlooked. Their contribution to post-consumer packaging material recovery is significant, highlighting the need for collaborative efforts to integrate informal waste management into formal systems. Recognising and empowering waste pickers can contribute to a more inclusive and efficient recovery process.

Amidst these challenges, the packaging industry also presents opportunities for job creation. As the sector adapts to social, economic, and environmental sustainability requirements and invests in advanced packaging recovery models, there will be potential for the generation of new employment opportunities. This not only supports economic growth but also aligns with global initiatives aimed at creating a circular economy.

In essence, the South African packaging industry stands at a crossroads, where addressing challenges and capitalising on opportunities are essential for long-term sustainability. By embracing extended producer responsibility, integrating waste pickers into formal systems, and prioritising eco-friendly practices, the industry can navigate its way towards a more resilient and responsible future.

The review that follows in Chapter Three comprehensively analyses theoretical and empirical literature surrounding the concepts of circular economies, sustainable development, EPR legislation, post-consumer metal packaging recovery models, packaging design for recycling, and models that enable energy recovery from waste.

CHAPTER THREE

THEORETICAL AND EMPIRICAL PERSPECTIVES

3.1 Introduction

The SA packaging industry is shaped and influenced by a complex framework of environmental, social, economic, legislative, political, demographic and technological factors, including global population growth and the supporting global supply chains. The following discussion extensively reviews these factors and identifies the effects of the interactions of such factors on the SA packaging industry.

3.2 The Industrial Revolution (IR) evolution

Anderson (2023: 1), Xu, David and Kim (2018: 90) and Schwab (2018: 7) clearly map out the sequence and impacts of the industrial revolutions over time, showing that with each stage of the industrial revolutions, coupled with an accelerated human population growth, the changes to the natural order of the earth began to show a measurable environmental imbalance.

Figure 3.1 illustrates the progressive revolution of manufacturing expertise from the year 1780 to year 2023, as society mastered and exploited technology to satisfy the human needs and wants Anderson (2023: 1).

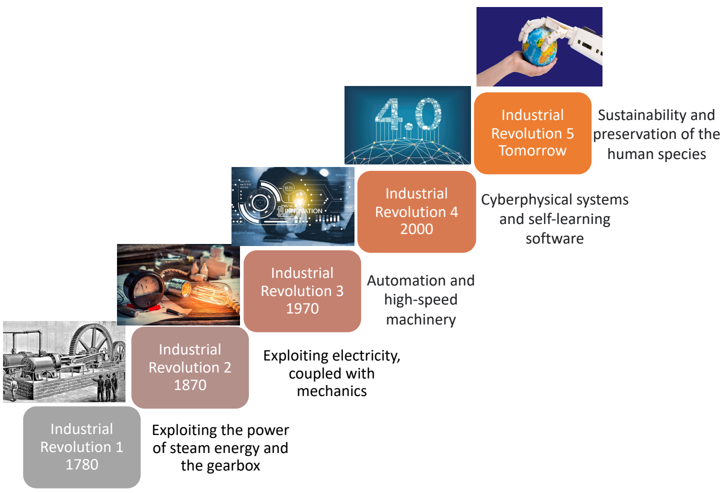

Figure 3.1: Industrial revolution evolution

Source: Adapted from Xu, David and Kim (2018: 90) and Anderson (2023: 1).

Schwab (2018: 7), Xu, David and Kim (2018: 90) and Anderson (2023: 1) point out that, although the industrial revolutions created enormous advancements, these came at a huge environmental cost that became the driving force behind climate change, as per the following discussion:

i. The first industrial revolution, around the year 1780, propelled by the exploitation of steam power, coupled with the development of the toothed wheel gears, which are mechanical rotational wheels that interlock at the gear interfaces, to transmit motion and power. This resulted in the creation of semi-automated factories for mechanical production, improving significantly from the historical, laborious hand crafting of goods. The advent of the first industrial revolution resulted in the replacement of traditional craftsman processes, that relied on manual tools, with industrial machinery to improve productivity and efficiency;
ii. Since the ability to harness electricity, the second industrial revolution was born around 1870, and mechanical machines, now also electrically supported, resulted in high-speed production of consumer goods, providing ease of living. People began using electronics and electricity for simple tasks that used to be done manually in the past;
iii. Binary systems, digital software, computers, and technological advancement presented the third industrial revolution around 1970, resulting in a society where there is a heavy reliance on the use of technology and mass production, to enable sophisticated supply chains across the planet;
iv. Now in the fourth industrial revolution, it is understood that each of the preceding industrial revolutions has gradually resulted in the increase of environmental pollutants, and a general degradation of the planet, resulting in a focus on sustainable development and
v. The predicted fifth industrial revolution will necessitate a paradigm shift towards preserving biodiversity through environmental sustainability, ensuring the continuity of the human species.

Xu, David and Kim (2018: 90) concluded that excessive industrialisation has resulted in society placing high emphasis on manufacturing efficiency and productivity, at the expense of limited natural resources, and this has resulted in the degradation of the environment, threatening the eco-systemic balance of the planet. Anderson (2023: 1), in a more recent study, also draws similar conclusions.

The current packaging manufacturing regime is referred to as fast-paced, smart factories, where the Fourth Industrial Revolution (4IR) or Industry 4.0 bouquet of technological offerings is exploited to shift from the traditional, inefficient packaging factories and this is illustrated in figure 3.2 (Kalsoom, Ahmed, Rafi-Ul-Shan, Azmat, Akhtar, Pervez, Imran and Ur-Rehman 2021: 11).

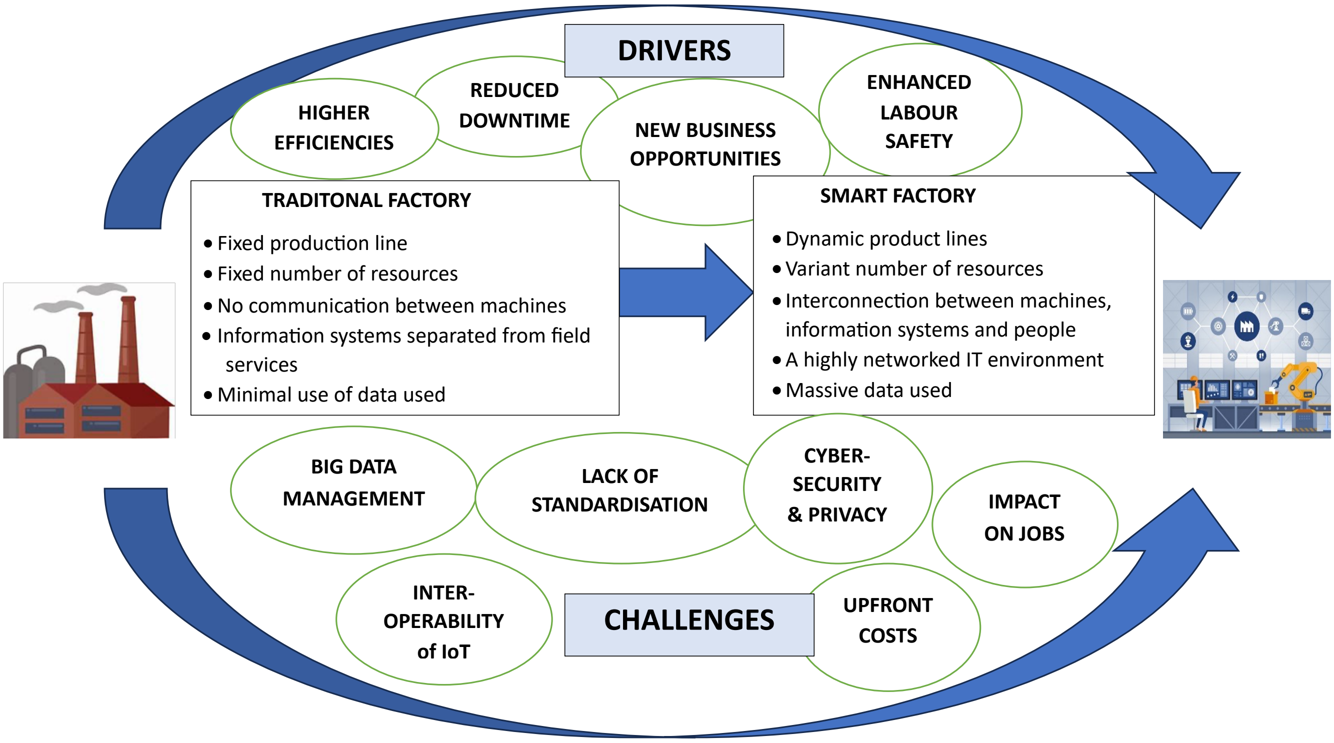

Figure 3.2: Traditional versus smart factories

Source: Adapted from Kalsoom et al. (2021: 11)

The researcher notes that it is vital to change the paradigm from traditional packaging manufacturing methods to smart 4IR packaging manufacturing methods to enable better finite resource utilisation, greater manufacturing efficiencies, lower unit costs, lower adverse environmental impact, driving greater circularity in packaging materials.

However, from the preceding literature review, it must be noted that the progressive industrial revolutions resulted in more products, which necessitated more packaging, and the 4IR has resulted in material and measurable planetary degradation.

Transitioning into the future, the researcher observes that the upcoming 5IR will be pivoted around planetary sustainability and the preservation of the human species. Consequently, this study is considered particularly timely and relevant.

According to Nasman, Dowling, Combes and Herweijer (2017: 3), the 4IR, with its multifaceted impacts on healthcare, employment, education, and societal dynamics, has played a pivotal role in shaping the landscape of population growth in the contemporary era. The following discussion now focuses on the human population dynamics across the industrial revolutions.

3.3 The human population growth and consumption of finite resources

Kaneda, Power, Patierno, and Haub (2023: 1) and Norrman (2023: 686) posited that, since 1750, the global human population has seen an accelerated growth from just under 1 billion to the current 7.98 billion, resulting in a corresponding increase in the demand for finite resources.

Lanz, Dietz, and Swanson (2017: 997) project an increase to approximately 8.5 billion by 2030, and 10 billion by the year 2050, potentially peaking at 12 billion by the year 2100.

Figure 3.3 illustrates the human population growth rate since the year 1050 (Norrman 2023: 686). The global population trend illustrates accelerated growth since the Industrial Revolution began in 1780 (Norrman 2023: 688).

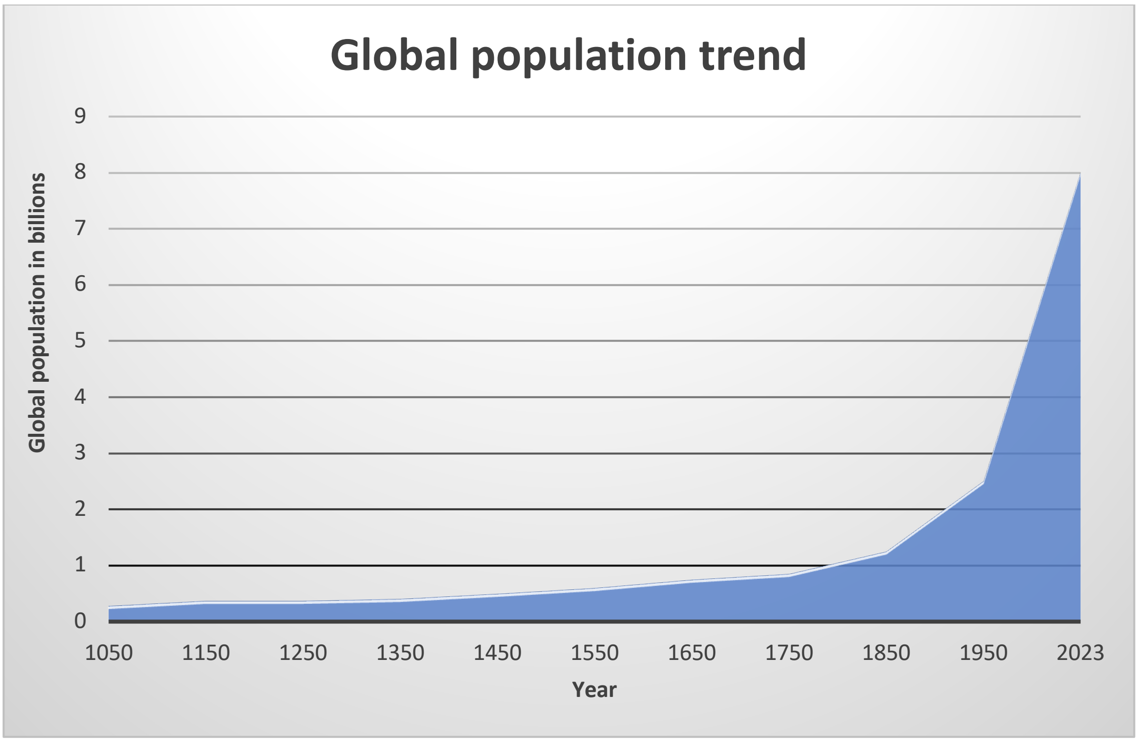

Figure 3.3: Global population growth

Source: adapted from Norrman (2023: 686)

This exponential population growth has led to an increase in the demand for finite resources like raw materials, water, energy, and agricultural land, exerting a detrimental impact on the earth's immediate habitat (Franklin-Johnson, Figge, and Canning 2016: 589).

Malik, Sharma, Batra, Sharma, Kaswan and Garza-Reyes (2023: 19) predict that the global demand for these resources could triple by 2050, surpassing the rate at which they can be replenished, rendering the planet unsustainable.

Figure 3.4 illustrates the accelerated global natural resource consumption over time, from the year 1800 to 2017 (Manowska and Nowrot 2019: 4).

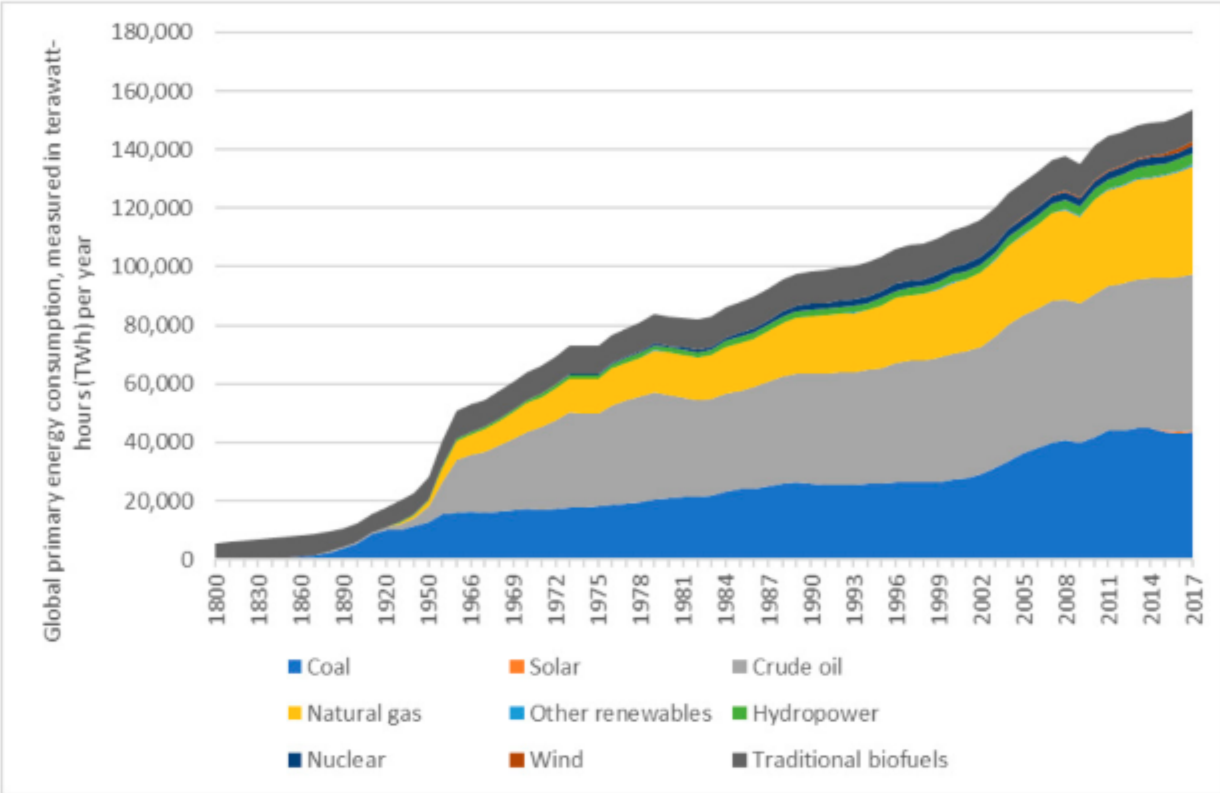

Figure 3.4: The global natural resource consumption over time

Source: Manowska and Nowrot (2019: 4)

The prediction of tripling the demand for finite resources by 2050, surpassing the rate at which such finite resources can be replenished, rendering the planet unsustainable is supported by Reh (2013: 119) as well as, more recently, by Hariyani, Mishra, Sharma and Hariyani (2022: 1).

Due to high-speed manufacturing delivered by the industrial revolutions and sophisticated supply chains, just over 100 million tons of the earth's finite resources are brought into the economy annually, but, more importantly, the utilisation of such resources has almost tripled since 1970 (McGinty 2021: 1).

McGinty (2021: 1) also anticipates that the current resource demand could potentially triple again by 2050 if global business and social practices remain unchanged.

The researcher notes that packaging demand is anticipated to follow this trend, given the close correlation between packaging GDPs and national GDPs, as shown earlier.

Projecting into the future, it is predicted that sustaining such a high volume of resource usage would require the equivalent of 1.5 times the earth's finite resources (McGinty 2021: 1).

The recent accelerated increase in the global human population, coupled with the declining availability of the earth's finite resources, now present new planetary challenges; consequently, the need for pollution reduction, waste minimisation, carbon footprint reduction, and recycling of post-consumer products are now becoming prominent concerns among millennials (Krishnan, Zulkapli, Kamyab, Taib, Din, Majid, Chaiprapat, Kenzo, Ichikawa, Nasrullah, Chelliapan and Othman 2021: 1).

Such rapid population growth, coupled with the increased demand for the earth's finite resources, has led to a significant critique of the traditional linear economy, which historically prioritised economic growth, often at the cost of social and environmental impact; consequently, there is now a compelling argument endorsing a more efficient and circular utilisation of finite resources (Vargas-Terranova, Rodrigo-Ilarri, Rodrigo-Clavero and Rozo-Arango 2022: 1).

3.4 Linear economy model

The prevailing linear economy model has been in place since the first Industrial Revolution in 1782 and was primarily measured by economic indicators, neglecting the long-term adverse impacts on the social and environmental sectors (Franklin-Johnson, Figge, and Canning 2016: 590).

This linear economy model, shown in figure 3.5, involves the manufacturing of products from finite resources, followed by consumer purchase, utilisation, and eventual disposal as waste to landfill sites (Didenko, Klochkov and Skripnuk 2018: 4). Known as the *"take, make, use, dispose"* model, it progresses linearly from the extraction of valuable raw materials from the planet to waste disposal in landfill sites after consumer use; however, this linear model is unsustainable as it depletes finite resources at a rate higher than the rate of replenishment (Ghisellini, Cialani and Ulgiati 2016: 11).

Human population growth, coupled with the rising demand for the earth's finite resources, has resulted in global criticism of the traditional linear economy model and, consequently, global support of a rapidly growing circular economy model, to extend the use of finite resources (Vargas-Terranova *et al.* 2022: 1).

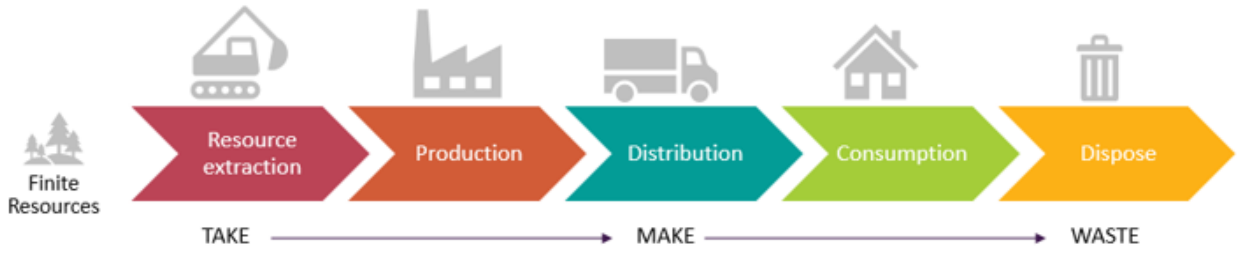

Figure 3.5: Linear economy model
Source: Franklin-Johnson, Figge, and Canning (2016: 590)

The typical global consumer, on average, will engage with and open approximately seven packages a day, and will discard such packaging immediately after use; consequently, post-consumer packaging now symbolises a throwaway society, contributing to a detrimental environmental impact (Borgman, Mulder-Nijkamp, and de Koeijer 2018: 1).

In the linear economy model, once a packaging or product's usefulness is exhausted, it transforms into waste that is discarded to landfill or into oceans and freshwater systems, necessitating the original production system to repeat itself, by extracting new basic raw materials from the earth's geosphere, whilst the circular economy model ensures that products and raw materials are kept within the manufacturing and utility circle for as long as possible, promoting environment sustainability (Puntillo 2022: 941).

3.5 Circular economy (CE) model

Pennington (2022: 2), defines CE as a system that intends to maximise the output of materials, to keep products and materials in use as long as possible and to design products to be recycled back into the economy, thereby eliminating waste.

The annual, global accumulation of high levels of industrial and post-consumer waste necessitates effective waste management protocols, and, the focus has been on re-use, re-manufacturing, and recycling, as these not only enhance cost-effectiveness over time but also contribute to the profitable growth of the material recovery businesses (Krishnan *et al*. 2021: 1).

In contrast with the linear economy model, the CE model, illustrated in figure 3.6, aims to retain a significant portion of materials in circulation, thereby mitigating the demand for finite resources (Didenko, Klochkov and Skripnuk 2018: 2).

Figure 3.6: Circular economy model

Source: Lederer, Bartl, Blasenbauer, Breslmayer, Gritsch, Hofer, Lipp and Muhl (2022:3)

As illustrated in figure 3.6, the CE is a transformative economic model that focusses on reducing waste by the recovery, re-use, and recycling of finite resources, supporting a closed-loop system, by embracing a regenerative approach to resource management, ultimately intending to create a sustainable economic system that reduces environmental impact, encouraging responsible stewardship of finite resources (Lederer, Bartl, Blasenbauer, Breslmayer, Gritsch, Hofer, Lipp and Muhl 2022:3).

The circular economy has emerged as a prominent global strategic concern in the pursuit of sustainable economic systems, where the traditional approach of taking, making, using, and throwing is now shifting towards a comprehensive integration of recycling and waste management throughout the entire product lifecycle, from its initial production stages to its ultimate utilisation by consumers (Tantau, Maassen and Fratila 2018: 1). The circular economy embodies the aspiration for an economy with zero waste and the fundamental premise is to prolong the lifespan of products, thereby reducing the amount of waste generated and the goal is to establish a closed loop that maximises resource utilisation instead of generating waste (Misztal and Dziekanski 2023: 1).

A CE transforms the concept of economic growth by shifting away from the linear model of “take-make-use-throw” within societies and, as an alternative, it promotes an approach that separates economic activity from negative environmental impact, facilitating a fair transition towards renewable energy sources (South Africa. Department of Environmental, Forestry and Fisheries 2020: 26).

As a result of the increase in climate change related issues, coupled with the call to reduce excessive natural resource consumption and waste, the circular economy model has generated growing attention from environmentalists and regulators who recognise the need to extend the lifespan of goods, and this has led to a heightened focus on abiding by circular economy principles (Maricut, Gradinaru and Matei 2022: 84).

According to Tantau, Maassen and Fratila (2018: 1), the circular economy model involves a complete overhaul of economic and social systems, necessitating a re-design of products and services from their initial conception stage.

The CE model translates into the following four principles (Tantau, Maassen and Fratila 2018: 1):

i. *CE design:* This refers to the process of manufacturing products from the initial production design phase with the intention of facilitating product re-use, recycling, or cascading. Cascading implies that the product can become input for another product once its current life cycle ends;
ii. *Novel and innovative business models*: These are emerging to facilitate the shift away from the traditional *"buy, consume, dispose"* approach towards closed loop, sustainability principles;
iii. *Reverse cycles*: These refer to the establishment of efficient and innovative systems that enable the cascading of new materials and products, as well as the return of used materials, either back to the soil or to the production process. This concept encompasses various aspects, including logistics, collections, sorting, treatment, and segmentation and
iv. *Enablers and accelerators*: Market mechanisms, educational institutions, policymakers, and financing in the field, play a vital role in encouraging the re-use of materials and increasing resource productivity. In a CE, the emphasis

shifts towards practices like reusing, repairing, refurbishing, and recycling existing materials and products.

The adverse effects of modern societies' lifestyles demand a large-scale effort to ensure sustainable development for both current and future generations and the CE package introduced by the EU represents precisely the type of project that can significantly propel societies in the right direction (Lederer *et al.* 2022: 12). Hence, waste management plays a crucial role in achieving the goals of the circular economy package, but its full potential can only be harnessed if every step in the waste management system is fully utilised.

As per the Platform for Accelerating the Circular Economy (PACE), a collaborative initiative comprising global changemakers, established by the World Economic Forum, there are five opportunities outlined in the work of McGinty (2021: 1) that should be embraced to showcase a circular economy:

i. *Reduction of consumption of finite resources:* The concept of the circular economy revolves around optimising the utilisation of finite natural resources. This involves shifting to recycled and recyclable materials, changing consumption patterns by reusing and re-purposing;
ii. *Reduction of emissions*: Developing strategies that reduce greenhouse gas emissions will prevent the adverse effects of climate change by an estimated 39%;
iii. *Protection of human health and bio-diversity:* Annually the human death toll due to air, water and soil pollution is nine million and this also threatens biodiversity. Waste that is mismanaged can become hazardous for human health and bio-diversity;
iv. *Boost economy:* CE creates the opportunity to boost the economy by waste reduction, innovation, stimulating employment, and
v. *Creation of more and better jobs:* A clear focus on social and environmental justice can lead to more and better job outcomes. Formalising informal waste pickers into formal employment can create better employment opportunities for them.

Lederer *et al.* (2022: 3) show that the European Union (EU) introduced the CE model to address such environmental challenges that arise out of reduced recycling rates of post-consumer waste. This comprehensive model comprises guidelines, directives, ordinances, as well as strategy documents that set specific SDGs and measures to establish a circular economy, and by doing so, the EU intends to reduce both material imports and environmental impacts (Lederer *et al.* 2022: 3).

Circular economies will play a crucial role by conservation of critical materials, use of low carbon material and by designing circular systems to build the energy infrastructure that is required globally (Pennington 2022:4).

Although there is extensive research that supports a CE, Yeh (2022: 2), argues that manufacturing organisations are typically incentivised to sell more, and not to design for longevity, which is an idea that will deliver product durability, maximising natural resource preservation and environmental sustainability.

Additional insights on this CE model will be explored in the subsequent discussion on the triple bottom line which prompted circular economy thinking (Didenko, Klochkov and Skripnuk 2018: 2).

3.6 The triple bottom line (TBL)

The triple bottom line concept, originating from John Elkington's introduction of the term in his seminal works in 1997, Elkington (1997: 116), has attracted increased attention over the last two decades. Literature endorsing and reinforcing the triple bottom line, which advocates the cyclical utilisation of materials, has become mainstream thinking within the business and commerce markets over the same period (Batista, Gong, Pereira, Jia and Bittar 2019: 7248).

Elkington (1997: 116) introduced the 'triple bottom line' concept, highlighting to businesses, the significance of a threefold, interconnected objective system encompassing business profitability, planetary sustainability, and social prosperity. Managing these three goals collectively is posited to achieve sustainability for the planet and ensure the continuity of businesses (Lacy and Rutqvist 2015: 112).

The triple bottom line model is illustrated in figure 3.7.

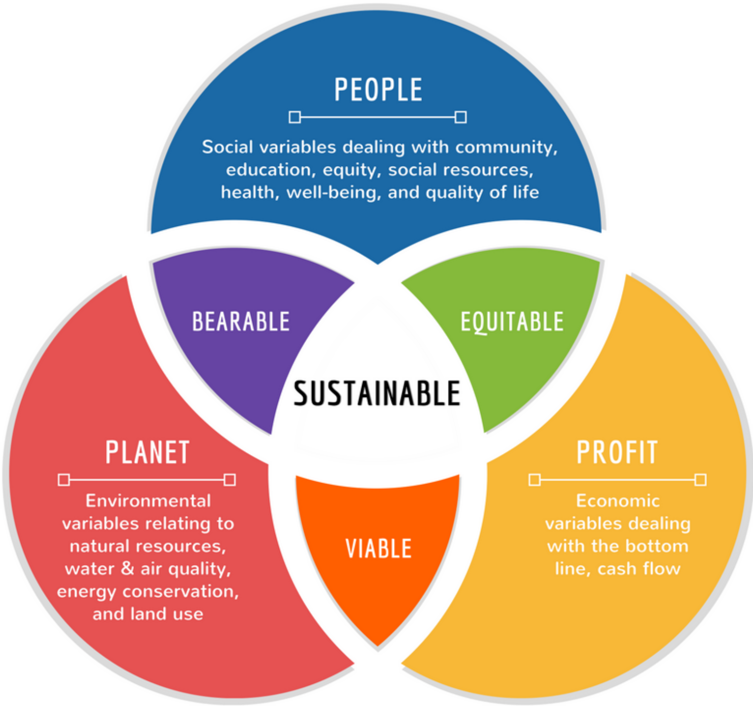

Figure 3.7: Triple bottom line model
Source: Elkington (1997: 116)

This overlapping triple bottom line model has been criticised because it conveys the idea that the planet, people and profit circles are independent of each other, yet equal in contribution to sustainability (Sorunke and Apanisile 2019: 42).

In reality, however, every process exists within the outer environment circle, where photosynthesis, powered by the sun, drives the environmental evolution on the planet, upon which are human beings, in a social circle that is nested within the environment circle, and nested within this social circle, lies an economy circle, created by human value added proceses (Sorunke and Apanisile 2019: 42).

This idea of nested circles is reinforced by Correia (2019: 31), who also argues that social and economical sustainability is derived purely from environmental sustainability and it is therefore incumbent upon businesses to integrate corporate social and environmental responsibility, to ensure continuty of economical equity. Parry (2018: 1), cited in Correia (2019: 34), is of the view that, “Sustainability is no longer an option but an imperative. Rather than a burden, it is the beta of future growth”.

The nested triple bottom line model, shown in figure 3.8, introduces a layered approach, conveying the message that economic equity, arises from social equity, which ultimately is dependent on environmental equity (Sorunke and Apanisile 2019: 42) and (Correia 2019: 34).

Figure 3.8: The nested triple bottom line model
Source: Adapted from Sorunke and Apanisile (2019: 42) and Correia (2019: 31)

Batista *et al.* (2019: 7248) supporting the nested triple bottom line idea, emphasise that economic growth should consider both the social impact and planetary considerations.

They proposed that the concept of natural resource 'utilisation' should focus on preventing material waste and ensuring the extended, circular use of materials. The promotion of natural resource utilisation is central to the circular economy (CE) model, as defined by Webster (2017: 16), which portrays CE as a triple bottom line, sustainable economy, designed to circulate products back into the manufacturing cycle after consumer use.

Figure 3.9 demonstrates the contributory relationship between Industry 4.0 and the triple bottom line (TBL).

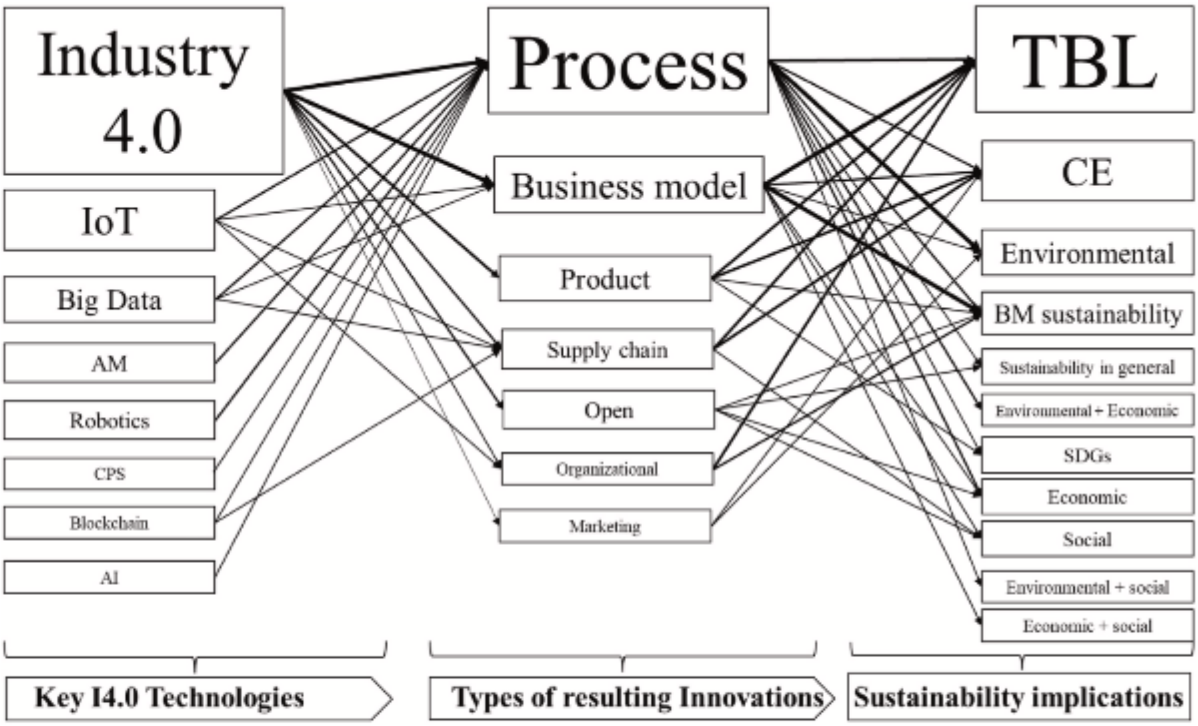

Figure 3.9: The contributory relationship between Industry 4.0 and the triple bottom line (TBL)
Source: Khan, Ahmad and Majava (2023: 8)

Figure 3.9 illustrates that the bouquet of technology offered by Industry 4.0, contributes to the innovation of business processes, including sophisticated supply chains, that support sustainable development, through a robust triple bottom line working model.

Hence, the researcher summarises that achieving planetary sustainability necessitates a meticulous equilibrium, utilising the earth's natural resources, addressing societal living aspects, and enjoying economic advantages. Therefore, it is crucial to realise and appreciate that the human-driven economy is completely dependent on the natural environment, emphasising the importance of re-using materials already in circulation to ensure economic continuity. The researcher reinforces the idea that Industry 4.0 technology has the potential to unlock the benefits of a TBL.

The next discussion will highlight the demands of global supply chains on natural resources and the need for circularity in global supply chain management.

3.7 Circular supply chains

The high-speed manufacturing across the industrial revolutions increased the quantity of packaged product, resulting in an increase in supply chain infrastructure to deliver such consumer products across the globe, presenting the need to reduce carbon emissions (Luther 2023: 1; Dull 2023: 12).

Such global supply chains then necessitated the design of packaging that was required to unitise, protect, contain, and preserve such products during rigorous transit journeys (Handan 2022: 1; Dull 2023: 12).

Consumer packaging in the modern world is often seen as unnecessary or excessive and, more importantly, as a source of litter despite its positive impact on modern supply chains that support extravagant lifestyles (de Koeijera, de Lange and Lutters 2023: 720).

The linear economy, single use, throw-away packaging has a significant adverse environmental impact and necessitates the Life Cycle Assessment (LCA), to explore packaging design for circularity, supporting supply chain circularity (de Koeijera, de Lange and Lutters 2023: 720).

Therefore, according to Borgman, Mulder-Nijkamp, and de Koeijer (2018: 1), business and social philosophies must adopt a triple bottom line approach to supply chains, mitigating adverse environmental impact, supporting a circular economy. Organisations that prioritise sustainability in their global supply chain operations contribute significantly to a more sustainable and responsible global business landscape (de Koeijera, de Lange and Lutters 2023: 720).

Another serious challenge, even as far back as 2011, as discussed by Coelho, Castro, and Gobbo (2011: 294), is the design and implementation of circular supply chains, particularly for packaging waste recovery. Such circular supply chains have been hampered by the lack of waste recovery training and education among various supply chain players who play crucial roles in packaging recovery ecosystems (Coelho, Castro, and Gobbo 2011: 294).

The global packaging industry, by maximising material recovery across all packaging materials, supports a circular supply chain and such an approach ensures that raw materials for packaging come from materials already in circulation within the economy, reducing the need to extract resources from the planet (Dervojeda, Verzijl, Rouwmaat, Probst and Frideres 2014: 116).

This circular flow of materials enhances value and broadens the scope of the supply chain (Govindan and Hasanagic 2018: 307). The design of supply chains is evolving to embrace a comprehensive view that integrates circular flows from raw material suppliers to consumers, facilitating post-consumer material recovery for closed loop, repeated usage, as pointed out by Govindan and Hasanagic (2018: 307). According to Mastos, Nizamis, Terzi, Gkortzis, Papadopoulos, Tsagkalidis, Ioannidis, Votis and Tzovaras (2021: 8), circular economy models and solutions, assisted by Industry 4.0 technologies have been developed to transform products at the end of their life cycle into new products with different use, driving circular supply chains.

Mastos *et al.* (2021: 8) present the ReSOLVE model, by the Ellen McArthur Foundation, that is designed to support global circular supply chains:

i. **Re**generate focuses on the transition to renewable energy and materials and to the preservation and improvement of natural ecosystems;
ii. **S**hare refers to 'sharing economy' which includes the extension of a product's lifecycle, while at the same time reducing the waste and duplication;
iii. **O**ptimise emphasises the minimisation of non-value-added activities within the firm and supporting supply chains by the use of big data, automation, remote sensing, and steering;
iv. **L**oop involves closed loop activities where products follow a circular path instead of a linear path which includes the "take-make-use-dispose" principle;
v. **V**irtualise refers to delivering utility virtually, visualising materials and processes. Within the CE concept, information availability and exchange that replaces or postpones actual physical goods consumption is also included in the virtualise dimension and
vi. **E**xchange involves the replacement of old materials with advanced non-renewable products and services, deploying new technologies such as blockchain and three-dimensional printing.

Transportation is the main contributor of greenhouse gas emissions in the United States followed by power generation; consequently, such greenhouse gas emission requires urgent action more than ever before, across all sectors, as this results in an increase in global temperature and carbon dioxide concentrations (Batista *et al.* 2019: 7256).

Utilities that are moving away from emission-intensive electricity sources can benefit significantly from decarbonisation, for example, through the sale of renewable energy credits, reduction in regulatory costs, and increased opportunities to gain tax credits Batista *et al.* (2019: 7256).

Another element to consider is synchronisation, the ability to coordinate, organise and manage end-to-end supply chain flows across products, services, information, and financials, is necessary, so that the supply chain functions as a single entity (Griffin and Kumar 2009: 1).

Supply chain visibility and collaboration are two of the key ingredients in the synchronisation recipe because they play a significant role in managing demand uncertainties, positively impacting an organisation's inventory status and time to market (Griffin and Kumar 2009: 1).

Hence, the researcher notes that business and social practices have seen a significant evolutionary change since the mid 1700's, leading to convenient consumer lifestyles, increased human population growth and a greater dependency on finite resources, resulting in a greater need for synchronised global supply chain infrastructure that supports post-consumer material recovery, at the lowest carbon footprint.

3.8 Synchronisation in business systems

Eroglu, Lamb and Pereira (2017: 1) in their work on business synchronisation models posit that dynamic networks amongst multiple businesses display behaviour in which deterministic chaos, exhibiting unpredictability and disorder, co-exists with synchronisation, which is a classical paradigm of order. Synchronisation in coupled systems, which are networks of interacting elements, describe a spontaneous transition to order because of the designed interactions, creating synergy (Eroglu, Lamb and Pereira 2017: 1).

Chaos in dynamics is one of the scientific revolutions of the twentieth century that has deepened the understanding of the nature of unpredictability and the consequential need for synchronised systems to maximise throughput across multiple independent operations through synergy (Eroglu, Lamb and Pereira 2017: 1)

Griffin and Kumar (2009: 1) support the synchronisation concept because this is crucial for businesses to adapt to the dynamic and fast-paced nature of the 4IR as synchronisation ensures the coordination of internal functions and external interactions to ensure a smooth flow of operations, including the integration of circular supply chain processes, ensuring efficient material movement.

Implementing integrated 4IR technology that allows for seamless communication and data sharing is essential for synchronisation, because integrated systems and software can streamline processes and enable real-time decision-making (Griffin and Kumar 2009: 1).

However, being fundamentally a non-equilibrium process, synchronisation comes with unavoidable energy costs and has to be maintained under the constraint of limited resources. Such resource constraints are often reflected as a finite coupling budget available in a network to facilitate interaction and communication (Zhang and Strogatz 2021:1).

The following segment will delve into the philosophy of sustainable development, a framework designed to address the contemporary issues of environmental harmony that have surfaced due to the increasing environmental challenges, social inequities, and economic disparities affecting the global community.

3.9 Sustainable development

Sustainable development, defined as the integration of environmental conservation, social equity, and economic prosperity, intends to meet the needs of the present without compromising the ability of future generations to meet their own needs (Misztal and Dziekanski 2023: 1). Sustainable development encompasses several essential expectations that revolve around achieving a balanced and harmonious coexistence of environmental, social, and economic well-being (Misztal and Dziekanski 2023: 1).

The key expectations of sustainable development include (Mensah 2019: 21):

i. *Environmental stewardship:*
    a. Conservation of natural resources;
    b. Mitigation of environmental degradation;
    c. Promotion of biodiversity and ecosystem health;
ii. *Social equity and inclusivity:*
    a. Ensuring fair distribution of benefits and opportunities;
    b. Fostering social cohesion and community engagement;
    c. Addressing social injustices and disparities;
iii. *Economic viability:*
    a. Encouraging responsible and ethical business practices;
    b. Supporting economic growth that benefits all segments of society;
    c. Balancing economic development with environmental and social considerations;
iv. *Interconnectedness:*
    a. Recognising and addressing the interdependencies between environmental, social, and economic factors;
    b. Understanding the holistic nature of sustainable development challenges;
v. *Long-term vision:*
    a. Planning and decision-making with a focus on the well-being of present and future generations;
    b. Striving for enduring solutions rather than short-term gains;
vi. *Global collaboration:*
    a. Encouraging international cooperation to tackle global challenges;
    b. Sharing knowledge, technology, and resources for mutual benefit;

vii. *Adaptability and resilience:*

a. Developing strategies that can adapt to changing circumstances;

b. Building resilience in communities and ecosystems to cope with environmental and social changes;

viii. *Innovation and technology:*

a. Harnessing innovation and technology to find sustainable solutions;

b. Promoting research and development that aligns with sustainable development goals;

ix. *Good governance and accountability:*

a. Implementing transparent and accountable governance structures;

b. Enforcing regulations and policies that support sustainable practices;

x. *Cultural sensitivity:*

a. Respecting and preserving cultural diversity and

b. Integrating traditional knowledge and practices that contribute to sustainability.

Thus, these expectations collectively form the foundation of sustainable development, reinforcing a holistic and integrated approach to address the complex challenges facing societies on the planet.

The next discussion focusses on a key sub-element of SD, namely green philosophy and related aspects.

3.9.1 Green philosophy

The escalating dependency on natural resources in modern lifestyles highlights the importance for a transition to a sustainable way of life, aligning with a green philosophy that encourages a reduction in natural resource consumption (Uren, Roberts, Dzidic, and Leviston 2019: 1). Notwithstanding, the combination of population growth and the desire for extravagant lifestyles compels brand-owners' to employ extensive packaging, leading to the production of a diverse range of consumer goods and such a heightened production not only consumes more energy and raw materials but also poses a significant threat to the environment (Reh 2013: 119). The term "Green Economy" (GE) is an economic system that aims to enhance human well-being and social equity while significantly reducing environmental risks and ecological scarcities (Reh 2013: 119). In a GE, sustainable development is pursued through the efficient use of natural resources, the promotion of clean and renewable energy sources, and the incorporation of environmentally friendly practices across various sectors (Uren, Roberts, Dzidic, and Leviston 2019: 1). The objective is to achieve an equilibrium amongst economic equity, environmental equity, and social inclusivity, ensuring that present and future generations can meet their needs without compromising the health of ecosystems or the planet (Reh 2013: 119).

Calza, Sorrentino and Tutore (2022: 54) suggest that green marketing promotes the education as well as the desire of organisations to enhance their bouquet of offerings, by incorporating environmental benefits into consumer products and service delivery, resulting in further business advantages such as increased revenue, positive client feedback, heightened customer engagement, as well as an enhanced corporate image. Dangelico and Vocalelli (2017: 1264) support this view and emphasise that the successful creation and production of environmentally sustainable products and services are paramount in minimising the environmental footprint of industrial activities, promoting cleaner production.

The concept of the green economy (GE) must be viewed as a trigger to stimulate economic expansion and progress, whilst simultaneously preventing environmental decay, biodiversity decline, as well as the prolific usage of the earth's natural resources (Misztal and Dziekanski 2023: 1). GE is an overarching strategy that embraces bio-economy, circular economy, value chain digital transformation, sustainable development and knowledge-based growth (Maricut, Gradinaru and Matei 2022: 84). Such a strategy manifests as an approach that intends to optimise natural resource usage on the planet, simultaneously minimising environmental degradation (Maricut, Gradinaru and Matei 2022: 84).

Consequently, the categories of environmentally friendly products have grown over the past 20 years, as shown in the Dangelico and Vocalelli (2017: 1263) report, and modern consumers are inclined to pay a higher price for these, based on the product's functional features, or their demonstrated environmental commitment.

Traditionally, organisations focused on economic criteria for supplier selection, but environmental deterioration has led to the inclusion of green criteria in supplier selection processes as part of green supply chain management strategies (Yazdani, Chatterjee, Zavadskas, and Zolfani 2017: 3729). GE, defined as one that improves human well-being and social equity while significantly reducing environmental risks, has gained prominence (Ramsarup and Ward 2017: 29).

Dangelico and Vocalelli (2017: 1264) show that the following green marketing inputs are crucial for shaping product concept and design:

i. *Product Research and Development:*
    a. Sustainable raw materials: using raw materials that demonstrate reduced environmental impact, such as recovered, recycled or biodegradable materials;
    b. Energy efficiency: engineering products to be energy efficient during production, use, and disposal;
ii. *Packaging materials:*
    a. Minimalistic packaging: removing unnecessary layers of packaging as well as utilising raw materials that are recovered, recycled or biodegradable;
    b. Environmentally-friendly printing: adopting eco-friendly printing systems, coatings, inks and varnishes on packaging;
iii. *Distribution networks:*
    a. Efficient transportation: utilising logistical systems that minimise carbon di-oxide emissions, such as hybrid or battery-operated vehicles;
    b. Local sourcing: procurement of raw materials locally, reducing the eco-impact of logistics;
iv. *Eco-promotion:*
    a. Educational campaigns: creating consumers awareness of environmental benefits of products and services;
    b. Certifications: demonstrating eco-friendly international certifications, such as ISO14001:2015, to provide eco-assurance;
v. *Pricing strategies:*
    a. Value proposition: reinforcing strategic product value and benefits, despite higher initial costs;
    b. Incentives: allowing discounts and price incentives to stimulate the purchase of eco-friendly products;

vi. *Consumerism:*
   a. Lifestyle marketing: showing how the product aligns with an eco-friendly lifestyle;
   b. Encouraging recycling: creating awareness of recycling systems;
vii. *Social Responsibility Index (SRI):*
   a. Planet, profit, people initiatives: commitment to improving living and social conditions of people local to the organisation;
viii. *Communication channels:*
   a. Digital marketing: engaging a wider audience through online platforms;
   b. Social media: interacting with clients through various social media platforms for the promotion of the triple bottom line thinking;
ix. *Transparency:*
   a. Supply chain transparency: delivering messages about the complete product lifecycle, from sourcing raw materials to product recovery, re-use and
   b. Honesty: misleading environmental claims, referred to as "greenwashing" must be avoided and marketing messaging must be an accurate reflection of environmental impact.

The Green Marketing strategy involves segmentation, targeting, positioning, and differentiation, and Dangelico and Vocalelli (2017: 1263), in the subsequent discussion, delve into the distinctive features of each of these:

i. *Segmentation and targeting*: By employing segmentation and targeting, a company pinpoints the specific group or groups of consumers it aims to serve; however, it is important to note that attempting to understand consumer buying behaviour, based on their characteristics, rather than purchase perceptions, might be erroneous;
ii. *Targeting*: There should be a reconsideration in targeting green marketing, instead of focusing solely on green consumers with green products, the approach should shift towards expanding the targeted consumer base by incorporating green features as one of the many characteristics of a product;

iii. *Positioning and differentiation*: Consumers are inclined to purchase green products from environmentally conscious organisations; therefore in addition to creating more sustainable products, organisations should portray a more sustainable image. Aligning ethical values with marketing efforts is a complex task, but allocating resources to enhance the perceived green value can positively impact intentions to purchase environmentally friendly products and foster trust. This trust is further reinforced by a green brand image, ultimately contributing to elevated green brand equity.

The following discussion explores the need for post-consumer metal packaging recovery, recycling and re-use, supporting a metal CE.

3.9.2 Recycling

Tantau, Maassen and Fratila (2018: 1), are of the view that recycling plays a pivotal role in the circular economy model, standing out as a strategic, global necessity, due to the increasing accumulation of post-consumer waste, coupled with inadequate regulations in several regions across the globe. This, along with insufficient training and education, and other related challenges, results in a retarded recycling rate, with large volumes of post-consumer waste ending up in the environment, compromising the health of the planet, climate, wildlife, and ultimately posing risks to humanity (Tantau, Maassen and Fratila 2018: 1).

In a Spanish study by Roger-Loppacher, Buil, Tintore and Prieto-Sandoval (2022: 51), the following obstacles to recycling were highlighted:

i. Accessibility to and inadequacy of recycling facilities and infrastructure is limited;
ii. Challenges like inadequate space and time for sorting waste at home;
iii. Limited training and education relating to recyclable materials;
iv. Lack of recycling policies and incentives, and a mistrust in system and governing leaders;
v. Financial considerations, such as the cost of recycling management;
vi. Discrepancy between environmental concerns and limited public action, resulting in a difference between intent and tangible effort;

vii. Emotive responses, associating waste with a perceived lack of utility and lack of personal gain from recycling and
viii. Unclear logos on packaging / multi-material packaging;

Enabling consumer awareness on post-consumer waste recovery, coupled with the convenience of waste collection and recycling infrastructure, increases an individual's volition to participate in recycling (Wagner 2013: 500). Knowledge on post-consumer waste recycling also influences whether people will sort or separate post-consumer materials, the types of materials they will separate, the extent of material separation, the frequency of separation, as well as the volume and frequency of material movement to a buy back centre (Wagner 2013: 500).

Roger-Loppacher *et al.* (2022: 49) identify the following social motivation recycling factors:

i. People tend to observe and emulate neighbour activities; so when a few people begin to demonstrate recycling behaviour within a neighbourhood, others will follow;
ii. Personal behaviour and a sense of moral duty to sustainable development;
iii. Creating a positive self-image through separation of material at the home and the encouragement of material recycling;
iv. Personal and community benefits, including lower costs of recovery and recycling in comparison with alternative waste management methods;
v. Personal values and ethics, reflecting priorities and the degree of responsibility toward recycling;
vi. Knowledge of recycling practices and the ability to implement them, encompassing awareness of where, when, and how to recycle and
vii. Environmental concern and the association between recycling and pro-environmental attitudes.

The following recycling factors related to infrastructure support were identified by Roger-Loppacher *et al.* (2022: 49):

i. Convenient access to suitable recovery and recycling infrastructure and projects, involving factors such as home bins, proximity to recycling centres, population-to-bin ratios, home storage space, frequency of collection, and visually appealing bins;
ii. Ease and effort of recycling, highlighting that the simpler and more user-friendly a recycling system is, the more likely it is to be utilised;
iii. Influence of previous behaviour, which considers whether recycling traits have been reinforced in the past;
iv. Environmental education and communication, focusing on recycling awareness.

The researcher notes that for consumers to embrace active recycling, the key obstacles must be removed so that the act of recycling becomes easier for the consumer. Additionally, given the necessary motivation and mentoring around recycling coupled with the right training, awareness and education of the critical reasons for recycling, will result in greater motivation for a change towards an environmentally sustainable future based on a cradle-to-cradle approach of finite materials.

3.9.3 The 6 R’s

The original '3R' philosophy illustrated the efficient economic utilisation of materials and energy through the principles of reduce, re-use, and recycle (Jawahir and Bradley 2016: 105). With the evolving mindset of CE and growing recognition of sustainable innovation, an extended set of '3Rs' was introduced, resulting in the development of a '6R' model within the circular economy framework. The '6R' model incorporates additional concepts of recover, re-design, and re-manufacture (Jawahir and Bradley 2016: 105).

Table 3.1 illustrates the '6R' model, underpinning a circular economy philosophy.

Table 3.1: The circular economy '6R' model

Operation	**Intent**	**Result**
Reduce	This focuses on all stages of the product life-cycle, including the reduction on resources, materials and energy used, and the reduction of the waste generated.	Reduced dependence on Earth's natural resources and energy.
Re-use	This focuses on maximising the second or alternate applications for the original product thereby extending product life and adding value.	Enhanced practical utility of existing products.
Recycle	This focusses on products or components that otherwise are considered as waste. These, when re-introduced into manufacturing, can reduce the use of virgin materials.	Diversion from landfill, re-introduction of materials into circular economy.
Recover	This focusses on the disassembly of used products, the recollection and sorting processes to derive further value of the already used materials.	Diversion from landfill, re-introduction of materials into circular economy.
Redesign	This involves the knowledge and information required to optimise the design of a new product, for greater reusability, recyclability and recovery.	Facilitates the reuse, recycling and recovery by inherent design advantages.
Remanufacture	This involves reconditioning, repairs and subsequent manufacture of similar or different products for re-use.	Diversion from landfill, re-introduction of materials into circular economy.

Source: Adapted from Jawahir and Bradley (2016: 105) and Hernandez, Lu, Beno, Fredriksson and Jawahir (2019: 546)

Hernandez, Lu, Beno, Fredriksson and Jawahir (2019: 546) present the 6R based closed-loop product life cycle process flow map, as illustrated in figure 3.10, that exploits the following stages:

i. Pre-Manufacture stage (PM) involves the extraction and processing of the primary raw materials for subsequent manufacture;
ii. Manufacturing (M) stage involves the conversion of the raw materials;
iii. The Use (U) stage refers to the lifetime of the product while it is being used by the consumer and includes upgrades, repairs and maintenance;
iv. Post Use (PU) stage refers to the preparation for the creation of sustainable value for the product and components end of life;

v. Reduce stage focuses on all stages of the product environment life cycle and includes the reduction of resources, raw materials, energy and waste generated;

vi. Re-use stage refers to reusing the product or components at the end of the product's life cycle instead of using new product;

vii. Recycle stage refers to the process of collecting, sorting, and processing used materials or products to convert them into new items.

viii. Recovery stage refers to the disassembly, recollection and sorting process for further shredding and recovery of materials;

ix. Redesign stage refers to the use of recovered materials, resources, knowledge and information to streamline the design of new generation environmentally friendly product;

x. Remanufacture of products or components refers to reconditioning, repairs and subsequent manufacture of similar or different products for re-use.

The researcher notes that the 6R idea in material recycling and re-use emphasises a comprehensive approach to waste management, promoting sustainability and environmental responsibility. The importance of the 6-R concept lies in its ability to guide individuals, businesses, and policymakers toward more responsible consumption and waste reduction.

Figure 3.10 illustrates the 6R-based closed-loop product life cycle.

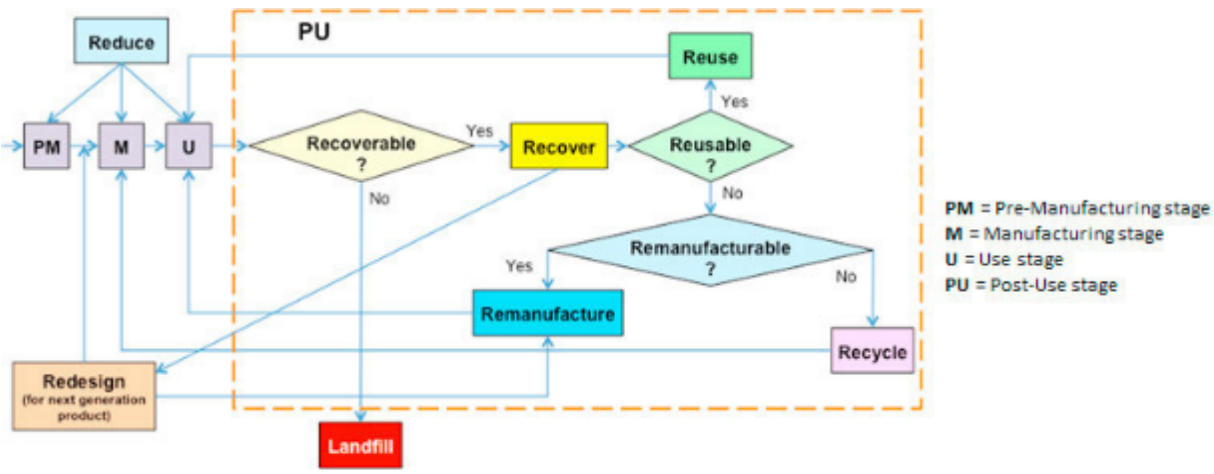

Figure 3.10: 6R-based closed-loop product life cycle

Source: Hernandez, Lu, Beno, Fredriksson and Jawahir (2019: 546)

The process map that is shown in figure 3.10 illustrates the decisions relating to each of the 6R's in relation to the premanufacturing stage, the manufacturing stage, the in-use stage as well as the post-use stage of the product, and by effectively adopting these principles, greater circularity of the packaging material will be realised, through a waste hierarchy system (Hernandez, Lu, Beno, Fredriksson and Jawahir 2019: 546).

3.9.4 Packaging design and development

Lifestyles have become increasingly resource-dependent, necessitating a shift toward more sustainable living by reducing natural resource consumption (Uren, Roberts, Dzidic, and Leviston 2019: 1). However, population growth and the pursuit of extravagant lifestyles necessitate the extensive use of packaging, driving organisations to manufacture a wide variety of consumer products, consuming more energy and raw materials, negatively impacting the environment (Reh 2013: 119).

Yeh (2022: 3) argues that packaging should be designed, such that the transition, post-consumer, from the original packaging application to a second life, is as easy as possible, thereby promoting the recovery and restoration of the material to its original performance level, resulting in an extended lifespan, as well as a CE, as opposed to manufacturing the packaging from new raw materials.

The role of packaging design in addressing resource sustainability challenges is crucial, serving as a pivotal element in transitioning from a linear economy to a circular one; this acknowledgment has spurred the development and acceptance of various product design approaches, such as eco-design (Franconi, Ceschin, Godsell, Harrison, Mate, and Konteh 2023: 316). These approaches aim to promote lasting and sustainable practices in product design and manufacturing while also encouraging behavioural shifts in consumption (Franconi, Ceschin, Godsell, Harrison, Mate, and Konteh 2023: 316).

One of the key challenges facing designers is to design packaging that is acceptable to consumers while considering the impact on the environment and environmental sustainability (Borgman, Mulder-Nijkamp, and de Koeijer 2018: 1). According to de Koeijera, de Lange and Lutters (2023: 720), packaging design decisions influence the pack-product compatibility as well as the related environmental impact of the packaging lifecycle. Guinee, de Koning, and Heijungs (2022: 673) posit that design for recycling (D4R) promotes the utilisation of Life Cycle Assessment (LCA) to exhaustively evaluate all conceivable environmental impacts that are associated with a particular product or service under development. This encompasses the evaluation of energy requirements, raw materials usage, the manufacturing and packaging processes, transportation and other logistical considerations, consumer use patterns, as well as the potential for recovery, re-use, recycling, and disposal (Fet, de Boer and Keitsch 2023: 52).

For a packaging system to be sustainable, it must embrace the planet and profit viability, profit and people equity, and also, a bearable planet and people relationship; therefore organisations are required to incorporate all three aspects of sustainability into the design of packaging, products, processes, systems, and supply chains (Hariyani, Mishra, Sharma and Hariyani 2022: 1).

Hence there is a need for robust sustainable packaging design and development models that supports CE.

Figure 3.11 represents a packaging sustainability design and development model that the private and public sectors can adopt globally to achieve absolute sustainability through compulsory sustainability (de Koeijera, de Lange and Lutters 2023: 723).

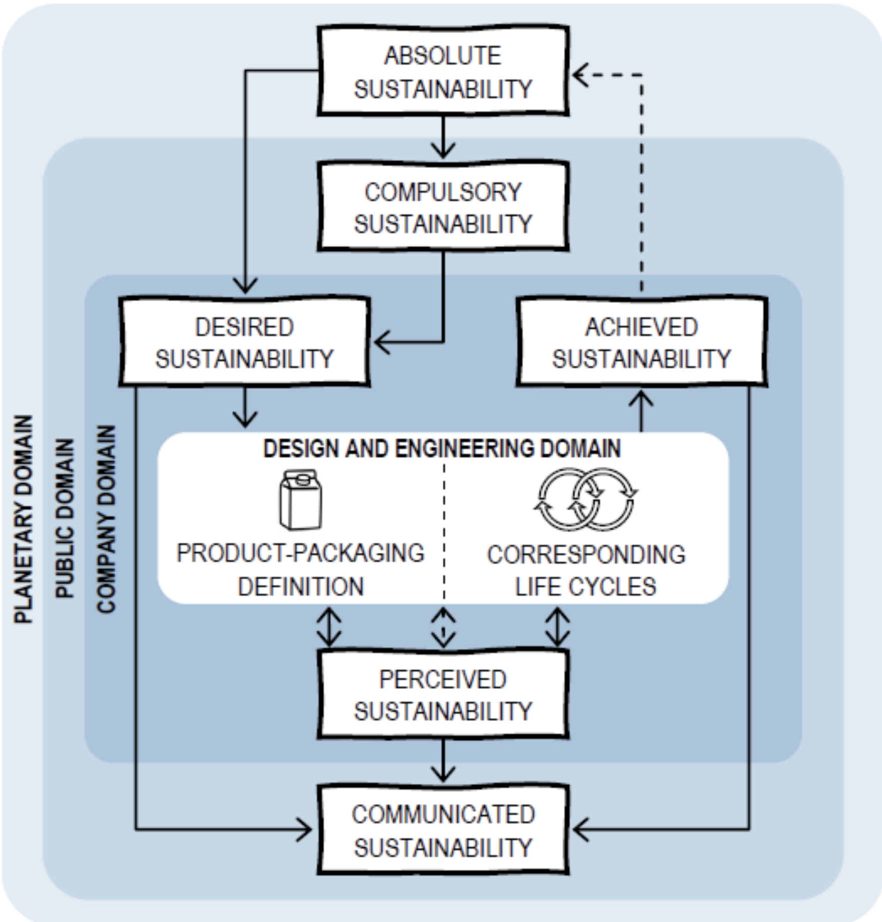

Figure 3.11: Sustainable packaging design and development model

Source: de Koeijera, de Lange and Lutters (2023: 723)

Figure 3.11 illustrates three fields, the innermost field shaded in dark blue, representing the company domain, through to the outer light blue field, representing the planetary domain, with the intermediate blue field, representing the public domain. de Koeijera, de Lange and Lutters (2023: 723), posit that absolute sustainability is governed by planetary harmonisation expectations, and such absolute sustainability is then translated into the public domain, where legislation dictates sustainability expectations through social and business reform; consequently, businesses adapt strategies relating to product and system design, to ensure continuity through sustainable development principles.

3.9.4.1 Design for recycling

Key elements of packaging design for recycling (D4R) include (Packaging SA 2023: para. 4 line 1) and (Horani, 2023: 1):

i. *Material choice:* Select more sustainable raw materials and integrate recycled materials into the design, reducing environmental impact of packaging;

ii. *Minimise packaging components:* Avoid the use of colorants, inks, adhesives, and other coatings whenever possible;

iii. *Simplicity:* Design packaging with simplicity in mind, making it simple for consumers to recycle used packaging without having to separate packaging materials or having to identify which packaging can and cannot be recycled, thereby reducing EPR fee liability, by adopting an “eco-modulated” approach;

iv. *Optimal recyclability:* Design packaging for maximum recyclability by using mono materials, avoiding combinations of different materials, thereby reducing EPR fee liability, by adopting an “eco-modulated” approach**;**

v. *Easy distribution and reuse:* Design packaging that is easy to transport, store, and reuse to promote a circular economy;

vi. *Design for recycling principles:* Embrace global design for recycling ideas and ensure that packaging will be able to be handled in various recycling streams and

vii. *Labelling and marketing:* Customise the external surface of packaging for labelling and marketing purposes, avoiding the need for secondary packaging such as wraps, sleeves, slips, or caps.

Hence, by considering these key elements in packaging design, businesses can contribute to increasing recycling rates and reducing the negative environmental impact of their packaging.

3.9.4.2 Design for Disassembly

Design for Disassembly (DfD) is a proactive approach to product and packaging design that enables the efficient and safe disassembly of product and packaging at the end of life (EOL) stages (Toniolo, Camana, Guidolin, Aguiari and Scipioni 2021: 1). Such a design strategy focuses on creating product and packaging, with the intent of easy recovery, reuse, and recycling of components and materials (Horani, 2023: 1):

By considering disassembly during the research, design and development stages, DfD reduces waste, and environmental impact, promoting a circular economy by re-purposing valuable materials (Horani, 2023: 1):

Although DfD is still in its infancy, it is an excellent strategy for extending the life of product and packaging, thereby reducing waste (Toniolo *et al.* 2021: 1).

3.9.4.3 Design for durability

In the context of packaging, design for durability is a critical factor in ensuring the protection of products during transit and maximising their shelf life (Mesa 2023: 443).

Well-designed packaging, made from durable materials such as stainless steel, glass, and engineered plastics, can resist scratches and damage from impact, contributing to the longevity of the packaged product (Mesa 2023: 443).

Additionally, durable packaging materials, when designed with eventual recycling and disassembly in mind, can support the principles of a circular economy by being reusable and easy to recycle, thus minimising environmental impact (Mesa 2023: 443).

The following section discusses the need to build manufacturing systems that are inherently aligned with sustainability development principles so that planetary equity, social equity and economic equity are sustained into the future.

3.9.5 Sustainable manufacturing

Figure 3.12 illustrates the six major elements of sustainable manufacturing processes that organisations must consider and adopt (Hernandez, Lu, Beno, Fredriksson and Jawahir 2019: 547).

Figure 3.12: Six major elements of sustainable manufacturing processes

Source: Hernandez, Lu, Beno, Fredriksson and Jawahir (2019: 547)

Figure 3.12 illustrates interconnection of the 6 elements and their contribution towards a sustainable manufacturing operation. The orange arrows in the figure shows the interdependence of these 6 elements and, when a business balance amongst these is achieved, the resulting effort is shown by the purple arrows, contributing to robustness and sustainability of manufacturing processes (Hernandez, Lu, Beno, Fredriksson and Jawahir 2019: 547).

Figure 3.13 compiled by Hariyani, Mishra, Sharma and Hariyani (2022: 1), illustrates a research framework for sustainable manufacturing that adopts a comprehensive approach to environment sustainability.

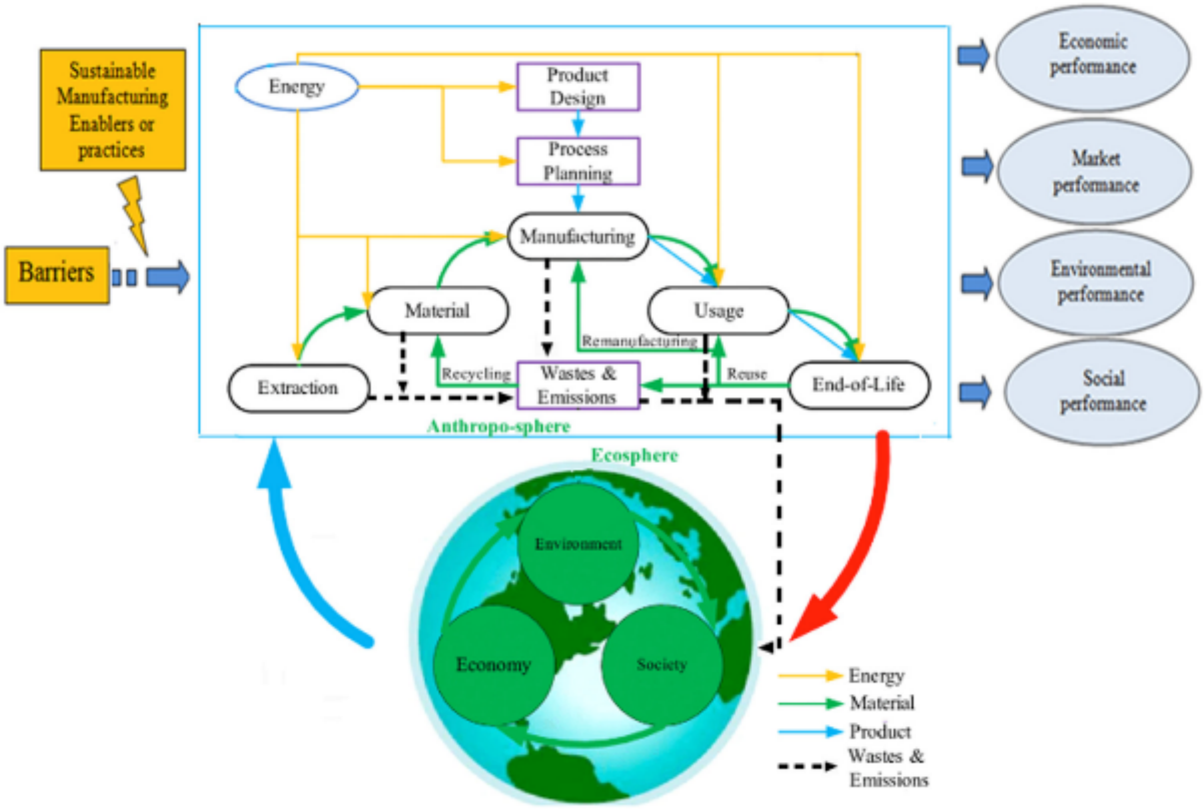

Figure 3.13: A research framework for sustainable manufacturing
Source: Hariyani, Mishra, Sharma and Hariyani (2022: 2)

Any literature review that is focused on circular economy must necessarily address product life cycle assessments. As such, the following section highlights the significance of knowledge and action related to a product's entire life cycle, from its inception to its useful life and end-of-life (EOL) decisions on the future utility of the materials that make up the product.

3.10 Life Cycle Assessment (LCA)

Guinee, de Koning, and Heijungs (2022: 673) as well as Uletilovic and Grbic (2018: 27) refer to the use of planetary boundaries in LCA, to define the absolute environmental sustainability of a system, an approach that provides a framework for defining estimates of the earth's carrying capacity and setting critical limits on environmental impacts.

Life Cycle Assessment (LCA) examines the entire life span of a product, encompassing its creation to its eventual disposal. This analytical approach originated in Switzerland during the 1960s and underwent further enhancement by the Society of Environmental Toxicology and Chemistry. Eventually, it was incorporated into the ISO 14001 environmental management system, gaining international recognition as the ISO14040 standard in 1996 (Fet, de Boer, and Keitsch 2023: 46).

The need to amend the waste management approach arose from the objective of reducing the space and volume that was needed for waste disposal, processing, and storage (Misztal and Dziekanski 2023: 1). The concept of "zero waste" encompasses a complete re-organisation of the resource life cycle, enabling the re-use of all residual materials (Misztal and Dziekanski 2023: 1).

LCA generates measurable impact indicators, triggering the analyst to compare against similar, alternative product systems, or to find "hotspots" along the life cycle, in support of planetary sustainability improvements (Guinee, de Koning, and Heijungs 2022: 673).

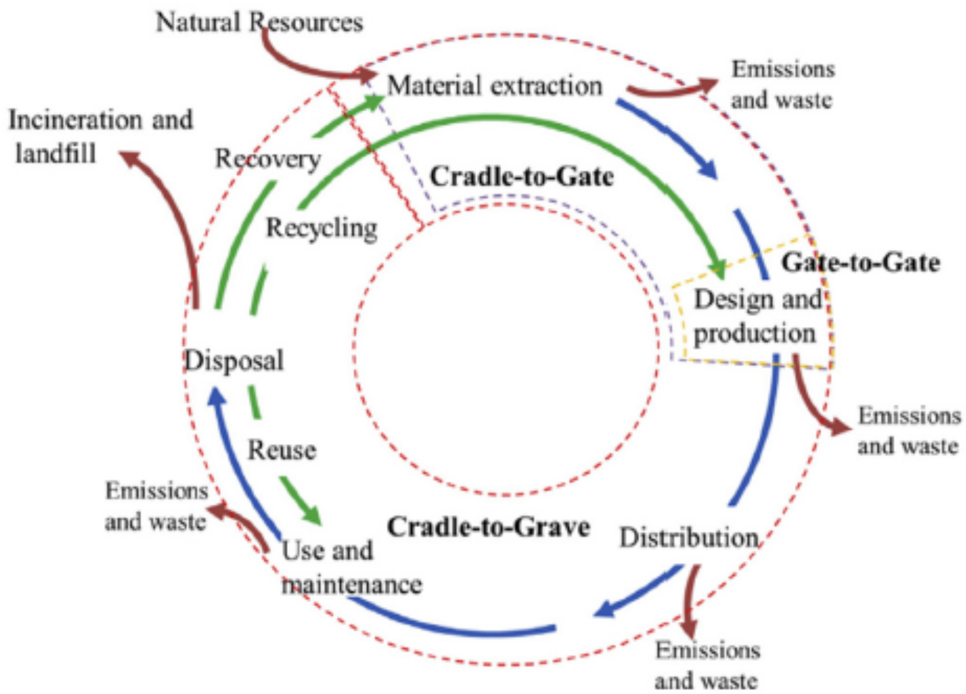

Figure 3.14: Life cycle rationale for sustainable manufacturing

Source: Hariyani, Mishra, Sharma and Hariyani (2022: 2)

Figure 3.14 illustrates that, to ensure a sustainable system design, a comprehensive view of the product environment life cycle must be taken by the organisation, from raw material extraction from the planet to production conversion, consumer consumption and end of life re-use or recycling including disposal of the residual material of the product (Hariyani, Mishra, Sharma and Hariyani 2022: 2).

According to Laurent, Weidema, Bare, Liao, de Souza, Pizzol, Sala, Schreiber, Thonemann and Verones (2020: 990), the main phases of an LCA include:

i. *Goal and scope definition:* Define the product or service to be assessed and classify resource use and emissions according to their potential impacts;

ii. *Inventory Analysis:* Quantify the inputs and outputs of the product or service, including raw materials, energy, and emissions;

iii. *Impact Assessment:* Evaluate the potential environmental impacts of the product or service throughout its life cycle, considering both upstream and downstream processes and

iv. *Interpretation:* Discuss the results in terms of contributions, relevance, robustness, data quality, limitations, and evaluate any opportunities for reducing the negative effects of the product or service.

Some of the benefits of LCA include (Laurent *et al.* 2020: 990):

i. providing a comprehensive understanding of a product's or service's environmental impact throughout its life cycle;
ii. identifying opportunities for reducing the negative environmental effects of products and services;
iii. supporting decision-making in product design, material selection, and waste management strategies and
iv. contributing to the development of sustainable products and services.

However, LCA also has some limitations, such as the need for accurate and comprehensive data on raw materials, energy, and emissions, as well as the potential for burden shifting, where the environmental impact of a product or service is shifted from one stage of the life cycle to another (Laurent *et al.* 2020: 990).

Despite these limitations, LCA remains an essential tool for assessing and reducing the environmental impact of products and services (Laurent *et al.* 2020: 990).

The ISO 14001:2015 Environmental Management System (EMS), now a globally respected environmental management standard, requires the *“control or influence of the organisation's products and services throughout their life cycle, including the design, manufacturing, distribution, consumption, and disposal”* and the objective is to avoid unintentional environmental impacts from being moved elsewhere within the product life cycle (South African National Standard 2015: 8).

Adopting the LCA model is strategic and advantageous because, such a comprehensive, holistic lifecycle perspective reveals the complete material flow analysis and avoids "problem shifting," where an apparent improvement might result in a more significant issue at another point in time or location (Wolper 2019: 8).

The following discussion will provide an appreciation of the strategy of ranking waste management options according to their environmental impact, supporting CE principles.

3.11 Waste hierarchy

The waste hierarchy, shown in figure 3.15, presented by Ferrari, Gamberini and Rimini (2016: 761), is a concept that stems from the EU directive 2008/98/EC, outlining the preferred sequence of waste management strategies, in order to minimise environmental impact and promote sustainable resource use. The hierarchy is typically represented as an inverted pyramid, with the most environmentally desirable options at the top and the least desirable at the bottom (Ferrari, Gamberini and Rimini 2016: 761).

Figure 3.15: Waste hierarchy
Source: Ferrari, Gamberini and Rimini (2016: 761)

The waste hierarchy, discussed by Ferrari, Gamberini and Rimini (2016: 761), consists of the following levels, listed in order of preference:

i. *Prevention:* The most effective way to manage waste is to prevent its generation in the first place. This involves reducing the use of materials, products, and packaging through strategies such as design for sustainability, efficient resource use, and encouraging the adoption of reusable items;
ii. *Preparing for re-use:* If waste cannot be entirely prevented, the next best option is to minimise its generation. This can involve efforts to reduce the quantity or toxicity of the waste produced through changes in production processes, product design, or consumption patterns. Re-using products or materials is the next level in the hierarchy. This involves using items again for their original purpose or finding alternative uses, extending their lifespan and reducing the need for new production;
iii. *Recycling:* Recycling involves the collection and processing of waste materials to produce new products. This can help conserve resources, reduce energy consumption, and decrease the amount of waste sent to landfills. However, recycling is not always a perfect solution and can have environmental impacts of its own, so it's generally preferable to prevent, minimise, and re-use;

iv. *Energy recovery (or recovery of energy from waste):* When recycling is not feasible or cost-effective, recovering energy from waste through methods such as incineration or anaerobic digestion can be considered. This involves using the energy content of the waste for power generation or other forms of energy recovery and
v. *Disposal (Landfill):* The least preferred option in the waste hierarchy is disposal in landfills. Landfilling should be considered only when all other options have been exhausted. It can lead to environmental pollution, habitat destruction, and the release of greenhouse gases.

Thus, the waste hierarchy is a guiding principle for waste management and encourages a shift towards more sustainable and environmentally friendly practices, and, by following this hierarchy, individuals, businesses, and governments can contribute to reducing the adverse environmental impact of waste and promoting a circular economy.

Figure 3.16 provides a comparative graphical representation of the quantum of energy reduction, CO_2 emission reduction, resulting in a reduction of water consumption, against the following variables (Cozzolino and De Giovanni 2023: 33):

i. Re-use of packaging;
ii. Simplification of the packaging system;
iii. Facilitation of recycling activities;
iv. Logistics optimisation;
v. Production optimisation;
vi. Raw material saving;
vii. Use of recycled materials and
viii. Other actions.

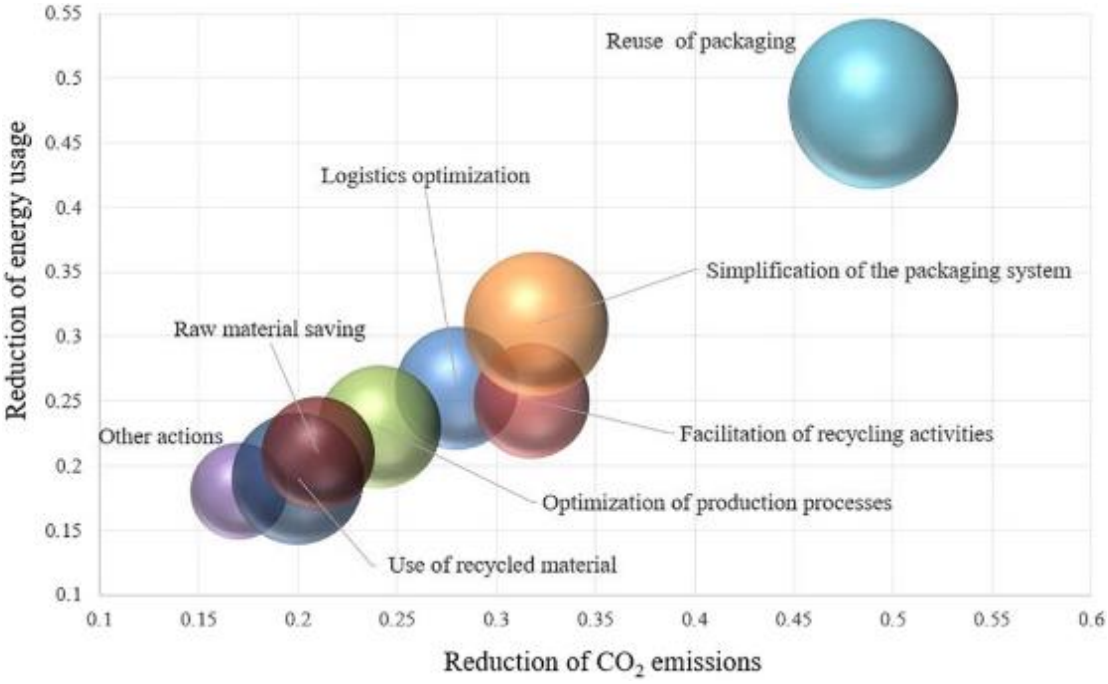

Figure 3.16: Energy reduction, CO_2 emission reduction, and water consumption reduction comparison
Source: Cozzolino and De Giovanni (2023: 33)

Cozzolino and De Giovanni (2023: 33) explain that in figure 3.16, each bubble represents a specific sustainable development practice, and its bubble size indicates the reduction in water consumption. As illustrated graphically, the most effective green practice, or alternatively, the largest bubble in the graph, is the re-use of packaging, which enables a reduction in CO_2 emissions (average reduction is 49%), a reduction in energy usage (average reduction is 48%), and a reduction in water consumption (average reduction is 50%).

This result implies that the most successful way to improve environmental sustainability key performance indices, is to enable and encourage the re-use of packaging and packaging materials, in a TBL circular economy, minimising the creation of waste.

Hajar, Moqbel, Al-Qaraleh and Alhawarat (2021:02), argue that despite the potential progress made in waste management, the prevailing practices fail to achieve the desired harmony among the economic, social and environmental aspects of sustainability, unless used in conjunction with an overarching idea of sustainable development.

Given the preceding discussion on waste hierarchy, the next discussion will focus on waste to energy, which is the second last option, or the second least preferred option, in the waste hierarchy.

3.12 Waste to energy (WtE)

Globalisation, according to Nosherwani and Nausherwani (2018: 1), acts as a critical catalyst for rapid digital transformation and technological advancements; therefore, the escalating global human population, coupled with single use packaging to support an "on the go" lifestyle, has resulted in an unexpected surge in waste generation. This has then led to heightened global demand for energy, and consequently, power outages and shortages, as well as environmental pollution, have seen a steady increase globally, hence waste to energy is seen as a viable option for environmental sustainability and clean energy (Nosherwani and Nausherwani 2018: 1).

Caneghem, Coster, Vandenbergh, Broyer, Lambrix and Weemaels (2019: 115) alludes that, in a typical waste to energy plant, the input waste is consolidated and presented to a boiler, and the energy that is released in the combustion process is recovered in a controlled process, from the hot combustion gas in the steam boiler. Thereafter, the gas is purified and emitted at the stack and the steam that is produced, can then be sent to a turbine for electricity production or can be used directly as a heat source in industry or residences (Caneghem *et al.* 2019: 115).

Figure 3.17 depicts a direct versus indirect waste to energy flow path.

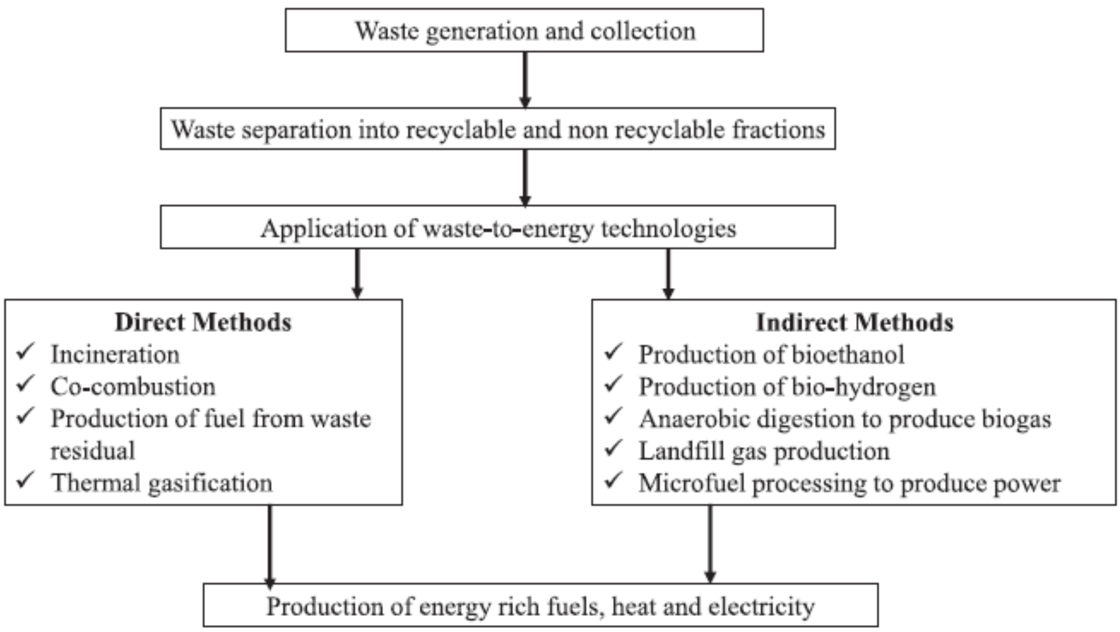

Figure 3.17: Direct and indirect processes in conversion of waste to energy

Source: Nyika and Dinka (2022: 1).

Figure 3.17 illustrates both the direct and indirect processes that support the conversion of WtE, and, according to Nyika and Dinka (2022: 5), the core process is the thermo-oxidative conversion (incineration) of post-consumer waste materials, whereas the indirect process adopts bio-chemical and esterification methods for managing such waste materials. Initially, the goal of incineration was to divert waste volume from landfill, safe-guarding the environment and eco-system from hazardous wastes, however, with recent digital and technological advancements, as well as effective pollution control measures, incineration has evolved as an effective residual energy extraction technique (Nosherwani and Nausherwani 2018: 1).

Figure 3.18 depicts a waste to energy model adapted from the work of Mastos *et al*. (2021: 9).

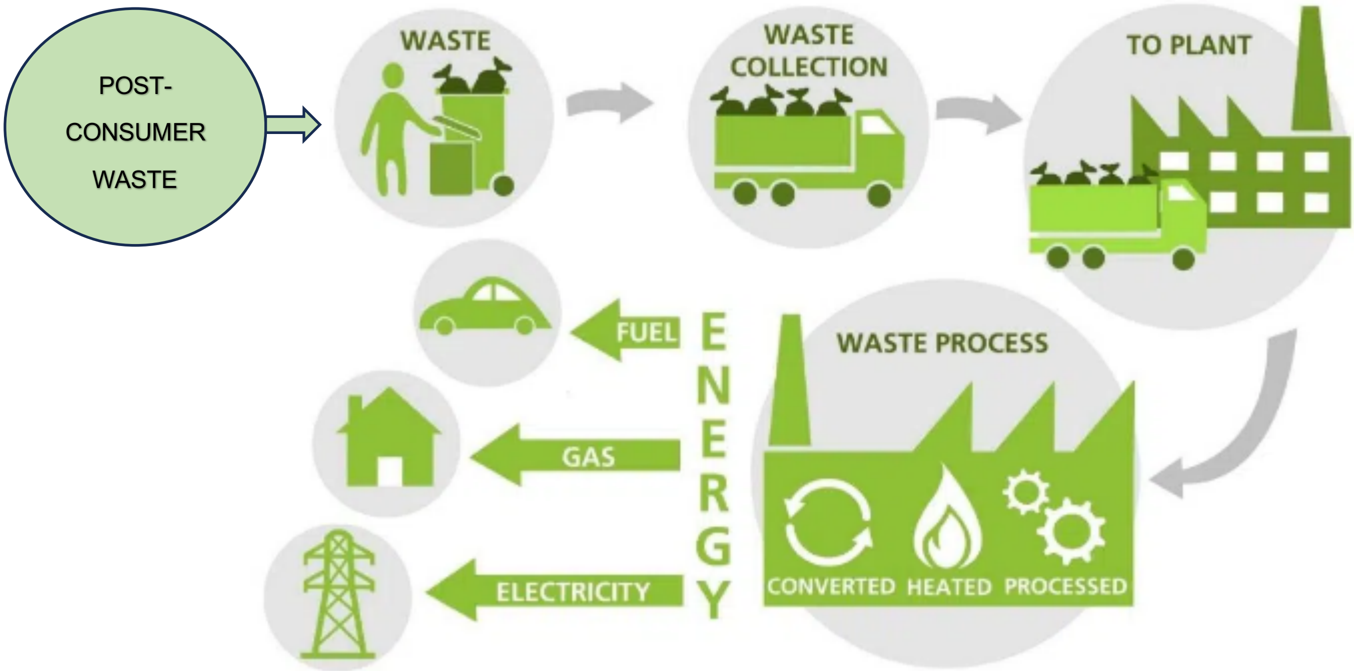

Figure 3.18: Waste to energy model
Source: Adapted from Mastos et al. (2021: 9)

The following are advantages of a waste to energy process (Mastos *et al.* 2021: 9):

i. *Energy production and utilisation:* Waste can be transformed into electricity and heat, providing an alternative energy source. Approximately 550 to 700 kilowatt-hours, generated from one ton of waste, can power a home for nearly a month;
ii. *Reduction of landfill waste:* Converting waste into energy significantly decreases the volume of waste sent to landfills, mitigating greenhouse gas emissions and preserving valuable land;
iii. *By-product utilisation as fertilisers:* Certain waste-to-energy processes, like anaerobic digestion, yield by-products that serve as fertilisers, enhancing soil nutrient content;
iv. *Mitigation of methane emissions:* Waste-to-energy facilities prevent the generation of methane that would occur in landfills, contributing to methane emission reduction;
v. *Recycling excess waste:* The technology employed in waste-to-energy not only converts waste into energy but also processes any remaining metal post-combustion, further reducing the amount of non-recyclable waste;
vi. *Reduced dependence on fossil fuels:* By converting waste materials into energy, there is a decrease in reliance on imported energy and a reduction in the environmental impact associated with energy transportation;
vii. *Domestic energy production:* Local waste generation eliminates the need for transporting materials over long distances, promoting efficient and sustainable domestic energy production;
viii. *Community and economic benefits:* The establishment of waste-to-energy plants not only generates electricity but also creates job opportunities, positively impacting the local community and economy;
ix. *Stability in energy supply and pricing:* Waste-to-energy contributes to a more stable energy supply, reducing fluctuations in energy prices and
x. *Sustainable process:* The waste-to-energy process is environmentally friendly, incorporating state-of-the-art pollution control facilities to clean and filter emissions, minimising their release into the environment.

Post-consumer waste materials act as a sustainable raw material resource, and the potential to generate heat energy and power from such post-consumer waste depends largely on their chemical composition and economic factors; hence harnessing waste-to-energy in Africa will represent a progressive move toward generating alternative electricity and heat in regions facing scarcity, contributing to sustainable solid waste management by minimising environmental pollution (Nyika and Dinka 2022: 1).

Conventional waste-to-energy, involving the incineration of non-recyclable municipal solid waste for energy recovery, plays a crucial role in the circular economy because, despite its lower position in the waste hierarchy, compared to recycling, it serves as a vital and complementary aspect of overall sustainability (Mastos *et al.* 2021: 9). Waste-to-energy specifically targets non-recyclable waste, aligning with recycling efforts, competing primarily with landfill and it helps maintain material cycles, safeguarding the environment by minimising exposure to toxic substances (Mastos *et al.* 2021: 9). Additionally, waste-to-energy facilitates the recovery of both energy and materials from non-recyclable waste, contributing to the continuous circulation of materials in the circular economy (Nyika and Dinka 2022: 1; Caneghem *et al.* 2019: 115).

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Figure 3.19 shows the results of opposing waste hierarchy models adopted across Europe.

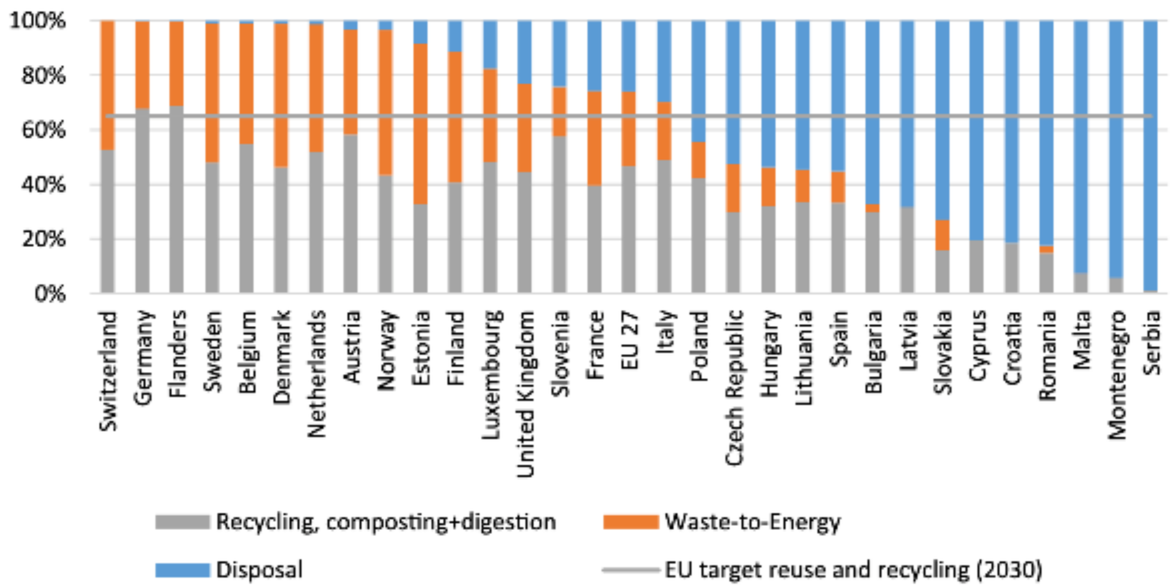


Figure 3.19: Waste management in EU member states

Source: Van Caneghem, Van Acker, De Greef, Wauters and Vandecasteele (2019: 928)

Figure 3.19 illustrates that, generally, West European countries, as opposed to East European countries, that measure high recovery rates, also show high waste to energy rates and low disposal or landfill rates (Van Caneghem *et al.* 2019: 928).

Milani, Montorsi, Storchi, Venturelli, Pirola and Falletta (2021:1) suggest that another industry solution for waste materials is the process of pyrolysis, which is a chemical process that involves the decomposition of organic materials at elevated temperatures, in the absence of oxygen. This thermal decomposition leads to the breakdown of complex organic compounds into simpler substances, such as gases, liquids, and char (Musivand, Bracciale, Damizia, De Filippis and De Caprariis 2023: 11) The term is derived from the Greek words "pyro," meaning fire, and "lysis," meaning separation or breakdown (Milani *et al.* 2021:1)

During pyrolysis, the absence of oxygen prevents combustion, and the organic material undergoes various chemical reactions, including dehydration, cracking, and polymerisation. The resulting products depend on the composition of the original material and the specific conditions of the pyrolysis process. Common products of pyrolysis include biochar, bio-oils, and synthetic fuels (Musivand *et al*. (2023: 11).

Milani *et al.* (2021:1) explain that pyrolysis, a promising technology for converting organic waste into useful products while minimising environmental impact, has applications in waste management, bioenergy production, and the production of valuable chemicals and materials from biomass and other organic feedstocks.

The following discussion highlights the global role played by the ISO14001:2015 international standard in industry. A literature review that is underpinned by sustainable development would be incomplete without a comprehensive discussion on such a crucial aspect.

3.13 ISO 14001:2015 Environmental Management System (EMS)

The concept of environmental sustainability, as defined by ISO 14001:2015, emerged in the late twentieth century due to a combination of environmental concerns and societies' emphasis on the economy rather than reducing raw material consumption (Poltronieri, Gerolamo, Dias, and Carpinetti 2018: 376). The overarching compliance objective of the international standard, ISO 14001:2015, is to minimise an organisation's carbon footprint, through effective material recovery practices as well as effective waste management, driving planetary sustainability (Aver 2021: 2). ISO 14001:2015 offers an environmental management system (EMS) framework that enables organisations to adopt a structured approach in the management of their environmental sustainability responsibilities (South African National Standard 2015: 8).

Environmental management, through ISO 14001:2015 EMS, encompasses all activities that could potentially adversely impact on the environment, as highlighted by Kahraman and Sari (2017: 1).

Over the years, environmental management, as a result of ISO14001:2015 requirements, has transitioned from a reactive approach to a proactive one, focusing on preventing environmental impacts in production processes and adopting a product life cycle perspective (Oliveira, Oliveira, Ometto, Ferraudo, and Salgado 2016: 1384).

To reduce climate change and poverty, there is a need for improved conventional energy source utilisation and an increased reliance on renewable energy sources (McKane, Daya, and Richards 2017: 389). However, Chowdhury, Prajogo, and Jayaram (2018: 340) suggest that the effective implementation of ISO 14001:2015 can be influenced by an organisation's strategic choices related to cost-benefit analysis.

The metal industry, particularly attentive to cost, quality, competitiveness, and efficiency, has embraced the ISO 14001:2015 EMS environmentally friendly practices, such as recovery, recycling and by-product re-use (Pinto, Sverdrup, and Diemer 2019: 2). For instance, the steel industry, a global economic driver, has a renowned tradition of recycling, making metal the most recycled material on the planet (Reh 2013: 128).

The ISO14001:2015 EMS high level structure (HLS), Annex SL is shown in figure 3.20 (South African National Standard 2015: 8).

Figure 3.20: ISO 14001:2015 high level structure
Source: Adapted from South African National Standard (2015: 8)

In 2012, the ISO committee decided to adopt a unified high-level structure (HLS) and standardised text and terminology across all ISO management systems, aligning with the Plan, Do, Check, Act (PDCA) cycle, popularised by Edward Deming post World War II (DNVGL 2015: 2). The Annex Statutory Limits (SL) serves as a framework with a consistent structure and text for all present and future revisions of ISO standards, which organisations are expected to adhere to (Hoyle 2018: 50). Developed by the international panel of experts within the ISO committee, Annex SL is a HLS that fosters similarities between ISO 9001, ISO 14001, and ISO 45001 standards, facilitating the integration process (Kopia, Kompalla, and Ceauşu 2016: 52). Comprising a high-level structure, uniform core text, common terms, and core definitions, Annex SL ensures consistency across ISO standards, facilitating management system integration (Jones 2018: 4). The Annex SL HLS encompasses ten standardised sections that establish the core content of management systems, streamlining the integration of ISO management systems (Baraforta, Mesquida, and Mas 2017: 178).

3.13.1 High Level Structure (HLS)

The following table 3.2 outlines the Annex SL HLS clauses of ISO 14001:2015.

Table 3.2: Annex SL HLS clauses of ISO 14001:2015

No.	Clause	ISO 14001:2015 clause requirements
1	Scope	*"This International Standard is applicable to any organisation, regardless of size, type and nature, and applies to the environmental aspects of its activities, products and services that the organisation determines it can either control or influence, considering a life cycle perspective."*
2	Normative reference	Specific to the ISO standard
3	Terms and definitions	Specific to the ISO standard
4	Context of the organisation	4.1 Understanding the organisation and its context 4.2 Understanding the needs and expectations of interested parties 4.3 Determining the scope of the specific management system 4.4 Specific management system establishment, implementation, maintenance and continual improvement
5	Leadership	5.1 Leadership and commitment 5.2 Policy specific to the management system 5.3 Roles, responsibilities and authority
6	Planning	6.1 Actions to address risks and opportunities of the specific management system
		6.2 Objectives and planning needed for the specific management system
7	Support	7.1 Resources 7.2 Competence 7.3 Awareness 7.4 Communication 7.5 Documented information
8	Operation	8.1 Operational planning and control of specific management system
9	Performance evaluation	9.1 Monitoring, measurement, analysis and evaluation 9.2 Internal auditing

		9.3 Management review
10	Improvement	10.1 Non-conformity, and corrective action 10.2 Continual improvement

Source: DNVGL (2015: 3) and South African National Standard (2015: 8).

3.13.2 Benefits of an ISO14001:2015 EMS

The ISO 14001 standard primarily focuses on environmental management systems (EMS) within organisations, emphasising a commitment to sustainable practices and continuous improvement in environmental performance (Greenworld 2016: 3). While the standard itself does not directly dictate specific post-consumer benefits, organisations that implement ISO 14001 and effectively maintain their EMS can experience several positive outcomes with potential post-consumer benefits. Some of these benefits include (Greenworld 2016: 3).

i. *Reduced environmental impact*: ISO 14001 encourages organisations to identify and control their environmental aspects and impacts. This can lead to a reduction in resource consumption, waste generation, and emissions, contributing to a lower overall environmental footprint;
ii. *Waste reduction and recycling*: Organisations implementing ISO 14001 often focus on waste minimisation and recycling efforts. This can result in less waste sent to landfills and increased recycling rates, promoting a more sustainable approach to waste management;
iii. *Energy efficiency:* ISO 14001 emphasises the need for organisations to monitor and improve energy efficiency. By implementing energy-saving measures, organisations can reduce energy consumption and associated environmental impacts, contributing to post-consumer benefits such as lower carbon emissions;
iv. *Improved compliance:* ISO 14001 helps organisations stay in compliance with environmental regulations. This not only avoids potential fines and legal issues, but also ensures that the organisation's activities have a minimal negative impact on the environment, benefiting the community and consumers;
v. *Enhanced corporate reputation:* Demonstrating a commitment to environmental responsibility through ISO 14001 certification can positively

influence the perception of consumers and other stakeholders. This improved corporate reputation may lead to increased customer loyalty and support from environmentally conscious consumers;

vi. *Market access and compliance with requirements*: Some markets and customers may require suppliers or service providers to adhere to certain environmental standards. ISO 14001 certification can open up opportunities for organisations to access these markets, satisfying consumer demands for environmentally responsible products and services;

vii. *Innovation and product development*: Implementing ISO 14001 often encourages organisations to be innovative in their processes and products, leading to the development of environmentally friendly products. This can attract environmentally conscious consumers who prioritise sustainability in their purchasing decisions and

viii. *Risk management:* ISO 14001 requires organisations to assess and manage environmental risks. This proactive approach can help prevent incidents that could harm consumers or communities, providing a post-consumer benefit in terms of safety and health.

The following discussion will present the key matrices and targets that are needed to monitor and determine success in the achievement of sustainable development goals.

3.14 Sustainability measurement matrices

The overarching reasoning behind environmental sustainability key performance metrics, is to develop a set of measurable factors to determine the environmental sustainability performance of an organisation and, to this effect, Hernandez, Lu, Beno, Fredriksson and Jawahir (2019: 550) propose the following metrics:

i. *Environmental impact:* this refers to the material consumption during the manufacturing process, and includes the waste emissions that is released into environment;

ii. *Energy usage:* this addresses all forms of energy used during the manufacturing process;

iii. *Waste management:* this measures the total amount of material that ends up in the waste stream;

iv. *Manufacturing cost:* this calculates the direct and indirect costs associated with the product manufacturing process;
v. *Resource utilisation:* this calculates the materials that are directly or indirectly used in the product design, and
vi. *Social / consumer impact:* this measures the impact that the organisation has on the society or consumers.

The World Economic Forum has set a “net zero” target and, at present, globally, greater than 70% of the GDP is committed to decarbonise by 2050, with China committing to decarbonise by 2060 (Pennington 2022:3). Franconi, Ceschin, Godsell, Harrison, Mate and Konteh (2023: 316), emphasise that the requirement to decarbonise the metal ecosystem in particular, and move towards a circular metal economy is growing rapidly, driving the metal fabrication sector of industry globally. As an illustration, the mass of a standard 73 millimetre diameter food can has decreased by 34% since 2000, and, by saving this mass of raw material per can, over 20 years, conservatively at 10 billion cans a year, such steel packaging mass reduction contributes significantly both to the global economy as well as environmental conservation (Wolper 2019: 8).

As illustrated in figure 3.21, Franconi, Ceschin, Godsell, Harrison, Mate and Konteh (2023: 316) adopted a co-creation methodology that involves twelve visions designed to steer current decision-making and actions, fostering a collective understanding of a more desirable future and these visions underscore the reason for coordinated efforts across the entire metal value chain to attain the 2050 target of net-zero emissions.

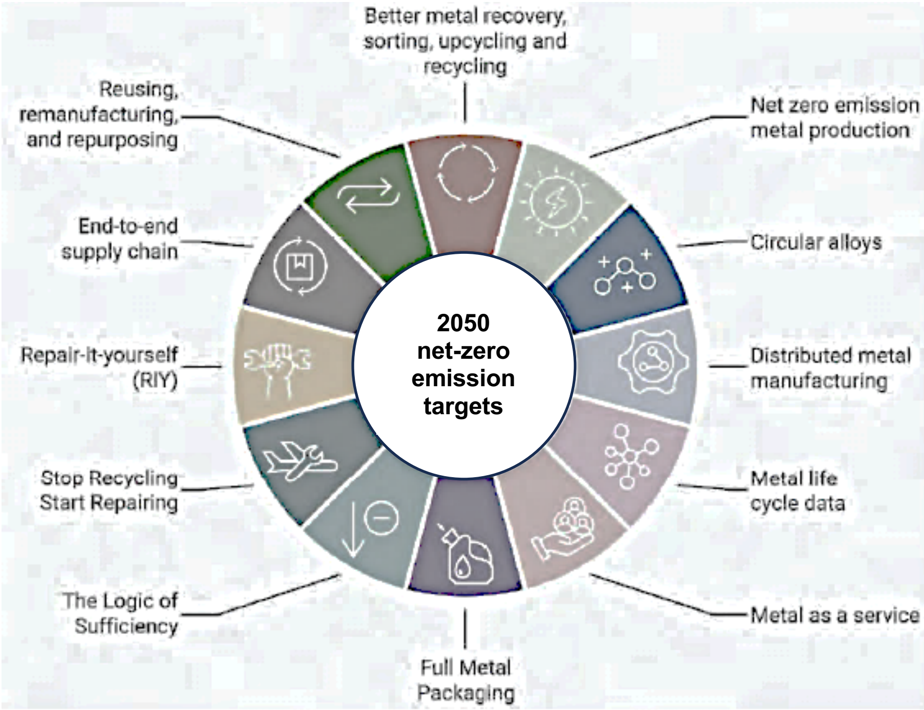


Figure 3.21: Preferred scenario for the circular metal economy in 2050
Source: Franconi, Ceschin, Godsell, Harrison, Mate and Konteh (2023: 316)

The following are global sustainable development initiatives that have been deployed over the past 35 years, in the interest of planet preservation.

3.15 Global sustainable development initiatives

3.15.1 World Commission on Environment and Development (WCED)

In 1987, the WCED portrayed sustainable development as:

> "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*",

and, to achieve sustainable development within the manufacturing industries, organisations must embrace sustainable manufacturing systems (Hariyani, Mishra, Sharma and Hariyani 2022: 1). The fundamental concept is that environmental sustainability is a catalyst for economic development and there is growing global evidence demonstrating how the shift towards a green economy can generate job opportunities, whilst supporting economic development (Ramsarup and Ward 2017: 11).

3.15.2 United Nation’s Environment Programme (UNEP)

Fet, de Boer and Keitsch (2023: 51) posit that in 1989, the United Nation’s Environment Programme (UNEP) began to develop global pollution prevention principles and the outcome, known as ‘Cleaner Production’, became a fundamental component of the ‘Sustainable Production and Consumption Policy’. Consequently, since the early 1990s, producers and designers across different industries began adopting cleaner production strategies, focusing on minimising adverse effects throughout a product's entire life cycle, from the extraction of raw materials to its final disposal (Fet, de Boer and Keitsch 2023: 51).

3.15.3 United Nation’s Sustainable Development Goals (SDGs)

Whittingham, Earle, Leyva-de la Hiz and Argiolas (2023: 45) posit that the United Nation’s (UN) Sustainable Development Goals (SDGs), adopted in 2015, are a set of 17 global objectives, designed to address a wide range of interconnected global challenges.

Figure 3.22 depicts the United Nations 17 Sustainable Development Goals.

Figure 3.22: United Nation’s Sustainable Development Goals

Source: Whittingham, Earle, Leyva-de la Hiz and Argiolas 2023: 45

The UN SDGs embrace critical areas of human lifestyle, such as poverty, hunger, health, education, gender equality, clean water, affordable and clean energy, decent work and economic growth, industry innovation and infrastructure, reduced inequalities, sustainable cities and communities, responsible consumption and production, climate action, life below water, life on land, peace, justice, and strong institutions, and partnerships for the goals (Whittingham, Earle, Leyva-de la Hiz and Argiolas 2023: 45).

The SDGs provide a universal framework for countries, organisations, and individuals to collaborate and work towards a more equitable, sustainable, and resilient future for people and the planet by 2030 (Whittingham, Earle, Leyva-de la Hiz and Argiolas 2023: 45).

According to the UN's Sustainable Development agenda for 2030, the achievement of sustainable development goals as well as performance improvement is encouraged by corporate culture and to achieve this objective, organisations are required to implement tools, concepts and systems on sustainability management as part of their corporate strategy (Di Vaio, Syriopoulos, Alvino and Palladino 2021: 691).

Borgman, Mulder-Nijkamp, and de Koeijer (2018: 1) contend that environmental sustainability has stimulated the global socio-political agenda since 1980 and the idea has gradually become a pivotal process and product innovation catalyst; consequently, there has been a measurable increase in the number of businesses dedicated to creating environmentally friendly products, through proven design for recycling regimes. Modern consumers are extremely eco-centric and are demonstrating a growing interest in such offerings that promote both cleaner production through the development of green products and sustainable consumption through effective resource management (Dangelico and Vocalelli 2017: 1263). According to a research conducted by Anderson, Bieck and Marshall (2020: 45), the modern consumer's passion for planetary sustainability issues, such as reduced carbon footprints, product Life Cycle Assessment, circular economies and more efficient waste management is increasing the global thrust to save the planet.

The recently adopted SDGs by UN members offer a comprehensive framework to address the limitations of traditional linear economic growth, simultaneously promoting the well-being of the environment, society and ecosystems and these SDGs therefore serve as a proven strategy for achieving a more sustainable future (Hajar, Moqbel, Al-Qaraleh and Alhawarat 2021: 1).

The SDGs, alternatively referred to as the "Global Goals", now serve as a universal call to action, aiming to eradicate poverty, protect the planet, ensure societal peace and prosperity and, by committing to the realisation of the UN's 2030 Agenda for Sustainable Development, all members, including South Africa, pledge to adopt a strategy that supports the triple bottom line approach (Ramsarup and Ward 2017: 11; Malik, Sharma, Batra, Sharma, Kaswan and Garza-Reyes 2023: 19).

Globally, governments, as well as manufacturing businesses, are increasingly embracing sustainable development principles within their operations, given the rapid depletion of finite resources and the rising ecological imbalance (Hariyani, Mishra, Sharma and Hariyani 2022: 1).

According to Maricut, Gradinaru and Matei (2022: 84), the application of the circular economy model will ultimately contribute to achieving the UN sustainability development goals on the following three distinct levels:

i. *Economic level*: assist in stimulating competitiveness by protecting companies against price volatility caused by the reduction of the availability of resources due to disposal thus allowing organisations to find innovative ways to recycle and re-use;
ii. *Social level*: allows the opportunity for job creation and
iii. *Environment consumption level:* assists in avoiding the irreversible damage caused by using natural resources that exceed the rate of replenishment by the planet.

The following United Nation's sustainable development goals (SDGs) are relevant to this study:

i. SDG1 – No poverty;
ii. SDG3 – Good health and well-being;
iii. SDG4 – Quality education;
iv. SDG8 – Decent work and economic growth and
v. SDG13– Climate action.

3.15.4 World Economic Forum - Platform for Accelerating the Circular Economy (PACE)

According to the neutral, public-private collaboration platform made up of global changemakers, the PACE, launched by the World Economic Forum in 2018, defines the following five opportunities that needs to be adopted, to demonstrate circular economy (McGinty 2021: 1):

i. *Reduction of consumption of finite resources:* The concept of the circular economy revolves around optimising the utilisation of finite natural resources. This involves shifting to recycled and recyclable materials, changing consumption patterns by reusing and repurposing;
ii. *Reduction of emissions:* Developing strategies that reduce such emissions, can limit greenhouse gas emissions, preventing the adverse effects of climate change by an estimated 39%;
iii. *Protection of human health and bio-diversity:* Annually the human death toll due to air, water and soil pollution is nine million and this also threatens biodiversity. Waste that is mismanaged can become hazardous for human health and biodiversity;
iv. *Boost economy:* Circular economy creates the opportunity to boost the economy by waste reduction, innovation, stimulating employment, and
v. *Creation of more and better jobs:* A clear focus on social and environmental justice can lead to more and better job outcomes. Formalising informal waste pickers into employment will create better lifestyles for them.

Lederer *et al*. (2022: 3) affirm that the European Union (EU) introduced the circular economy model to address environmental challenges that arise out of reduced recycling rates of post-consumer waste. This comprehensive model comprises guides, directives, ordinances, as well as strategy documents that set specific SDGs, targets and measures to establish a circular economy, and by doing so, the EU intends to reduce both material imports and environmental impacts (Lederer *et al* 2022: 3).

The adverse effects of modern societies' lifestyles demand a large-scale effort to ensure sustainable development for both current and future generations and the circular economy package introduced by the EU, through the SDGs, represents precisely the strategies that can significantly propel societies towards sustainable development (Lederer *et al*. 2022: 12).

Post-consumer metal packaging recovery management is crucial in achieving the goals of the circular economy model, but its full potential can only be harnessed if every stakeholder in the metal packaging recovery management system is fully integrated and synchronised (Lederer *et al*. 2022: 12).

3.16 Barriers to sustainable development

A research study conducted by Hariyani, Mishra, Sharma and Hariyani (2022: 3) identified the following barriers to environmental sustainability:

i. *Weak legislation*: The government must establish effective, simple but efficient, and industry-specific environmental laws and guidelines;
ii. *Weak audit protocols*: Regular and effective audits of organisations are essential to verify their commitment to sustainable manufacturing and to integrate sustainability as a routine aspect of their operations;
iii. *Lack of government support:* Organisations, faced with the substantial initial investment costs and extended payback periods, often turn to government assistance to secure funds for sustainable manufacturing. Government support in the form of funding, investment subsidies, grants, research and development backing for green projects, and support for sustainable system design enhances organisational inclination towards and engagement in sustainable manufacturing. Additionally, government aid may facilitate the establishment of relevant policies to replace outdated technology and supply chain methodologies;
iv. *Low public and peer pressure*: Inadequate awareness of environmentally friendly products, sustainable manufacturing practices, green innovation, eco-friendly supply chain management, and initiatives in reverse logistics, recycling, and re-use, along with untapped opportunities in the green sector, leads to a deficiency in societal, Non-Governmental Organisations (NGO), and environmental advocacy group pressure for sustainable manufacturing;
v. *The misconception, and uncertain financial benefits*: Despite the perceived risk and initial investment involved in sustainable manufacturing, business

organisations consistently prioritise profit-making for their growth. Consequently, adopting sustainable manufacturing becomes imperative. Numerous organisations have observed that, while the initial investment in sustainable manufacturing may be substantial, the long-term benefits, including improved financial health, economic performance, subsidies for technological enhancements, opportunities for upgrades and expanded trading possibilities, outweigh the initial costs;

vi. *Low customer awareness, and demand for sustainable products*: An educational initiative on sustainable policies for customers and consumers, highlighting the environmental and ecological impact of products, processes, systems, and supply chains, can influence customer demand for sustainable alternatives. This, in turn, is likely to boost organisational willingness to invest in sustainability innovations and adoption;

vii. *Complexity in the design of the sustainable product, process, and system:* Achieving successful design for sustainable products, processes, and systems requires the inclusion of all stakeholders in the design process. Addressing various sustainability issues at the early stages of manufacturing can be accomplished through concurrent design. For sustainable manufacturing, organisations must engage in strategic, holistic planning to design human systems, information systems, technical systems, and management systems aligned with the goal of sustainability. Establishing a strong partnership and cultivating sustainability management skills among practitioners will diminish the managerial complexity of the sustainable manufacturing system;

viii. *Low top management commitment, lack of leadership and technical expertise*: Government officials and policymakers must arrange awareness and training programs targeted at senior management. This initiative will influence their dedication to sustainability and enhance their skills in planning and managing projects related to sustainability;

ix. *Financial constraints:* The availability of funding, encourages the embracement of sustainable manufacturing in the design of products, processes, supply chains, and systems. Government-backed financial support further stimulates initiatives for sustainability development;

x. *Insufficient access to current information resulting in challenges in assessing system performance over an entire product life cycle:* The environment sustainability information system is an important factor in an organisation's shift towards sustainability. Access to updated data and information, along with effective communication, enables organisations to make real time and informed decisions regarding sustainability issues. This not only reduces uncertainties but also mitigates risks in decisions related to sustainability initiatives and collaboration with supply chain partners. To achieve this, organisations need to leverage information and communication technologies to gather, integrate, automate, and monitor sustainability information and performance and

xi. *Lack of continuous improvement culture*: Organisations must set targets against benchmarked best practices in sustainable manufacturing and should prioritise and strive in all aspects of continual improvement.

The researcher notes that to enhance metal packaging recovery for reuse necessitates addressing key barriers discussed above, including improving the collection infrastructure, raising consumer awareness, implementing effective incentive mechanisms, investing in 4IR technological innovation, strengthening policy and regulation, fostering synchronised collaboration among stakeholders, promoting ISO14001:2015 standardisation, encouraging infrastructure investment, enforcing EPR, and ensuring a robust market demand for recycled materials. Thus a comprehensive and co-ordinated synergised and synchronised approach is essential to create a more efficient and sustainable system for the recovery of metal packaging.

3.17 Sustainable development challenges

Achieving both environmental sustainability and delivering successful customer experiences is essential for businesses, demanding a strategic approach; however, companies continue to face challenges in effectively implementing such strategies (Calza, Sorrentino and Tutore 2022: 54).

Typical sustainability challenges, drawn from several sources, are listed below:

i. The sustainability of the metals packaging industry faces a potential risk due to the presence of illegal scrap exports and such illicit practices diminish the availability of locally sourced scrap, thereby posing a challenge to the industry's sustainability (Bulbulia 2017: 3);

ii. Proper management of waste is expensive and the cheap alternatives to manage waste, for example, illegal disposal and landfill disposal, negatively impacts the environment (Aver 2021: 2);

iii. Based on the research study conducted by Hajar, Moqbel, Al-Qaraleh and Alhawarat (2021:01), the key challenges identified in their research included inadequate enforcement of laws and regulations, ineffective management practices, limited financial capacity, insufficient legislation, and a lack of public awareness and participation;

iv. Significant disparities exist in waste composition between developing and developed countries, leading to the realisation that management practices and techniques derived from developed nations may not yield the same level of effectiveness in developing countries (Hajar, Moqbel, Al-Qaraleh and Alhawarat 2021:02);

v. There is often a disconnect between the desire for sustainability at a strategic level and its actual implementation at an operational level, particularly in the development of product packaging. Sustainability-related considerations are frequently not adequately integrated into the process, leading to undershooting of sustainability goals (de Koeijera, de Lange and Lutters 2023: 720);

vi. Waste to energy incineration is deemed effective in both developed and developing nations; however, the oxidising process in incinerators is not flawless and leads to emissions that can significantly impact the environment. The primary components of flue gas from an incinerator include water vapor, nitrogen, carbon dioxide, and oxygen. Depending on the type of waste combusted and the operating conditions of the incinerator, trace amounts of carbon monoxide, halogenated gases, nitrogen oxides, sulphur oxides, volatile organic compounds, furans, dioxins, and heavy metal compounds may also be present in the flue gas (Nosherwani and Nausherwani 2018: 4);

vii. Reducing energy input has consistently posed a significant challenge for those in the steelmaking industry (Wolper 2019: 8);

viii. Studies have confirmed that curbside collection stands out as the most convenient system for households. Nevertheless, due to its higher cost, the time-intensive nature of its design, implementation, and operation, as well as the need for special considerations in handling hazardous, fragile, or economically less valuable materials, certain challenges are associated with curbside collection (Wagner 2013: 500) and

ix. The primary motivation for implementing Industry 4.0 is generally more closely associated with enhancing productivity and competitiveness rather than sustainability improvements, particularly in its social dimension. There is the necessity to gain a better understanding of the role of promoting and integrating new technologies within the framework of sustainable production (Viles, Kalemkerian, Garza-Reyes, Antony and Santos 2022: 1043).

Calza, Sorrentino and Tutore (2022: 54) are of the view that, with the emergence of the COVID-19 pandemic, awareness has grown among citizens, businesses, and governments regarding the significance of preserving the environmental ecosystem; furthermore, in a market that is becoming more competitive due to digitisation, companies are compelled to prioritise placing the customer at the core of corporate decision-making, aiming for enhanced and innovative customer experiences. Hence, organisations must re-assess their strategic and operational priorities, placing increased emphasis on both the environment and consumer considerations.

Dangelico and Vocalelli (2017: 1263) are of the view that the growing global concern regarding environmental sustainability and climate change are inducing companies to confront the task of incorporating environmental considerations into their business strategies and operations and these challenges encompasses various functional areas, such as research and development, design, manufacturing, and marketing, within most companies.

The researcher points out that key sustainable development (SD) challenges encompass a complex interplay of economic, social, and environmental factors. Economic inequalities, inadequate access to education and healthcare, environmental degradation, climate change, and resource depletion pose formidable challenges. Thus achieving SD requires global collaboration, innovative solutions, and a shift towards sustainable practices to ensure the well-being of current and future generations while preserving the planet's ecosystems. Further reference to challenges relating to global metal packaging collection and recovery is discussed in Chapter Five.

The next discussion will introduce metal packaging, its applications and impact on society. Metal packaging stands as a linchpin in the modern packaging industry, offering dynamic and sustainable solutions for a diverse array of consumer products and the following review addresses complexities of metal packaging, encompassing its core materials, manufacturing processes, design requirements, and environmental ramifications (Metal Packaging Manufacturers Association United Kingdom 2023: 1).

According to MetPac-SA, the metal packaging PRO in SA, metal packaging uses either aluminium or steel as the primary raw material (Board Committee 2023:1).

Through a multidisciplinary lens, the next discussion aims to highlight the role of metal packaging within the context of contemporary packaging solutions.

3.18 Metal (aluminium and steel) packaging

Aluminium and steel packaging are infinitely recyclable and offer exceptional barrier properties, making them highly suitable for a wide range of food, beverage, aerosol, paint, polish and pharmaceutical packaging applications; therefore, they are utilised in various packaging formats, including closures for glass bottles and composite cans (Deshwal and Panjagar 2019: 1).

Due to the distinctive material properties, manufacturing procedures, and recycling challenges that are associated with metal packaging, the metal industry requires specialised circular product design strategies, principles, and guidelines essential for the creation of durable metal products designed to facilitate the circular flow of material resources, particularly aluminium and steel, within a CE (Konteh, Ceschin, Harrison, Franconi and Minton 2023: 524).

The increasing urgency for a paradigm shift to a circular model necessitates a systemic re-evaluation of global resource consumption and minimisation strategies to address the persistent debate and tension surrounding the search for new mines, unless a significant reduction in current metal consumption is achieved (Yeh 2022: 3).

In a CE perspective, the metal packaging is not seen just as a protection of the contents of the can, but also to yield the base material, post-consumer, as a secondary source, for further production of new metal packaging (Niero and Olsen 2016: 20).

According to Tantau, Maassen and Fratila (2018: 1), the metal packaging CE model requires a complete overhaul of economic and social systems, necessitating a re-design of products and services from their initial conception stage and the CE translates into the following four principles:

i. Metal packaging CE design refers to the process of manufacturing products from the initial production design phase with the intention of facilitating product re-use, recycling, or cascading. Cascading implies that the metal packaging can become input for another product once its current life cycle ends;
ii. Novel and innovative metal packaging circular economy business models are emerging to facilitate the shift away from the traditional "buy, consume, dispose" approach towards sustainable principles;
iii. Reverse cycles refer to the establishment of efficient and innovative systems that enable the cascading of new materials and products, as well as the return of used materials, either back to the soil or to the production process. This concept encompasses various aspects, including logistics, collections, sorting, treatment, and segmentation and
iv. Enablers and accelerators, such as market mechanisms, educational institutions, policymakers, and financing in the field, play a vital role in encouraging the re-use of metal packaging and increasing resource productivity. In a metal packaging CE, the emphasis shifts towards practices like re-using, recovering, re-melting, and recycling existing post-consumer metal packaging.

The metal packaging CE presents itself as a viable alternative to the traditional linear economy by emphasising the extension of the product lifespan, as well as the continuous circulation of raw materials and finished goods, without losing the intrinsic value of metal, striving to minimising the disposal of such metal (Vargas-Terranova *et al.* 2022: 1).

According to the Metal Packaging Manufacturers Association United Kingdom (2023: 1), metal is a durable, infinitely recyclable material, with inherent properties that remain unchanged during use. Even after multiple recycling processes into new products, metal recycling does not necessarily depend on the addition of primary materials or additives to maintain its fundamental functions and properties (Metal Packaging Manufacturers Association United Kingdom 2023: 1).

The following section will discuss the recent history and contribution of aluminium as a packaging substrate.

3.18.1 Aluminium packaging

Aluminium beverage cans entered the global arena in the 1960's, and, despite severe competition arising from the surge in plastic packaging in that period, aluminium as a packaging substrate, has gained popularity amongst environmentally conscious consumers and brand owners, because it is infinitely recyclable, at energy costs lower than primary aluminium manufacture (Karidis 2023: 1).

Figure 3.23 depicts the stages in the life cycle of the aluminium beverage can from the manufacturing process through to consumer use, material recovery and recycling back to secondary aluminium (Pratt 2023:1).

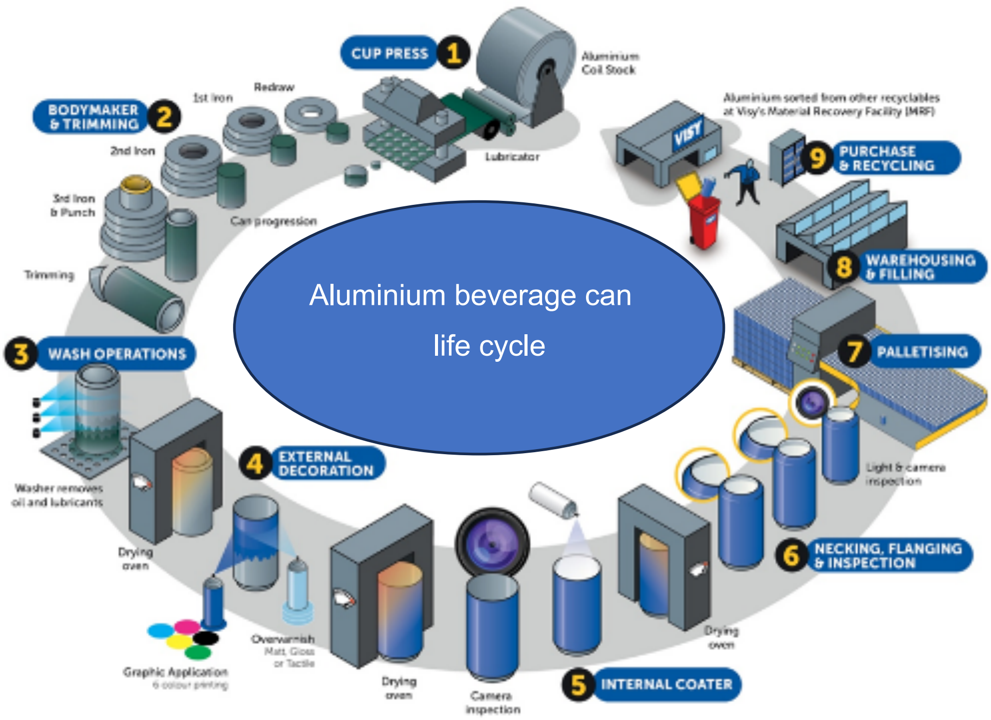


Figure 3.23: Aluminium beverage can life cycle

Source: Pratt (2023: 1)

In their study on aluminium beverage can life cycle, Niero and Olsen (2016: 20) outline the following stages in the life cycle of the beverage can:

i. *Virgin material extraction and alloy adjustment:* The life cycle begins with the extraction of bauxite, the primary raw material for aluminium. Bauxite is mined, refined, and processed to extract alumina. Alumina is then smelted to produce aluminium in a process that involves electrolysis. The resulting aluminium is typically cast into ingots, and rolled into thin sheets;

ii. *Can manufacturing and filling:* Aluminium sheets are punched into discs, which are then formed into the body of the beverage can. The can is decorated, a processes that includes printing and coating, for branding and aesthetics. The interior and exterior are coated to protect the beverage and maintain its quality. The lids are manufactured separately and coated, and the subsequent body/lid assembly, after the filling operation, produces the sealed can;

iii. *Distribution:* Filled and sealed cans are packaged and distributed to various points of sale, including retailers and beverage distributors;

iv. *Consumer use:* Consumers purchase beverages in aluminium cans, enjoying the convenience and portability of the packaging. The can is opened, and the beverage is consumed;

v. *Collection and end-of-life (EOL) options:* The recycling stage is a crucial part of the aluminium can life cycle. Collected cans are transported to recycling facilities where they undergo processes such as shredding, compaction, melting, and purification to produce aluminium ingots which can be used to remanufacture beverage cans or used for alternate applications.

Specifically, with respect to aluminium based products, these will be infinitely recycled into either the original or alternative aluminium products, without any degradation in metal quality, or loss of alloying elements such as magnesium, manganese, silicon, copper and chrome, and therefore their life cycle is not the typical linear, “cradle-to-grave”, sequence, but rather, a renewable, circular, “cradle-to-cradle”, sequence (Bulbulia 2017: 1; Arratia and Gillis 2023: 2)

Sulaiman, Makanjuola and Samson (2022: 998) explain that, on a technical level, global recognition of the exceptional properties of aluminium and its nearly limitless potential for re-use, results in aluminium becoming the preferred choice of packaging for converters, brand-owners and consumers and this idea is supported by Scamans (2021: 2).

Since its initial commercial production, aluminium has been subject to recycling, and currently, approximately one-third of the world's aluminium consumption is derived from recycled sources (Sulaiman, Makanjuola and Samson 2022: 998). As a reinforcement to the above point, according to the Metal Packaging Manufacturers Association United Kingdom (2023: 1), the processing of recovered and recycled aluminium saves 95% of the energy as opposed to processing aluminium from the primary ore, bauxite. This fact was noted in 2006 in the study by Olivieri, Romani and Neri (2006: 275) who also confirmed that the recovery and recycling of secondary aluminium saves 95% of the energy cost of extracting primary aluminium from bauxite.

Roger-Loppacher *et al.* (2022: 48) and Uletilovic and Grbic (2018: 27) emphasise that aluminium is one of the most attractive, recyclable materials for the following reasons:

i. Aluminium is a typical household packaging material that people are familiar with;
ii. The environmentally-friendly system of recovery and recycling of aluminium presents noteworthy benefits, including a decrease in the use of the primary ore, bauxite, coupled with a 95% reduction in energy consumption during the manufacturing of new products;
iii. Aluminium packaging is infinitely recyclable, without loss of metallic attributes and
iv. The volume of aluminium packaging currently recycled is expected to be increased to reach the established rates by European regulations, 60%, by year 2030.

As far back as 2006, Olivieri, Romani and Neri (2006: 269) outlined the following benefits of recycling aluminium:

i. *Conservation of natural resources*: Recycling aluminium conserves natural resources such as bauxite ore, which is the primary source of aluminium. By using recycled aluminium, there is less dependence on mining, reducing the environmental impact associated with extracting and processing raw materials;
ii. *Reduction in greenhouse gas emissions*: Primary aluminium production is an energy-intensive process and results in the emission of greenhouse gases. Recycling post-use aluminium reduces such emissions, delivering a lower carbon footprint, mitigating climate change;
iii. ***Economic benefits:*** Aluminium recycling supports the economy by creating jobs in the recycling industry. The collection, processing, and manufacturing of

recycled aluminium contribute to local economies and provide employment opportunities;

iv. *Extended Product Life Cycle*: Aluminium is a durable and corrosion-resistant material. Recycling allows for the extension of its life cycle, reducing the need for constant production of new materials and promoting a more sustainable approach to resource management;

v. *Reduced landfill waste:* Recycling aluminium prevents the accumulation of aluminium waste in landfills. Aluminium does not degrade during the recycling process, and it can be recycled indefinitely without losing its quality. This reduces the pressure on landfill capacity and minimising environmental hazards associated with waste disposal;

vi. *Consistent quality:* Aluminium maintains its properties through the recycling process, so recycled aluminium can be used in the same applications as primary aluminium without compromising performance. This ensures a consistent and reliable supply of high-quality material;

vii. *Less mining impact:* Bauxite mining can have detrimental effects on ecosystems, soil, and water. By relying on recycled aluminium, there is a reduced demand for bauxite extraction, minimising the environmental impact associated with mining activities;

viii. *Global resource management:* Aluminium recycling contributes to a more sustainable and responsible approach to global resource management. It aligns with the principles of the circular economy by keeping materials in use for as long as possible and minimising waste and

ix. *Community engagement:* Recycling initiatives often involve community participation, raising awareness about the importance of recycling and environmental sustainability. This engagement fosters a sense of responsibility and collective action toward a more sustainable future.

The pursuit of aluminum production with reduced emissions has emerged as a key objective, and the realisation of a low carbon future involves investing in research, developing breakthrough solutions, implementing extensive technological improvements, and utilising renewable sources of energy in the aluminum production process (Battle and

Hobley 2020: 2; Arratia and Gillis 2023: 2). This idea is supported by Williams, Mallaburn, Gagola, O'toole, Jones and Peyton (2023: 1).

Figure 3.24 is extracted from “The Aluminium Bottle Report” (Bali 2022: 4).

Figure 3.24: Benefits of aluminium packaging
Source: Bali (2022: 4)

As reflected in figure 3.24, extracted from “The Aluminium Bottle Report” by Ball Corporation, Bali (2022: 4), the following pertinent facts are noted:

i. 75% of all of the aluminium produced is still in circulation today;
ii. Aluminium is a permanent material that can be recycled infinitely with zero loss of quality;
iii. Recycling of aluminium saves 95% of the energy requirement from virgin sources resulting in sustainable packaging that has the highest material recycling yield and
iv. Irrespective of format, all aluminium can be fully recycled.

Figure 3.25 shows that the aluminium circular economy is an epitome of global circularity of materials.

Figure 3.25: Perfect circular economy
Source: Bali (2022: 5)

As depicted in figure 3.25, the aluminium circular economy is the epitome of circularity without losses (Bali: 2022: 5 and Williams, Mallaburn, Gagola, O'toole, Jones and Peyton 2023: 1).

Figure 3.26 illustrates the prominence of China as a source of aluminium.

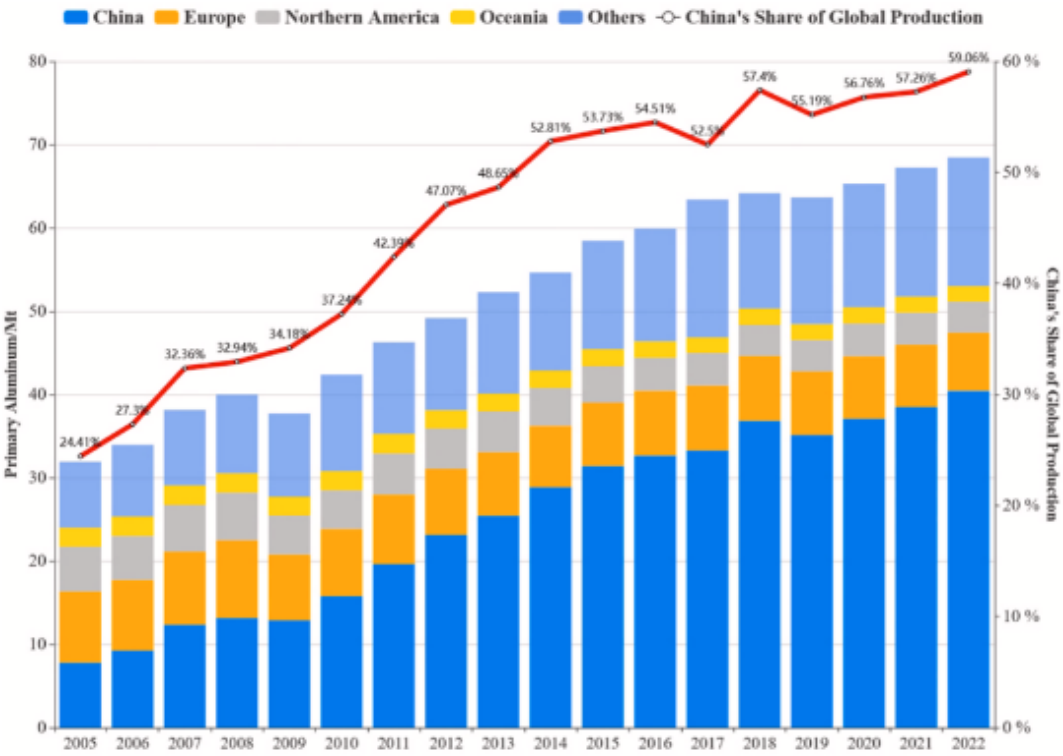


Figure 3.26: Global production sources of aluminium

Source: Shen and Zhang (2023: 3)

Figure 3.26 illustrates the following key points (Shen and Zhang 2023: 3):

i. Primary aluminium output of China rose rapidly at a mean annual growth rate of 15.7 % for 2005–2014, which was consistent with the acceleration of the production capacity of aluminium production in China;

ii. Although this rapid growth rate lost its momentum after 2015, China's output of aluminium still reflected growth.

iii. Global initiatives in industrialisation, coupled with the demand for aluminium has positioned China as the predominant driving force behind the growth of global primary aluminium production in the 21st century.

Having reviewed aluminium as a packaging substrate, the discussion moves to the opportunities that steel presents as a substrate for modern packaging.

3.18.2 Steel packaging

Steel cans emerged in the 19th-century, as a result of a need for food preservation, and evolved with key contributions from pioneers like Nicholas Appert, initially using wrought iron coated with tin and later transitioning to cost-effective and robust steel (Pearson 2016: 418). The prominence of steel cans grew during World War II, due to its use for military food supplies, reinforcing its ubiquity in post-war supermarkets because of steel can durability, recyclability, and ongoing relevance in modern packaging (Pearson 2016: 418; Conte 2021: 3).

Figure 3.27 depicts the stages in the life cycle of the steel can from the manufacturing process through to consumer use, material recovery and recycling back to secondary steel (Pratt 2023:1).

Figure 3.27: Steel can life cycle

Source: Pratt (2023: 1)

Due to its distinctive magnetic characteristics, the mechanical retrieval of steel packaging from mixed waste is not only highly cost-effective, but also readily automatable and every steel packaging item is fully recyclable, with new steel packaging incorporating a portion of recycled steel packaging scrap (Wolper 2019: 6).

According to the Metal Packaging Manufacturers Association United Kingdom (2023: 1), with recycled steel, around 70% of the energy is saved compared to steel made from primary ore. This idea is supported by Conte (2021: 3).

Wolper (2019: 8), further proclaims the following sustainability credentials of steel packaging:

i. Two of the planet's most available and abundant natural resources, iron ore and coal are required to manufacture steel;
ii. Steel can be repeatedly recycled without a deterioration in metallic properties;
iii. Steel is 100% recoverable and recyclable and therefore sustainable;
iv. All steel products are recyclable into new, alternative, steel applications, thus promoting a closed-loop recycling process;
v. There is a "virtually unlimited" market for steel;
vi. The use of scrap to produce steel reduces the amount of raw materials required and provides up to 65% energy savings that contribute to prevention by source reduction;
vii. Greater than 50% of the steel in current production has already been recycled from scrap, and
viii. Virtually no steel is disposed of in landfills, given the intrinsic economic value of steel coupled with its wide re-use in the steel industry.

The adoption of magnetic retrieval of steel, coupled with divergent metal recovery strategies that are bespoke for local conditions, assures efficient sorting, recovery and recycling of steel, an approach that pushes a sustainable, integrated waste management agenda (Wolper 2019: 8).

The following sustainability advancements in steel packaging are pertinent:

i. The advancement of new steel grades, enabling a decrease in thickness, is advantageous for all applications of steel packaging. As an illustration, the weight of a standard 425ml food can has decreased by 34% in the last two decades. By requiring reduced mass of raw materials, steel packaging contributes both to the global economy as well as environmental conservation (Wolper 2019: 8);
ii. The introduction of the fourth industrial revolution (4IR) or Industry 4.0 has resulted in the improvement of environment circularity since steel packaging

contributes to reduced material, reduced energy consumption, as well as reduced generation of waste and emissions. Industry 4.0 has resulted in technology and big data that assists in decision making along the value chain that supports circular economy (Viles *et al.* 2022: 1044) and

iii. Ensuring the social dimension of sustainability necessitates the adoption of sustainable manufacturing and the need to achieve ecological sustainability necessitates the implementation of lean six sigma practices, emphasising the adoption of reduce, re-use, recycle, recovery, re-design and re-manufacture (6R's) principles in the design of products, processes, systems, and supply chains (Hariyani, Mishra, Sharma and Hariyani 2022: 2).

Environmental sustainability, positive customer engagement and the benefits of the 4IR are key elements of the modern organisation in an increasingly competitive market, to ensure business continuity as suggested by Calza, Sorrentino and Tutore (2022: 54); therefore senior management must re-define strategic and operational priorities, by greater focus on the environment, 4IR and the customer.

Calza, Sorrentino and Tutore (2022: 54) are of the view that, by adding the benefits of environmental sustainability in all aspects of an organisation's services and products, the organisation will achieve a "win-win" situation attaining added benefits such as increased revenue, positive feedback from customers and improved corporate image.

3.18.3 Benefits of metal packaging (aluminium and steel)

Aluminium is favoured particularly for packaging food and beverages due to its lightweight nature, strength, appealing metallic appearance, plasticity, coupled with its ability to provide a complete barrier to light, gases, and moisture (Lopez, Roman, Garcia-Diaz and Alguacil 2015: 162).

According to the Metal Packaging Manufacturers Association United Kingdom (2023: 1), canned food offers a significantly extended shelf life compared to most other packaging types, it effectively preserves the nutrients without requiring the use of preservatives and additionally, as an ambient pack, it conserves energy by eliminating the need for refrigeration during transportation, in-store, and at home. In a steel sustainability report by Wolper (2019: 8), it is shown that numerous studies indicate that the environmental impact of steel packaging is considerably lower than that of the product it contains. In fact, steel packaging stands out as the optimal packaging material in terms of safeguarding the product for the following reasons (Wolper 2019: 8):

i. It provides effective evidence of tamper-proofing;
ii. It serves as an impenetrable barrier against UV, light, and oxygen;
iii. It offers optimal resistance to solvents;
iv. It is secure for pressurised systems;
v. It mitigates the risk of food poisoning resulting from power supply disruptions or outages, and
vi. It guarantees the integrity of the content throughout its extended shelf life and this is a hallmark of excellence.

Figure 3.28 illustrates the global emission of CO_2, in billion tons per annum, from current level to the level anticipated in 2050.

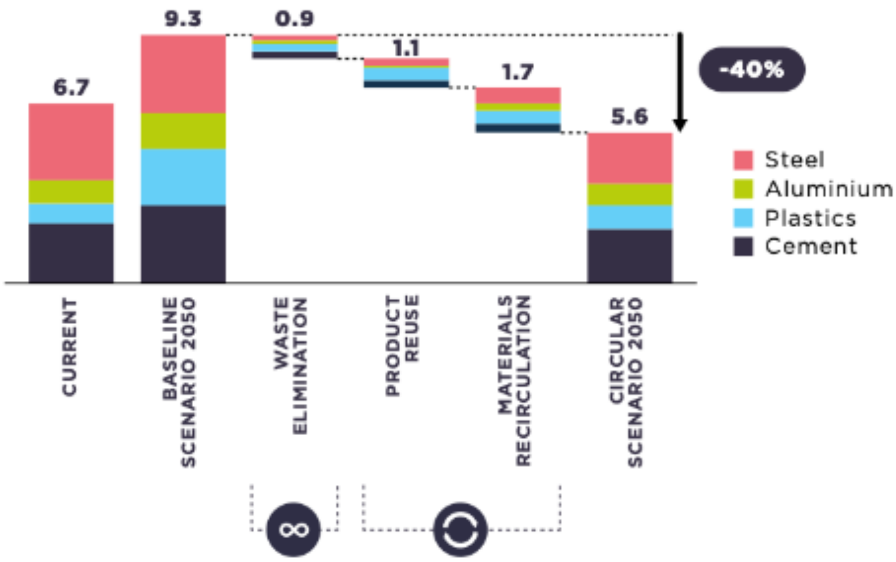


Figure 3.28: Global CO_2 emission anticipated to 2050

Source: Battle and Hobley (2020: 4) and (Gueye and Jeffries 2021:26)

In reports by Ellen MacArthur Foundation, Gueye and Jeffries (2021: 1) and Battle and Hobley (2020: 4), the global CO_2 emission, measured in billion tonnes per annum, is currently 6.7, and at the current rate, the CO_2 emission per annum is projected to 9.3 by the year 2050.

However, the following initiatives, as shown on the Battle and Hobley (2020: 4) waterfall graph, will yield a CO_2 emission of 5.6 billion tons per annum by 2050, and that will be lower than the current emission level of 6.7 billion tons per annum, if the following initiatives are executed efficiently:

i. Waste elimination is expected to contribute to a drop of 0.9 billion tons per annum of CO_2 emission;
ii. Product re-use will contribute to a drop of 1.1 billion tons per annum of CO_2 emission and
iii. Material re-circulation will contribute to a drop of 1.7 billion tons per annum of CO_2 emission.

Therefore, the production of steel, aluminium, plastic and cement can potentially result in emissions being reduced by 40% against the 2050 baseline scenario, and aluminium, as well as steel, which are infinitely recyclable materials, can contribute to achieving this objective, however collaboration is required across the steel, aluminium, plastic and cement sectors (Battle and Hobley 2020: 4).

3.18.4 Challenges in achieving metal packaging sustainability targets

In general, when organisations attempt light weighting of metal packaging, they are faced with the following challenges in meeting customer requirements, cost considerations, regulatory compliance, and supply chain considerations (Butler 2023: 1):

i. increasing the percentage recycled content into new metal packaging is restricted by melting recovery processes;
ii. chemical boundaries reduction;
iii. carbon footprint reduction;
iv. water consumption reduction;
v. waste reduction and
vi. volatile organic compound (VOC) emission reduction during production.

Butler (2023: 1) suggests that overcoming these challenges requires a sustainable approach to innovation, collaboration with customers and suppliers, investment in advanced technologies, and prioritising sustainability as a core business objective.

3.18.5 Metal packaging recycling awareness

Despite employing various activities to educate stakeholders about the importance of metal packaging circularity and its benefits, gaining people's participation remains challenging, given that the human being is at the core, acting as both the focal point and a limiting factor for sustainable development, with a complex, historical foundation that is rooted in unsustainability (Roger-Loppacher *et al.* 2022: 49).

The next generation will inherit the world of tomorrow, facing a planet that is increasingly challenged by various environmental pressures; however, by gaining a comprehensive understanding of these issues, the new generation can develop a profound respect for their environment, thereby actively endorsing initiatives aimed at its protection (Wolper 2019: 8).

According to Wagner (2013: 500), the following factors must be considered to facilitate effective recovery and recycling rates:

i. *Knowledge requirements*: To navigate waste management effectively, individuals need to acquire information regarding the materials included, the extent of required segregation, the schedule for both curbside and non-curbside collection programs, and the locations, timings, and procedures for material drop-offs. Acquiring this knowledge demands a significant investment of time;

ii. *Proximity to the collection site*: The close proximity to a recycling drop-off site has a substantial impact on recycling participation due to the associated effort and time commitments. Individuals are more likely to visit a drop-off site regularly when it is nearby. The inconvenience increases with greater distances or extended travel times to the drop-off location;

iii. *Opportunity to drop-off recyclable materials*: Enhancing the convenience of material drop-off can be achieved by extending evening and/or weekend hours and increasing the number of available days. Expanding the days and times for drop-off opportunities provides individuals with greater flexibility, thereby increasing the overall convenience of participation;

iv. *Desirable location of drop off sites:* The higher the appeal of a site, the more convenient it becomes. The presence of additional services is particularly crucial in determining whether a dedicated or special trip is necessary, which can be highly inconvenient. The location of a site plays a significant role in minimising the requirement for special trips for recycling, thereby enhancing overall convenience;

v. *Ease of the process*: Several factors may demand additional time, effort, or resources from individuals during the drop-off and collection of recyclable materials. Therefore, a streamlined and convenient process fosters increased participation and

vi. *Required effort:* The duration needed for sorting and separating materials is linked to the level of convenience, and the separation requirements may deter certain individuals who are potential recyclers.

3.19 Deposit Return Schemes (DRS)

Deposit refund systems dates back to 1984 with the commencement of the first modern deposit refund system in Sweden and advanced deposit refund systems are established as a very efficient instrument to reduce metal packaging littering and provide a secondary source of material (Schneider, Tomic and Raal 2021: 1).

In a deposit return scheme, a deposit fee is charged upon purchase and is returned when the packaging is returned (Kükenthal, Mitchell, Mounzer and Rtabi 2021: 1). The objective of the scheme is to encourage consumers to shift from a disposal culture to a circular economy culture that promotes the collection, recycling, and re-use of metal packaging materials (Kükenthal, Mitchell, Mounzer and Rtabi 2021: 1; Scamans 2021: 2).

There is a finite availability of raw material for metal packaging and a deposit return scheme offers the opportunity for a source of recycled material that can be used instead of extraction of prime material (Schneider, Tomic and Raal 2021: 1).

According to Patorska and Paca (2019: 3), upon reflection of the countries that implemented the deposit return scheme, there is evidence that there is a wide range of benefits, which include an increase in post-consumer packaging material recovery, secondary raw material availability and the promotion of a positive environmental awareness.

Patorska and Paca (2019: 3) highlight the following facts:

i. There is an increase in the number of countries that are implementing a deposit return scheme;

ii. The deposit return scheme has a positive impact on waste packaging recycling;

iii. The deposit return scheme model will depict the efficiency of the collection rate;

iv. The introduction of a deposit return scheme can result in structural changes of the packaging market;

v. A deposit return scheme model is country specific and the introduction of the scheme will require an extensive marketing campaign and

vi. A deposit return scheme will require financial investment of at least one of the market players

Patorska and Paca (2019: 17) are of the view that the success of deposit return schemes depend on the cost of implementing and running a deposit return scheme together with functionality and consumer convenience using a manual system as explained in figure 3.29, or an automatic system, as explained in figure 3.30.

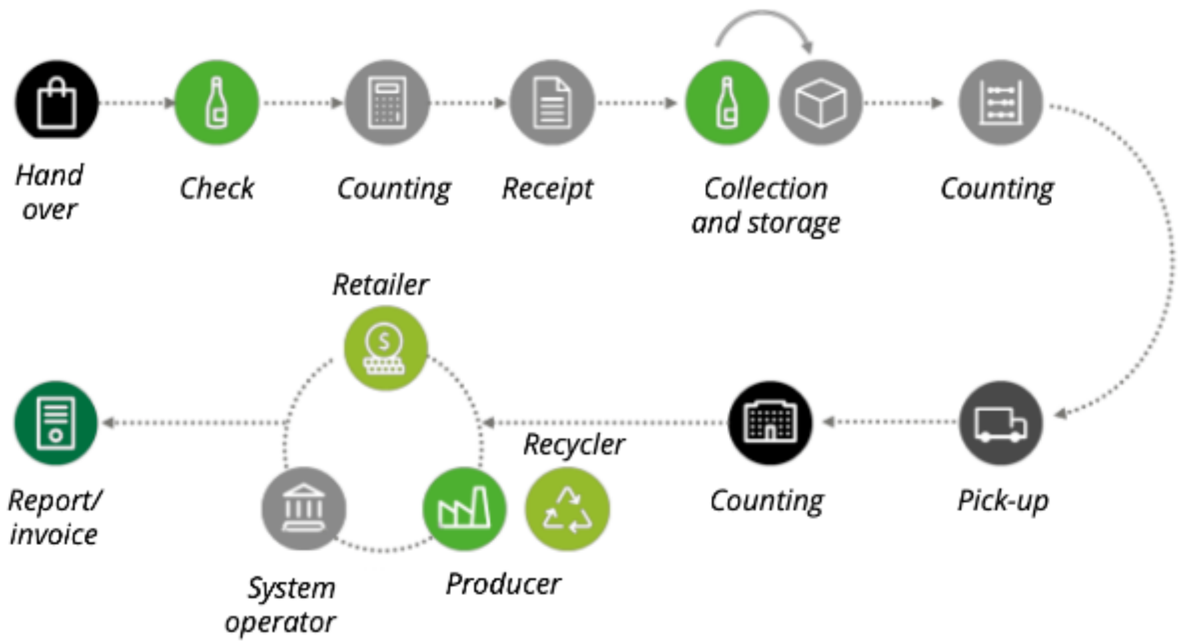


Figure 3.29: Manual collection in the deposit-refund system

Source: Patorska and Paca (2019: 17)

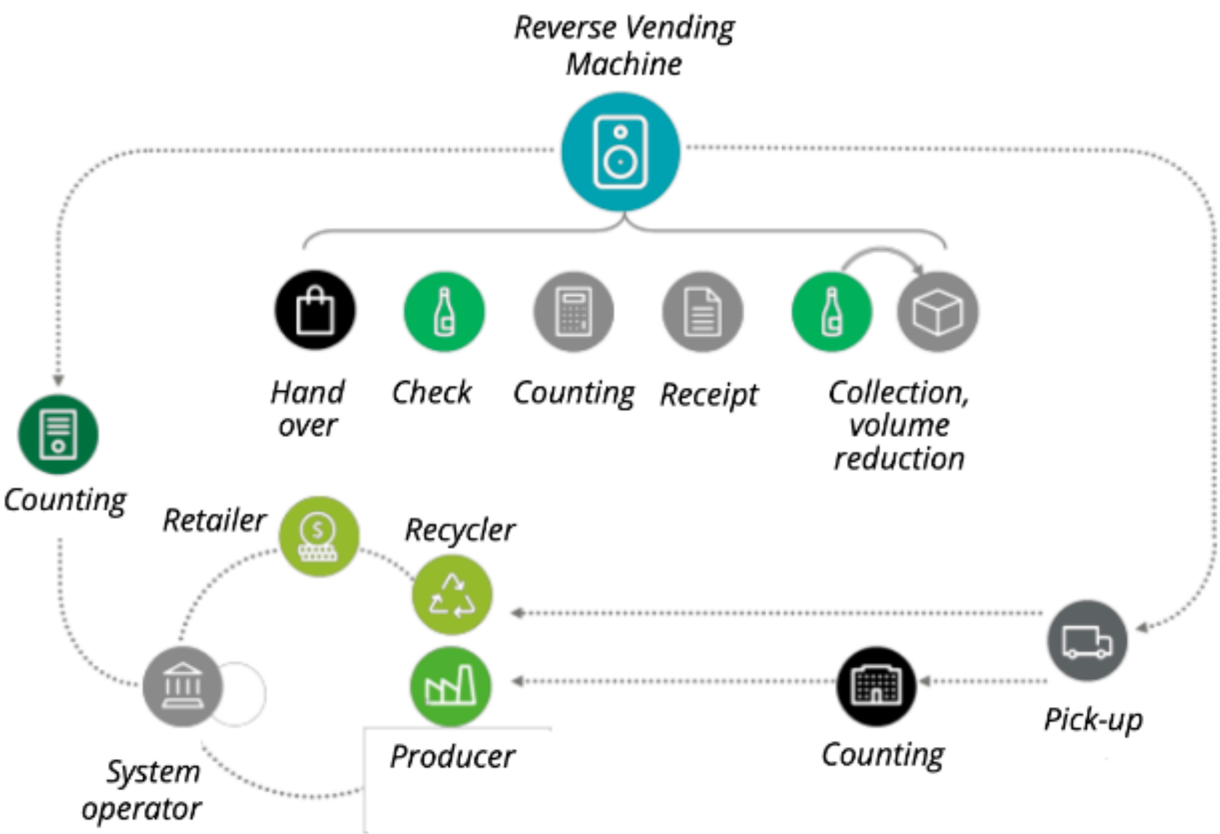


Figure 3.30: Automatic collection in the deposit-refund system
Source: Patorska and Paca (2019: 17)

The merits of such a deposit return system are listed below (Maier 2018: 22):

i. *Encourages recycling*: DRS provides a financial incentive for consumers to return their containers, leading to increased recycling rates. The prospect of getting a deposit refund motivates individuals to actively participate in recycling efforts;

ii. *Reduces littering*: Since there is a monetary value attached to the containers, people are less likely to litter. The deposit creates a sense of responsibility, and individuals are more likely to dispose of their beverage containers appropriately to reclaim their deposit;

iii. *Resource conservation*: By promoting the return and recycling of containers, a DRS contributes to resource conservation. The materials from recycled containers can be re-used in the production of new products, reducing the demand for raw materials;

iv. *Environmental impact*: Recycling has environmental benefits, including the reduction of energy consumption and greenhouse gas emissions compared to the production of new materials. DRS plays a role in mitigating environmental impact by promoting a circular economy for beverage containers;
v. *Job creation*: Implementing and managing a deposit return system involves the establishment of collection points and recycling facilities, which can create job opportunities in the waste management and recycling sector;
vi. *Promotes Circular Economy*: DRS supports the principles of a circular economy by closing the loop on materials. Instead of a linear model where products are manufactured, used, and disposed of, a circular economy aims to keep materials in use for as long as possible through recycling and reusing;
vii. *Public awareness*: A DRS raises awareness about the environmental impact of single-use packaging. It educates consumers about the value of recycling and fosters a sense of responsibility for waste management and
viii. *Reduced landfill usage*: By diverting recyclable materials from landfills, a deposit return system contributes to the reduction of landfill usage, which can help mitigate the negative environmental impact associated with land disposal.

While deposit return systems have numerous merits, it's important to consider the system's design, logistical aspects, and the cooperation of stakeholders for successful implementation (Maier 2018: 22). Tailoring the system to the specific needs of a region and addressing potential challenges can enhance its effectiveness in promoting sustainable waste management practices (Maier 2018: 22).

3.20 Global packaging legislation

3.20.1 Extended Producer Responsibility (EPR)

Responsible packaging manufacturers globally, through EPR, play a crucial role in demonstrating the use, and re-use, of existing materials, instead of extracting them from the planet as discussed in 2014, by Lovins and Braungart (2014: 120), a viewpoint that is more recently supported by Batista *et al*. (2019: 7249). EPR is a sustainable development philosophy that mandates the producers and brand-owners globally to demonstrate “extended” producer responsibility with respect to the management products at the end of their life cycle, encompassing both financial and operational obligations that may vary in nature and extent (Greenblue 2021: 1).

In SA, post-consumer packaging material recovery and recycling has been practiced since the 1950's, supported by some form of market intervention, such as industry subsidies, and this is primarily due to the high costs associated with formal and informal collection, which is a significant portion of the recovery and recycling costs (Godfrey 2021: 1).

According to Godfrey (2021:1), a key objective of the EPR model is to define the funding of EPR fees, incentives, subsidies, as well as infrastructure, enabling the availability of recyclable materials and such a system will benchmark against recovery and recycling economies in developed nations.

The success of an effective EPR system depends upon the active participation of the consumer who generates, sorts, separates, stores and ultimately delivers the waste to recycling centres, and therefore the recycling system must be convenient for the consumer to participate in the waste recycling process enabling improvement in the post-consumer recovery rate (Wagner 2013: 499). The EPR system is acknowledged globally as an effective model to manage the challenges presented by the expectations of circular economy and its success is largely attributed to achieving both downstream effects, such as promoting separate collection and recycling, as well as upstream effects, such as supporting material efficiency, encouraging decarbonisation, and adopting "cleaner" technologies (Favot, Grassetti, Massarutto and Veit 2022: 60).

The concept of EPR was introduced in 1990 by the German government's ordinance on the prevention of waste packaging and this motivated the adoption of the program by other countries; however, the success of these EPR programs has proved to be elusive, given the complexity and synchronisation of the EPR pre-requisite processes (Park 2021: 586). EPR programs appear to display limited effectiveness as evidenced by failure in multiple countries to meet the collection and the recycling targets, by the appointed PROs (Park 2021: 586).

The manufacturing organisations and importers of metal cans do not engage directly in the collecting and sorting of scrap metal, however these organisations are compelled by legislation to comply with the recycling targets and, to achieve these targets, these organisations pay an EPR fee, based on production tonnage and/or import tonnage, to their PRO, to facilitate the recovery and recycling of metal packaging (Park 2021: 586).

3.20.2 Landfill tax and ban

Various countries, including the United Kingdom, employ a multi-tiered approach when it comes to implementing measures such as landfill tax, landfill bans, and incineration taxes (Malek, Mortazavi, Cialani and Nordstrom 2023: 5). However, the specific implementation of these policies can vary between countries.

Figure 3.31 depicts landfill country taxation in Europe and UK since 1996.

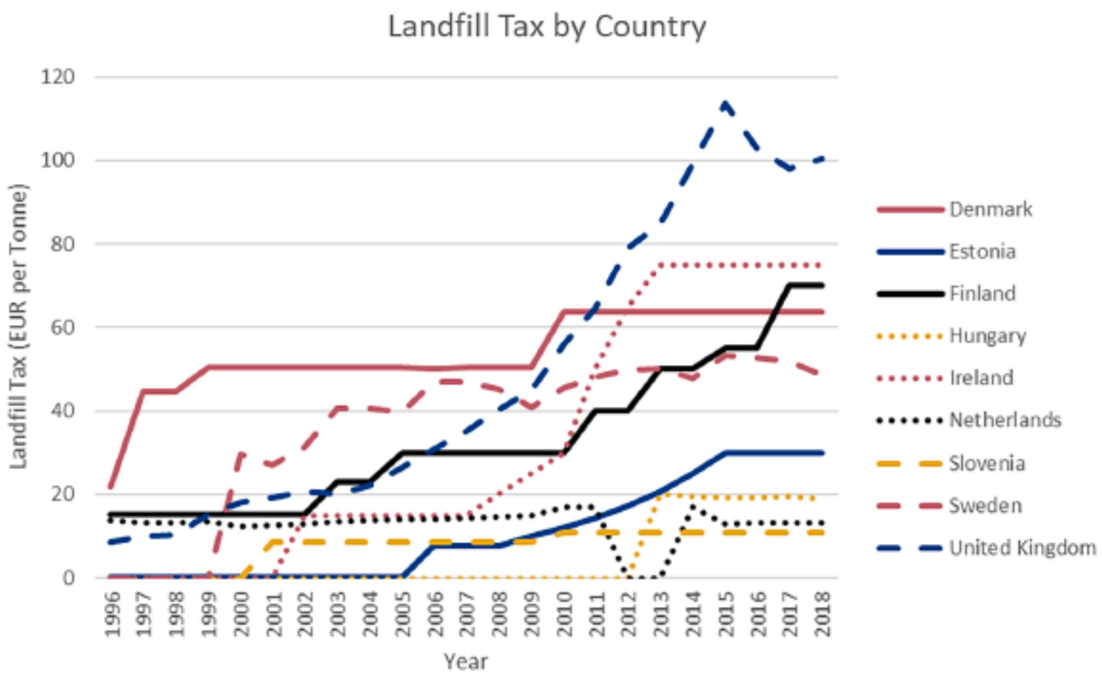


Figure 3.31: Landfill tax

Source: Malek, Mortazavi, Cialani and Nordstrom (2023: 5)

The trend is that landfill taxes in European countries and the UK, have been generally increasing since 1996.

The researcher notes that such landfill tax trends will drive the EPR legislation and CE initiatives globally, supporting the sustainable development goals currently prevalent across mainstream countries.

3.21 Unmanned Aerial Vehicles (UAV)

Kim and Hong (2019:1) posit that Unmanned Aerial Vehicles (UAVs), commonly known as advanced, heavy-duty drones, capable of lifting masses greater than 250 kg, can play a crucial role in supporting packaging recovery efforts in remote areas, where buy back centres and MRF’s are not available.

These technological devices can be employed for several purposes (Koubaa, Ammar, Abdelkader, Alhabashi and Ghouti 2023: 1):

i. They can facilitate aerial surveys and assessments, providing a bird's-eye view of remote locations to identify areas with potential packaging waste accumulation;
ii. UAVs equipped with cameras and sensors can aid in monitoring and mapping the extent of litter and packaging debris, allowing for more targeted and efficient clean-up strategies and
iii. Such drones can be utilised for the transportation of lightweight recyclables from remote areas to collection points, enhancing the logistics of recovery operations.

This technology not only expedites the identification and retrieval processes but also reduces the need for extensive manual labour in challenging terrains, making it a valuable tool in advancing packaging recovery efforts, especially in hard-to-reach locations (Kim and Hong 2019: 1).

The comprehensive approach of packaging recovery represents a paradigm shift, transitioning from a reactive recovery model to a proactive one that aligns with the principles of resilience and waste reduction in disaster-affected areas (Vermiglio, Noto, Bolivar, and Zarone 2021: 1095).

This strategic shift recognises the importance of not only responding to packaging waste accumulation challenges within remote areas, but also implementing proactive measures to minimise the environmental impact and enhance the recovery of packaging materials (Vermiglio, Noto, Bolivar, and Zarone 2021: 1095).

The researcher notes that embracing a resilient and sustainable approach to packaging recovery, through the use of UAV's, is vital to mitigate the long-term consequences of packaging waste accumulation in remote, outlying areas in SA. Such an initiative will complement post-consumer metal packaging recovery in urban areas and will be considered for integration into a post-consumer metal packaging recovery model.

3.22 Conclusion

Considering the high levels of industrialisation, urbanisation, overpopulation and consumption of finite resources on the planet, it is crucial that radical changes are adopted. The urgency of the situation requires a proactive approach to align lifestyles and business models with the necessary measures to preserve a cleaner, healthier, and safer planet. There is a growing global focus on holding producers responsible for the waste management of their products that is transforming how businesses operate globally in facilitating a CE, aligning with UN's SDGs. The CE has emerged as a key strategy for addressing environmental challenges, given that it can contribute to an increase in GDP, improve employment opportunities and reduce greenhouse gas emissions.

In a business context, it is crucial to emphasise that the CE is intrinsically connected to environment sustainable development. All stages within the circular flow of products and services should prioritise ecosystem and societal environment sustainability. The primary objective is to decrease reliance on non-renewable energy sources and fossil-based products, which have substantial environmental carbon footprints.

Packaging design must consider all the downstream post-consumer packaging recovery and recycling systems, and post-consumer packaging must facilitate easy recovery and recycling by D4R principles, and the exploitation of the 6R model.

Waste hierarchy principles need to be understood and appreciated across the packaging value chain to maximise the circularity of materials. Although waste to energy is the second least preferred option, a viable method of waste disposal involves generating electricity where waste to energy plants not only diminish the volume of waste sent to landfills but also concurrently produce valuable energy in the form of heat and/or power.

EPR systems, driven by PROs must focus on legislation compliance obligations and deliver against expected KPI's to measure success in managing a planetary eco-systemic balance.

Although seemingly futuristic, the concept of utilising UAVs to increase the recovery of post-consumer packaging in remote areas of SA, where buy back centres and recycling operations are lacking, must be actively pursued, in alignment with the principles of the CE for packaging materials.

The next chapter addresses the research methodology that this study is based on.

CHAPTER FOUR
RESEARCH METHODOLOGY

4.1 Introduction

This chapter presents the research design, and addresses the research aim, as well as the research methodology. This chapter also outlines the research population within the context of the SA packaging industry, discusses the sampling strategy, the data collection method, the research instruments deployed, and provides a description of the data analysis technique. Additionally, this chapter addresses the merits of triangulation, and the need to test data reliability and validity. Supporting ontology and epistemology definitions and stances are presented in this chapter outlining the researcher's views and the creation of new knowledge. The chapter concludes with the ethical considerations of the research.

4.2 Research aim

The research aim is a brief statement of the intent of the research, and it defines what the researcher wants to achieve by conducting the research (Saunders, Lewis and Thornhill 2016: 71).

The study aimed to propose a model that will improve the recovery and recycling rates, as well as the data reporting integrity, of post-consumer metal packaging in SA, enhancing the metal packaging circular economy, aligning with global sustainable development principles and South African legislation.

4.3 Research objectives

The objectives of research are to find solutions to problems, using scientific methods, understanding different phenomena, finding undiscovered truth and explaining unexplored knowledge (Bairagi and Munot 2019: 3).

The objectives of this study are outlined below:

i. To ascertain the global best practices with respect to post-consumer metal packaging recovery models by conducting a systematic literature review.
ii. To evaluate the current South African post-consumer metal packaging recovery model against global best practice models by deploying two qualitative surveys.
iii. To determine the reliability of the current South African post-consumer metal packaging data acquisition and reporting systems by deploying two qualitative surveys.
iv. To determine the converter/brand-owner commitment to post consumer metal packaging recovery within SA by deploying two qualitative surveys.
v. To develop a sustainable model for the post-consumer metal packaging recovery system in SA, that supports job creation and transformation.

4.4 Research paradigm

According to Schwandt (2001:183-4), Thomas Kuhn, in his seminal works, The Structure of Scientific Revolutions in 1962, used the term ‘paradigm’ in two ways:

i. to represent a particular way of thinking that is shared by a community of scientists in solving problems in their field and
ii. to represent the *“commitments, beliefs, values, methods, outlooks and so forth, shared across a discipline”.*

Rehman and Alharthi (2016: 51-52) posit that a paradigm serves as a description of a worldview informed by alternate philosophical assumptions regarding the nature of social reality. These assumptions, also articulated by Leavy (2017: 12) and Berryman (2019: 272), encompass three key dimensions:

i. Ontology, exploring beliefs about the nature of reality;
ii. Epistemology, delving into the ways knowledge is acquired and the understanding of the world; and
iii. Axiology, probing convictions about what is considered true.

In essence, a paradigm serves as a comprehensive lens through which researchers interpret and engage with the multifaceted aspects of social phenomena, rooted in their foundational perspectives on reality, knowledge, and truth (Leavy 2017: 12: Berryman 2019: 272).

Aligning with the philosophical underpinnings, the three most popular research paradigms, as noted by Rechberg (2018: 63) are:

i. Positivism: which subscribes that there is a single reality, which can be measured and therefore known, utilising quantitative methods to measure such reality;
ii. Constructivism: which accepts that there is no single reality and reality can be interpreted differently by different people, using qualitative methods to measure such reality and
iii. Pragmatism: which contends that reality keeps changing and therefore it can be debated and interpreted and that there is no single way to understand the reality.

Positivism, interpretivism, and critical theory emerge as three widely recognised theoretical research paradigms that guide research methods and analysis, as outlined by Ryan (2018: 1). According to Crossman (2019: 1), the positivism research paradigm is characterised by the adoption of scientific evidence, such as experiments, statistics, and qualitative findings, to uncover objective truths. Ryan (2018: 1) further emphasises that positivists prioritise objectivity and assert the existence of verifiable facts. In contrast, interpretivism argues that truth and knowledge are subjective, grounded in personal experiences and moreover, critical theory emphasises the importance of modified subjectivity influenced by power structures, as highlighted by Ryan (2018: 1).

4.4.1 Ontology

Ontology involves the exploration of subjects deemed worthy of investigation and from which knowledge can be obtained (Eriksson and Kovalainen 2011: 15) or the understanding of the fundamental nature of reality (Lee and Saunders 2019: 15). King and Brooks (2017: 2) define ontology as "philosophical assumptions about the nature of being, shaping our understanding of what is real and exists." Additionally, Saunders, Lewis, and Thornhill (2016: 127) explain that ontological assumptions that shape a researcher's perspective of the organisational and management environment, influences the selection of research topics.

In the current study, the focus was on assessing the South African packaging industry's potential to enhance circularity in post-consumer metal packaging, aligning with sustainable development goals.

4.4.2 Epistemology

Epistemology encompasses the process of knowledge generation (Eriksson and Kovalainen 2011: 15) or the determination of what constitutes valid and legitimate knowledge (Lee and Saunders 2019: 15).

The researcher notes that, in the context of this research, the conceptual framework acted as a guiding structure, and the examination of existing literature laid the groundwork for comprehending the prevailing knowledge pertinent to the research study. This method facilitated the exploration and development of fresh insights into the research topic. The conceptual framework in this research delineated the overarching elements specific to SA that collectively contributed to the research problem, and a thorough review of existing literature provided the foundation for understanding the current knowledge related to this research. This enabled the exploration of perspectives and the creation of new knowledge on the research topic.

4.4.3 Pragmatism

As a research paradigm, pragmatism does not involve itself in the contentious metaphysical concepts such as truth and reality; instead, pragmatism accepts that there can be single or multiple realities that are open to empirical inquiry (Kaushik and Walsh 2019: 255). Pragmatist scholars are of the view that there is an objective reality that exists apart from human experience. However, this reality is grounded in the environment and can only be encountered through human experience (Kaushik and Walsh 2019: 255).

In fact, Kaushik and Walsh (2019: 255) are of the view that a major underpinning of pragmatist philosophy is that knowledge and reality are based on beliefs and habits that are socially constructed. Pragmatists generally agree that all knowledge in this world is socially constructed, but some versions of those social constructions match individuals' experiences more than others (Kaushik and Walsh 2019: 255).

This study was founded upon the pragmatism philosophy and deployed a combination of a systematic literature review, coupled with converter/brand-owner, as well as the metal recycler qualitative interviews, that together generated data for analysis and interpretation.

4.5 Research design

A research design typically emanates from the specific research objectives to provide the basic direction for conducting the research, by addressing gaps in the knowledge, hence, a rigorous research design ultimately results in a more effective execution of the research (Hair, Page and Brunsveld 2020: 35).

Further, Akhtar (2016: 68), elaborates that research design is a vital element of a study and must be seen as the planned structure of research and as the substratum that holds all elements in a research project together.

The research design process can be staged as follows (Akhtar 2016: 70):

i. Defining the problem to be studied;
ii. Framing research design;
iii. Planning a sample (probability or non-probability, or combination of the two);
iv. Collecting the data;
v. Analysing the data (editing, coding, processing, tailgating) and
vi. Preparing the report.

The types of research designs vary depending on the nature of the study and the expected outcome of the study.

The following figure 4.1 reflects the typical research design types.

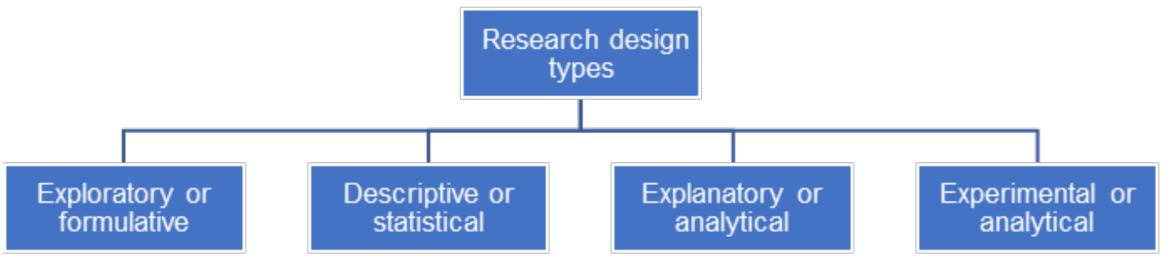


Figure 4.1: Research design types

Source: Akhtar (2016: 73)

This research deployed an exploratory research design, focusing on the initial stage of the study, with the aim of gaining new insights into post-consumer metal packaging recovery in South Africa.

Exploratory studies are usually more appropriate in case of a problem about which little research knowledge is available on the subject (Akhtar 2016: 73).

4.6 Research approach

4.6.1 Introduction

The research approach involved a comprehensive strategy that integrated a Systematic Literature Review (SLR), with two subsequent, and distinct qualitative surveys, one probing the converter/brand-owner responses to current post-consumer metal packaging recovery systems, and the other probing the metal recycler views of metal recovery and re-integration into the SA economy, to gain a balanced understanding of the research questions. The research approach was sequential, with the SLR output guiding the qualitative survey input.

The initial step was to define precise research questions that can be effectively addressed through both qualitative and literature review approaches. The SLR component encompassed the systematic search and selection of relevant studies, followed by a rigorous analysis and synthesis of the existing literature to identify patterns, gaps, and trends. This formed the foundation for the subsequent qualitative analyses.

The converter/brand-owner qualitative analysis adopted a thematic approach and required the collection, coding, and interpretation of qualitative data, obtained through individual interviews. The analysis was conducted using the NVivo software to reveal themes or patterns.

Subsequently, the second qualitative analysis, employing an adapted set of interview questions, was targeted at the metal recyclers in SA, and also adopted a thematic approach requiring the collection, coding, and interpretation of qualitative data obtained through individual interviews. Again, the analysis was conducted using the NVivo software to reveal themes or patterns, providing a complementary perspective.

Both the converter/brand-owner interviews as well as the metal recycler interviews were based on the same set of research objectives, to ensure objectivity. The results from both qualitative analyses were compared and contrasted to identify converging or diverging themes, enhancing the robustness of the overall findings. This triangulation approach helped to validate the results derived from the qualitative data.

Figure 4.2 illustrates the integrated SLR and qualitative analysis research approach.

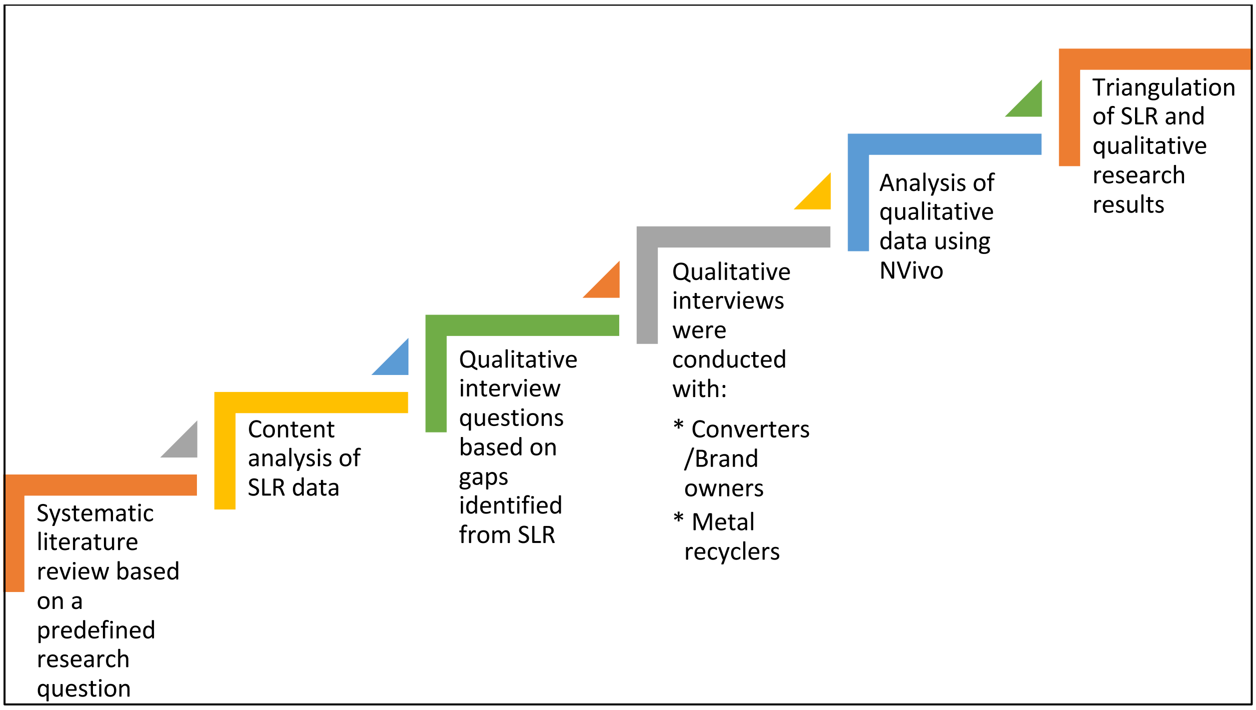


Figure 4.2: Research approach

Source: Researcher's own construction

The integration and synthesis phase involved comparing the results from the SLR and the two qualitative analyses. By combining these diverse sources of information, a more comprehensive understanding of the research questions was gained. Overarching themes were developed to capture the essence of the findings, and the triangulated results contributed to a more robust conclusion. The research approach concluded with recommendations for future studies based on the integrated insights gained from the systematic literature review and the two qualitative analyses.

4.6.2 Systematic literature review

4.6.2.1 Background

The exponential growth of academic and research literature across multidisciplinary fields necessitates robust and objective methodologies for comprehensively interpreting and synthesising existing knowledge (Pollock and Berge 2018: 138). The systematic literature review has gained reputation as a methodological framework designed to address this challenge (Kraus, Breier and Dasí-Rodríguez 2020: 1024). The number of SLR's conducted specifically on sustainable packaging and circular packaging supply chains are fewer in comparison with the large number of SLR's conducted generally in sustainable development (Morashti, An and Jang 2022: 2). Hence, this SLR, encompassing global best practices related to post-consumer metal packaging recovery models, as well as an extensive range of sustainable development themes, will be a valuable reference to the global packaging industry.

4.6.2.2 Purpose of an SLR

A systematic literature review serves multiple purposes within the research domain because it offers a critical examination of existing literature to identify gaps, trends, and inconsistencies (Pollock and Berge 2018: 138). Additionally, an SLR enables the consolidation of multiple, diverse perspectives, contributing to the development of a clearer interpretation and understanding of a particular research question. SLR's provides robust, transparent and reproduceable research methodologies, resulting in an increase in the credibility of research outcomes (Kraus, Breier and Dasí-Rodríguez 2020: 1025).

The researcher notes that whilst traditional literature reviews are often more flexible and subjective, SLRs prioritise a structured and systematic approach to minimise bias, enhance transparency, and provide a rigorous synthesis of existing literature on a specific topic.

4.6.2.3 SLR methodology

This study deployed a systematic literature review to ascertain the global best practices with respect to post-consumer metal packaging recovery models currently in use. In the works of Kraus, Breier and Dasí-Rodríguez (2020:1023), it is noted that systematic (also known as 'structured') literature review (SLR) is a popular research methodology for reviewing historically published literature, to bring the field closer together and to derive logical and significant patterns to develop new or extended theory. A systematic literature review attempts to answer a specific research question (Kraus, Breier and Dasí-Rodríguez 2020:1033), and, in the context of this study, the research question is:

> *"What are the global best practices relating to post-consumer metal packaging recovery?"*

This SLR was driven by the above research question and therefore generated data and trends which were used in the interpretation and analysis of the study. Search protocols were informed by specific key words and key phrases that triggered search results for a comparable analysis. Selected databases were targeted to ensure a cross spectrum field of research. Research criteria included country specific producer responsibility organisation activities, post-consumer metal recovery trends, extended producer responsibility fees, as well as statutory and regulatory impositions and governmental interventions. Search screening was deployed across journals, article titles, abstracts, full texts, and the research timeframe was restricted to the past eight years of research activity ensuring relevance and avoiding excessively dated information.

This study employed a thematic analysis to identify global trends in post-consumer metal packaging recovery. By examining such themes and subthemes, the study aimed to illuminate the multiple factors that are required to promote the sustainable recovery of post-consumer metal packaging in SA.

Nowell, Norris, White and Moules (2017: 8) posit that a theme is defined as "an abstract entity that brings meaning and identity to a recurrent experience and its variant manifestations and, as such, a theme captures and unifies the nature or basis of the experience into a meaningful whole".

4.6.3 Qualitative research

Qualitative research entails gathering data through semi structured, in-depth interviews and recording verbal expressions, in contrast to SLR research, where data collection involves the systematic review of existing literature, based on a specific research question against, a specified time period (Hair *et al*. 2020: 161; Kraus, Breier and Dasí-Rodríguez

2020:1023). To complement the SLR synthesis, the researcher interviewed prominent SA packaging industry convertors, brand-owners and metal recyclers.

Qualitative data is expressed through words, and researchers identify themes within the data (Patten and Newhart 2018: 5). This approach offers insights into individuals' experiences and provides an understanding that can be applied to develop interventions, comprehend barriers, or facilitate the implementation of successful improvements (Denny and Weckesser 2018: 369).

The qualitative interview questions were formulated after the collection and analysis of the SLR data. These questions were subsequently refined to ensure that a clear understanding of the converter’s/brand-owner’s, as well as the metal recycler’s views on metal packaging recovery and recycling in SA. One-on-one interviews were conducted with participants, and the notes extracted from these interviews were verified with participants before the data analysis.

4.6.3.1 Research instruments

Blanche, Durrheim and Painter (2006: 21) believe semi-structured interviews give the researcher an opportunity to know the intimately in order to understand how they think and feel. Creswell and Creswell (2018: 31) note that interviews can be either face-to-face, telephonic, or via the internet such as emails or skype.

The research instrument, used to conduct the converter/brand-owner interviews consisted of 21 items, 6 of these were related to the biometric data in Section A, and there were 15 open-ended questions in Section B.

The research instrument, used to conduct the metal recycler interviews consisted of 14 items, 6 of these were related to the biometric data in Section A, and there were 8 open-ended questions in Section B.

Both sets of open-ended questions were based on the study research questions, ensuring objectivity in the process. The actual questions were designed to extract the participant’s views on metal packaging recovery success and integrity in SA and some of the questions were formulated to probe the gaps that were identified through the SLR.

The research instruments are described below:

Section A - Biometric data (6 items, common to converter/brand-owner and metal recycler)

The biometric data consisted of the following 6 items:

i. Province;
ii. Gender;
iii. Race;
iv. Age;
v. Designation and
vi. Duration in designation.

Section B – converter/brand-owner and metal recycler

This section consisted of focused, semi-structured interview questions that required between 60 and 90 minutes to answer.

These open-ended interview questions covered salient aspects of the packaging industry from general global trends in sustainable development and circular economy, to specific challenges within the SA packaging industry, aligning with the research questions.

The interviews were conducted online through a Zoom interface, given the tight calendars, limited availability and geographical location of the targeted individuals, who represented leadership within the SA packaging and metal recycling industries.

The interview sessions required the participant to respond to a fixed set of open-ended discussion questions and the researcher recorded the responses on a laptop, capturing as much as possible in the exact words of the participant.

4.6.3.2 Target population

A research does not require an entire population to be studied; instead, a carefully selected sample of the population is surveyed to examine individual characteristics to find population trends to gain an understanding of the phenomena (Mills, Durepos and Wiebe 2012: 2).

The estimated population for each of the target sets of stakeholders in South Africa are shown in table 4.1.

Table 4.1: Estimated population of target stakeholders in South Africa

No	Stakeholder	Estimated population	Source reference
1	Converter/brand-owner	80	Metal Packaging South Africa, 2023 AGM Minutes
2	Metal recyclers	131	Metal Recyclers Association website

Source: Adapted from Metal Packaging South Africa (Board Committee 2023:1); Metal Recyclers Association (Starkey 2023:1)

4.6.3.3 Sampling

The purpose of sampling is to pursue an understanding of a situation, rather than just to achieve population representation (Saunders, Lewis and Thornhill 2016: 194). Researchers use samples of a population because it is not practical to include every member of the population, especially if the size of the population is large and the sample infers that what is true for the sample is probably true for the population (Patten and Newhart 2018: 5).

The two qualitative studies generated responses that were collected through personal interviews. Such interviews were conducted with key converters/brand-owners, as well as with metal recyclers within the South African packaging and metal recycling industries to determine the levels of commitment to metal packaging recovery, circular economy and sustainable development and principles.

It is accepted that, for qualitative studies, a minimum of 18-20 interviews is recommended for comparative and saturation adequacy (Given 2008: 195; Leavy 2017: 77). Therefore, a sample size of 18 interviews for each of the two qualitative studies, stratified across the main provinces of South Africa, was considered to be satisfactory and manageable, given the time frame and available budget.

According to Denny and Weckesser (2018: 369), multiple qualitative data analyses provide an insight and an understanding of individuals' experiences, and the results may be used to develop interventions, understand barriers or to facilitate implementation of successful improvements. Therefore, a two-group qualitative approach was used, in addition to the systematic literature review.

Table 4.2 reflects the target sample of MetPac-SA converters and brand-owner members, whose aggregate, annual tonnage of metal packaging generated in SA is estimated as greater than 80% of the total metal packaging tonnage placed in SA annually, as reflected in the minutes of the 2023 MetPac-SA AGM (Board Committee 2023: 3).

Table 4.2: Target sample of converters/brand-owners

No	Organisation	Converter/ Brand-Owner	Participant designation
1	Rhodes Food Group	Brand-Owner	Logistics Manager
2	Pick n Pay SA	Brand-Owner	Sustainability Head
3	The Coca Cola Company	Brand-Owner	Sustainability Director
4	Woolworths SA	Brand-Owner	Sustainability Director
5	Red Bull SA	Brand-Owner	Operations Director
6	Kingsley Beverages	Brand-Owner	Operations Director
7	Nestle (Pty) Ltd	Brand-Owner	Packaging Technical Director
8	Oceana Group	Brand-Owner	Procurement Manager
9	AB-in-Bev/SAB Miller	Brand-Owner	Sustainability Manager
10	Hulamin (Pty) Ltd	Brand-Owner	General Manager
11	Heineken SA	Brand-Owner	Procurement Manager
12	Checkers SA	Brand-Owner	Sustainability Manager
13	Tigerbrands Group	Brand-Owner	Procurement Director
14	Nampak DivFood	Converter	Procurement Manager
15	Nampak Bevcan	Converter	Sustainability Director
16	GZ Industries	Converter	Legal Officer
17	Golden Era	Converter	General Manager
18	CanSmart	Converter	Managing Director

Source: Researcher's own construction

Table 4.3 reflects the target sample of the metal recycler members of the South African Metal Recyclers Association (MRA), whose aggregate, annual tonnage of metal recycled in SA, is greater than 70% of the total metal recycled in SA annually (Starkey 2023:1). In addition, the Get Metal Group, not a member of MRA, but also interviewed, represents approximately 10% of the total metal recycled in SA (Nadar 2023: 5).

The researcher notes that this brings the population representation of this study up to 80% of the metal recycled in SA.

Table 4.3: Target sample of metal recyclers

No	Metal recycler	Participant designation
1	Get Metal Group	Technical Director
2	Nieuwco (Pty)	Technical Director
3	Free State Metals	General Manager
4	Get Metal Group	Managing Director
5	Grid Metals	General Manager
6	Vortex Recycling Company (Pty) Ltd	General Manager
7	Industrial Scrap Metal CC	Operations Director
8	Africa Scrap Recyclers	General Manager
9	The (Metal) Reclamation Group	General Manager
10	Dark Metals	General Manager
11	Collect-a-Can SA	Managing Director
12	Fine Metals SA	Managing Director
13	Gauteng Metal Recyclers	General Manager
14	Rustivia Metals	General Manager
15	Metal Recyclers Association	Managing Director
16	Mega Metals CC	General Manager
17	GfE-MIR Alloys and Minerals SA Pty Ltd	Managing Director
18	SA Metals	Managing Director

Source: Researcher's own construction

4.6.3.4 Gatekeeper's letters

The following gatekeeper's letters were obtained and are attached as appendices:

i. Gatekeeper's letter (converter/brand-owner)
   The target converters/brand-owners are members of Packaging SA, and written gatekeeper permission (Appendix 4) was therefore sought and obtained from Packaging SA.
ii. Gatekeeper's letter (MRA metal recyclers)
   The target metal recyclers are members of the Metal Recycler Association (MRA) and written gatekeeper permission (Appendix 5) was therefore sought and obtained from MRA.
iii. Gatekeeper's letter (Get Metal South Africa)
   Gatekeeper permission was sought and obtained from Get Metal SA (Appendix 6).
iv. Gatekeeper's letter (MetPac-SA)
   Gatekeeper permission was sought and obtained from MetPac-SA (Appendix 7).

4.6.3.5 The recruitment and interview process

The recruitment and interview process is described below:

i. The gatekeepers' permissions (Appendices 4, 5, 6 and 7) were obtained via email;
ii. Upon gatekeeper permission, an interview permission from each participant, representing converter/brand-owner and metal recycler, was obtained through email. The participants' designations are identified in tables 4.2 and 4.3. Participant names are not declared for reasons of confidentiality, in support of the Protection of Personal Information Act (POPIA), Act No. 4 of 2013. Notwithstanding, this information is available;
iii. The interviews were planned as ninety-minute slots and were conducted through Zoom or as personal, physical interviews, depending on the preference of the participant. English was the medium of communication;
iv. The interviews were guided by the questionnaires and these templates are attached as appendices in this thesis and
v. All participants were informed that, should they feel uncomfortable during the interview, for whatever reason/s, they may request that the process is terminated and that they were not obligated to furnish reasons for such

termination. In this manner, informed consent was obtained prior to the interview.

4.7 Exclusions

Excluded from the study are the metal stakeholders that represent less than 20% of the metal packaging, by volume, placed on the SA economy annually. This section of the metal packaging industry is considered minor. The study therefore focused on the 80% of the metal packaging volume in SA, annually, regarded as the critical mass.

Also excluded from the study is all non-packaging metal that is recovered and recycled in SA, as this does not constitute an *"identified product"* as defined by DFFE (South Africa. Department of Forestry, Fisheries and Environment 2020: 6).

4.8 Data validity

Hudson (2011: 63), defines data validity as a method to establish if the intended concept is measured and this definition is echoed by Sekaran and Bougie (2016: 204), who infer that data validity ensures that the right thing is being measured.

Patten and Newhart (2018: 123) further elaborate that validity refers to the extent that the data is measured in comparison to what it is designed to measure.

Sekaran and Bougie (2016: 206) extend the following definitions of validity:

i. *Content validity*: that ensures that the measurements include an adequate and representative set of items of the concept and
ii. *Face validity*: refers to the intended measurement of a concept on the face measures the intended concept.

In the context of this research, content and face validity were established prior to the data collection by having the research instrument subject to scrutiny by peers, academics, and practitioners. The feedback from these subject experts was used to make the recommended corrections to the research instruments, thus ensuring content and face validity.

To check the language appropriateness, potential interview duration, and areas of the interview questionnaire that may have been ambiguous, a pre-interview of the draft interview questionnaire was conducted with a subject expert. Based on the results of the pre-interview, the draft survey questionnaire was amended to ensure that the language was appropriate, duration was acceptable, ambiguity removed, and confusion rephrased. The final data analysis did not include the responses to the draft pre-interview. Pre-testing pinpoints any errors to ensure that the interview questionnaire will function as a proper research tool (Ruel, Wagner III and Gillespie 2018:101).

Saunders, Lewis and Thornhill (2016: 203), posited that internal validity is established when there is a casual relation between two variables and the following are threats to internal validity:

i. Past or present events that may change a participant's perception;
ii. Participants may alter their behaviour during testing if they believe that the research will lead to future consequences for them;
iii. Change of behaviour between different stages of the research;
iv. The impact of participants of the research resigning from their jobs or getting promoted during the research study;
v. Any changes outside the research may impact on the participant's response; and
vi. A lack of clarity between the cause and effect of a situation.

In this study, the transcripts of qualitative interviews were submitted individually to the participants for validation and confirmation. The researcher minimised potential threats to the internal validity of the qualitative interviews by employing rigorous data collection methods, implementing validation checks, and ensuring consistency across the interview process. Transparent reporting, coupled with independent validation, also contributed to minimising risks and increasing the applicability of findings across the converter/brand-owner, as well as the metal recycler.

4.9 Data analysis

Nowell, Norris, White and Moules (2017: 2) allude that thematic analysis is a well-structured approach in summarising large sets of data, highlighting similarities and differences and generating insights of the research findings. King and Brooks (2019: 219), support this definition by alluding that thematic analysis is a basic method for identifying and analysing qualitative data patterns and principally focuses on identifying, organising, and interpreting themes in textual data.

The analysis and interpretation technique deployed, guided by qualitative research methods, supported by Bazeley (2013: 32) and Creswell and Creswell (2018: 291) define data analysis as a series of processes and methods wherein qualitative data collected is subjected to transformations aimed at clarifying, understanding, or interpreting individuals and situations under investigation. The term "qualitative" specifically refers to words and observations, with the goal of interpreting the data and expressing it in a more meaningful way (Creswell and Creswell 2018: 254).

Thematic nodes and sub-nodes were identified and analysed using descriptive analyses to identify trends using the NVivo version 12 software. This was achieved by collating all 36 transcript responses, coding the participants, and coding their responses against the research questions. The NVivo version 12 revealed repetitive trends and phrases in the transcript responses, enabling common response themes to be identified. Where appropriate, subthemes that connected to the main theme, were also elucidated by identifying common phrases. This was carried out for each of the transcript questions. In addition, to enhance the validity of the analysis, the researcher also examined a cross section of each of the transcript responses for a common participant, referred to as “common participant - cross section of questions”, identifying themes and subthemes. In addition, the responses were weighted according to the individuals, as well as their positions within the industry, to strengthen the validity of the analysis. The results of this method were collated, and the emerging themes and subthemes have been presented and discussed in detail, with comments and recommendations, in Chapter Six. The qualitative analysis rationale discussed above is repeatable and will yield the same results if executed as described.

Responses to the qualitative research questions were triangulated with the SLR and the literature review, either reinforcing or negating the themes and subthemes. The patterns of the responses of the qualitative research were analysed and categorised into specific opportunities for improvement in alignment with the research objectives and research questions.

4.10 Reliability

The term reliability in qualitative analysis relates to the consistency, dependability, and stability of the study results (Creswell and Creswell 2018: 274; Spiers, Morse, Olson, Mayan and Barrett 2018: 2).

Reliability refers to the extent to which the study's methods, procedures, and coding processes are dependable and replicable with similar results and is crucial because it increases the trustworthiness and confidence in the validity of the research (Creswell and Creswell 2018: 274; Spiers, Morse, Olson, Mayan and Barrett 2018: 2).

Saunders, Lewis and Thornhill: (2016: 203), allude that the following are threats to the reliability of a research:

i. Participant error refers to any aspect that adversely changes the way a participant performs in the research;
ii. Participant bias refers to any aspect that induces a false response;
iii. Research error, refers to any aspect that alters the researcher’s interpretation; and
iv. Researcher bias refers to any aspect that induces the way the researcher records the participants response.

The following aspects related to reliability were adopted in this research:

i. *Consistency in data collection:* Reliability was not limited to the analysis phase but extended to data collection, ensuring consistency in data collection, enhancing the reliability of the research.
ii. *Transparent coding procedures:* The coding procedure was clearly defined by coding schemes, and decision rules. Such transparency enables the replication of the study by other researchers.
iii. *Pilot testing:* Pilot testing of the research instruments were conducted to test potential concerns and participant fatigue.
iv. *Use of software:* NVivo qualitative analysis software was used to ensure consistency across the study.

Hence, maintaining reliability in qualitative analysis enhances the credibility and trustworthiness of the study, supporting the validity of the findings.

4.11 Trustworthiness

As posited by Nowell, Norris, White and Moules (2017: 3), as well as Korstjens and Moser (2018: 121), the trustworthiness in qualitative techniques is based on several criteria. The use of the following research trustworthiness criteria will ensure the acceptability and usefulness of qualitative analyses (Nowell, Norris, White and Moules 2017: 3; Korstjens and Moser 2018: 122).

4.11.1 Credibility

Credibility refers to the truth that can be cited in the research findings and establishes if the research findings demonstrate plausible representation and interpretation of respondents' data (Korstjens and Moser 2018: 120). This definition is supported by Nowell, Norris, White and Moules (2017: 2), who add that credibility is the fit between the respondents' views and the researcher's presentation of these views.

Techniques to address credibility include activities such as prolonged engagement, persistent observation, data triangulation, and researcher triangulation as shown by Lincoln and Guba (1985: 32) in their seminal works.

Upon completion of the interview, the researcher then refined the grammar, punctuation and layout of the responses. A copy of each response was returned to the participant by email to establish whether the researcher had captured the ideas and thoughts of the participants accurately. None of the responses were amended or rejected by the participants.

In this research, the findings were confirmed with the participants as plausible, and as a true representation of the interviews, ensuring the credibility of the qualitative data.

4.11.2 Transferability

Transferability refers to the degree to which the qualitative research results can be transferred to other contexts, with other (Korstjens and Moser 2018: 120).

Tobin and Begley (2004: 388), further allude to transferability as the generalisability of inquiry and, in qualitative research, this relates to case-to-case transfer of the analysis.

A description of the research process and the details of the participating organisations are provided in this research to enable readers to make a transferability judgement of the qualitative data to other settings.

The researcher is responsible for providing ‘thick’ descriptions of findings, so that others intending to transfer the findings to their own circumstances can determine applicability (Lincoln and Guba 1985: 37; Korstjens and Moser 2018: 122).

Adequate descriptions of study output was provided by the researcher, for each set of qualitative analyses, enabling independent researchers to determine transferability of output to their own circumstances.

4.11.3 Dependability

Dependability refers to the stability of data over time and over conditions (Korstjens and Moser 2018: 120). To achieve dependability, researchers must ensure the research process is logical, traceable, and clearly documented (Tobin and Begley 2004: 390). Readers must be able to examine the findings, interpretation and recommendations of the study and confirm that the output is supported by the data as received from participants of the study (Nowell, Norris, White and Moules 2017: 3; Korstjens and Moser 2018: 122).

In this study, the researcher maintained an audit trail of records of the raw data, the field notes and transcripts in a documented, reflexive journal for independent examination, ensuring data integrity and preservation over time.

4.11.4 Confirmability

Confirmability, in research, pertains to ensuring that the data and research findings accurately reflect the research data without being products of the researcher's imagination (Tobin and Begley 2004: 392). Confirmability involves establishing that the interpretations and conclusions are explicitly derived from the data, necessitating the researcher to demonstrate the process of reaching such conclusions (Tobin and Begley 2004: 392). Additionally, it is vital that researchers include markers such as the reasons for theoretical, methodological, and analytical choices throughout the entire study, so that others can understand how and why decisions were made (Korstjens and Moser 2018: 122).

In this study, the research plan, interview execution and findings arising out of the qualitative analyses were audited by independent subject experts to ensure confirmability. Interpretation and findings of the study were examined by two subject experts to confirm that the conclusions derived were in fact objective and a true reflection of the data generated from the SLR and the two qualitative analyses.

4.11.5 Audit trails

An audit trail, as exemplified by Koch's seminal article (1994: 981), offers the reader substantiation of the researcher's decisions and choices concerning theoretical and methodological aspects throughout the study, necessitating a transparent rationale for these decisions.

Nowell, Norris, White and Moules (2017: 3) suggest that a study and its findings are auditable when another researcher can clearly follow the decision trail and, using the same data, perspective, and situation, is able to arrive at similar or comparable, but not contradictory, conclusions. Tobin and Begley (2004: 392) encourage researchers to maintain a self-critical account of the research process, including internal and external dialogue through the use of a reflexive journal to support the auditing process.

This study ensured that records of the raw data, the field notes, transcripts, and a reflexive journal was maintained in support of such research audit trails.

4.11.6 Reflexivity

This is a process of critical self-reflection about oneself as researcher (own biases, preferences, preconceptions), the research relationship with the participant, and how the relationship affects participants' answers to questions (Korstjens and Moser 2018: 121).

In this study, notes were taken during the interview process and the interpretation was confirmed with participants to ensure reflexivity of the research. The researcher examined his own conceptual lens, explicit and implicit assumptions, as well as his own pre-conceptions and values, to determine how these affected research decisions in all phases of qualitative studies. This process was audited independently by the main supervisor, as well as the co-supervisor that were overseeing this study.

4.12 Triangulation

Wilson (2016: 66) defines triangulation as, using more than one research method to gain richer and fuller data and assists in confirmation of the research results and this is supported by Yin (2014: 313) and Leavy (2017: 153), defining, triangulation as using multiple sources to verify what is being reported in a study.

Patten and Newhart (2018: 156), further support the definition that triangulation refers to using multiple methods to obtain data to strengthen the researcher's arguments and mitigate the weaknesses of using one research method.

Triangulation facilitates validation of data through cross verification from more than two sources (Flick, Hirseland and Hans 2018: 801; Leavy 2017: 153). It tests the consistency of findings obtained through different instruments and increases the chance to control, or at least assess, some of the threats or multiple causes influencing the results (Flick, Hirseland and Hans 2018: 801).

Carvalho and White (1997: v) propose four reasons for undertaking triangulation:

i. Enrichment, where the outputs of different informal and formal instruments add value to each other by explaining different aspects of an issue;
ii. Refutability, where one set of options disproves a hypothesis generated by another set of options;
iii. Confirmation, where one set of options confirms a hypothesis generated by another set of options; and

iv. Explanation, where one set of options illuminates unexpected findings derived from another set of options.

Hence, given the multiple views by multiple authors on the use of triangulation in an academic study, it can be concluded that triangulation is a valuable tool to test the reliability and integrity of findings arising out of multiple studies.

The principles of triangulation were used to strengthen the reliability and integrity of the research study.

The results of the systematic literature review were triangulated separately with the results of the two qualitative interview analyses. Each of the two qualitative surveys were also triangulated with each other.

This study was enriched by the value-added output of the different research instruments and provided an integrated qualitative analysis that translated into a working business model for post-consumer metal packaging recovery in South Africa.

4.13 Limitations

Whilst the topic of this research can be generalised across the packaging substrates prevalent in South Africa, this research focused primarily on the recovery and circular economy of metal packaging in South Africa.

4.14 Ethical consideration

The foregoing study was conducted in an ethical manner to ensure that individuals were not subjected to unnecessary stress, within their own working environments. Written permissions were requested and obtained from the interviewees, prior to commencement of interviews. The privacy, safety and confidentiality of organisational information were protected at all times. The participation in the interviews was completely voluntary and the letter of information and consent, attached to this thesis as Appendices 8 and 9, clearly allows participants to withdraw at any time, without explanation.

All participants were informed that, should they feel uncomfortable during the interview, for whatever reason/s, they may request that the process is terminated and that they are not obligated to furnish reasons for such termination. In this manner, informed consent was obtained.

The confidentiality of the individuals that participated in this study was maintained. All information collected during the research project was treated confidentially and was coded so that the participants remained anonymous.

Prior to collecting data, ethics approval, attached in this thesis, (Appendix 2), was obtained from the Research Ethics Committee of the Faculty of Management Sciences (DUT). In addition, multiple gatekeepers' letters were obtained from the researched organisations and attached as appendices. This required the researcher to maintain a moral and professional obligation and to be guided by ethics, even when the participants involved were unaware of ethics. The confidentiality and anonymity of participants, together with their informed consent to participate in this study, ensured that the study complied with ethical codes of practice. The researcher took reasonable measures to safeguard all data. The captured data was password protected on a google drive.

The study was undertaken along the following guidelines:

i. Collaborative partnership – the study conducted respected the views of the participants and the results of the study benefitted both the researcher as well as the SA packaging industry;
ii. The study respected the social values of the target population, and did not adversely impact on society;
iii. Industry participants were advised that they were not obligated to participate and that they were free to exit the research at any point if they so wished;
iv. The benefits of the study outweighed the risks presented to all participants; and
v. The researcher provided all participants with factual background information of the study and made available the written research proposal approval by the DUT Institutional Research Ethics Committee, prior to commencement of this study.

4.15 Conclusion

This chapter presented the research aim and objectives, the research paradigm, the research design, research sampling, data collection, systematic literature review protocols, the qualitative research method, data analysis, data reliability, data context, research limitations, and a chapter conclusion. The research was based on an objective positivism research paradigm and the ontology was a holistic systems approach supported by the conceptual framework of the research. The SLR and qualitative research methods complemented each other, adopting a divergent research method that provided a better understanding of the research problem using the case study research design. The chapter also discussed the trustworthiness of both the SLR and qualitative research methods.

The next chapter presents the SLR.

CHAPTER FIVE
SYSTEMATIC LITERATURE REVIEW STATEMENT OF FINDINGS, INTERPRETATION AND DISCUSSION OF THE DATA

5.1 Introduction

The SLR is a critical component of this thesis and provides a comprehensive analysis of existing research related to the best global practices of post-consumer metal packaging recovery. This chapter identified, critiqued, and synthesised all relevant literature enabling a solid foundation for the study.

By adopting a rigid, rigorous, transparent, and therefore, a reproducible research methodology, the SLR sought to address strategic research questions and fill knowledge gaps, thereby supporting the theoretical framework of the thesis.

The sections that follow in this chapter present a detailed overview of the literature search process, aligning with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), addressing the search criteria, removal of duplicate records, inclusion and exclusion criteria, data extraction, and synthesis of findings, ultimately contributing to a deeper understanding of the research topic.

This SLR explored the global best practices related to post-consumer metal packaging recovery models.

5.2 The SLR process

5.2.1 Defining the research

Table 5.1 illustrates how the SLR research question was derived from the research topic.

Table 5.1: Research definition

No.	Criteria	Description
1	Thesis topic	Evaluating post-consumer metal packaging recovery systems in South Africa
2	SLR Research objective	To ascertain the global best practices with respect to post-consumer metal packaging recovery models by conducting a systematic literature review
3	SLR Research question	What are the global best practices relating to post-consumer metal packaging recovery?

Source: Researcher's own construction

5.2.2 SLR search strategy

Based on the research question, the following search criteria were defined. The words that were deemed critical to identify the research articles that related to the research objective and question were strung together using specific Boolean operators.

Boolean operators are used in search queries to combine or exclude keywords in order to narrow down or broaden search results; three basic Boolean operators are "AND", "OR", and "NOT" (Hollier 2020: 1).

Table 5.2 explains the Boolean operator functions as used in academic database searches (Hollier 2020: 1).

Table 5.2: Boolean operator functions and examples

Boolean operator	Intention	Example
AND	The AND operator is used to narrow down search results by combining two or more keywords. When you use "AND" between terms, the search engine will return results that include all of the specified keywords.	Searching for "data AND analytics" will retrieve documents that contain both "data" and "analytics."
OR	The OR operator is used to broaden search results by combining synonyms or related terms. When you use "OR" between terms, the search engine will return results that include any of the specified keywords.	Searching for "machine learning OR artificial intelligence" will retrieve documents that contain either "machine learning" or "artificial intelligence" or both.
NOT	The NOT operator is used to exclude specific terms from search results. When you use "NOT" before a term, the search engine will return results that include the first term but exclude the second term.	For example, searching for "cloud computing NOT security" will retrieve documents that mention "cloud computing" but exclude those that also mention "security."

Source: (Hollier 2020: 1)

Boolean operators provide a powerful way to customise and refine search queries, allowing users to express complex search criteria and by combining these operators strategically, users can tailor their searches to find information that is more relevant to their needs (Hollier 2020: 3). Boolean operators are commonly used in various search engines, databases, and information retrieval systems to help users efficiently locate specific information in a vast amount of data (Hollier 2020: 3).

Table 5.3 reflects the search strategy deployed in this SLR.

Table 5.3: Search strategy

“Post-consumer **metal packaging”** OR “Post consumer **metal packaging”** OR “Postconsumer **metal packaging”** OR “Metal packaging” OR “steel packaging” OR “aluminium packaging” OR “scrap metal”
AND
Recovery OR reuse OR “Deposit return scheme” OR “Waste to energy” OR recycling OR “extended producer responsibility” OR “circular economy” OR incineration.

Source: Researcher’s own construction

The choice of databases searched in a systematic literature review is a critical decision that can significantly impact the comprehensiveness and reliability of the review, therefore researchers typically consider several factors when selecting databases to address a specific research question (Kraus, Breier and Dasí-Rodríguez 2020:1033). In this study, Web of science, Scopus and Emerald Insight were used, given that these databases held journal articles closely related to research question of this thesis. This was noted by the researcher during preliminary searches against the search strategy indicated in Table 5.3.

The search strategy was deployed within the Web of science database and yielded 99 records which were downloaded onto EndNote version 21. EndNote 21 is a reference management, as well as a citation style tool, providing a comprehensive solution for managing and formatting references in academic and research writing. The Web of science website query link, search query and results are attached as Appendix 12 to this thesis. The search strategy was then deployed within the Scopus database and yielded 1024 records which were downloaded onto EndNote version 21. The Scopus website query link, search query and results are attached as Appendix 14 to this thesis. The search strategy was then deployed within the Emerald Insight database and yielded 15 records which were downloaded onto EndNote version 21. The Emerald Insight website query link, search query and results are attached as Appendix 13 to this thesis.

5.2.3 Inclusions and exclusions

The following were the inclusions and exclusions that were integrated into the search strategy:

5.2.3.1 Inclusions:

i. Year of publication : November 2018 to December 2023;
ii. Language : English;
iii. Journal article : Full text and
iv. Geographic location : Global.

5.2.3.2 Exclusions:

i. Packaging substrates : non-metal packaging substrates and
ii. Automatic exclusion : all duplicated records eliminated by EndNote21.

5.2.4 Limitations

Limitations related to the SLR were:

i. *Limited availability of full text*: Full texts of certain articles were not available and these were excluded during the screening process to ensure integrity of the SLR results and
ii. *Content written in a language other than English*: These articles were excluded during screening to ensure integrity of SLR results.

5.2.5 Prisma flow chart

Figure 5.1 presents the SLR record screening process map, aligning with the PRISMA protocol, providing an identification and screening overview.

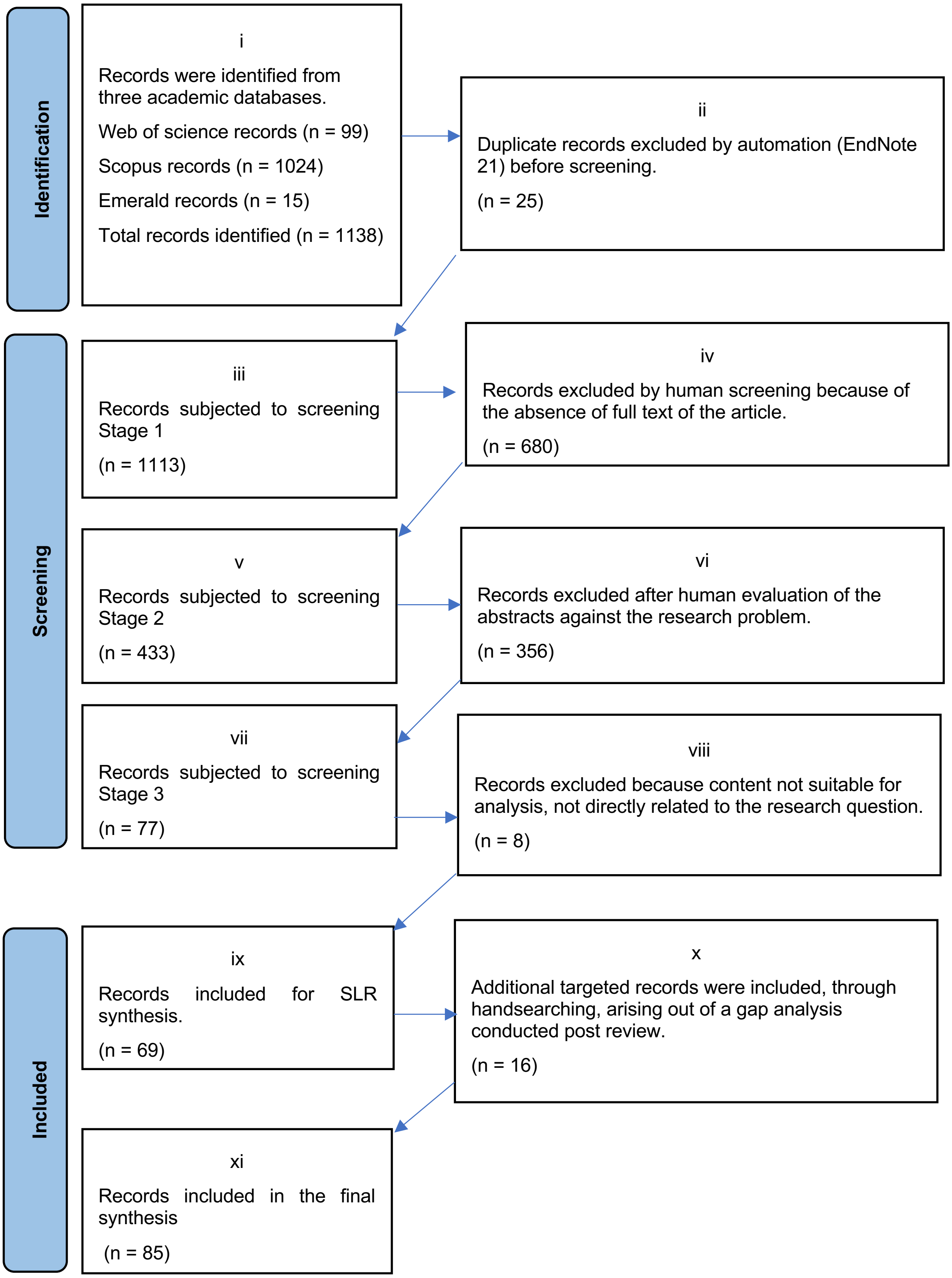


Figure 5.1: SLR PRISMA flow chart

Source: Researcher's own construction

The figure 5.1 explains, through the adjacent roman numerals, the sequential steps that resulted in the final number of records that were subjected to the SLR:

i. Records accumulated from a search of three academic databases;
ii. Records excluded by automation;
iii. Records subjected to screening Stage 1;
iv. Records excluded by human screening;
v. Records subjected to screening Stage 2;
vi. Records excluded by human screening;
vii. Records subjected to screening Stage 3;
viii. Records excluded by human screening;
ix. Records included for SLR synthesis;
x. Records included by hand search and
xi. Records included in the final SLR synthesis.

5.2.6 Hand search articles in an SLR

Hopewell, Clarke, Lefebvre and Scherer (2007: 1), explain that *"hand search articles"* are pieces of literature that serve as connectors or bridges between disparate domains or disciplines within the literature and these articles play a crucial role in establishing connections between two or more related but distinct areas of study, contributing substantially to the development of a comprehensive understanding of the research topic. Through their interdisciplinary nature, hand search articles serve as pivotal components in the synthesis of knowledge, facilitating a more holistic perspective in the SLR process (Hopewell, Clarke, Lefebvre and Scherer 2007: 1).

Table 5.4 presents the additional 16 hand search articles that were included in the SLR post review.

Table 5.4: Hand search articles and sources

No.	Hand search article title	Source
1	Sustainability: An overview of the Triple Bottom Line and sustainability implementation	International Journal of Strategic Engineering
2	Circular supply chains in emerging economies – a comparative study of packaging recovery ecosystems in China and Brazil	International Journal of Production Research
3	Cannibals with forks: The triple bottom line of 21st century business	Cannibals with forks: The triple bottom line of 21st century business
4	Economic Viability of the Deposit Refund System for Beverage Packaging Waste – Identification of Economic Drivers and System Modelling	Journal of Sustainable Development of Energy, Water and Environment Systems
5	Optimising Recycling Policy in the UK: The UK's Deposit Return Scheme. Cambridge	Journal of Science & Policy
6	Deposit-Refund System (DRS) Facts & Myths. Deloitte	Deloitte
7	Deposit - Return Schemes. Data and figures from 16 member countries of the EPA Network	European Network of the Heads of Environment Protection Agencies (EPA Network) - Interest group on Plastics - Working paper.
8	Organisational barriers to the sustainable manufacturing system: A literature review	Environmental Challenges
9	What are the sustainability benefits, challenges and limitations of metal packaging?	Packaging Europe
10	Sustainability of reusable packaging–Current situation and trend	Resources, Conservation and Recycling
11	Completing the picture. How the circular economy tackles climate change	Material economics
12	Environmental Management System ISO 14001 factors for promoting the adoption of cleaner production practices	Journal of Cleaner Production
13	Comparing symbolic and substantive implementation of international standards – the case of ISO 14001 certification	Australasian Journal of Environmental Management
14	The waste hierarchy: A strategic, tactical and operational approach for developing countries. The case study of Mozambique	International Journal of Sustainable Development and Planning

15	Waste-to-energy is compatible and complementary with recycling in the circular economy	Clean Technologies and Environmental Policy
16	Process sustainability evaluation for manufacturing of a component with 6R application	Procedia Manufacturing

Source: Researcher's own construction

5.3 Results of the SLR

5.3.1 SLR statistical overview

Table 5.5 presents comprehensive statistics relating to the SLR, providing a holistic view of the SLR depth and breadth.

Table 5.5: Systematic Literature Review statistics

Reference article information	Results
Number of databases used	3
Number of journals used	55
Number of books	1
Number of reference articles used	85
Number of articles with single authors	8
Number of articles with multiple authors	77
Website references	2
Total number of authors	373
Total number of citations	107
Number of countries represented	39
Number of themes generated	26
Mean age of reference articles in years	3
Number of reference articles that were based on an SLR	9
Total number of articles referenced within the 9 SLR's	707

Source: Researcher's own construction

Table 5.5 demonstrates that the SLR referenced a diverse range of scholarly sources, encompassing 3 databases, 55 journals, 1 book, and 85 reference articles. The collaborative nature of the SLR is evident, with 77 articles featuring multiple authors, compared to 8 with single authors. The study exhibits a global perspective by referencing materials from 39 countries, emphasising inclusivity in the literature review. Recognition of the significance of online sources is reflected in the inclusion of 2 website references. The thorough categorisation of literature into 26 themes illustrates a detailed understanding of the subject matter. Referencing a total of 373 authors signifies an extensive reach of academic individuals, contributing diverse perspectives to the SLR. The total number of 107 citations indicates the impact of referenced literature on the study. The focus on recent literature, with a mean age of 3 years for reference articles, reinforces a commitment to keeping abreast of current global initiatives. These statistics indicate that the SLR research methodology demonstrated a comprehensive, collaborative, and globally informed approach to the literature review, ensuring depth, diversity, and relevance in the study.

5.3.2 Timeline of the articles referenced

Figure 5.2 provides an insight into the timeline of the articles referenced for the study.

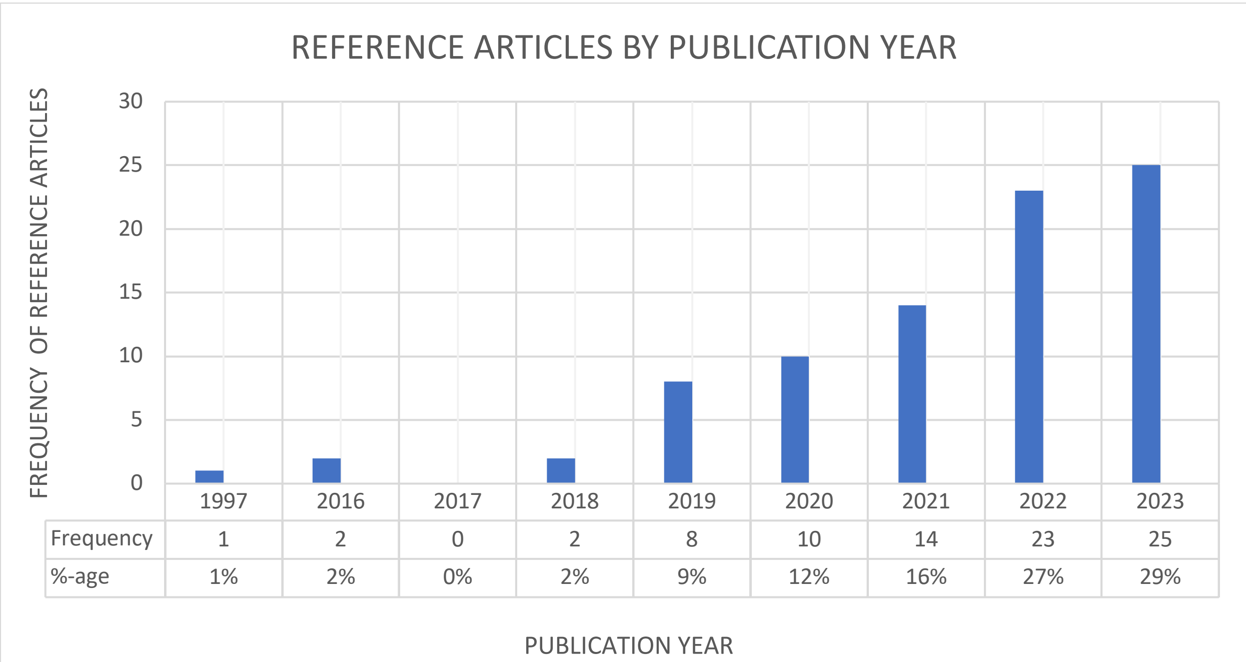


Figure 5.2: Reference articles by publication year
Source: Researcher's own construction

Figure 5.2 presents a comprehensive overview of the distribution of referenced journal articles based on the respective years of publication. The arrangement is organised chronologically, enabling a visual representation of the temporal trends in the literature reviewed. The study focused on literature since 2016, with one seminal source, John Elkington's discussion on the TBL, dating back to 1997. It is important to note that the study focused on the most recent information, therefore the searches were limited to the past eight years to extract current practices. 56% of the reference articles were published in 2022 and 2023.

5.3.3 Ranking of countries

Figure 5.3 depicts the ranking of countries based on the quantity of referenced articles per country.

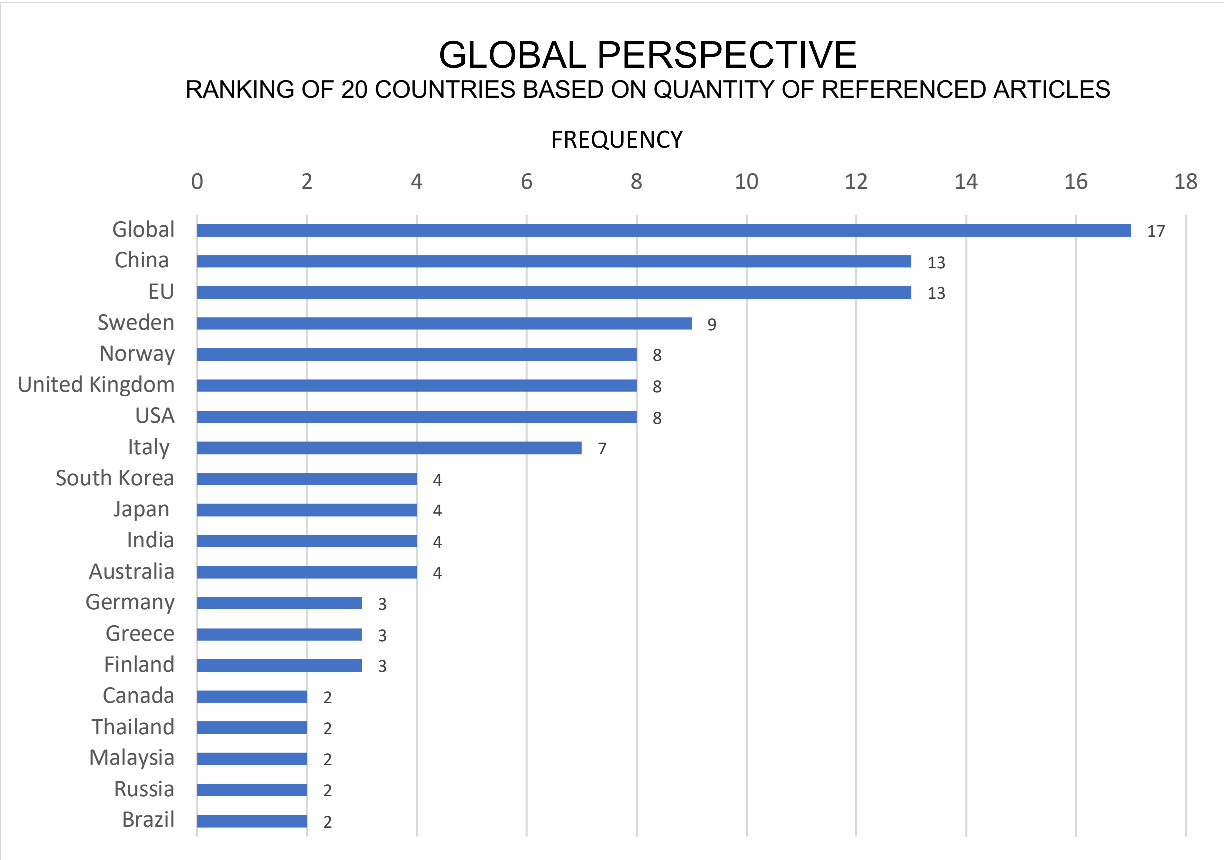


Figure 5.3: A global representation of articles reviewed
Source: Researcher's own construction

From 85 reference articles, a total of 137 citations were made, representing 39 countries, including the description "global", indicating multiple countries.

Figure 5.3 ranks the 20 countries that were represented by the most number of reference articles.

The y-axis represents different countries pertaining to the study whilst the x- axis indicates the frequency of cited articles originating from the country. The varying lengths of the bars offer insights into the concentration and dispersion of academic contributions across the globe, enabling patterns and trends across different parts of the world to be discerned.

The graph underscores the international spread of the literature reviewed, illustrating the extent to which research findings and perspectives were drawn from diverse global sources. The analysis of the distribution of references graphically, provided an appreciation of the geographic influence on the study's knowledge base, pointing out regional emphases and potential areas for further exploration.

The researcher notes that although the 85 academic articles referenced in this SLR represented 39 countries, dedicated academic studies on post-consumer metal packaging recovery in SA was not found within the context of the search strategy adopted in this SLR. The SA practices related to the post-consumer metal packaging recovery is highlighted in the qualitative analyses discussed later in Chapter Six.

5.3.4 Key themes arising out of SLR

Fig 5.4 illustrates the key themes arising from the referenced articles.

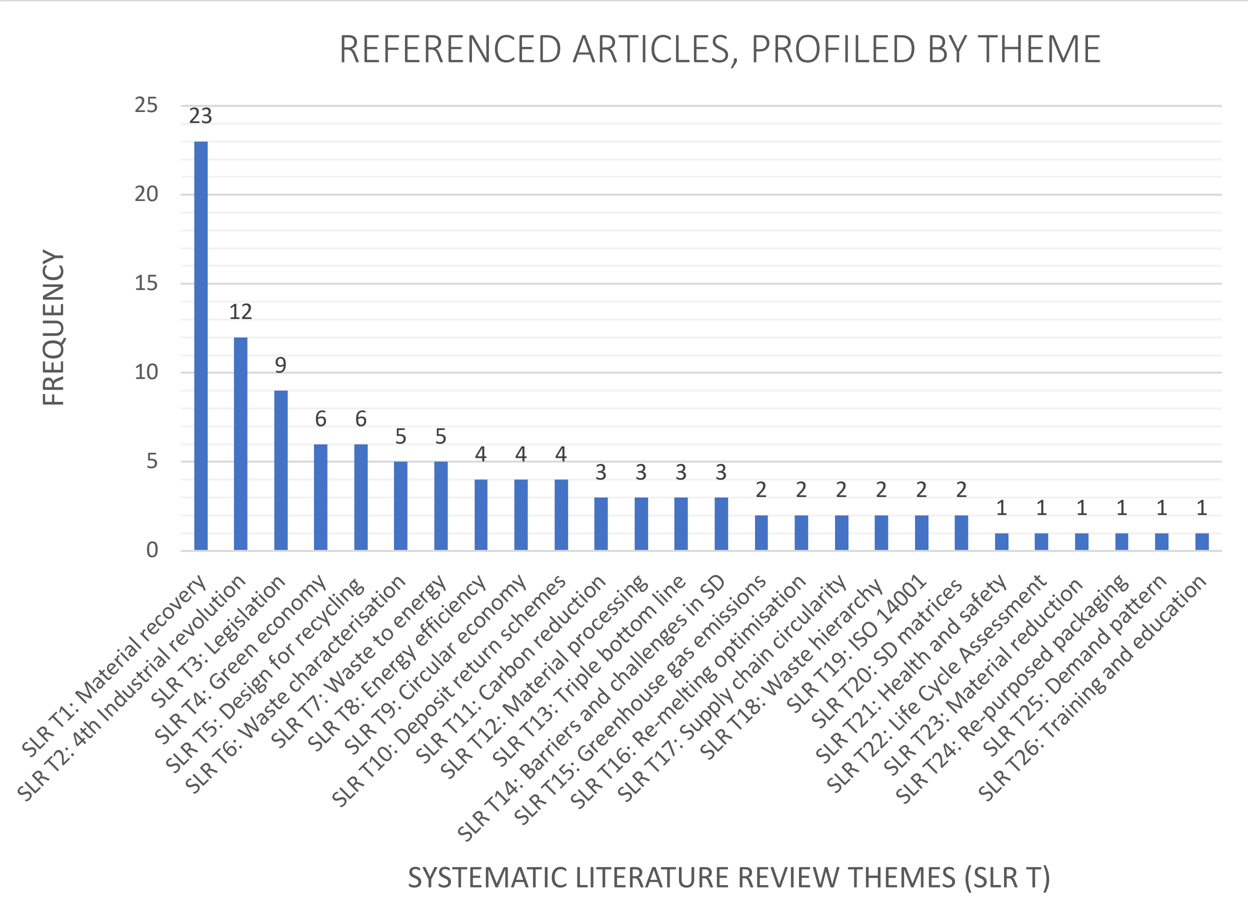


Figure 5.4: Referenced articles profiled by sustainable development theme
Source: Researcher's own construction

Figure 5.4 presents a visual breakdown of the referenced articles based on the 26 themes that have emerged from the systematic literature review. Each bar in the graph corresponds to a distinct thematic category, and its height reflects the number of articles associated with that particular theme.

Significantly, figure 5.4 indicates that the key ideas arising out of the SLR were:

i. Material recovery;
ii. Industry 4.0;
iii. Packaging legislation;
iv. Green economy and
v. Design for recycling

The graph not only serves as a quantitative representation of the prevalence of different themes, but also highlights the relative emphasis placed on each theme within the study.

This enables the identification of predominant areas of research interest, as well as the observation of potential intersections between themes, asserting the overall diversity of perspectives within the literature.

5.3.5 Referenced articles profiled by theme, split into aluminium and steel

Figure 5.5 illustrates the number of referenced articles, profiled by 26 themes, split into aluminium and steel.

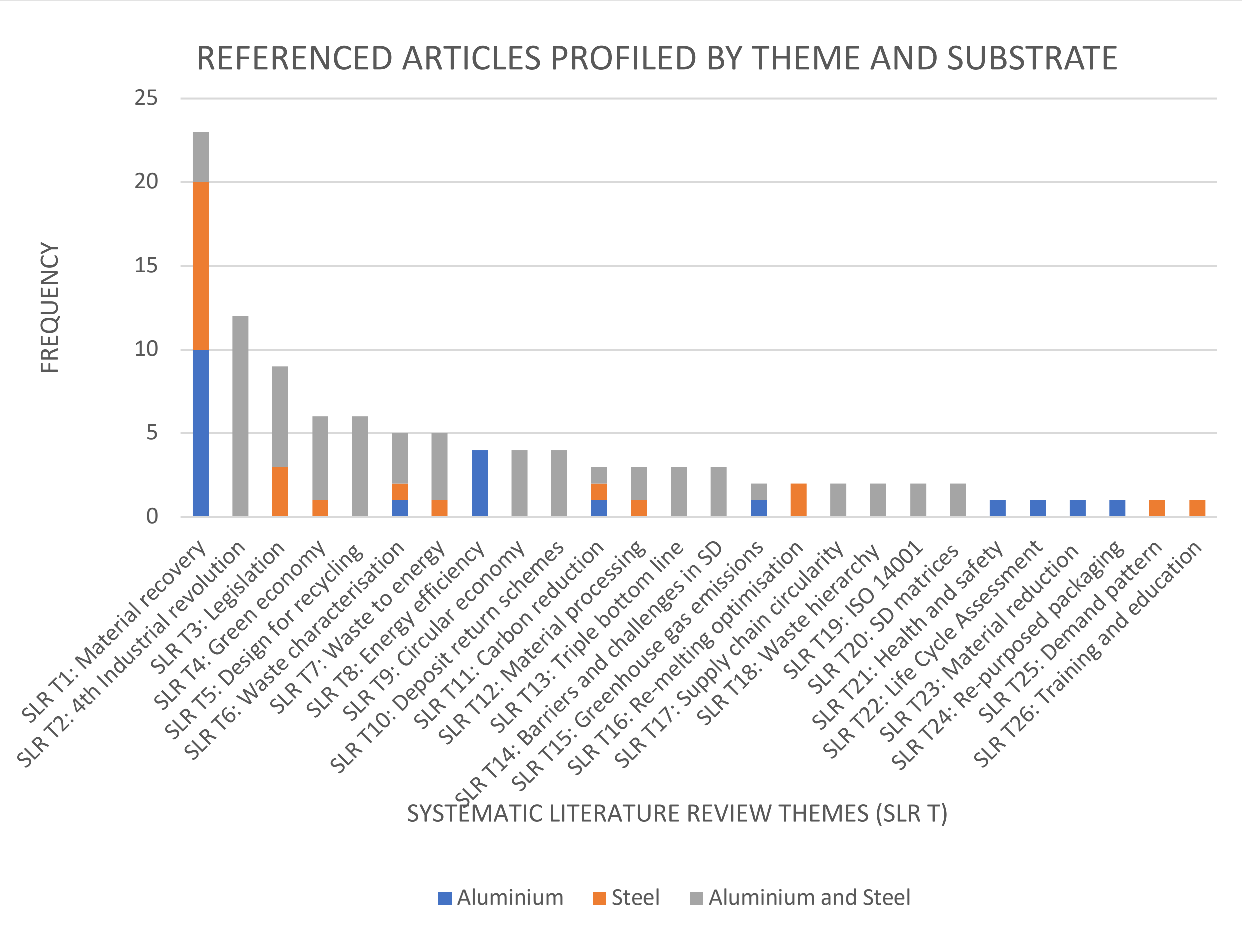


Figure 5.5: Referenced articles, profiled by sustainable development theme, split into aluminium and steel
Source: Researcher's own construction

Figure 5.5 presents the same information as figure 5.4 but is split into aluminium and steel substrates, indicating the research emphasis by substrate.

5.3.6 Top 15 journals by citation frequency

Figure 5.6 presents the ranking of the top 15 journals, by citation frequency.

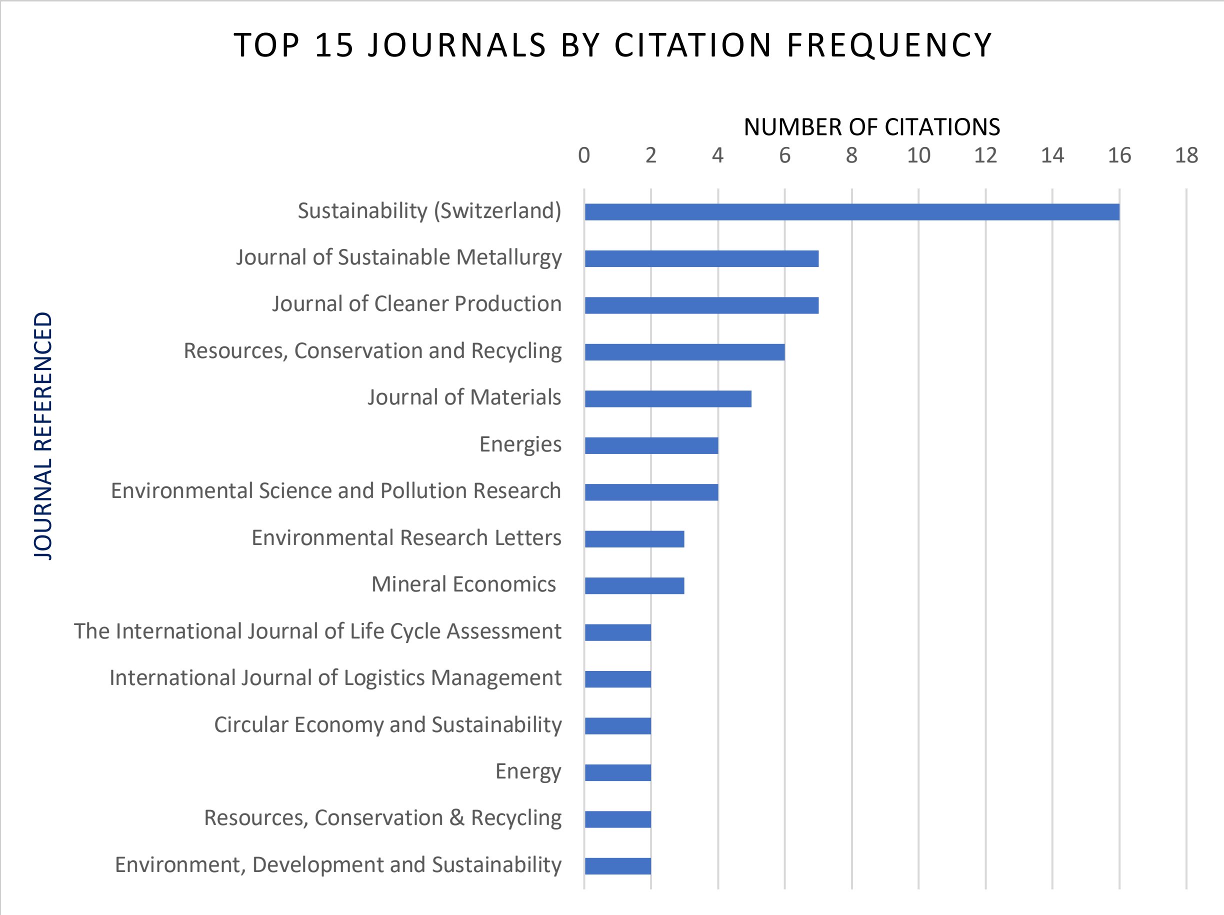


Figure 5.6: Top 15 journals, by citation frequency

Source: Researcher's own construction

A total of 85 reference articles, from a total of 55 journals were cited in this SLR. A total of 107 citations were made from these reference articles, during the SLR synthesis. Figure 5.6 provides a graphical representation of the citation frequency of referenced articles, ranked by the respective journals in which they were published. The top 15 journals are ranked in figure 5.6.

Each bar on the graph corresponds to a specific journal, with the length of the bar indicating the frequency of citations attributed to articles from that journal. The visualisation illustrates the journals contributing significantly to the SLR, pointing out the citation dynamics and journal prominence inherent in the referenced literature.

Figure 5.6 emphasises not only the diversity of sources, but also highlights key publication outlets that have contributed to this SLR. Analysing citation frequency by journal provides valuable insights into the academic impact and dissemination patterns of the literature reviewed, demonstrating the relative importance of different academic sources within the context of the study.

The next section will illustrate the 50 most frequent words derived from the SLR, depicted as a word cloud, arising from the SLR input into NVivo, version 12.

5.3.7 Word cloud - SLR

Figure 5.7 presents a word cloud that reflects the key words, by frequency, arising from the SLR.

Figure 5.7: Word cloud arising from the SLR

Source: NVivo version 12

Analysing the word cloud in figure 5.7, the following points are pertinent:

i. The predominant words arising from the SLR were aluminium, steel, recycling, recovery, process, waste to energy, melting, circular, sustainable, DRS, system, carbon reduction, efficiency and emission;

ii. This clearly emphasised the global concepts, derived from the SLR, that were fundamental to realising the objectives that underpinned this thesis and

iii. This SLR word cloud, underpinned by the research questions, was triangulated with the two word clouds that arose out of the qualitive analyses, and will be discussed later in Chapter Six, validating the research data integrity.

The next section presents, in table format, the 26 themes that were extracted from the synthesis of the 85 academic articles that were used in this SLR.

5.3.8 SLR thematic tables

A comprehensive SLR of 85 academic articles was conducted, wherein the key concepts derived from the literature were systematically organised into thematic groups. These ideas were then collated into thematic tables, each named after the overarching theme identified in the respective articles. Each thematic table reflects the article title, the journal that published the article, the related citation, the country that the study was conducted in, and the summary of the findings.

The thematic tables are sequenced, where applicable, as specific to aluminium, then as specific to steel, then as specific to a combination of aluminium and steel. After each set of tables, the researcher provided a synthesised summary.

Tables 5.6 to 5.8 address SLR Theme 1 on material recovery.

Table 5.6: SLR T1 - Material recovery (Aluminium)

Article Title	Journal	Citation	Country	Summary of findings
Thermal De-coating Pre-treatment for Loose or Compacted Aluminum Scrap and Consequences for Salt-Flux Recycling	Journal of Sustainable Metallurgy	Vallejo-Olivares, Hogasen, Kvithyld and Tranell (2022: 1485)	Norway	Thermal decoating and remelting of shredded and compacted secondary aluminium yielded the following results: i. compaction limits the efficiency of the de-coating process and ii. compaction significantly increases efficiency of the melting process as a result of higher density and quicker melting.
Collection, Thermal Treatment, and Remelting End-of-Life Al Packaging in Norway	Journal of Materials	Bao, Eggen, Syvertsen and Kvithyld (2023: 5756)	Norway	The recovery and re-use of post-consumer, end of life, aluminium packaging in Norway is managed through three schemes: i. Household residual waste collection by local municipalities, ii. Collection of mixture of glass and metal waste by local municipalities and iii. Deposit–refund systems that incentivise return of used packaging.
Collection, Thermal Treatment, and Remelting End-of-Life Al Packaging in Norway	Journal of Materials	Bao, Eggen, Syvertsen and Kvithyld (2023: 5756)	Norway	Manual sorting of post-consumer mixed waste results in higher re-melting yields of aluminium, because manual sorting ensures minimal or no contamination of aluminium, even though it is not as quick as a mechanised Material Recovery Facility (MRF).

				This demonstrates the importance of consumer awareness for separation-at-source (SAS) to minimise contamination thereby enabling higher aluminium recovery yields.
Hydrogen-Rich Gas Produced by the Chemical Neutralization of Reactive By-Products from the Screening Processes of the Secondary Aluminium Industry	Sustainability (Switzerland)	Ercoli, Orlando, Borrini, Tassi, Bicocchi and Renzulli (2021: 1)	European Union	The pre-treatment of beverage cans and other end-of-life aluminium products, results in aluminium-rich by-products, which are great secondary raw material resources, as long as these are chemically neutralised. The European Union law classifies metallic aluminium-rich by-products as hazardous waste, due to a high risk of fire and explosion. Therefore, the secondary aluminium industry must improve workplace safety by minimising the risks related to the storage of hazardous aluminium-rich by-products.
Refining of Secondary Aluminum: Important Chemical Factors	Journal of Materials	Sigworth (2021: 2594)	USA	Although there are strong economic and environmental incentives to recycling, secondary aluminium often consists of unwanted impurity elements that limit the volume of recoverable secondary material. More intelligent design of aluminium alloys is necessary so that alloy composition does not limit recovery and recycling.
Separation of Aluminium from More Noble Elements in an Electrolysis Cell with Side-by-Side Geometry	Metallurgical and Materials Transactions B-Process Metallurgy and Materials Processing Science	Solheim, Kjos, Gudbrandsen and Skybakmoen (2021: 1550)	Norway	Aluminium production from EOL aluminium, comparable to primary aluminium alloy composition, is possible through the manipulation and refinement of the electrolytic process.
Classification of Shredded Aluminium Scrap Metal Using Magnetic Induction Spectroscopy	Sensors	Williams, Mallaburn, Gagola, O'toole, Jones and Peyton (2023: 1)	UK	Magnetic induction spectroscopy (MIS) enables effective separation of wrought aluminium from cast aluminium. Separation is critical because wrought aluminium contains high levels of impurities. This is possible due to the conductive difference between cast and wrought aluminium.
Design and Control of Pneumatic System for	International Journal of Precision Engineering and	Cho, Kwon and Park (2022: 574)	South Korea	High powered laser induced-break down spectroscopy (LIBS), reflected onto the target scrap surface, deploying an induced plasma technique, delivers a chemical

Recycling Classification of Non-Ferrous Metals	Manufacturing-Green Technology			analysis of the composition of aluminium scrap, enabling higher quality of recovered aluminium.
Simulation-Based Exergy and LCA Analysis of Aluminium Recycling: Linking Predictive Physical Separation and Re-melting Process Models with Specific Alloy Production	Journal of Sustainable Metallurgy	Hannula, Godinho, Llamas, Luukkanen and Reuter (2020: 175)	Germany and Finland	To make optimal use of information regarding the quality of aluminium scrap and the subsequent sorting and separation processes, it is essential to establish connections among various stages of the recycling process, including collection, separation, re-melting, and alloy production. Essentially, this approach mirrors the principles of geo-metallurgy applied in primary processing.
Impact of rolling processes in the production of aluminium packaging assessed through LCA	The International Journal of Life Cycle Assessment	Astarita De Luca and Sinagra (2023: 1756)	Italy	Reduction of adverse environmental impact can be achieved through optimised material usage, where material thickness reduction results in light-weighting the beverage can, using less material for the same packaging.

Source: Researcher's own construction

Table 5.7: SLR T1 - Material recovery (Steel)

Article Title	Journal	Citation	Country	Summary of findings
Mapping the global flows of steel scraps: an alloy elements recovery perspective	Environmental Research Letters	Cai, Geng, Gao and Wei (2023: 10)	Global	Steel scrap is now accepted as a viable source to replace virgin steel and this practice will contribute significantly to global net-zero efforts. The alloy elements, chromium (Cr), nickel (Ni), manganese (Mn), molybdenum (Mo), cobalt (Co), vanadium (V), and niobium (Nb), embodied in steel have been transferred across different countries, as a result of international steel scrap trade, resulting in the rarity of such critical metals.
Mapping the global flows of steel scraps: an alloy elements recovery perspective	Environmental Research Letters	Cai, Geng, Gao and Wei (2023: 10)	Global	Recovery and recycling of end of life steel products through the use of electric arc furnaces is now the preferred technique for the global steel industry to achieve net-zero emissions. As a result of the uneven distribution of global scrap steel, many countries are becoming actively involved in the global scrap steel trade.

Circular Steel: How Information and Actor Incentives Impact the Recyclability of Scrap	Journal of Sustainable Metallurgy	Companero, Feldmann, Samuelsson, Tilliander, Jonsson and Gyllenram (2023: 1663)	Sweden	There is relationship between information of embedded alloys in scrap steel and the use of virgin steel. The more that is known about the embedded alloys in the scrap steel, the less virgin steel will be required to adjust the embedded alloy content of the melt. To achieve sustainability, it is necessary to minimise the use of virgin steel, through the knowledge of alloys present in the scrap steel
Circular Steel: How Information and Actor Incentives Impact the Recyclability of Scrap	Journal of Sustainable Metallurgy	Companero, Feldmann, Samuelsson, Tilliander, Jonsson and Gyllenram (2023: 1663)	Sweden	Steel mills prefer to buy scrap steel that: i. presents little or no non-steel contamination, ii. has high levels of desired embedded alloys. iii. has higher scrap density, because this increases melt yield and efficiency. Shredding and compaction of scrap steel is recommended to increase density.
Circular Steel: How Information and Actor Incentives Impact the Recyclability of Scrap	Journal of Sustainable Metallurgy	Companero, Feldmann, Samuelsson, Tilliander, Jonsson and Gyllenram (2023: 1663)	Sweden	Buy back centres prefer high-quality steel scrap since this is easier to sell. The stakeholders in the scrap value chain make decisions based on economic considerations, rather than steel resource efficiency. Operational drivers such as lot sizes, and economic factors such as inventory holding costs, lead to the downcycling and devaluing of steel.
Assessment of Electric Arc Furnace (EAF) Steel Slag Waste's Recycling Options into Value Added Green Products: A Review	Metals	Teo, Zakaria, Salleh, Taib, Sharif, Abu Seman, Mohamed, Yusoff, Mohamad, Masri and Mamat (2020: 16)	Malaysia	Recycling rates of steel Electric Arc Furnace (EAF) slag is still very low in Malaysia. The rising cost of landfilling of the residual slag, coupled with the high levels of land pollution in the country, necessitates recycling of EAF slag

Research on co-disposal and utilisation of ferrous packaging containers contaminated with hazardous wastes by steel converter	Sustainable Environment Research	Wang, Chen, Fu, Zhang, Liu, Huang and Song (2022: 1)	China	Used 210 litre steel drums are pre-treated to remove residue, flattened into steel blocks and introduced into the steel furnace at charge masses of 180kg to 540kg. This results in an improvement in furnace efficiency and control, and avoids the cleaning and reuse of 210 litre drums.
Supply network collaborations in a circular economy: A case study of Swedish steel recycling	Resources, Conservation and Recycling	Berlin, Feldmann and Nuur (2022: 1)	Sweden	Transparent relationships among steel suppliers ensure that price fixing is avoided. Transparent relationships among steel recyclers ensure higher quality of steel due to effective separation of scrap. An independent procurement intermediary then connects these two parties through fair commodity pricing that is determined by global market trends.
How will tramp elements affect future steel recycling in Europe? – A dynamic material flow model for steel in the EU-28 for the period 1910 to 2050	Resources, Conservation & Recycling	Dworak, Rechberger and Fellner (2022:1)	Europe	It is necessary to manage the ratio of scrap of low purity, pre-consumer scrap (scrap arising from production) as well as post-consumer scrap, so that future steel production consumes a higher percentage of scrap steel. The expectation is that by 2050, Europe will be producing steel that has a composition of 75% scrap steel.
Scrap endowment and inequalities in global steel decarbonization	Journal of Cleaner Production	Watari, Giurco and Cullen (2023: 1)	Australia	The future availability of scrap metal is predicted to be unequally distributed globally, favouring the affluent Global North over the struggling Global South. Projections suggest that by 2050, the European Union, North America, and developed Asia could amass scrap stocks equivalent to their entire steel demand, with China holding about half of its demand in domestic scrap. In contrast, developing regions like India and African states are expected to possess less than 5% of their demand in domestic scrap. Termed "scrap endowment," this imbalance, rooted in historical carbon emissions, enables the Global North to produce low-cost, zero-emission steel, highlighting the necessity for equitable measures to aid the Global South in achieving net-zero emissions by 2050.

Source: Researcher's own construction

Table 5.8: SLR T1 - Material recovery (Aluminium and steel)

Article Title	Journal	Citation	Country	Summary of findings
A Synergy Between Sustainable Solid Waste Management and the Circular Economy in Tanzania Cities: a Case of Scrap Metal Trade in Arusha City	Urban Forum	Onesmo, Mabhuye and Ndaki (2023: 1)	Tanzania	In developing countries, waste pickers play a vital role in the recovery and sale of metal and other material to recyclers in the waste stream circular economy, yet are usually ignored by cities. Cities should consider post-consumer material recovery models that recognise waste pickers' views and knowledge to facilitate more inclusive and effective CE models, that promote a synergistic relationships with the waste value chain.
Size-resolved characterization of particles >10 nm emitted to air during metal recycling	Environment International	Loven, Isaxon, Ahlberg, Bermeo, Messing, Karedal, Hedmer and Rissler (2023:1)	Sweden	Two metal recycling waste streams of significant relevance are: i. waste of electrical and electronic equipment (WEEE) and ii. post-consumer metal scrap. WEEE is currently one of the fastest-growing waste streams in the EU. The recycling and recovery procedures for these waste streams produce hazardous and allergenic metals. When subjected to mechanical or thermochemical waste treatment, these metals can be released into the air, posing risks to occupational health and the environment.
A review of recent trends to increase the share of post-consumer packaging waste to recycling in Europe	Detritus: Multidisciplinary Journal for Waste Resources and Residues	Lederer, Bartl, Blasenbauer, Breslmayer, Gritsch, Hofer, Lipp, and Muhl (2022:13)	Europe	**This was an SLR based on 45 reference articles** The negative impact of a single use, throwaway lifestyle necessitates a sustainable development strategy The EU circular economy package is an effective model that enables measurable social and business behaviour change.

Source: Researcher's own construction

Researcher's synthesis on SLR Theme 1 - Material recovery

The following discussion is synthesised from the evaluation of the information in tables 5.6 to 5.8.

i. Compaction of used aluminium results in improvement in yields of secondary aluminium. Despite recycling incentives, impurities in secondary aluminium present a persistent challenge, necessitating intelligent alloy design for optimal recovery. Manual sorting of the used metal to isolate non-aluminium materials will enhance aluminium re-melting yields. In the steel industry, there's a shift towards net-zero emissions through the recovery of end-of-life steel products using electric arc furnaces.
ii. It is important to understand that embedded alloy composition is vital to minimise reliance on virgin steel and highlights concerns about the unequal global distribution of scrap metal, favouring developed regions. Equitable measures are urged to assist developing regions in achieving net-zero emissions by 2050.
iii. Steel mills prioritise acquiring scrap steel with minimal non-steel contamination, high levels of desired alloys, and increased density for improved melt yield and efficiency. Shredding and compaction are recommended practices to enhance scrap density.
iv. Buy back centres favour high-quality steel scrap for easier resale. Economic considerations, driven by operational factors like lot sizes and economic factors such as inventory holding costs, often result in downcycling and devaluation of steel within the scrap value chain.

Table 5.9 will present SLR Theme 2, based on the 4IR.

Table 5.9: SLR T2 - Fourth Industrial Revolution (Aluminium and steel)

Article Title	Journal	Citation	Country	Summary of findings
Technological Enablers and Prospects of Project Management in Industry 4.0: A Literature Review	Academic Journal of Interdisciplinary Studies	Baque-Cantos, Moreira-Canarte, Ultreras-Rodríguez, Nieves-Lizarraga, De J. Gonzalez-Rodríguez, Moreira-Choez, Campos-Sanchez, De L. Cantos-Figueroa and Rincon-Guio (2023: 61)	Global	The characteristics and emerging trends of Industry 4.0, such as Internet of Things (IoT), Big Data Analytics, Cyber-Physical Systems, Supply Chain Management (SCM) are now powerful enablers for advanced manufacturing, circular economies in support of delivery against the sustainable development goals.
The Economic Aspect of Digital Sustainability: A Systematic Review	Sustainability (Switzerland)	Cricelli and Strazzullo (2021:1)	Italy	**This was an SLR, 32 academic articles were systematically reviewed in this journal article.** The exploitation of Industry 4.0 tools and technologies offers greater opportunities in the field of economic and environmental sustainability. This conclusion was derived through a systematic literature review that examined 32 academic articles.
The Relationship between Circular Economy, Industry 4.0 and Supply Chain Performance: A Combined ISM/Fuzzy MICMAC Approach	Sustainability (Switzerland)	Filho, Monteiro, Mota, Gonella and Campos, (2022: 17)	Global	Global concern, around the negative impacts of linear production and consumption models, has increased over the past 40 years. Consequently, environmental and economic crises have arisen, showcasing the detrimental impact on the planet. Therefore there is a critical need to hasten the shift from a linear economy into a circular economy. Industry 4.0 technological development will support this crucial transition.
Impact of IoT on Manufacturing Industry 4.0: A New Triangular Systematic Review	Sustainability (Switzerland)	Kalsoom, Ahmed, . Rafi-Ul-Shan, Azmat, Akhtar, Pervez,	UK	**This was an SLR, 108 academic articles were systematically reviewed in this journal article.**

		Imran and Ur-Rehman (2021: 11)		Internet of Things (IoT), through miniature embedded systems, modern electronics, wireless data communication systems and low-power interconnected devices enables: i. higher levels of connectivity and accessibility to Big Data; ii. access to extensive information; iii. easier monitoring and control of processes and iv. Quicker decision making. Consequently, such Industry 4.0 technology promotes efficient waste analysis, recovery, processing and re-use.
Technological Revolution and Circular Economy Practices: A Mechanism of Green Economy	Sustainability (Switzerland)	Khan, Umar, Asadov, Tanveer and Yu (2022: 3)	Romania, Ukraine, Russia, Slovakia, Poland, Bulgaria, Moldova, Belarus, Hungary, and Czechia	Industry 4.0 has a positive effect on CE practices which are found to have a significant positive effect on environmental, economic, and operational performance. The adoption of Internet of Things in CE increases end-of-life material availability, optimise response time, and reduce adverse emissions. Industry 4.0 technology such as IoT enables superior product design, integrating the principles of design for recycling, design for disassembly, and design for durability. Industry 4.0 also provides transparency in business operation and reduces data tempering and double spending
Spatial Layout Assessment of Urban Mining Pilot Bases in China Based on Multi-Source Data Collaboration	Sustainability (Switzerland)	Liu, Xu, Yang, Shi, and Deng (2023: 19)	China	The current level of technology and equipment does not align with Industry 4.0, thus limiting the recovery and recycling of urban waste metal. Scrap metal recycling and treatment technologies must be therefore be encouraged in China through emerging information technologies such as Big Data and cloud computing.
The application of Industry 4.0 technologies in sustainable logistics: a systematic literature review (2012–2020) to explore future research opportunities	Environmental Science and Pollution Research	Sun, Solvang, Wang and Wang (2022: 9560)	Global	**This was an SLR based on 19 reference articles** Industry 4.0 technologies promotes the improvement of the economic efficiency, environmental impact as well as the social impact of supply chains. Notwithstanding, challenges arise with such rapid technological transformation, and these include:

				i. trade-offs among various sustainability KPI's; ii. undefined advantages; iii. impact of environmental lifecycle analysis; iv. inequity issues and technology maturity.
Waste Management 4.0: An Application of a Machine Learning Model to Identify and Measure Household Waste Contamination—A Case Study in Australia	Sustainability (Switzerland)	Zaman (2022: 1)	Australia	**This was an SLR based on 19 reference articles.** A machine learning model was designed as a proof-of-concept and trialled to identify and separate household waste at material recovery facilities (MRF). The model identified waste objects and contamination, and, although the consistency of waste material detection varied for different waste streams, the overall outcome was positive.
Can green finance facilitate Industry 5.0 transition to achieve sustainability? A systematic review with future research directions	Environmental Science and Pollution Research	Dhayal, Giri, Kumar, Samadhiya, Agrawal and Agrawal (2023: 102158)	India	The following components are necessary to develop a framework to transition from Industry 4.0 to Industry 5.0: i. green manufacturing practices; ii. green innovation; iii. circular economy; iv. green supply chain management; v. emerging economies; vi. net zero economy and vii. Green financing.
Can green finance facilitate Industry 5.0 transition to achieve sustainability? A systematic review with future research directions	Environmental Science and Pollution Research	Dhayal, Giri, Kumar, Samadhiya, Agrawal and Agrawal (2023: 102158)	India	**This was an SLR based on 196 reference articles** Industry 5.0 must create a symbiotic relationship with Society 5.0 through the following components: i. social (driving human/machine centricity); ii. ecological (driving zero emissions) and iii. technological (driving green innovations).
The circular economy implementation at the European Union level. Past, present and future	Journal of Cleaner Production	De Pascale, Di Vita, Giannetto, Loppolo, Lanfranchi, Limosani and Szopik-Depczyńska (2023: 1 - 15)	European Union	**This was an SLR based on 34 reference articles** It is clear that some CE strategies in EU countries require more focussed implementation, particularly those regarding ecological products or packaging design.

				Despite the availability of Industry 4.0 tools and technology, the sharing of resources, opportunities and information, through online platforms, is not being exploited to advance EU business and social capital.
Industry 4.0 innovations and their implications: An evaluation from sustainable development perspective	Journal of Cleaner Production	Khan, Ahmad and Majava (2023: 8)	Finland	**This was an SLR based on 58 articles** Industry 4.0 generates a range of innovative types, encompassing process, product, business model, supply chain, organisational, open, and marketing innovations. These innovations collectively promote triple bottom line (TBL) sustainability, circular economy (CE), sustainable business models (SBMs), and the attainment of sustainable development goals (SDGs). Although existing studies predominantly concentrate on process, product, and business model innovations with implications for TBL and CE, there is a notable gap in research addressing overlooked areas like open, organisational, and marketing innovations. A more comprehensive exploration of these dimensions is essential to further the sustainability of business models and contribute to the achievement of SDGs.

Source: Researcher's own construction

Researcher’s synthesis on SLR Theme 2 – Fourth Industrial Revolution

The following discussion is synthesised from the evaluation of the information in table 5.9.

i. Industry 4.0, encompassing transformative technologies like IoT, Big Data Analytics, Cyber-Physical Systems, and SCM, plays a crucial role in advancing manufacturing and CE’s, aligning with SDGs.
ii. The utilisation of Industry 4.0 tools provides substantial opportunities for economic and environmental sustainability. Specifically, IoT, with its embedded systems and wireless communication, enhances connectivity to Big Data, enabling efficient waste analysis, recovery, and re-use.
iii. Industry 4.0 positively influences CE practices, improving environmental, economic, and operational performance.
iv. The integration of IoT in CE fosters increased material availability, optimises response time, and minimises emissions.
v. Additionally, Industry 4.0 supports superior product design and transparency in business operations, reducing data risks.
vi. Looking ahead, Industry 5.0 underscores a symbiotic relationship with Society 5.0, emphasising human/machine centricity, zero emissions, and green innovations.

Tables 5.10 and 5.11 will present SLR Theme 3, based on packaging legislation.

Table 5.10: SLR T3 - Packaging legislation (Steel)

Article Title	Journal	Citation	Country	Summary of findings
Circular Economy of Steel Recycling Companies in Thailand	Circular Economy and Sustainability	Taghipour and Akkalatham (2021:909)	Thailand	Governments and industry collaboration is crucial for the development of legislative framework and policies supporting the development of the circular economy. Governments may impose a restriction or a complete ban on exports of scrap steel to protect domestic availability Such action by governments also influence steel prices. A more important reason for steel export bans is to reduce the demand for steel within the country, minimising the theft of steel infrastructure within the country.
Carbon-Neutral Steel Production and Its Impact on the Economies of China, Japan, and Korea: A Simulation with E3ME-FTT:Steel	Energy	Vercoulen, Lee, Han, Zhang, Cho and Pang (2023: 1)	China, Japan, and Korea	The primary iron and steel industry emits significant CO_2 globally. Legislation that imposes carbon tax penalties will force a transition towards steel scrap recycling, However such legislation does not support the reduction of the carbon footprint during carbon primary steelmaking. A combination of legislation that subsidises the carbon footprint reduction of primary steel manufacturing. as well as carbon penalties for carbon intensive processes, is necessary.
Carbon-Neutral Steel Production and Its Impact on the Economies of China, Japan, and Korea: A Simulation with E3ME-FTT:Steel	Energy	Vercoulen, Lee, Han, Zhang, Cho and Pang (2023: 1)	China, Japan, and Korea	Forward thinking countries are committing to a net-zero carbon future with respect to emissions from steel production by 2050. Achieving carbon neutrality necessitates a transition from fossil fuels to using renewable energy.

Source: Researcher's own construction

Table 5.11: SLR T3 - Packaging legislation (Aluminium and steel)

Article Title	Journal	Citation	Country	Summary of findings
Steel, Aluminum, and FRP-Composites: The Race to Zero Carbon Emissions	Energies	Rajulwar, Shyrokykh, Stirling, Jarnerud, Korobeinikov, Bose, Bhattacharya, Bhattacharjee and Sridhar (2023: 1)	USA	The production of iron and steel is a prominent contributor to CO_2 emissions globally, contributing to 25–30% of the manufacturing sector's CO_2 emissions and 6–8% of total worldwide emissions. In October 2014, the European Council enforced a climate and energy policy framework aiming to reduce greenhouse gas emissions by 40% by 2030 and at least 80% by 2050, in comparison to 1990 baseline. The goal was to ensure that global temperature does not increase greater than 2°C.
Metal markets and recycling policies: impacts and challenges	Mineral Economics	Soderholm and Ekvall (2020: 257)	Sweden	Unilateral, country-specific, recycling policies are necessary and will significantly impact the global supply chain only if the domestic market is large enough to influence prices in the global market.
Legal situation and current practice of waste incineration bottom ash utilisation in Europe	Waste Management	Blasenbauer, Huber, Lederer, Quina, Blanc-Biscarat, Bogush, Bontempi, Blondeau, Chimenos, Dahlbo, Fagerqvist, Giro-Paloma, Hjelmar, Hyks, Keaney, Lupsea-Toader, O'Caollai, Orupold, Pajak, Simon, Svecova, Syc, Ulvang, Vaajasaari, Van Caneghem, Van Zomeren, Vasarevicius, Wegner	EU, Norway and Switzerland	Strict legislative framework that provides clear guidelines for the recycling and utilisation of Municipal Incinerated Bottom Ash (MIBA) and the restriction of MIBA to landfill is necessary. Such legislation will result in increased utilisation of MIBA as a result of recycling obligation. Therefore, landfill restriction will stimulate the MIBA recycling market.

		and Fellner (2020: 868)		
A Framework to Assess Manufacturers' Circular Economy Readiness Level in Developing Countries: An Application Case in a Serbian Packaging Company	Sustainability (Switzerland)	Demko-Rihter, Sassanelli, Pantelic and Anisic (2023: 22)	Serbia	Environmental responsibility is not optional for organisations. A country's environmental legislative requirements make it mandatory for compliance Statutory compliance is a legal duty that: i. will attract local and foreign financial investors; ii. will increase customer base and iii. will build wider market reputation and improve business performances.
The End-of-Waste for the Transition to Circular Economy: A Legal Review of the European Union Waste Framework Directive	Environmental Policy and Law	Johansson (2023: 167)	Sweden European Union	The Waste Framework Directive (WFD) of the European Union relates to human rights Article 6(1) of the Waste Framework Directive (WFD) relates to: i. The occurrence of bottlenecks that exist in the waste stream must be prevented by creating a demand for such waste; ii. Required legislation that is needed to support the recovery and re-use of end of life products, with the responsibility ultimately resting on the producer and iii. The preparation of waste management plan, by EU member states, every 6 years, which enables national, regional or local authorities to evaluate the effective execution of waste management plans.
Spatial Layout Assessment of Urban Mining Pilot Bases in China Based on Multi-Source Data Collaboration	Sustainability (Switzerland)	Liu, Xu, Yang, Shi, and Deng (2023: 19)	China	National pollution control and environmental management legislation is required across all stages of scrap metal treatment to enable the advancement of high metal recycling efficiency at minimal pollution levels.

Source: Researcher's own construction

Researcher's synthesis on SLR Theme 3 – Packaging legislation

The following discussion is synthesised from the evaluation of the information in tables 5.10 and 5.11.

i. The collaboration between governments and industries is crucial in shaping legislative frameworks that support the growth of the circular economy.
ii. Government interventions, such as restrictions or bans on scrap steel exports, play a vital role in safeguarding domestic availability and influencing steel prices.
iii. Legislation, including carbon taxes, encourages the shift towards steel scrap recycling, but an effective reduction in the carbon footprint requires a combination of subsidies for carbon footprint reduction in primary steel manufacturing and penalties for carbon-intensive processes.
iv. Countries are committing to achieving net-zero carbon emissions from steel production by 2050, emphasising a transition to renewable energy sources.
v. Given the significant contribution of iron and steel production to global CO_2 emissions, legislative measures, such as those outlined by the European Council, aim to reduce emissions and promote recycling.

Tables 5.12 and 5.13 will present SLR Theme 4, based on green economy.

Table 5.12: SLR T4 - Green economy (Steel)

Article Title	Journal	Citation	Country	Summary of findings
Portfolios of sustainable practices for packaging in the circular economy: an analysis of Italian firms	International Journal of Logistics Management	Cozzolino and De Giovanni (2022: 24)	Italy	Organisations prefer to focus on single environmentally sustainable models rather than on multiple initiatives to achieve packaging circularity. To improve the circularity of packaging, the most frequent areas of focus within businesses are raw material saving and logistics optimisation. The reuse of packaging allows firms to simultaneously reduce CO_2 emissions, energy usage and water consumption.

Source: Researcher's own construction

Table 5.13: SLR T4 - Green economy (Aluminium and steel)

Article Title	Journal	Citation	Country	Summary of findings
Portfolios of sustainable practices for packaging in the circular economy: an analysis of Italian firms	International Journal of Logistics Management	Cozzolino and De Giovanni (2022: 24)	Italy	To reduce energy consumption and CO_2 emission, it is necessary to focus on: i. the re-use of packaging as the primary driver; ii. facilitation of recycling activities and iii. simplification of packaging systems
A Hybrid Fuzzy AHP-TOPSIS Approach for Implementation of Smart Sustainable Waste Management Strategies	Sustainability (Switzerland)	Demircan and Yetilmezsoy (2023:1)	Belgium, China, Turkey, Malaysia	The continued success of sustainable, smart city, waste management strategies relies on a collaborative alignment and engagement between industry, the general public and the local government.
Rational Behaviour of an Enterprise in the Energy Market in a Circular Economy	Resources	Gitelman, Magaril, Kozhevnikov and Rada (2019:1)	China, Finland, Sweden, Germany, Canada, and Japan	Expenses associated with energy production and transmission, along with the volatility of energy processes, pose uncertainties, risks, and challenges for organisations striving to adopt a resource-efficient and low-carbon business model, especially impacting energy-intensive consumers who are reliant on expensive and high-grade energy sources like gas and electricity. In such a competitive business environment, this necessitates a heightened focus on efficient energy utilisation supporting the principles of CE.
Main Dimensions in the Building of the Circular Supply Chain: A Literature Review	Sustainability (Switzerland)	Gonzalez-Sanchez, Settembre-Blundo, Ferrari and Garcia-Muina (2020: 1)	Global	The global competitive environment dictates that organisations become innovative in their production systems and to rethink the use of resources and waste management. Circular supply chains must enable higher yields by using fewer resources, minimising emissions and energy usage. Economic growth is a function of material flows and energy. These findings were based on a systematic literature review of 50 academic articles, across the past 10 years.
A road map for environmental sustainability and green	Environmental Science and Pollution Research	Khan, Yu and Umar (2022:16082)	China	A measure of green total factor productivity (GTFP) indicates a country or region's ability to achieve long-term sustainable development goals.

economic development: an empirical study				Technological input, environmental policies, manufacturing, and logistics industry co-operation significantly influence GTFP.

Source: Researcher's own construction

Researcher's synthesis on SLR Theme 4 – Green Economy

The following discussion is synthesised from the evaluation of the information in tables 5.12 and 5.13.

i. Organisations are increasingly prioritising singular environmentally sustainable models as opposed to pursuing multiple initiatives to achieve packaging circularity.
ii. Their primary focus lies on strategies such as raw material savings and logistics optimisation, aiming to enhance the overall sustainability of packaging.
iii. The adoption of packaging reuse is highlighted, not only for its contribution to reducing CO_2 emissions, but also for its positive impact on decreasing energy usage and water consumption.
iv. Effective and sustainable waste management strategies in smart cities rely on collaborative alignment and engagement among industry stakeholders, the public, and local government.
v. Despite facing uncertainties and challenges related to expenses and energy process volatility, especially for energy-intensive consumers relying on costly sources, organisations recognise the importance of efficient energy utilisation in line with circular economy principles.
vi. To remain competitive on a global scale, businesses are actively seeking innovative production systems and circular supply chains that can deliver higher yields with fewer resources, thereby reducing emissions and energy usage.

Table 5.14 will present SLR Theme 5, based on D4R.

Table 5.14: SLR T5 - Design for recycling (Aluminium and steel)

Article Title	Journal	Citation	Country	Summary of findings
Potential global GHG emissions reduction from increased adoption of metals recycling	Resources, Conservation and Recycling	Gorman, Dzombak and Frischmann (2022: 1)	USA	Design for durability, design for recovery, design for disassembly and finally, design for recycling are vital enablers of end-of-life management and circular economy of metal packaging.
A Systematic Literature Review on Packaging Sustainability: Contents, Opportunities, and Guidelines	Sustainability (Switzerland)	Sastre, De Paula and Echeveste (2022: 25)	Global	A systematic literature review of 472 papers was performed over 30 years. The search for sustainable packaging solutions remains focused on new materials and technologies, coupled with analytical packaging performance verification methods. Although such projects are already being addressed systemically, adopting mathematical approaches coupled with applications on CE, SCM, and reverse logistics, these systemic approaches are complex and need to be simplified for general acceptance and use.
A Systematic Literature Review on Packaging Sustainability: Contents, Opportunities, and Guidelines	Sustainability (Switzerland)	Sastre, De Paula and Echeveste (2022: 25)	Global	Design for recycling models have not evolved adequately to address the rapidly rising sustainability challenges. The planning of packaging design must be robust to promote design for recycling, design for disassembly and design for durability.
Circularity in Practice: Review of Main Current Approaches and Strategic Propositions for an Efficient Circular Economy of Materials	Sustainability (Switzerland)	Megevand, Cao, Di Maio and Rem (2022: 15)	Global	Historically, the deposit return scheme (DRS) has demonstrated success for the following reasons: i. Incentivisation of the return of waste metal packaging; ii. Shortest path of waste metal packaging to recycling process; iii. Default waste segregation; iv. Pristine condition of waste metal packaging and v. Job creation.

				However, the DRS weaknesses are: i. Reliance on both the involvement of consumers and the initiative of companies; ii. it currently applies on small scales; iii. the system needs to be bespoke with respect to specific packaging types and iv. policy can only be applied at a local level, to avoid counter-productive logistic costs and emissions.
Potential global GHG emissions reduction from increased adoption of metals recycling	Resources, Conservation and Recycling	Gorman, Dzombak and Frischmann (2022: 1)	USA	Opportunities to address challenges of metal recovery and reuse lie in effective deployment of DRS, shown to be successful in improving end-of-life collection Also legislation pertaining to end-of-life management will drive circular economy of metal packaging.

Source: Researcher's own construction

Researcher's synthesis on SLR Theme 5 – Design for recycling

The following discussion is synthesised from the evaluation of the information in table 5.14.

i. Crucial for metal packaging's circular economy are design principles focused on durability, recovery, and disassembly.
ii. However, existing design for recycling models face challenges, necessitating robust planning to address sustainability effectively.
iii. The deposit return scheme (DRS) has historically succeeded in boosting metal packaging recovery through incentivising consumers and streamlining recycling processes.
iv. Challenges include reliance on consumer participation, limited scalability, customisation needs, and the requirement for local-level policy implementation.
v. Despite weaknesses, effectively deploying DRS offers opportunities to address metal recovery challenges, contributing to the circular economy through improved end-of-life collection and reuse.

Tables 5.15 to 5.17 will present SLR Theme 6, based on waste characterisation.

Table 5.15: SLR T6 - Waste characterisation (Aluminium)

Article Title	Journal	Citation	Country	Summary of findings
Automated Identification of Used Beverage Cans for Deposit Return using Deep Learning Methods	IEEE Conference on Technologies for Sustainability	Ploeger and Dasovic (2022: 165)	Canada	In this work, a can classification dataset was created on an electronic system that separates alcoholic used beverage cans from non-alcoholic used beverage cans and other aluminium. The dataset contains images of returnable and non-returnable cans. These mixed cans were collected through a deposit return scheme that offered incentives for the return of alcoholic beverage cans. Neural networks based on Mask R-CNN are then trained to classify can images as returnable or non-returnable. The system achieved extremely high accuracy and shows significant potential for practical implementation.

Source: Researcher's own construction

Table 5.16: SLR T16 - Waste characterisation (Steel)

Article Title	Journal	Citation	Country	Summary of findings
Scrap Metal Classification Using Magnetic Induction Spectroscopy and Machine Vision	IEE Transactions on Instrumentation and Measurement	Williams, O'Toole and Peyton (2023:1)	Europe	Magnetic Induction Spectroscopy (MIS) measures how a metal fragment scatters an excitation magnetic field over different frequencies. The study demonstrated, for the first time, the use of MIS with machine learning to classify non-ferrous scrap metals drawn from commercial waste streams.

Source: Researcher's own construction

Table 5.17: SLR T6 - Waste characterisation (Aluminium and steel)

Article Title	Journal	Citation	Country	Summary of findings
A historical-technical analysis of packaging waste flows in Vienna	Resources, Conservation & Recycling	Gritsch and Lederer (2023: 1)	Vienna	Urban waste management is crucial for supplying secondary raw materials for packaging waste recycling. A study on Vienna's packaging waste material flows from 2006 to 2020 revealed increasing separate collection rates for certain materials, such as plastic bottles and aluminium beverage packaging, achieved through commingled collection and expanded collection points. The sorting rate of metal packaging increased notably due to bottom ash sorting. To enhance secondary raw material provision, effective communication with consumers, improved technical sorting of mixed waste and bottom ash, and cautious testing of door-to-door collection methods for certain materials are recommended.
Electrodynamic Sorting of Industrial Scrap Metal	Kona Powder and Particle Journal	Nagel, Cohrs, Salgado and Rajamani (2020:258)	USA	Electro Dynamic Sorting (EDS) is a modern technology designed to sort scrap metals by using an electromagnet that is placed directly under the sorting conveyor belt. As the magnetic field varies due to varying eddy currents, the material on the conveyer is separated, enabling higher purity input material in the remelting process.
Reducing Volume to Increase Capacity—Measures to Reduce Transport Energy for Recyclable Waste Collection	Energies	Santos, Da Silva, Gouveia , Felgueiras and Caetano (2022:1)	Portugal	As a result of a rapidly growing human population, municipal waste is increasing globally. Typically, although a significant part of the waste is collected from households as a mixed stream, much of it is recyclable if properly separated. Therefore a separate@source (SAS) model of segregation and collection from the household is crucial because it minimises pollution and such efficient recycling will ensure higher recovery and recycling yields and purity.

Source: Researcher's own construction

Researcher’s synthesis on SLR Theme 6 – Waste characterisation

The following discussion is synthesised from the evaluation of the information in tables 5.15 to 5.17.

The project aims to create a dataset for classifying beverage cans into alcoholic and non-alcoholic categories, differentiating them from other aluminium items.

i. Collected through a deposit return scheme that encourages the return of alcoholic beverage cans, images of returnable and non-returnable cans are included in the dataset, using an electronic system for effective separation.
ii. Efficient urban waste management is crucial for providing secondary raw materials for packaging waste recycling.
iii. The study of Vienna's packaging waste flows from 2006 to 2020 reveals increased collection rates for materials like plastic bottles and aluminium beverage packaging, credited to commingled collection methods and expanded collection points.
iv. Notably, enhanced bottom ash sorting improves the sorting rate of metal packaging.
v. To further boost the supply of secondary raw materials, the study recommends effective consumer communication, improved technical sorting methods, and careful testing of door-to-door collection for specific materials.
vi. The global surge in municipal waste, driven by rapid population growth, necessitates implementing a Separation@Source (SAS) model for segregation and collection from households. This model minimises pollution, enhances recycling efficiency, leading to higher recovery rates, increased recycling yields, and improved material purity.

Tables 5.18 and 5.19 will present SLR Theme 7, based on waste to energy.

Table 5.18: SLR T7 - Waste to energy (Steel)

Article Title	Journal	Citation	Country	Summary of findings
Introduction of Steelmaking Process with Resource Recycling	Journal of Sustainable Metallurgy	Manabe, Miyata and Ohnuki (2019: 328)	Japan	The rubber and carbon from used tyres are burned in a rotary hearth reduction furnace and the resulting high calorie gasification is recovered at high temperature and used as fuel gas in the steelworks. Steel scrap does not need 'reduction' energy; therefore, it is efficient in terms of recycling steel resources whilst suppressing CO_2 gas emissions when melting large quantities of scrap.

Source: Researcher's own construction

Table 5.19: SLR T7 - Waste to energy (Aluminium and steel)

Article Title	Journal	Citation	Country	Summary of findings
An Innovative Approach of Recycling Aluminium Scrap for Ferrotitanium Production	Journal of the Institution of Engineers (India)	Janakiram, Jayasankar, Babu, Bhargava and Mukherjee (2020: 7)	India	The effectiveness and efficiency of household aluminium waste metal recycling depend significantly on the chosen recycling process. A non-traditional recycling approach utilises the exothermic heat from various aluminium sources (e.g., automobiles, appliances, windows, doors, and packaging) to produce a much sought after ferrotitanium alloy.
Evaluation of symbiotic waste resources ecosystem: a case study of Hunan Miluo Recycling Economy Industrial Park in China	Environment, Development and Sustainability	Xu, Su, Shao, Huang and Liu (2023: 1131)	China	In this paper, a multiple renewable resource recycling system is divided into 5 subsystems, namely, "management, marketisation, supply, recovery, resource". Such a multi-industry ecosystem must operate symbiotically for overall system efficiency. Inefficiency in any one of the subsystems will adversely impact on the rest of the system.
Development of an experimental test rig for the pyrolysis of plastic residues and waste tires	E3S Web of Conferences	Milani, Montorsi, Storchi, Venturelli, Pirola and Falletta (2021:1)	Italy	Pyrolysis of polymers such as end-of-life plastic and tyres yields oil that can be used as fuel to in furnaces that remelt end-of-life aluminium and steel products and packaging.
Viable Recycling of Polystyrene via Hydrothermal Liquefaction and Pyrolysis	Energies	Musivand, Bracciale, Damizia, De Filippis and De Caprariis (2023: 11)	Italy	Yields from pyrolysis of polystyrene is 45% gas and 55% oil at 500◦C. Pyrolysis is therefore a viable process to generate a highly calorific oil that can be used a fuel source in furnaces that remelt end-of-life aluminium and steel products and packaging.

Source: Researcher's own construction

Researcher's synthesis on SLR Theme 7 – Waste to energy

The following discussion is synthesised from the evaluation of the information in tables 5.18 and 5.19.

i. Various innovative approaches are being explored for efficient resource utilisation and reduced environmental impact. One such method involves burning rubber and carbon from used tyres in a rotary hearth reduction furnace, providing high-calorie gasification used as fuel in steelworks.
ii. Additionally, the resource-efficient nature of steel scrap, requiring no 'reduction' energy, contributes to a reduction in CO_2 emissions during large-scale melting.
iii. Another non-traditional approach employs the exothermic heat from diverse aluminium sources for ferro-titanium alloy production.
iv. The pyrolysis of polymers, including end-of-life plastics and tires, is highlighted for producing oil used as fuel in remelting end-of-life aluminium and steel.
v. Furthermore, polystyrene pyrolysis emerges as a viable process, yielding 45% gas and 55% oil at 500◦C, making it an attractive option for generating highly calorific oil as a fuel source in furnaces for remelting aluminium and steel products and packaging.

Table 5.20 will present SLR Theme 8, based on energy efficiency.

Table 5.20: SLR T8 - Energy efficiency (Aluminium)

Article Title	Journal	Citation	Country	Summary of findings
Separation of Aluminum from More Noble Elements in an Electrolysis Cell with Side-by-Side Geometry	Metallurgical and Materials Transactions B-Process Metallurgy and Materials Processing Science	Solheim, Kjos, Gudbrandsen and Skybakmoen (2021: 1550)	Norway	Aluminium production from scrap aluminium, comparable to virgin alloy composition, is achievable through the effective management of the electrolytic process, but such secondary aluminium is produced with significantly lower specific energy than primary aluminium.
Energy saving potentials of an efficient recycling process of different aluminium rejects	Energy Reports	Borgert and Homberg (2022: 399)	Germany	The friction induced recycling of industry waste aluminium chips provides an effective, energy and resource efficient solution for secondary use of aluminium.
Green Power Furnaces in Aluminum Cast House for Scrap Preheating Using CO_2-Flue Gas	Journal of Sustainable Metallurgy	Diop, Shi, Fafard, Bousso, Wenju Wang (2021:46)	UK	Fuel burners power aluminium holding furnaces to maintain the aluminium in a molten state, around 760 °C, before the casting process. Such holding furnaces release hot flue gas at temperatures close to the aluminium melting point, resulting in considerable energy loss. By re-routing the hot flue gases from the holding furnace to a metal scrap pre-heating furnace, where aluminium scrap is to be melted, one can efficiently pre-heat the material before loading it into the metal melting furnace. This introduction of a pre-heating step, utilising extremely hot flue gas, not only decreases the required melting time, but also contributes to energy conservation.
Energy resilient foundries: The "Small is beautiful" projects	Minerals, Metals and Materials Series	Jolly, Salonitis, Pagone, Papanikolaou and Saxena (2022: 748)	UK	The metal foundry industry is among the most energy intensive industries. Therefore great impact can be achieved by energy efficiency modelling. Industry 4.0 leads to the concept of Foundry 4.0 which adopts a “smart foundry” approach, exploiting advanced available technology.

				There are nine critical tools that form the basis of the smart foundries: i. Industrial Internet of Things (IIoT); ii. Additive manufacturing; iii. The cloud; iv. Cybersecurity; v. System Integration; vi. Augmented reality; vii. Autonomous robots; viii. Simulation and ix. Big data and analytics By integrating these nine tools, “traditional foundries” can be transformed to “smart foundries”.

Source: Researcher’s own construction

Researcher’s synthesis on SLR Theme 8 – Energy efficiency

The following discussion is synthesised from the evaluation of the information in table 5.20.

i. Efficient aluminium production from scrap, mirroring the virgin alloy composition, relies on well-managed electrolytic processes, yielding secondary aluminium with significantly lower specific energy than primary counterparts.
ii. The friction-induced recycling of industrial waste aluminium chips offers an energy and resource-efficient solution for secondary aluminium use.
iii. Aluminium holding furnaces, powered by fuel burners, release hot flue gas resulting in energy loss; redirecting this gas to pre-heat aluminium scrap in a separate furnace enhances efficiency and reduces melting time.
iv. Adopting Industry 4.0 principles as in Foundry 4.0, with tools like IIoT, additive manufacturing, and big data, can transform energy-intensive, traditional foundries into smart, energy-efficient entities.

Table 5.21 will present SLR Theme 9, based on circular economy.

Table 5.21: SLR T9 - Circular economy (Aluminium and steel)

Article Title	Journal	Citation	Country	Summary of findings
How Far Away Are World Economies from Circularity: Assessing the Capacity of Circular Economy Policy Packages in the Operation of Raw Materials and Industrial Wastes	Sustainability (Switzerland)	Ignatyeva, Yurak., Dushin, Strovsky, Zavyalov, Malyshev and Karimova (2021: 1)	Russia, European Union, South Korea, China and Greece	CERPP is defined as the capacity of Circular Economy Regulatory Policy Packages in managing finite raw materials usage and industrial waste. The dimensions of CERPP are: i. basic waste management ii. integrated waste management iii. 3R (reduce, recover, recycle) iv. CE The Degree Level of Capacity (DLC) that measures effectiveness of CERPP must be defined clearly within a country / economy.
Circularity in Practice: Review of Main Current Approaches and Strategic Propositions for an Efficient Circular Economy of Materials	Sustainability (Switzerland)	Megevand, Cao, Di Maio and Rem (2022: 15)	Global	Moving to a Circular Economy necessitates robust, clearly defined legislation and policies, coupled with key performance indicators: i. Recovery Rates ii. Yield Rates iii. % Recycled Content iv. Waste to Energy v. Life Cycle Assessment vi. Energy consumption Such guidelines will adopt standardised, objective, evaluation methods, avoiding greenwashing, which is fraudulent misrepresentation of CE data and information.
The circular economy implementation at the	Journal of Cleaner Production	De Pascale, Di Vita, Giannetto, Loppolo, Lanfranchi, Limosani and Szopik-	European Union	**This was an SLR based on 34 articles** This SLR concluded that the food and beverage, as well as the plastics industry in the UK, demonstrates the most effective CE models.

European Union level. Past, present and future		Depczyńska (2023: 1 - 15)		Through the lens of the European policy framework, CE implementation is a complex, political, and multi-dimensional process that provides a basis for sustainability investment decisions.
Industrial packaging and its impact on sustainability and circular economy: A systematic literature review	Journal of Cleaner Production	Silva and Palsson (2022:1)	Sweden	**This was an SLR based on 98 articles** Improve supply chain circularity by integrating industrial packaging, exploring possibilities like leasing and renting of industrial packaging. Minimise environmental impact of industrial packaging. Recycling and re-use are two distinct operations both supporting circular economy. Another approach to be explored is industrial symbiosis, where the residual waste of packaging is passed on as an input to another process. Design industrial packaging for recycling. Ensure regulatory compliance of industrial packaging

Source: Researcher's own construction

Researcher's synthesis on SLR Theme 9 – Circular economy

The following discussion is synthesised from the evaluation of the information in tables 5.21.

i. Transitioning to a Circular Economy demands clear and robust legislation and policies, accompanied by key performance indicators such as Recovery Rates, Yield Rates, % Recycled Content, Waste to Energy, Life Cycle Assessment, and energy consumption.
ii. The implementation of standardised, objective evaluation methods are crucial to prevent greenwashing, ensuring accurate representation of CE data.
iii. Enhancing supply chain circularity involves integrating industrial packaging, exploring leasing and renting options, and minimising the environmental impact through recycling, reuse, and industrial symbiosis.

iv. Designing industrial packaging with recycling in mind and ensuring regulatory compliance are essential steps towards achieving a sustainable CE.

Table 5.22 will present SLR Theme 10, based on DRS.

Table 5.22: SLR T10 - Deposit return schemes (Aluminium and steel)

Article Title	Source	Citation	Country	Summary of findings
Economic Viability of the Deposit Refund System for Beverage Packaging Waste – Identification of Economic Drivers and System Modelling	Journal of Sustainable Development of Energy, Water and Environment Systems	Schneider, Tomic and Raal (2021: 1)	Croatia	The deposit refund system, functioning as an extension of the producer responsibility principle, can be viewed as a carefully devised market-based tool for tackling externalities. Simultaneously, the deposit's flexibility and economic incentives play a crucial role in efficiently addressing environmental pollution challenges that are challenging to regulate, including issues like illegal waste disposal, which were prevalent in Croatia before the introduction of the Deposit Refund Scheme (DRS) in 2006. The success of collecting packaging within the deposit system can be attributed more to the presence of the deposit itself rather than the material value of the packaging.
Optimising Recycling Policy in the UK: The UK's Deposit Return Scheme. Cambridge	Journal of Science & Policy	Kükenthal, Mitchell, Mounzer and Rtabi (2021: 1)	UK	Deposit return schemes (DRS) serve the purpose of enhancing the collection rates of beverage containers to mitigate their environmental impact caused by littering. Defra plans to introduce a DRS covering England, Wales, and Northern Ireland in 2025, while Scotland will independently implement its scheme in August 2023. The study conducted revealed a significant negative correlation between the deposit value and the willingness to pay (WTP) for all materials. Various socio-demographic and attitudinal factors, including age, income, and the weekly quantity of purchased bottles, also influenced WTP for specific materials. Taking these factors into account, the research estimated the anticipated WTP to be £0.17,

				£0.19, and £0.19 for glass, plastic, and cans, respectively, with upper confidence bounds of £0.21, £0.25, and £0.25. The study identified key barriers to DRS adoption, such as limited space in households for container storage and scepticism towards the overall recycling system. To ensure effective operation and adherence to the precautionary principle, the study recommends that the deposit management organisation should implement a flexible deposit value exceeding £0.21 for glass bottles, £0.25 for plastic bottles, and £0.25 for cans. Additionally, public campaigns promoting recycling effectiveness and the distribution of leaflets suggesting space-efficient storage approaches were suggested to address the identified barriers to DRS uptake. It is important to note that the study has limitations, including the ambiguous nature of the dichotomous question, design and sample bias, with an over-representation of English and environmentally conscious , which may limit the generalisability of the findings.
Deposit-Refund System (DRS) Facts & Myths. Deloitte	Deloitte	Patorska and Paca (2019: 3)	European Union	A regulated deposit-refund system operates in 10 European countries, covering 26% of the population, and other countries are considering its introduction due to strict legal requirements for packaging waste recycling. The average collection and recycling rate for packaging waste under the deposit-refund system in European countries is about 91%, but in Poland, it would only account for approximately 6% of total municipal waste. The extended producer responsibility (EPR) system is recommended as the primary approach to increase the recycling rate. The arrangement, cost, and functionality of a deposit-refund system are interconnected and can be capital-intensive. Automation is highlighted as a way to improve efficiency, but it requires significant investment. Equal treatment for all participants, including trade entities and product launchers, is crucial for a successful deposit-refund system. Failure to ensure fairness may lead to negative changes, such as alterations in packaging structure.

				Proposing an effective deposit-refund system is a complex, long-term process. Developing appropriate consumer attitudes is vital for implementation success. No perfect solution has been developed or replicated globally, and individual tailoring is necessary for each country. Before introducing a deposit-refund system, an extensive information-educational campaign on selective waste collection, especially for challenging-to-sort household waste, is necessary. Higher costs for the industry, resulting from tools like the deposit-refund system or extended producer responsibility (EPR), may lead to increased food and beverage prices. However, these costs are considered unavoidable, as producers are responsible for the packaging they launch.
Deposit - Return Schemes. Data and figures from 16 member countries of the EPA Network	European Network of the Heads of Environment Protection Agencies (EPA Network) - Interest group on Plastics – Working paper –	(Maier 2018: 22)	Global	Deposit refund systems (DRS) for are predominantly in place, exhibiting a variety of exceptions that may not always appear logical. Deposit rates often differ for various packaging types, and return rates generally range from 80% to close to 100%. Multi-use systems slightly outnumber single-use systems, and the establishment of some DRS dates back long ago, while others are relatively new. The introduction of DRS, in most instances, resulted from regulatory measures, and the majority of these systems are industry-managed. Return points are predominantly located in supermarkets, and DRS operations are typically nationwide. The primary outcomes include elevated recycling rates and reduced littering. Slightly more than half of the cases involve DRS combined with an environmental tax. The main obstacles to DRS implementation are high costs and inadequate infrastructure in slightly over half of the cases.

Source: Researcher's own construction

Researcher's synthesis on SLR Theme 10 – DRS

The following discussion is synthesised from the evaluation of the information in table 5.22.

i. The deposit refund scheme (DRS), an extension of the producer responsibility principle, addresses environmental externalities through economic incentives and flexibility.
ii. Barriers to DRS adoption include limited household space and scepticism toward recycling, with recommendations for flexible deposit values and public campaigns.
iii. Regulated deposit-refund systems in 10 European countries cover 26% of the population, with varying success rates. DRS, a complex, long-term process, requires tailored solutions and extensive information-educational campaigns.
iv. Implemented worldwide, DRS shows variations in deposit rates, return rates, and management structures, primarily in supermarkets, leading to increased recycling rates and reduced littering.

Tables 5.23 to 5.25 will present SLR Theme 11, based on carbon reduction.

Table 5.23: SLR T11 - Carbon reduction (Aluminium)

Article Title	Journal	Citation	Country	Summary of findings
Technologies for CO_2 emission reduction and low-carbon development in primary aluminium industry in China: A review	Renewable and Sustainable Energy Reviews	Shen and Zhang (2023: 3)	China	China's primary aluminium industry accounts for 57 % of the total global production. However, the proportion of secondary aluminium production was less than 20 % of global production. The focus of China's primary aluminium industry should be on cost-effective technology improvement in the short term, on power decarbonization and secondary aluminium production in the medium term, and on technologies with a higher cost but lower emission reduction in the long term.

Source: Researcher's own construction

Table 5.24: SLR T11 - Carbon reduction (Steel)

Article Title	Journal	Citation	Country	Summary of findings
Mapping the global flows of steel scraps: an alloy elements recovery perspective	Environmental Research Letters	Cai, Geng, Gao and Wei (2023: 10)	Global	Through the global lens, scrap steel trade and recycling are significant contributors to the decarbonization efforts of the international steel industry and simultaneously address resource shortages in some countries. It is critical to advocate the general resource efficiency of steel scrap and the recovery of embedded alloy elements that are regarded as rare minerals.

Source: Researcher's own construction

Table 5.25: SLR T11 - Carbon reduction (Aluminium and steel)

Article Title	Journal	Citation	Country	Summary of findings
Steel, Aluminium, and FRP-Composites: The Race to Zero Carbon Emissions	Energies	Rajulwar, Shyrokykh, Stirling, Jarnerud, Korobeinikov, Bose, Bhattacharya, Bhattacharjee and Sridhar (2023: 1)	USA	As carbon taxes are implemented globally, it is expected that the competitiveness of steel products will shift, based upon the individual manufacturers' potential to minimise its CO_2 emission footprint, as informed by cradle-to-gate LCA.

Source: Researcher's own construction

Researcher's synthesis on SLR Theme 11 – Carbon reduction

The following discussion is synthesised from the evaluation of the information in tables 5.23 to 5.25.

i. China's primary aluminium industry accounts for 57% of global production, while secondary aluminium production comprises less than 20%. In the short term, the industry's focus is on cost-effective technology improvement.
ii. The medium-term goal involves power decarbonisation and an increase in secondary aluminium production. Long-term aspirations target technologies with higher costs but lower emission reduction.
iii. Globally, scrap steel trade and recycling play a pivotal role in the international steel industry's decarbonisation efforts.
iv. The trade addresses resource shortages in some countries, emphasising the importance of advocating for the general resource efficiency of steel scrap and the recovery of embedded alloy elements, considered rare minerals.
v. The anticipated implementation of global carbon taxes is set to shift the competitiveness of steel products based on manufacturers' ability to minimise CO_2 emissions, guided by cradle-to-gate life cycle assessments (LCA).

Tables 5.26 and 5.27 will present SLR Theme 12, based on material processing.

Table 5.26: SLR T12 - Material processing (steel)

Article Title	Journal	Citation	Country	Summary of findings
How will tramp elements affect future steel recycling in Europe? – A dynamic material flow model for steel in the EU-28 for the period 1910 to 2050	Resources, Conservation & Recycling	Dworak, Rechberger and Fellner (2022:1)	Europe	Steel scrap will be of low purity (undesirable embedded alloys > 0.25%), unless active embedded alloy sorting measures are enforced. Scrap steel quality, related to embedded alloys, must be effectively controlled at recycling plants to enable higher steel production quality, where a higher percentage scrap steel inclusion is expected.

Source: Researcher's own construction

Table 5.27: SLR T12 - Material processing (Aluminium and steel)

Article Title	Journal	Citation	Country	Summary of findings
Greener reactants, renewable energies and environmental impact mitigation strategies in pyrometallurgical processes: A review	MRS Energy & Sustainability	Harvey, Courchesne, Oishi., Robelin, Mahue, Leclerc and Al-Haiek (2022: 238)	Global	The pyrometallurgical industry must evolve to reduce its environmental impact, whilst sustaining elevated productivity. Greener process reactants such as biofuel, biochar, hydrogen and ammonia, as well as recycled input material, will reduce CO_2 emissions because of the replacement of carbon-based reactants, Additionally, the energy requirement associated with recycling will be minimised.
A Three-Dimensional Comprehensive Numerical Model of Ion Transport during Electro-Refining Process for Scrap-Metal Recycling	Materials	Liu, Li, Zhang, Wang and Wang (2022: 1)	China	Poisson–Nernst–Planck equations were used to understand ion movement in the electrolytic recovery process of waste metals. The management of the ion concentration and ion migration rates within the electrolyte is critical for efficient metal recovery.

Source: Researcher's own construction

Researcher's synthesis on SLR Theme 12 – Material processing

The following discussion is synthesised from the evaluation of the information in tables 5.26 and 5.27.

i. Ensuring the purity of steel scrap with undesirable embedded alloys (> 0.25%) is a concern, unless active sorting measures are enforced.

ii. Effective control of scrap steel quality, particularly concerning embedded alloys, is crucial at recycling plants for higher steel production quality.

iii. The pyrometallurgical industry needs to evolve for a reduced environmental impact while maintaining high productivity. Introducing greener process reactants like biofuel, biochar, hydrogen, and ammonia, along with recycled input materials, can lower CO_2 emissions by replacing carbon-based reactants, simultaneously minimising energy requirements associated with recycling.

iv. Employing Poisson–Nernst–Planck equations aids in understanding ion movement in the electrolytic recovery process of waste metals.

v. Efficient metal recovery requires critical management of ion concentration and ion migration rates within the electrolyte.

Table 5.28 will present SLR Theme 13, based on TBL.

Table 5.28: SLR T13 - Triple bottom line - Aluminium and steel

Article Title	Source	Citation	Country	Summary of findings
Sustainability: An Overview of the Triple Bottom Line and Sustainability Implementation.	International Journal of Strategic Engineering	Correia (2019: 29)	UK	Consumers demonstrate a preference for sustainability, and a noteworthy interaction exists between corporate sustainability efforts and consumer support for sustainability, underscoring the necessity for increased corporate social responsibility.
Circular supply chains in emerging economies – a comparative study of packaging recovery ecosystems in China and Brazil.	International Journal of Production Research	Batisita *et al.* (2019: 7248)	China and Brazil	The triple bottom line philosophy underpins the circular economy model needed for sustainable development.
Cannibals with forks: The triple bottom line of 21st century business	Cannibals with forks: The triple bottom line of 21st century business	Elkington (1997: 116)	UK	Introduced the idea of the triple bottom line in 1997, which became the mainstream concept driving sustainable development practices.

Source: Researcher's own construction

Researcher's synthesis on SLR Theme 13 – TBL

The following discussion is synthesised from the evaluation of the information in table 5.28.

i. Consumers prioritise sustainability, creating an interaction effect between corporate sustainability and consumer support.
ii. Recognising the growing importance of consumer preferences, greater corporate social responsibility is considered a necessity.
iii. The circular economy model for sustainable development is underpinned by the triple bottom line philosophy. Introduced in 1997, the concept of the triple bottom line has since become a mainstream driving force for sustainable development practices.

Table 5.29 will present SLR Theme 14 (Aluminium and steel), based on barriers and challenges to sustainability.

Table 5.29: SLR T14 - Barriers and challenges to sustainability

Article Title	Source	Citation	Country	Summary of findings
Organisational barriers to the sustainable manufacturing system: A literature review.	Environmental Challenges	Hariyani, Mishra, Sharma and Hariyani (2022: 3)	India	Identification and prioritisation of industry-specific barriers affecting the successful implementation of sustainable manufacturing. i. Development of facilitators and novel technologies incorporating the 6Rs to promote the effective adoption of sustainable manufacturing. ii. Formulation of a policy framework aimed at overcoming obstacles to sustainable manufacturing. iii. Examination of benchmarking practices related to the development of sustainable manufacturing. iv. Establishment of generic practices fostering sustainable manufacturing. v. Investigation and ranking of the interplay of barriers on diverse performance outcomes in sustainable manufacturing.

				vi. Assessment of the impact of individual barriers on organisational social, environmental, market, ecological, financial, and economic performance using structural equation modelling. vii. Analysis of the individual and combined effects of facilitators in overcoming barriers. viii. Examination of the individual and combined effects of facilitators on various performance outcomes specific to the manufacturing unit within the sector. ix. Investigation into the impact of barriers on business supply chain practices and market image.
What are the sustainability benefits, challenges and limitations of metal packaging?.	Packaging Europe	Butler (2023: 1)	Global	Though steel and aluminium have been historically seen as emissions intensive industries there has been significant progress in this area. The challenge for the industry is now to explore low and carbon-neutral solutions that can lead to a carbon-neutral future under an optimum regulatory framework. Aluminium post-consumer regrind (PCR) (up to 100%) and green aluminium are now available options and more steel suppliers are now offering low-carbon steel based on a mass balance approach. This must be sustained into the future. Metal down-gauging remains a challenge as process management becomes more critical, meeting customer and regulatory targets becomes more difficult.
Sustainability of reusable packaging–Current situation and trend.	Resources, Conservation and Recycling	(Coelho, Corona, ten Klooster and Worrell 2020: 1)	UK	The primary challenge faced by converters and brand owners lies in the heightened logistical intricacies, necessitating a restructuring of supply chains. This restructuring aims to ensure the availability and efficient return of packaging through improved management of distribution, returns, brand recognition, loyalty, and inventory.

				For business-to-business systems dealing with reusable packaging such as crates and pallets, the sluggish rates of return and turnover pose significant obstacles for many companies. Implementing deposit and refund systems becomes crucial to incentivise customers to return packaging in good condition and within the stipulated timeframe. On a global scale, the customs handling of empty refillable containers has proven to be problematic, leading to unnecessary handling costs and delays in supply chains. Additionally, the substantial upfront investments required for a new reusable packaging system serve as a deterrent for producers. While the design of a reusable packaging system is acknowledged as pivotal for its success, few studies have delved into evaluating the design and impacts of policies specifically aimed at introducing or enhancing the role of reusable packaging systems.

Source: Researcher's own construction

Researcher's synthesis on SLR Theme 14 – Barriers and challenges to sustainability

The following discussion is synthesised from the evaluation of the information in table 5.29.

i. Consumers prioritise sustainability, creating an interaction effect between corporate sustainability and consumer support.
ii. Recognising the growing importance of consumer preferences, greater corporate social responsibility is considered a necessity.
iii. The circular economy model for sustainable development is underpinned by the triple bottom line philosophy. Introduced in 1997, the concept of the triple bottom line has since become a mainstream driving force for sustainable development practices.

Tables 5.30 and 5.31 will present SLR Theme 15, based on GHG emissions.

Table 5.30: SLR T15 - Greenhouse gas emissions (Aluminium)

Article Title	Journal	Citation	Country	Summary of findings
Impact of rolling processes in the production of aluminium packaging assessed through LCA	The International Journal of Life Cycle Assessment	Astarita De Luca and Sinagra (2023: 1756)	Italy	The aluminium beverage can industry has invested great effort into measuring the adverse environmental impact of used beverage cans through Life Cycle Assessment. The energy consumption during primary aluminium manufacturing was identified as the main contributor to the emissions of greenhouse gases (GHG). Therefore, the use of recycled aluminium is recommended to reduce both the emissions of greenhouse gases (GHG) and the dependence on primary aluminium, in alignment sustainable development.

Source: Researcher's own construction

Table 5.31: SLR T15 - Greenhouse gas emissions (Aluminium and steel)

Article Title	Journal	Citation	Country	Summary of findings
Potential global GHG emissions reduction from increased adoption of metals recycling	Resources, Conservation and Recycling	Gorman, Dzombak and Frischmann (2022: 1)	USA	The primary production of metals has been advancing, accompanied by a consistent decrease in ore grades. This trend leads to increased energy demands for extracting and processing larger volumes of ore containing lower metal concentrations. In contrast, secondary production from recycled materials entails lower energy requirements compared to primary production, contributing to a reduced greenhouse gas footprint.

Source: Researcher's own construction

Researcher's synthesis on SLR Theme 15 – Greenhouse gas emissions

The following discussion is synthesised from the evaluation of the information in tables 5.30 and 5.31.

i. The Aluminium Beverage Can Industry is under scrutiny for its environmental impact, focusing on Life Cycle Assessment (LCA). Greenhouse gas emissions in primary aluminium manufacturing are primarily due to energy consumption.
ii. To mitigate this, the recommendation is to increase the use of recycled aluminium.
iii. Secondary production from recycled materials emerges as a more sustainable alternative, requiring less energy and reducing the greenhouse gas footprint in metal production.

Table 5.32 will present SLR Theme 16, based on re-melting.

Table 5.32: SLR T16 - Re-melting (Steel)

Article Title	Journal	Citation	Country	Summary of findings
Appraising the value of compositional information and its implications to scrap-based production of steel	Mineral Economics	Companero, Feldmann and Tilliander (2021: 477)	Global	The creation of recipes, or blends of input materials that must be introduced to the furnace, will depend on partial or full knowledge of material quality and this is a decision that will impact on scrap steel versus virgin steel usage in recycling.
Appraising the value of compositional information and its implications to scrap-based production of steel	Mineral Economics	Companero, Feldmann and Tilliander (2021: 477)	Global	There is a need for a greater focus on the scrap steel characterisation and sorting processes and infrastructure.

Source: Researcher's own construction

Researcher's synthesis on SLR Theme 16 – Re-melting

The following discussion is synthesised from the evaluation of the information in table 5.32.

i. The development of recipes or blends for furnace input relies on partial or full knowledge of material quality, significantly impacting the usage of scrap steel versus virgin steel in recycling processes.
ii. Emphasising the improvement of scrap steel characterisation processes is crucial.

Table 5.33 will present SLR Theme 17 based on supply chain circularity.

Table 5.33: SLR T17 - Supply chain circularity (Aluminium and steel)

Article Title	Journal	Citation	Country	Summary of findings
Introducing an application of an industry 4.0 solution for circular supply chain management	Journal of Cleaner Production	Mastos, Nizamis, Terzi, Gkortzis, Papadopoulos, Tsagkalidis, Ioannidis, Votis and Tzovaras (2021: 8)	Greece	Circular economy models and solutions assisted by industry 4.0 technologies have been developed to transform products in the end of their life cycle into new products with different use. The adoption of the ReSOLVE model supports circular supply chains: vii. **Re**generate – shift to renewable energy viii. **S**hare – shared utilisation of products and extending life cycle ix. **O**ptimise -increase performance efficiency x. **L**oop – keep components and materials in closed systems xi. **V**irtualise – non-physical value add by electronic systems xii. **E**xchange – replacing old materials with advanced non-renewable products and services
Circular economy practices in third world nations: challenges and implications for environmental sustainability	Environment, Development and Sustainability	Ofori, (2023:53)	Ghana	There is no clear legislation around material recovery and re-use and therefore the circularity of local supply chains are not being driven

				Not enough governmental focus exists with respect to managing waste. As a result, waste is poorly managed at source compounding the challenges of environmental sustainability across all stakeholders.

Source: Researcher's own construction

Researcher's synthesis on SLR Theme 17 – Supply chain circularity

The following discussion is synthesised from the evaluation of the information in table 5.33.

i. Lack of clear legislation around material recovery and re-use hinders the circularity of local supply chains.
ii. Governmental focus on waste management is insufficient, compounding challenges of environmental sustainability for all stakeholders.

Table 5.34 will present SLR Theme 18, based on waste hierarchy.

Table 5.34: SLR T18 - Waste hierarchy (Aluminium and steel)

Article Title	Journal	Citation	Country	Summary of findings
The waste hierarchy: A strategic, tactical and operational approach for developing countries. the case study of Mozambique	International Journal of Sustainable Development and Planning	Ferrari, Gamberini and Rimini (2016: 761)	Mozambique	Each country must tailor its waste management strategy to its specific local conditions, considering cultural, socio-economic, and environmental factors. In the case of Mozambique, a developing country, managing increasing waste quantities with limited resources and minimal experience poses a significant challenge. The country often resorts to landfilling due to the abundance of available space and the relatively low associated costs. Reusing, viewed as a preventive measure to be

				implemented before materials become waste, is primarily carried out informally. The informal sector plays a crucial role in recycling and reuse without receiving financial support or incentives from policymakers. Although policymakers acknowledge the valuable contribution of informal waste pickers, they do not provide the necessary financial support for their activities. The most urgent challenge in Mozambique is to create greater awareness among the population of the risk posed by a deficient waste management system, to increase the quantity collected and sorted to be reused, recycled or even recovered and, finally, disposed of in a controlled space. Additional research efforts are focused on gathering and analysing data to substantiate the waste hierarchy proposed through a Life Cycle Assessment (LCA) study. The objective is to identify technological or practical options that, in the context of Mozambique's everyday life, can yield the most favourable overall impacts on the environment, human health, economy, and social aspects.
Waste-to-energy is compatible and complementary with recycling in the circular economy.	Clean Technologies and Environmental Policy	(Van Caneghem, Van Acker, De Greef, Wauters and Vandecasteele 2019: 925)	European Union	Conventional waste-to-energy, involving the incineration of non-recyclable municipal solid waste for energy recovery, plays a crucial role in the circular economy. Despite its lower position in the waste hierarchy compared to recycling, it serves as a vital and complementary aspect of overall sustainability. Waste-to-energy specifically targets non-recyclable waste, aligning with recycling efforts and competing primarily with landfill. Moreover, it helps maintain material cycles, safeguarding the environment by minimising exposure to toxic substances. Additionally, waste-to-energy facilitates the recovery of both energy and materials from non-recyclable waste, contributing to the continuous circulation of materials in the circular economy.

Source: Researcher's own construction

Researcher's synthesis on SLR Theme 18 – Waste hierarchy

The following discussion is synthesised from the evaluation of the information in table 5.34.

i. Conventional waste-to-energy, involving incineration for energy recovery, plays a crucial role in the circular economy.
ii. While lower in the waste hierarchy than recycling, it complements sustainability efforts, targeting non-recyclable waste and competing with landfill.
iii. This approach maintains material cycles, minimising exposure to toxic substances and facilitating energy and material recovery from non-recyclable waste, contributing to continuous material circulation in the circular economy.

Table 5.35 will present SLR Theme 19 (Aluminium and steel), based on EMS.

Table 5.35: SLR T19 - ISO14001:2015 Environmental Management System

Article Title	Journal	Citation	Country	Summary of findings
Environmental Management System ISO 14001 factors for promoting the adoption of cleaner production practices.	Journal of Cleaner Production	(Oliveira, Oliveira, Ometto, Ferraudo, and Salgado 2016: 1384).	Brazil	ISO14001:2015 proactively supports circular economies and sustainable development.
Comparing symbolic and substantive implementation of international standards – the case of ISO 14001 certification	Australasian Journal of Environmental Management	Chowdhury, Prajogo, and Jayaram (2018: 340)	Australia and New Zealand	Top management commitment is considered as a key driver of an organisation's strategic programs and initiatives. Symbolic ISO 14001 Implementation A symbolic approach to ISO 14001 leads mainly to environmental benefits, with limited impact on economic and market performance. This method, often a response to external pressures, allows organisations to showcase environmental progress but may lack substantial improvements. Consequently,

				organisations may miss out on essential economic and market advantages crucial for long term success. Substantive ISO 14001 Implementation A substantive ISO 14001 implementation yields positive outcomes across environmental, economic, and market performance. In contrast to symbolic implementation, the substantive approach involves genuine efforts to improve environmental practices, recognising the tangible benefits and enduring value of ISO 14001:2015. Substantive implementation outperforms symbolic implementation even in achieving environmental benefits.

Source: Researcher's own construction

Researcher's synthesis on SLR Theme 19 – ISO14001:2015 Environmental Management System (EMS)

The following discussion is synthesised from the evaluation of the information in table 5.35.

i. The distinction between symbolic and substantive ISO 14001 implementations is crucial for understanding the potential impact on overall organisational performance.
ii. While symbolic implementation may serve as a short-term response to external pressures, substantive implementation aligns with long-term goals and values, contributing to sustained success.
iii. Organisations should recognise the comprehensive benefits of ISO 14001, not limiting its implementation to mere symbolism. Emphasising both environmental and economic aspects in ISO 14001 implementation aligns with the principles of sustainable development and circular economies.

Table 5.36 will present SLR Theme 20, based on sustainable development matrices.

Table 5.36: SLR T20 - Sustainable development matrices (Aluminium and steel)

Article Title	Journal	Citation	Country	Summary of findings
Completing the picture. How the circular economy tackles climate change.	Material economics	Gueye and Jeffries (2021: 29)	Global	These are a few suggested matrices for measuring sustainable development success: i. Resource Efficiency: Metric: Resource productivity Measurement: Gross Domestic Product (GDP) per unit of resource consumed (e.g., GDP per ton of material used) ii. Closed-Loop Systems: Metric: Percentage of products designed for circularity Measurement: Ratio of products designed for reuse, recycling, or refurbishment to total product output iii. Waste Reduction: Metric: Total waste generated Measurement: Reduction in the volume or weight of waste produced compared to a baseline period iv. Extended Product Lifespan: Metric: Average product lifespan Measurement: Duration a product remains in use before disposal or recycling v. Recycling Rates: Metric: Recycling rate by material type Measurement: Percentage of materials recycled compared to the total materials used vi. Eco-Design Adoption: Metric: Percentage of products incorporating eco-design principles Measurement: Ratio of products designed with environmental considerations to total new product designs

				Circular Business Models: Metric: Revenue from circular business models vii. Measurement: Percentage of total revenue generated through circular models like product-as-a-service or leasing Carbon Footprint Reduction: Metric: Carbon intensity Measurement: Reduction in greenhouse gas emissions per unit of economic output viii. Consumer Awareness and Engagement: Metric: Consumer surveys and awareness campaigns Measurement: Percentage increase in consumer understanding and adoption of circular economy principles ix. Policy and Regulatory Support: Metric: Number of supportive policies enacted Measurement: Count of regulations and policies at different levels of government supporting circular economy practices

Source: Researcher's own construction

Researcher's synthesis on SLR Theme 20 – SD matrices

The following discussion is synthesised from the evaluation of the information in table 5.36.

i. A combination of these metrics provides a holistic view of sustainable development success.
ii. Interconnectedness between resource efficiency, closed-loop systems, waste reduction, and other metrics ensure a comprehensive approach to achieving circular economy goals.
iii. Continuous monitoring and improvement based on these metrics can drive ongoing commitment to sustainable development practices at various levels - individual, organisational, and governmental.

Table 5.37 will present SLR Theme 21, based on health and safety.

Table 5.37: SLR T21 - Health and safety (Aluminium and steel)

Article Title	Journal	Citation	Country	Summary of findings
Collection, Thermal Treatment, and Remelting End-of-Life Al Packaging in Norway	Journal of Materials	Bao, Eggen, Syvertsen and Kvithyld (2023: 5756)	Norway	Aerosol cans are dangerous during re-melting, because of residual content in the can, such as pesticides and chemical perfumes, coupled with pressurised propellants which increases the risk of explosion. Aerosol cans must be collected separately, and valves must be detached before re-melting.

Source: Researcher's own construction

Researcher's synthesis on SLR Theme 21 – Health and Safety

The following discussion is synthesised from the evaluation of the information in table 5.37.

i. Aerosol cans pose dangers during re-melting due to residual content like pesticides and chemical perfumes, along with pressurised propellants.
ii. To mitigate explosive risks, aerosol cans should be collected separately, and valves must be detached before the re-melting process.

Table 5.38 will present SLR Theme 22, based on LCA.

Table 5.38: SLR T22 - Life Cycle Analysis (Aluminium)

Article Title	Journal	Citation	Country	Summary of findings
Life cycle thinking: towards the sustainable management of resources in aluminium production	Euro-Mediterranean Journal for Environmental Integration	Achillas, Vlachokostas and Koroneos (2020:1)	Greece	Life Cycle Assessment enables greater circularity of primary aluminium through a comprehensive understanding of material paths, recovery and re-use. LCA of aluminium is a not “cradle-to-grave” approach, but rather “cradle-to-cradle” approach.

Source: Researcher’s own construction

Researcher’s synthesis on SLR Theme 22 – LCA

The following discussion is synthesised from the evaluation of the information in table 5.38.

i. Life Cycle Assessment (LCA) facilitates increased circularity of primary aluminium by providing a comprehensive understanding of material paths, recovery, and re-use.
ii. The LCA approach for aluminium is not "cradle-to-grave" but rather a "cradle-to-cradle" perspective, emphasising sustainable and cyclical material management throughout its life cycle.

Table 5.39 will present SLR Theme 23, based on material reduction.

Table 5.39: SLR T23 Material reduction - Aluminium

Article Title	Journal	Citation	Country	Summary of findings
Collection, Thermal Treatment, and Remelting End-of-Life Al Packaging in Norway	Journal of Materials	Bao, Eggen, Syvertsen and Kvithyld (2023: 5756)	Norway	Aluminium material losses during re-melting is a direct function of the thickness of metal packaging. The thinner the metal packaging, the higher the loss at re-melting, in particular, for gauge thickness under 2 mm.

Source: Researcher's own construction

Researcher's synthesis on SLR Theme 23 – Material reduction

The following discussion is synthesised from the evaluation of the information in table 5.39.

i. Aluminium material losses during re-melting are directly influenced by the thickness of metal packaging.
ii. Thinner metal packaging, especially with a gauge thickness under 2 mm, leads to higher losses during the re-melting process.

Table 5.40 will present SLR Theme 24, based on re-purposed packaging.

Table 5.40: SLR T24 - Re-purposed packaging (Aluminium)

Article Title	Journal	Citation	Country	Summary of findings
Passive Daytime Cooling Foils for Everyone: A Scalable Lamination Process Based on Upcycling Aluminum-Coated Chips Bags	ACS Sustainable Chemistry and Engineering	Song and Retsch (2023: 10 637)	USA	Metallised, biaxially orientated polypropylene is predominant as packaging for the snacks and crisps products. By coupling the metallised, biaxially orientated polypropylene and a laminated pouch foil, an effective but simple and low-cost passive daytime cooling device is obtained, which exhibits satisfactory optical properties and, consequently, daytime cooling performance, achieving secondary use and diverting from landfill.

Source: Researcher's own construction

Researcher's synthesis on SLR Theme 24 – Re-purposed packaging

The following discussion is synthesised from the evaluation of the information in table 5.40.

i. Metallised, biaxially oriented polypropylene is widely used for packaging snacks and crisps.
ii. Combining this material with a laminated pouch foil creates a simple, low-cost, and effective passive daytime cooling device.
iii. This cooling device, with satisfactory optical properties, achieves effective daytime cooling, providing a secondary use and diverting the materials from landfill.

Table 5.41 will present SLR Theme 25, based on demand pattern.

Table 5.41: SLR T25 - Demand pattern (Steel)

Article Title	Journal	Citation	Country	Summary of findings
Material Flow Analysis with Multiple Material Characteristics to Assess the Potential for Flat Steel Prompt Scrap Prevention and Diversion without Remelting	Environmental Science and Technology	Flint, Cabrera Serrenho, Lupton., and Allwood (2020: 2459)	European Union	Changes in the demand for specific steel grades, coupled with the progress in engineering and manufacturing technology, dictate the evolution of manufacturing practices. As a result, the demand for material grades is also likely to evolve. As a result, the potential for redirecting steel scrap will rely on the evolving demand patterns for various grades and quantities of steel products, as time progresses.

Source: Researcher's own construction

Researcher's synthesis on SLR Theme 25 – Demand pattern

The following discussion is synthesised from the evaluation of the information in table 5.41.

i. Alterations in the demand for specific steel grades, alongside advancements in engineering and manufacturing technology, shape the transformation of manufacturing practices. Consequently, the demand for material grades is expected to undergo changes.
ii. The prospect of redirecting steel scrap will hinge on the evolving demand patterns for different grades and quantities of steel products as time advances.

Table 5.42 will present SLR Theme 25, based on training and education.

Table 5.42: SLR T26 - Training and education (Steel)

Article Title	Journal	Citation	Country	Summary of findings
Circular Economy of Steel Recycling Companies in Thailand	Circular Economy and Sustainability	Taghipour and Akkalatham (2021:909)	Thailand	Metal industry training and education for all stakeholders within the value chain will create a stronger appreciation for steel and other metals, and their applications, ensuring higher recovery and re-use rates.

Source: Researcher's own construction

Researcher's synthesis on SLR Theme 26 – Training and education

The following discussion is synthesised from the evaluation of the information in table 5.42.

i. Training and educating all stakeholders in the metal industry value chain will foster a greater understanding of steel and other metals, enhancing appreciation for their applications.
ii. This, in turn, is expected to contribute to higher rates of recovery and re-use.

The preceding tables reflected the content derived through the SLR, grouped into 26 themes, revolving around metal packaging sustainable development.

The following section will consolidate the 26 themes, in alignment with the five research questions, to produce five main themes.

5.4 Reconciliation of 26 SLR Themes (SLR T) with the five research questions.

The SLR yielded a comprehensive compilation of 26 distinct metal packaging sustainable development themes. In the subsequent section, a detailed examination was conducted to align and allocate these identified SLR themes to the five research questions. This process used NVivo, version 12, to create project maps that clearly depicted the 26 SLR themes as five main themes and sixteen subthemes, directly relevant to and reflective of the underlying research questions.

The following discussion will now focus on the researcher's synthesis of the SLR, allocating the SLR themes to the five primary research questions, for alignment. The project maps that follow will indicate the relationship between the research questions and the SLR Themes (SLR T) that underpin each question. The 26 SLR themes are reflected on the project maps, as SLR T1 to SLR T26.

5.5 Theme 01: Global best practice.

Research question 1: ***What are the global best practices related to post-consumer metal packaging recovery?***

Figure 5.8 is a project map that depicts the SLR themes and subthemes that underpin the research question 1.

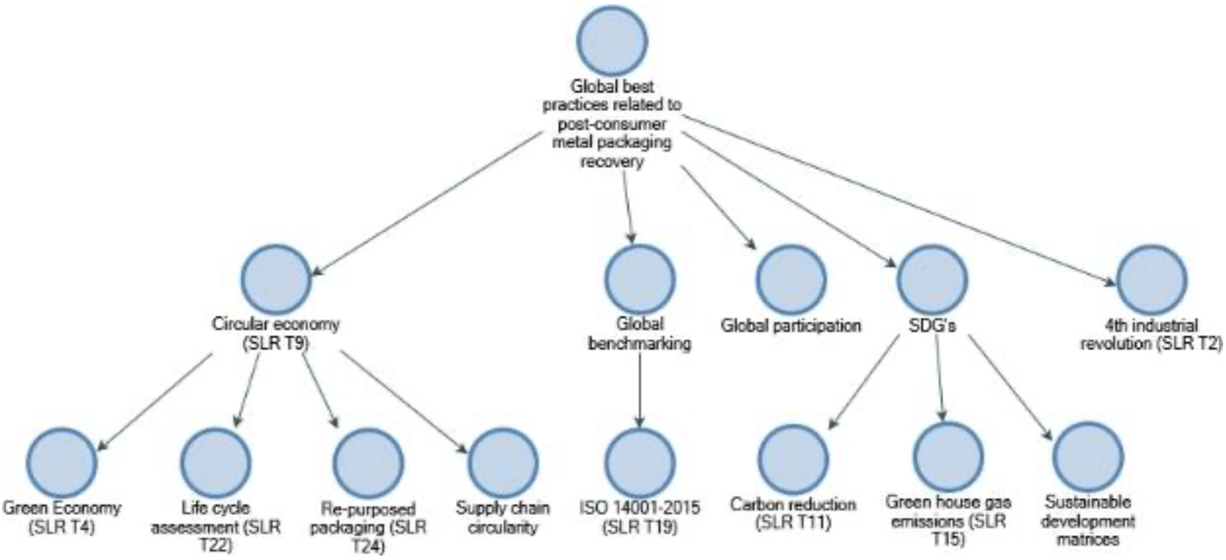


Figure 5.8: Global best practices related to post-consumer metal packaging recovery. Source: NVivo version 12

5.5.1 Subtheme 1.1: Circular economy

The global shift towards a circular economy, as highlighted by Tantau, Maassen, and Fratila (2018: 1), involves a comprehensive integration of recycling and waste management throughout a product's entire life cycle, departing from the traditional linear model of taking, making, using, and disposing. The following key ideas emerged from the synthesis of the SLR:

i. Transitioning to a CE demands clear and robust legislation and policies, accompanied by key performance indicators such as recovery rates, yield rates, % recycled content, waste to energy, Life Cycle Assessment, and energy consumption.

ii. The implementation of standardised, objective evaluation methods is crucial to prevent green washing, ensuring accurate representation of CE data.

iii. Enhancing supply chain circularity involves integrating industrial packaging, exploring leasing and renting options, and minimising the environmental impact through recycling, re-use, and industrial symbiosis.

iv. Designing industrial packaging with recycling in mind and ensuring regulatory compliance are essential steps towards achieving a sustainable CE.

5.5.1.1 Sub-subtheme: Green economy (SLR T4)

The following key ideas emerged from the synthesis of the SLR:

i. Organisations prioritise singular environmentally sustainable models over multiple initiatives for achieving packaging circularity, with a primary focus on raw material savings and logistics optimisation to enhance packaging circularity.

ii. The adoption of packaging reuse not only reduces CO_2 emissions but also contributes to decreased energy usage and water consumption.

iii. The effectiveness of sustainable, smart city waste management strategies hinges on collaborative alignment and engagement among industry, the public, and local government.

iv. Organisations face uncertainties and challenges due to expenses and volatility in energy processes, especially impacting energy-intensive consumers reliant on costly sources. In a competitive business environment, efficient energy utilisation becomes crucial, aligning with circular economy principles. To thrive globally, organisations need innovative production systems, circular supply chains for higher yields with fewer resources, reduced emissions, and energy usage.

5.5.1.2 Sub-subtheme: Life cycle analysis (SLR T22)

The following key ideas emerged from the synthesis of the SLR:

i. Life Cycle Assessment (LCA) facilitates increased circularity of primary aluminium by providing a comprehensive understanding of material paths, recovery, and re-use.

ii. The LCA approach for aluminium is not “cradle-to-grave” but rather a “cradle-to-cradle” perspective, emphasising sustainable and cyclical material management throughout its life cycle.

5.5.1.3 Sub-subtheme: Re-purposed packaging (SLR T24)

The following key ideas emerged from the synthesis of the SLR:

i. Metallised, biaxially oriented polypropylene is widely used for packaging snacks and crisps.
ii. Combining this material with a laminated pouch foil creates a simple, low-cost, and effective passive daytime cooling device.
iii. This cooling device, with satisfactory optical properties, achieves effective daytime cooling, providing a secondary use and diverting the materials from landfill.

5.5.1.4 Sub-subtheme: Supply chain circularity (SLR T17)

The following key ideas emerged from the synthesis of the SLR:

i. Lack of clear legislation around material recovery and re-use hinders the circularity of local supply chains.
ii. Insufficient governmental focus on waste management exists.
iii. Poor waste management at the source compounds challenges of environmental sustainability for all stakeholders.

5.5.2 Subtheme 1.2: Global benchmarking

It must be noted that the SA metal packaging industry post-consumer recovery rate in 2021, reflected as 61.63% in table 2.8, is below the 2021 European benchmark of 78.5% (Rivers 2023:1).

5.5.2.1 Sub-subtheme: ISO 14001:2015 (SLR T19)

The following key ideas emerged from the synthesis of the SLR:

i. Global steel industry preferences shift towards recovery and recycling of end-of-life steel products using electric arc furnaces for net-zero emissions.
ii. The distinction between symbolic and substantive ISO 14001 implementations is crucial for understanding the potential impact on overall organisational performance.
iii. While symbolic implementation may serve as a short-term response to external pressures, substantive implementation aligns with long-term goals and values, contributing to sustained success.
iv. Organisations should recognise the comprehensive benefits of ISO 14001, not limiting its implementation to mere symbolism but embracing it as a tool for holistic improvement.
v. Emphasising both environmental and economic aspects in ISO 14001 implementation aligns with the principles of sustainable development and circular economies, fostering a more balanced and resilient organisational strategy.

5.5.3 Subtheme 1.3: Global participation

Figure 5.3 represents the 39 countries that were reviewed during the SLR process. Figure 5.3 underscores the global spread of the SLR, demonstrating the extent to which research findings and perspectives were drawn.

The researcher notes that although the academic articles used in the SLR represented 39 countries, the SA practices related to the post-consumer metal packaging recovery was not forthcoming in the SLR. Therefore, this gap was addressed by the qualitative interview questions and will be highlighted in the qualitative analyses discussed later in Chapter Six.

There were no sub-subthemes under this subtheme.

5.5.4 Subtheme 1.4: SDGs

The United Nation's SDGs encompass crucial facets of human life, including, but not limited to, sustainable energy, decent employment and economic advancement, advancements in industry and infrastructure, decreased inequalities, the development of sustainable cities and communities, responsible consumption and production, climate action, along with fostering partnerships to achieve these objectives (Whittingham, Earle, Leyva-de la Hiz, and Argiolas 2023: 45).

5.5.4.1 Sub-subtheme: Carbon reduction (SLRT 11)

The following key ideas emerged from the synthesis of the SLR:

i. China's primary aluminium industry represents 57% of global production, while secondary aluminium production is less than 20%.
ii. Short-term focus for China's primary aluminium industry: cost-effective technology improvement.
iii. Medium-term focus: power decarbonisation and increasing secondary aluminium production.
iv. Long-term focus: technologies with higher costs but lower emission reduction.
v. Globally, scrap steel trade and recycling play a significant role in the decarbonisation efforts of the international steel industry because:
    a. Scrap steel trade addresses resource shortages in some countries.
    b. Advocacy for the general resource efficiency of steel scrap and the recovery of embedded alloy elements considered rare minerals is crucial.
    c. Implementation of global carbon taxes is expected to shift the competitiveness of steel products based on manufacturers' potential to minimise CO_2 emissions, guided by cradle-to-gate life cycle assessments (LCA).

5.5.4.2 Sub-subtheme: Greenhouse gas emissions (SLR T15)

The following key ideas emerged from the synthesis of the SLR:

i. The aluminium beverage can industry is under scrutiny for its environmental impact, with efforts focused on Life Cycle Assessment (LCA). Greenhouse gas emissions in primary aluminium manufacturing are primarily attributed to high energy consumption.

ii. To mitigate this impact, the recommendation is to increase the use of recycled aluminium, aligning with sustainable development goals.

iii. Despite advancements in primary metal production, which sees a continuous decrease in ore grades, there is a parallel increase in energy demands due to processing larger volumes of ore with lower metal concentrations. However, secondary production from recycled materials emerges as a more sustainable alternative, requiring lower energy and contributing to a reduced greenhouse gas footprint in metal production.

5.5.4.3 Sub-subtheme: Sustainable development matrices (SLR T20)

The following key ideas emerged from the synthesis of the SLR:

i. A combination of these metrics provides a holistic view of sustainable development success.

ii. Interconnectedness between resource efficiency, closed-loop systems, waste reduction, and other metrics ensures a comprehensive approach to achieving circular economy goals.

iii. Continuous monitoring and improvement based on these metrics can drive ongoing commitment to sustainable development practices at various levels - individual, organisational, and governmental.

5.5.5 Subtheme 1.5: Fourth Industrial Revolution (SLR T2)

According to Xu, David and Kim (2018: 90), the industrial revolutions, from steam power to digital technology, have transformed production methods but have also led to environmental degradation and now in the current 4IR, there is a heightened focus on sustainable development in response to past environmental impacts. The predicted fifth industrial revolution emphasises a crucial shift towards environmental sustainability, particularly in preserving biodiversity and ensuring the continuity of the human species (Schwab 2018: 7).

The following key ideas emerged from the synthesis of the SLR:

i. Industry 4.0's transformative features, encompassing IoT, Big Data Analytics, Cyber-Physical Systems, and SCM, act as powerful enablers for advanced manufacturing and circular economies, aligning with sustainable development goals.
ii. The utilisation of Industry 4.0 tools and technologies presents significant opportunities for economic and environmental sustainability.
iii. The Internet of Things (IoT), utilising miniature embedded systems, modern electronics, and wireless data communication, enhances connectivity to Big Data, simplifies monitoring and control of processes, and supports efficient waste analysis, recovery, processing, and re-use.
iv. Industry 4.0 positively impacts CE by enhancing environmental, economic, and operational performance, integrating IoT for increased end-of-life material availability, optimised response time, reduced emissions, superior product design, and enhanced transparency in business operations.
v. Industry 5.0 requires a synergistic relationship with Society 5.0, emphasising three key components: social aspects (human/machine centricity), ecological goals (zero emissions), and technological advancements (promotion of green innovations).

There were no sub-subthemes under this subtheme.

5.6 Theme 02: Effectiveness of SA post-consumer metal packaging recovery system.

Research question 2: ***How effective is the post-consumer metal packaging recovery model in SA?***

Figure 5.9 is a project map that depicts the SLR themes and subthemes that underpin the research question 2.

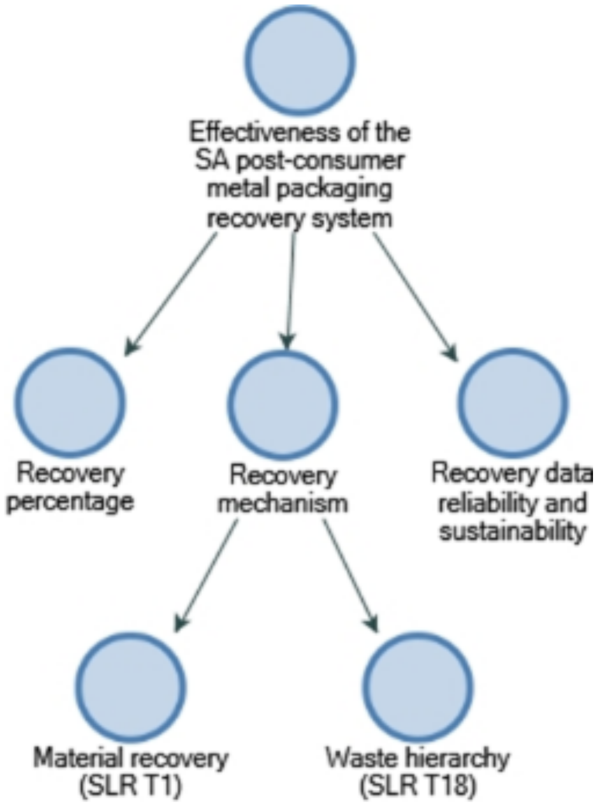


Figure 5.9: Effectiveness of the post-consumer metal packaging recovery in SA
Source: NVivo version 12

5.6.1 Subtheme 2.1: Recovery percentage

This information was not forthcoming from the SLR, given that it is unique to SA, and will be explored in qualitative analyses that follows in Chapter Six.

There were no sub-subthemes under this subtheme.

5.6.2 Subtheme 2.2: Recovery mechanism

Onesmo, Mabhuye and Ndaki (2023: 1) posit that in developing countries, waste picking contributes significantly to the recovery and sale of metals and other recyclable materials within the circular economy of waste streams, but unfortunately, these waste pickers are often overlooked by urban areas. Cities ought to explore post-consumer material recovery frameworks that acknowledge the perspectives and expertise of waste pickers, fostering more inclusive and efficient circular economy models that enhance synergistic relationships within the waste value chain (Onesmo, Mabhuye and Ndaki 2023: 1).

5.6.2.1 Sub-subtheme: Material recovery (SLR T1)

The following key ideas emerged from the synthesis of the SLR:

i. Compaction enhances melting efficiency due to increased density
ii. DRS increases packaging material recovery.
iii. Manual sorting is crucial for enhancing aluminium re-melting yields.
iv. Consumer awareness in separation-at-source initiatives is essential for efficient manual sorting.
v. Impurities in secondary aluminium pose a persistent challenge despite recycling incentives.
vi. Intelligent alloy design is necessary for optimal recovery, and electrolytic process manipulation can mimic primary alloy composition.
vii. Understanding alloys in scrap steel is crucial for sustainability, minimising the need for virgin steel and contributing to net-zero goals.

5.6.2.2 Sub-subtheme: Waste hierarchy (SLR T18)

The following key ideas emerged from the synthesis of the SLR:

i. Conventional waste-to-energy, involving incineration for energy recovery, is crucial in the circular economy.
ii. While lower in the waste hierarchy than recycling, it complements sustainability efforts.
iii. Targets non-recyclable waste, aligning with recycling and competing with landfill.
iv. Maintains material cycles, minimising exposure to toxic substances.
v. Facilitates energy and material recovery from non-recyclable waste, contributing to continuous material circulation in the circular economy.

5.6.3 Subtheme 2.3: Recovery data reliability and sustainability

This information was not forthcoming in the SLR, given that this is unique to SA, and will be explored in qualitative analyses that follows in Chapter Six.

There were no sub-subthemes under this subtheme.

5.7 Theme 03: Accuracy and reliability of existing post-consumer SA metal packaging recovery data.

Research question 3: ***How accurate and reliable are the South African post-consumer metal packaging data acquisition and reporting systems?***

Figure 5.10 is a project map that depicts the SLR themes and subthemes that underpin the research question 3.

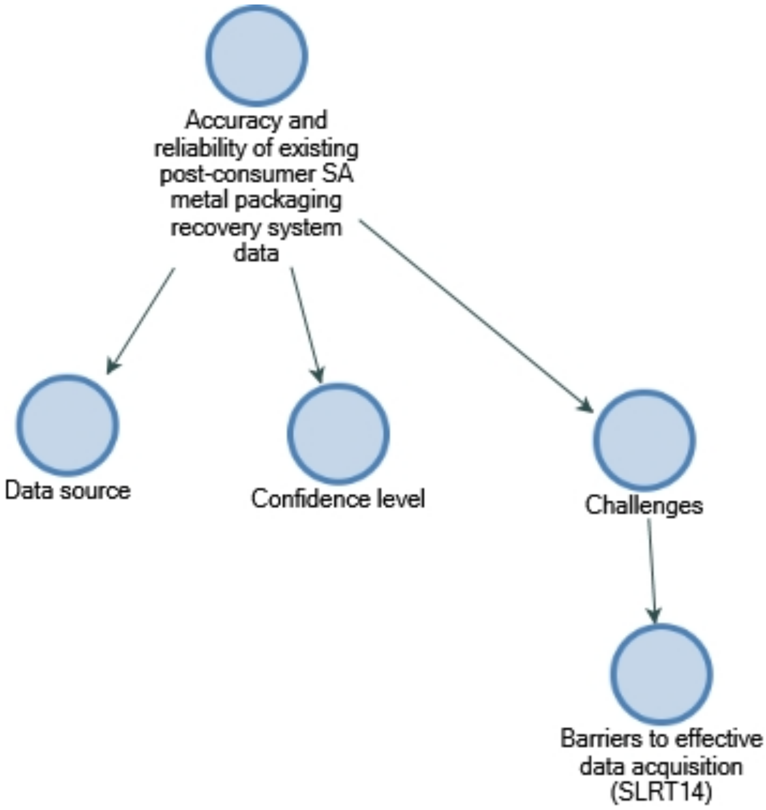


Figure 5.10: Accuracy and reliability of existing post-consumer South African metal packaging data acquisition and reporting systems
Source: NVivo version 12

5.7.1 Subtheme 3.1: Data source

This information was not forthcoming from the SLR, given that it is unique to SA, and will be explored in qualitative analyses that follows in Chapter Six.

There were no sub-subthemes under this subtheme.

5.7.2 Subtheme 3.2: Confidence level

This information was not forthcoming from the SLR, given that it is unique to SA, and will be explored in qualitative analyses that follows in Chapter Six.

There were no sub-subthemes under this subtheme.

5.7.3 Subtheme 3.3: Challenges (SLR T14)

5.7.3.1 Sub-subtheme: Barriers to effective data acquisition for SD

The following key ideas emerged from the synthesis of the SLR:

i. The research agenda delineates a comprehensive approach to advancing sustainable manufacturing. It proposes the development of facilitators and innovative technologies aligned with the 6Rs, alongside the formulation of a policy framework to address obstacles. Benchmarking practices, generic strategies, and the interplay of barriers on performance outcomes are examined.
ii. Structural equation modelling is employed to assess the impact of individual barriers on various organisational aspects.
iii. The research also delves into the combined effects of facilitators in overcoming barriers, specifically within the manufacturing unit.
iv. Furthermore, it investigates the influence of barriers on business supply chain practices and market image, fostering a holistic understanding of sustainable manufacturing dynamics.

5.8 Theme 04: Commitment to SA post-consumer metal packaging recovery.

Research question 4: ***To what extent is the South African metal packaging value chain committed to post-consumer metal packaging recovery.***

Figure 5.11 is a project map that depicts the SLR themes and subthemes that underpin the research question 4.

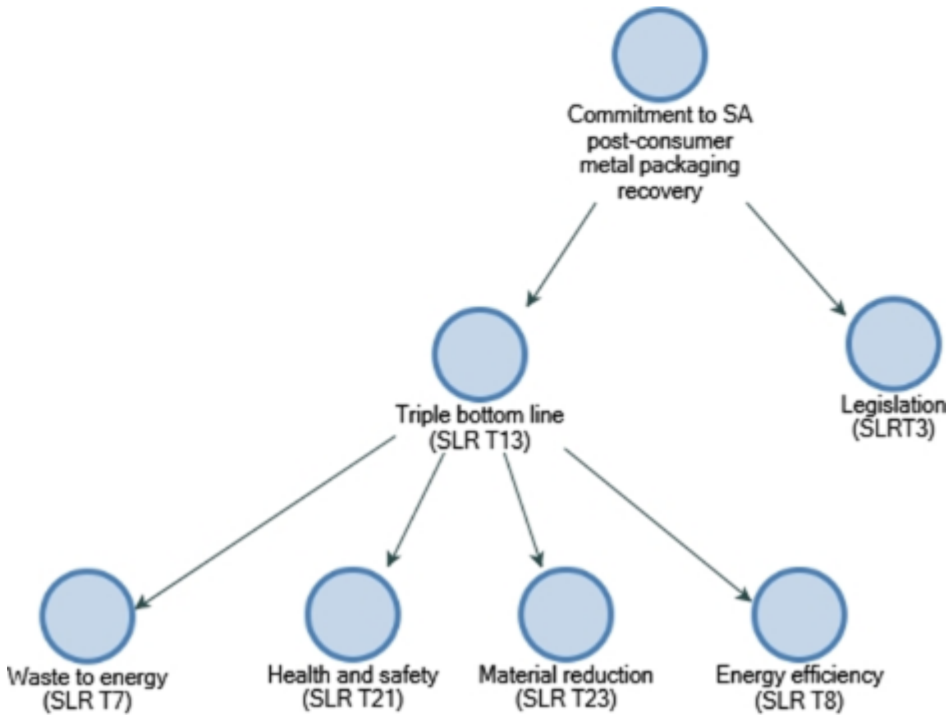


Figure 5.11: Commitment to post-consumer metal packaging recovery

Source: NVivo version 12

5.8.1 Subtheme 4.1: Triple bottom line (SLR T13)

Webster (2017: 16) articulates that the emphasis on natural resource utilisation should prioritise the prevention of material waste and the promotion of extended, circular material use. Central to the circular economy (CE) model, as proposed by Webster (2017: 16), is the concept of natural resource utilisation, portraying the CE as a triple bottom line, sustainable economy designed to reintegrate products into the manufacturing cycle after consumer use.

The following key ideas emerged from the synthesis of the SLR:

i. Consumers prioritise sustainability, leading to an interaction effect between corporate sustainability and consumer support.
ii. Greater corporate social responsibility is recognised as a necessity in response to consumer preferences.
iii. The circular economy model for sustainable development is underpinned by the triple bottom line philosophy.
iv. The concept of the triple bottom line was introduced in 1997 and has since become a mainstream driving force for sustainable development practices.

5.8.1.1 Sub-subtheme: Waste to energy (SLR T7)

The following key ideas emerged from the synthesis of the SLR:

i. Burning rubber and carbon from used tyres in a rotary hearth reduction furnace for high-calorie gasification used as fuel in steelworks.
ii. Steel scrap, requiring no 'reduction' energy, proves resource-efficient while reducing CO_2 emissions during large-scale melting. Household aluminium recycling efficiency hinges on the chosen process.
iii. A non-traditional approach uses exothermic heat from diverse aluminium sources for ferro-titanium alloy production.
iv. The pyrolysis of polymers, including end-of-life plastics and tires, produces oil for use as fuel in remelting end-of-life aluminium and steel.
v. Polystyrene pyrolysis yields 45% gas and 55% oil at 500◦C, making it a viable process for generating highly calorific oil as a fuel source in furnaces for remelting aluminium and steel products and packaging.

5.8.1.2 Sub-subtheme: Health and safety (SLR T21)

The following key ideas emerged from the synthesis of the SLR:

i. Aerosol cans pose dangers during re-melting due to residual content like pesticides and chemical perfumes, along with pressurised propellants, increasing the risk of explosions.

ii. To mitigate risks, aerosol cans should be collected separately, and valves must be detached before the re-melting process.

5.8.1.3 Sub-subtheme: Material reduction (SLR T23)

The following key ideas emerged from the synthesis of the SLR:

i. Aluminium material losses during re-melting are directly influenced by the thickness of metal packaging.

ii. Thinner metal packaging, especially with a gauge thickness under 2 mm, leads to higher losses during the re-melting process.

5.8.1.4 Sub-subtheme: Energy efficiency (SLR T8)

The following key ideas emerged from the synthesis of the SLR:

i. Efficient aluminium production from scrap, mirroring virgin alloy composition, relies on well-managed electrolytic processes, yielding secondary aluminium with significantly lower specific energy than primary counterparts.

ii. The friction-induced recycling of industrial waste aluminium chips offers an energy and resource-efficient solution for secondary aluminium use.

iii. Aluminium holding furnaces, powered by fuel burners, release hot flue gas resulting in energy loss. Re-directing this gas to pre-heat aluminium scrap in a separate furnace enhances efficiency and reduces melting time.

iv. As the metal foundry industry is energy-intensive, adopting Industry 4.0 principles as in Foundry 4.0, with tools like IIoT, additive manufacturing, and big data, can transform traditional foundries into smart, energy-efficient entities.

5.8.2 Subtheme 4.2: Legislation (SLR T3)

The following key ideas emerged from the synthesis of the SLR:

i. Collaborative efforts between governments and industries are crucial for creating legislative frameworks that promote the growth of the circular economy, with measures like scrap steel export restrictions to ensure domestic availability and address theft concerns.

ii. Legislation, including carbon taxes, plays a pivotal role in encouraging the transition towards steel scrap recycling. A comprehensive approach combining incentives for carbon footprint reduction and penalties for carbon-intensive processes is essential for effective change.

iii. Countries globally are committing to achieving net-zero carbon emissions from steel production by 2050, emphasizing a shift from fossil fuels to renewable energy sources to meet environmental goals.

iv. The significant contribution of iron and steel production to global CO_2 emissions underscores the urgency for emission reduction measures. The European Council's targets reflect a commitment to substantial reductions in greenhouse gas emissions over specific timelines.

v. A stringent legislative framework is essential to guide the recycling and limit landfilling of Municipal Incinerated Bottom Ash (MIBA). The focus on recycling obligations serves to stimulate the market for MIBA recycling.

vi. The Waste Framework Directive (WFD) of the European Union, particularly Article 6(1), emphasises the importance of legislative support to prevent bottlenecks in waste streams, promote demand for waste, and ensure effective waste management through recovery and re-use strategies.

There we no sub-subthemes under this subtheme.

5.9 Theme 05: Alternate post-consumer metal packaging recovery

Research question 5: *How can remodelling the post-consumer metal packaging recovery system support job creation and transformation?*

Figure 5.12 is a project map that depicts the SLR themes and subthemes that underpin the research question 5.

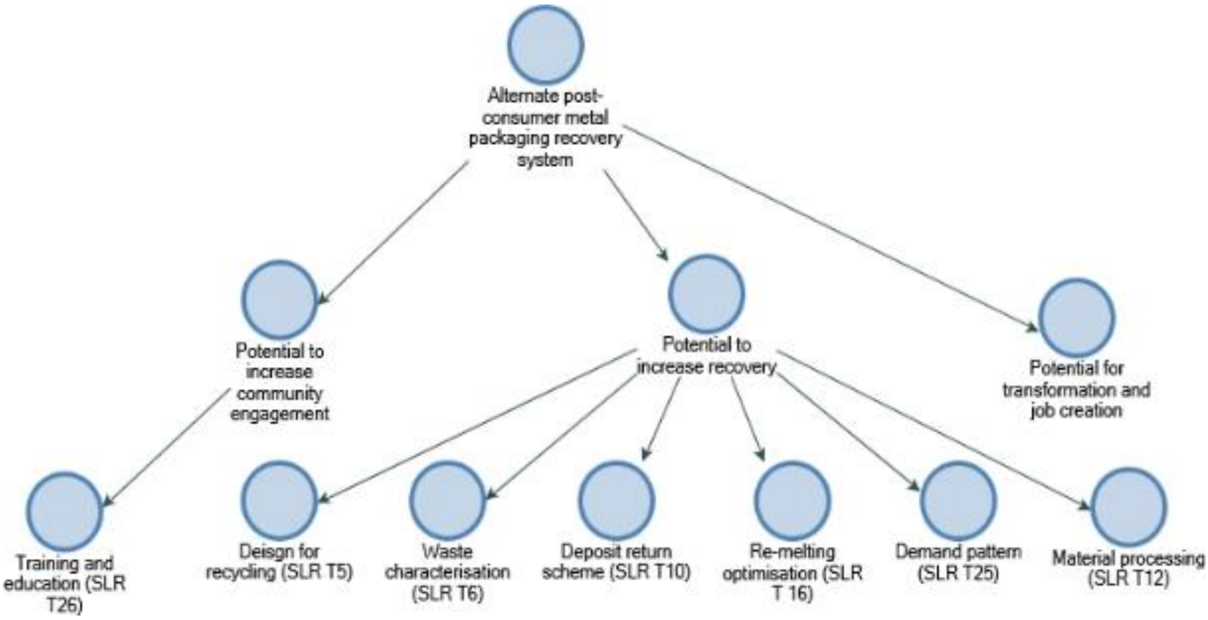


Figure 5.12: Alternate post-consumer metal packaging recovery system

Source: NVivo version 12

5.9.1 Subtheme 5.1: Potential to increase community engagement

5.9.1.1 Sub-subtheme: Training and education (SLR T 26)

Training and educating all stakeholders in the metal industry value chain will foster a greater understanding of steel and other metals, enhancing appreciation for their applications. This, in turn, is expected to contribute to higher rates of recovery and re-use.

5.9.2 Subtheme 5.2: Potential to increase recovery

5.9.2.1 Sub-subtheme: Design for recycling (SLR T5)

The following key ideas emerged from the synthesis of the SLR:

i. Vital enablers for metal packaging's end-of-life management and circular economy include design for durability, recovery, and disassembly. However, design for recycling models face challenges and require robust planning to address sustainability issues effectively.
ii. Current design for recycling models inadequately address escalating sustainability challenges, necessitating the development of robust packaging planning that promotes design for recycling, disassembly, and durability.
iii. The deposit return scheme (DRS) historically boosts metal packaging recovery through incentivisation and streamlined recycling but faces challenges such as reliance on consumer and company efforts, limited scalability, and packaging-specific customisation.
iv. Despite weaknesses, effective DRS deployment, supported by legislation, offers opportunities to enhance metal recovery and contribute to the circular economy by improving end-of-life collection and reuse.

5.9.2.2 Sub-subtheme: Waste characterisation (SLR T6)

The following key ideas emerged from the synthesis of the SLR:

i. This project creates a dataset for classifying beverage cans (alcoholic/non-alcoholic) and other aluminium items, collected through a deposit return scheme incentivising returns.
ii. Vienna's urban waste management analysis (2006–2020) shows improved collection rates for plastic and aluminium packaging, credited to commingled methods and more collection points. Recommendations include better consumer communication and advanced sorting methods.
iii. To tackle the global surge in municipal waste, implementing a separation@source (SAS) model is crucial. This model enhances recycling efficiency and boosts recovery rates, achieved through household segregation and collection.

5.9.2.3 Sub-subtheme: Deposit return scheme (SLR T10)

The following key ideas emerged from the synthesis of the SLR:

i. The deposit refund system (DRS), an extension of the producer responsibility principle, functions as a market-based tool to address environmental externalities. Introduced in Croatia in 2006, the DRS successfully tackled issues like illegal waste disposal through economic incentives and flexibility.

ii. In the UK, Defra plans to implement a DRS covering England, Wales, and Northern Ireland in 2025, while Scotland will have its scheme by August 2023. A study revealed a negative correlation between deposit value and willingness to pay (WTP) for materials, with estimated WTP values for glass, plastic, and cans.

iii. Identified barriers to DRS adoption include limited household space and scepticism toward recycling. Recommendations include flexible deposit values and public campaigns to enhance DRS effectiveness. Limitations include the study's dichotomous-question design and sample bias.

iv. Regulated deposit-refund system, covering 26% of the population in 10 European countries, is being considered by others due to strict legal requirements for packaging waste recycling.

v. While the average collection and recycling rate under this system in European countries is 91%, in Poland, it would only address about 6% of total municipal waste, prompting the recommendation of the extended producer responsibility (EPR) system to boost recycling rates. The arrangement, cost, and functionality of a deposit-refund system are interconnected and capital-intensive, with automation as a potential but costly efficiency improvement.

vi. Equal treatment for all participants is crucial, and proposing an effective deposit-refund system is a complex, long-term process requiring tailored solutions for each country. Before implementation, an extensive information-educational campaign is necessary. Higher industry costs may result in increased food and beverage prices, seen as unavoidable due to producers being responsible for their packaging.

vii. DRS is widely implemented, showcasing variations and exceptions. Deposit rates vary for different packaging types, and return rates typically range from 80% to nearly 100%. Multi-use systems slightly outnumber single-use ones, with varying establishment dates.
viii. DRS introductions are often driven by regulations, and the majority are managed by the industry. Return points are primarily in supermarkets, and DRS operations usually span nationwide. The main outcomes include increased recycling rates and reduced littering. In slightly over half of the cases, DRS is combined with an environmental tax. High costs and inadequate infrastructure are the primary obstacles to DRS implementation in just over half of the cases.

5.9.2.4 Sub-subtheme: Remelting optimisation (SLR T16)

The following key ideas emerged from the synthesis of the SLR:

i. Development of recipes or blends for furnace input depends on partial or full knowledge of material quality; this significantly affects the usage of scrap steel versus virgin steel in recycling processes.
ii. Emphasis on improving scrap steel characterisation processes is crucial.
iii. Sorting processes and infrastructure need greater attention for effective recycling practices.

5.9.2.5 Sub-subtheme: Demand pattern (SLR T25)

The following key ideas emerged from the synthesis of the SLR:

i. Alterations in the demand for specific steel grades, alongside advancements in engineering and manufacturing technology, shape the transformation of manufacturing practices. Consequently, the demand for material grades is expected to undergo changes.
ii. The prospect of redirecting steel scrap will hinge on the evolving demand patterns for different grades and quantities of steel products as time advances.

5.9.2.6 Sub-subtheme: Material processing (SLR T12)

The following key ideas emerged from the synthesis of the SLR:

i. Steel scrap purity is a concern, with undesirable embedded alloys (> 0.25%) unless active sorting measures are enforced.
ii. Effective control of scrap steel quality, especially related to embedded alloys, is crucial at recycling plants for higher steel production quality.
iii. The pyrometallurgical industry needs to evolve for reduced environmental impact while maintaining high productivity.
iv. Greener process reactants like biofuel, biochar, hydrogen, and ammonia, along with recycled input materials, can lower CO_2 emissions by replacing carbon-based reactants.
v. This shift also minimises energy requirements associated with recycling.
vi. The use of Poisson–Nernst–Planck equations helps understand ion movement in the electrolytic recovery process of waste metals.
vii. Efficient metal recovery requires critical management of ion concentration and ion migration rates within the electrolyte.

5.9.3 Subtheme 5.3: Potential for transformation and job creation

This information was not forthcoming from the SLR, given that it is unique to SA, and will be explored in qualitative analyses that follows in Chapter Six.

There were no sub-subthemes under this subtheme.

5.10 SLR gaps identified

There were six distinct gaps, against the research questions, that were identified from the SLR, and these gaps were addressed by adapting the qualitative interview questions to interrogate each of these gaps. The identified gaps were:

i. *Global participation:* dedicated academic articles, specifically discussing post-consumer metal packaging recovery in SA, related to global participation, were conspicuously absent. This gap pertains to research question one;

ii. *Percentage data recovery:* the SLR did not provide insights on this particular aspect of global recovery systems, specific to the South African landscape and was therefore identified as a gap related to research question two;

iii. *Reliability and sustainability of data recovery systems:* the SLR did not elucidate this particular aspect of global recovery systems, specific to the South African landscape and was therefore identified as a gap related to research question two;

iv. *Data source:* the SLR did not provide insight to this aspect of global recovery systems, specific to the South African landscape and was therefore identified as a gap related to research question three;

v. *Confidence levels of data:* the SLR did not elucidate this aspect of global recovery systems, specific to the South African landscape and was therefore identified as a gap related to research question three and

vi. *Transformation and job creation specific to SA:* was the sixth gap identified in the SLR and this was against the research question five.

There were no gaps identified in relation to research question four; notwithstanding, this will be further explored in the qualitative analysis discussed in Chapter Six.

5.11 Conclusion

To conclude, this systematic literature review (SLR) has provided a comprehensive content analysis of the existing body of knowledge on global post-consumer metal packaging recovery trends. By synthesising and critically evaluating a diverse range of studies, valuable insights into the current state of research in this field have been gained.

The SLR has yielded 26 themes, and the main ideas arising from the SLR are material recovery, Industry 4.0, packaging legislation, green economy and design for recycling. Material recovery, which is the thrust of this thesis, is clearly an aspect that is most researched and most acted upon globally. Yet in SA, material recovery is only now in vogue because of the recent EPR legislation.

The 26 SLR themes were consolidated and aligned with the five research questions, resulting in five research themes and sixteen subthemes that are carried into Chapter Six.

Despite the progress made, there remain opportunities for future investigations, such as further decarbonisation of both the aluminium and steel primary manufacturing processes. Although the deposit return schemes yield positive results, this system has not been adopted widely globally.

The results of this SLR were triangulated in Chapter Seven, together with the themes generated from the qualitative interviews, and the results were integrated into the recommended post-consumer metal packaging recovery model as illustrated in Chapter Seven.

The next chapter presents the findings, interpretation and discussion of the data that was derived from the two qualitative analyses conducted.

CHAPTER SIX
QUALITATIVE ANALYSIS STATEMENT OF FINDINGS, INTERPRETATION AND DISCUSSION OF THE DATA

6.1 Introduction

The qualitative interviews were the primary tools that were used to collect data and were executed with targeted participants within the packaging and metal recycling industries in SA. These participants represent the packaging leadership, across geographical regions of SA, and are therefore best suited to offer a cross-sectional view into the interview questions. The interview questions were designed to gain the perspectives of the converter/brand-owner as well as the metal recycler, on aspects relating to the research questions. Additionally, the interview questions integrated the six gaps identified in the SLR to ascertain a clearer understanding of the research problem, enabling the build of a practical, post-consumer, metal packaging recovery model.

This chapter outlines the results derived from the qualitative, semi-structured interviews conducted by the researcher with selected participants comprising SA metal packaging converter/brand-owners and metal recyclers. The data arising from the interviews was subjected to deductive coding, and a thematic analysis, facilitated by the NVivo version 12 software. The results are presented as emerging themes and subthemes in the form of tabulations, graphs, and project maps for the qualitative data that was collected.

This chapter discusses the findings obtained from the data collected during the interviews conducted.

6.2 The research sample

In total, 18 semi-structured interviews were conducted with the converter/brand-owners and 18 semi-structured interviews were conducted with metal recyclers in SA, resulting in a 100% response rate against the planned target samples.

6.3 The research instruments

The interview discussion guides were divided into Section A (biometrics) and Section B (interview questions).

6.3.1 Section A: Biometric data (6 items)

i. Province;
ii. Gender;
iii. Race;
iv. Age;
v. Designation and
vi. Duration in designation

6.3.2 Section B - Converter/brand-owner

15 open-ended interview questions covered salient aspects of the packaging industry from general global trends in sustainable development and circular economies, to specific challenges within the SA packaging industry, aligning with the research questions.

Table 6.1 presents the converter/brand-owner research questions, the intent behind each question and the alignment with the research question.

Table 6.1: Converter/brand-owner research interview questions and the intent

No.	Interview question	Question intent	Related research question
1	*How does your business relate to circular economy principles?*	Establishing global best practices	Research question 1
2	*Which countries are actively delivering against circular economy principles?*		
3	*How are you constantly benchmarking with global best practices on post-consumer metal packaging recovery?*		
4	*How is post-consumer metal packaging recovered in SA?*	Determining the effectiveness of current post-consumer metal packaging recovery system	Research question 2
5	*How reliable/sustainable is the current post-consumer metal packaging recovery system?*		
6	*Can you estimate the % of post-consumer metal packaging that is recovered by informal waste pickers and the formal waste collection systems in SA?*		

7	*What is the source of your statistics (above question)?*	Understanding the reliability of post-consumer metal packaging data acquisition and reporting	Research question 3
8	*Are you confident that these statistics are an accurate reflection of post-consumer metal packaging recovery in SA?*		
9	*If not, where do you think lies the challenges in accurate data reporting?*		
10	*Discuss the level of commitment of your business / brand to a triple bottom line strategy.*	Establishing commitment to metal packaging recovery and circularity	Research question 4
11	*Are there formal sustainable development goal setting within your business? Discuss measurement and successes achieved. How do you set new targets and timelines? Test for realism and practicality.*		
12	*How does your brand / business address post-consumer metal packaging recovery and recycling?*		
13	*How can such a model ensure transformation and job creation?*	Understanding how remodelling post-consumer metal packaging recovery may increase recovery volumes through local entrepreneurship.	Research question 5
14	*How can community awareness and education campaigns be integrated into the recovery model to promote responsible recycling behaviour?*		
15	*How would you be able to increase the metal packaging recovery in SA?*		

Source: Researcher's own construction

6.3.3 Section B - Recycler

Eight open-ended interview questions covered salient aspects of the packaging industry from general global trends in sustainable development and circular economy, to specific challenges within the SA packaging industry, aligning with the research questions.

Table 6.2: Recycler research interview questions and the intent

No.	Interview question	Question intent	Related research question
1	*How does the metal recovery and processing model in South Africa compare with global best practices?*	Establishing global best practices	Research question 1
2	How effective is the SA metal recovery systems in SA?	Determining the effectiveness of current post-consumer metal	Research question 2
3	*How do you ensure data accuracy and transparency in your metal supply chain, especially regarding the sources of scrap metal and raw materials?*	Understanding the reliability of post-consumer metal packaging data acquisition and reporting	Research question 3
4	*How does your facility ensure compliance with EPR legislation and environmental regulations and standards in SA?*	Understanding the commitment to legislation and material circularity	Research question 4
5	*Are there alternative models to recover and process metal more effectively and more efficiently in SA?*	Understanding how re-modelling the metal recovery system can support job creation and transformation	Research question 5

6	*What waste management practices do you have in place to minimise the environmental impact of your operations?*	Establishing global best practices within the recycling sector	Research question 1
7	*Can you share information about any initiatives or technologies implemented to enhance energy efficiency in your metal recycling/foundry processes?*	Establishing global best practices within the recycling sector	Research question 1
8	*What initiatives or programs do you have in place to engage with and benefit the local community surrounding your facility?*	Understanding how re-modelling the packaging recovery system can support job creation and transformation	Research question 5

Source: Researcher's own construction

Table 6.2 presents the metal recycler research questions, the intent behind each question and the alignment with the research question

6.4 Presentation of biographical data of the participants.

6.4.1 Geographical location of the participants.

Figure 6.1 illustrates the geographical location of the participants.

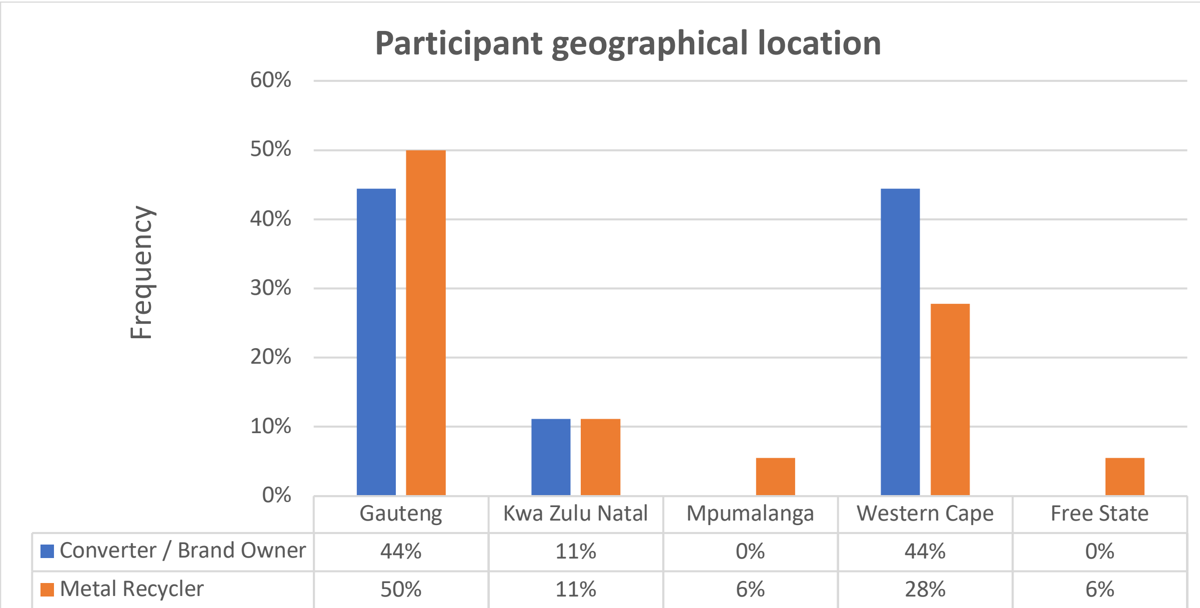


Figure 6.1: Participant graphical location

Source: Researcher's own construction

Figure 6.1 indicates that the interviews were conducted with selected participants across the main provinces in SA, namely Gauteng, Kwa-Zulu Natal, Mpumalanga, Western Cape and Free State

88% of the converter/brand-owners and 78% of the metal recyclers interviewed were in the Western Cape and Gauteng.

The converter/brand-owners and the metal recyclers are situated predominantly in Western Cape, Gauteng and Kwa Zulu Natal, because these are the hubs of the business sectors in SA. However, the metal recyclers are situated across more of the provinces in SA, given the volume of metal collection and re-melting requirements.

It is noted that the interviews represented the volume of metal packaging distribution across SA and were therefore reasonably stratified, representing the key role-players within the higher industry density in SA.

6.4.2 Participant gender profile.

Figure 6.2 illustrates the gender profile of the participants.

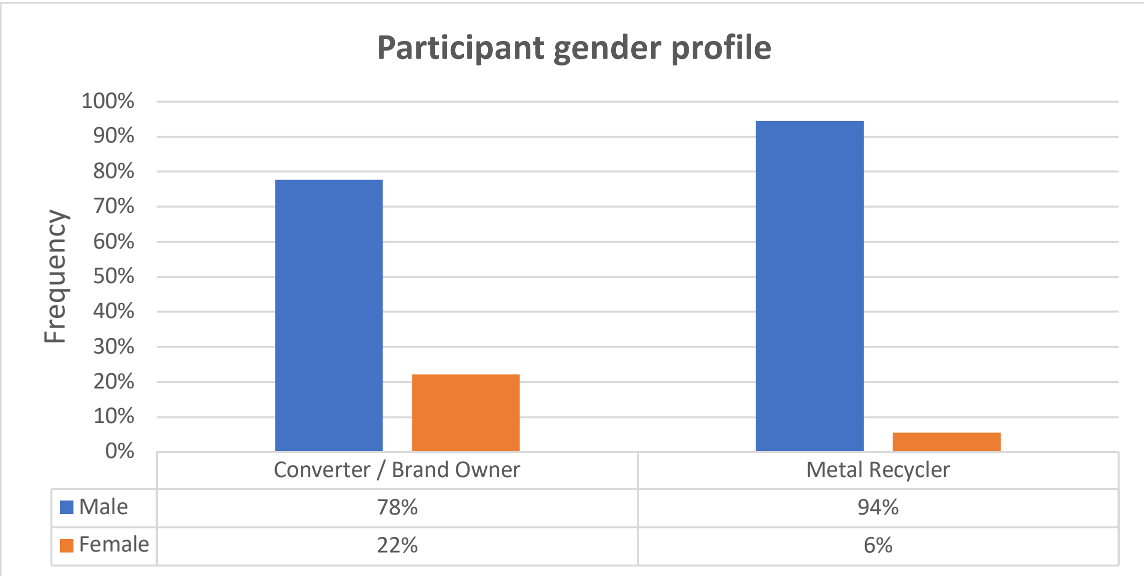


Figure 6.2: Participant gender profile

Source: Researcher's own construction

Of the converter/brand-owner interviews conducted, 22% were females, against 78% of males. However with respect to the metal recycler interviews, 6% were females against 94% of males.

It is evident that both the converter/brand-owner and the metal recycler sectors are male dominated, moreso within the metal recycling sector (Bala 2021: 44).

However, It is important to highlight that the interviews targeted converter/brand-owners and metal recyclers who represented a significant volume of metal within South Africa, irrespective of gender.

6.4.3 Racial profile of the participants.

Figure 6.3 illustrates the racial profile of the participants.

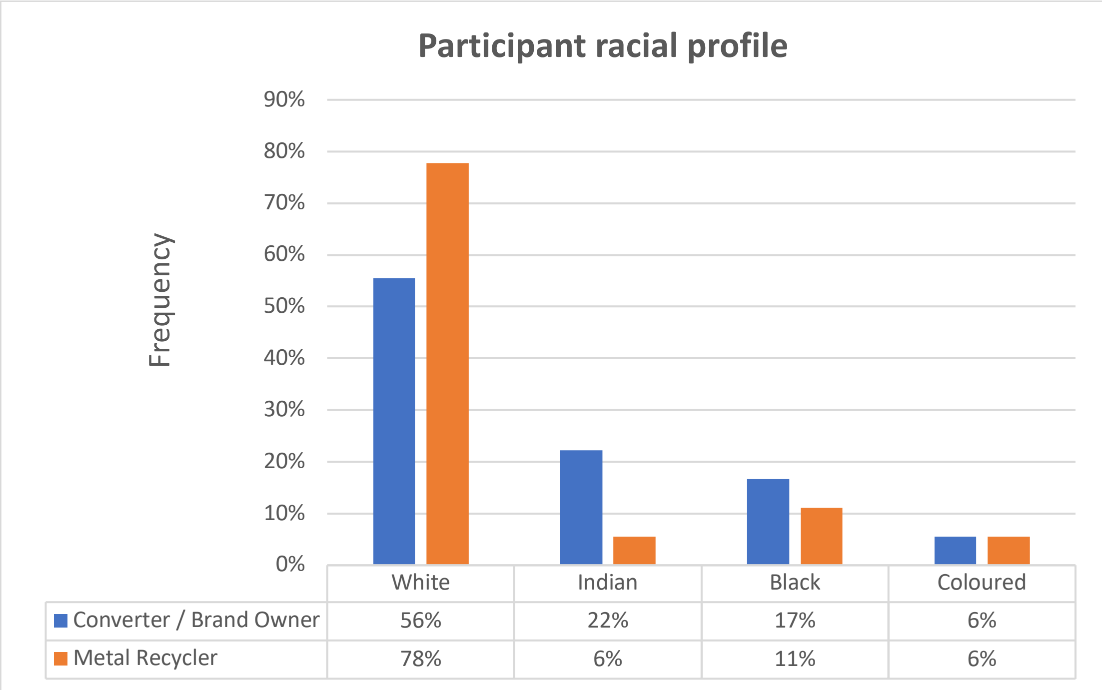


Figure 6.3: Participant racial profile
Source: Researcher's own construction

The racial profile of both the converter/brand-owner as well as the metal recycler indicate a prevalance of Whites followed by Indians, then Blacks and Coloured.

It is important to note that the racial profile observed, with a prevalence of Whites followed by Indians, then Blacks and Coloured individuals among both converter/brand-owners and metal recyclers, may be influenced by SA's historical, socio-economic, and systemic factors, beyond the scope of this study.

6.4.4 Age profile of the participants.

Figure 6.4 illustrates the age profile of the participants.

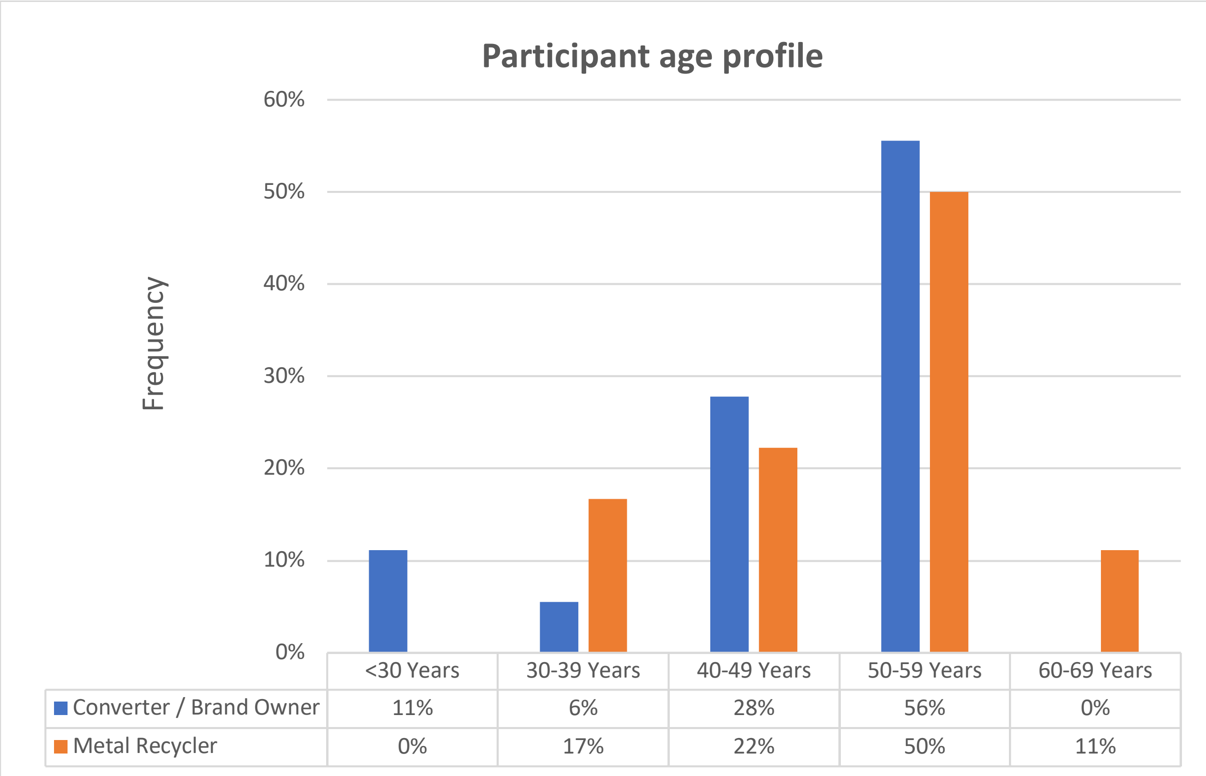


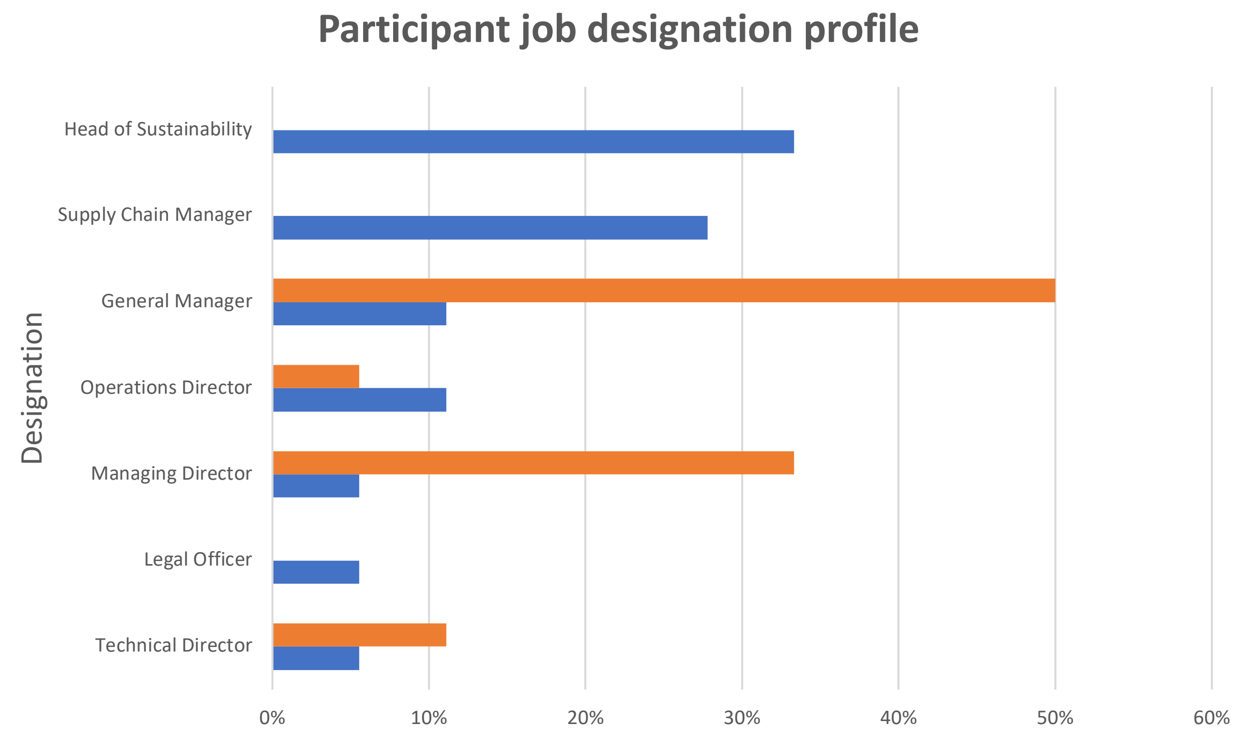
Figure 6.4: Participant age profile

Source: Researcher's own construction

The noteworthy observation that 84% of converter/brand owner participants and 83% of metal recycler participants are aged 40 years and older, suggests a mature workforce with substantial industry knowledge, reflecting the stability and longevity of individuals in these roles.

6.4.5 Job designation profile of the participants.

Figure 6.5 illustrates the job designation profile of the participants.



	Technical Director	Legal Officer	Managing Director	Operations Director	General Manager	Supply Chain Manager	Head of Sustainability
Metal Recycler	11%	0%	33%	6%	50%	0%	0%
Converter / Brand Owner	6%	6%	6%	11%	11%	28%	33%

Figure 6.5: Participant designation profile

Source: Researcher's own construction

Figure 6.5 indicates the rank and leadership status of the people selected for the interviews executed during this study. These high ranking individuals represent the leadership of the packaging industry, as well as the metal recycling industry, in SA, and are therefore best suited to offer a cross sectional view into the research questions.

It is interesting to note that the supply chain and sustainability roles are not as prevalent within the metal recycling sector, in comparision with the converter/brand-owner sector of the metal packaging industry. This may be attributable to the fact that the converters/brand-owners are predominantly global corporate entities that are driven by global markets and supply chains, hence the needs for roles in the areas of sustainability and supply chain (Bag, Dhamija, Bryde and Singh 2022: 64).

6.4.6 Experience profile of the participants.

Figure 6.6 illustrates the experience profile of the participants.

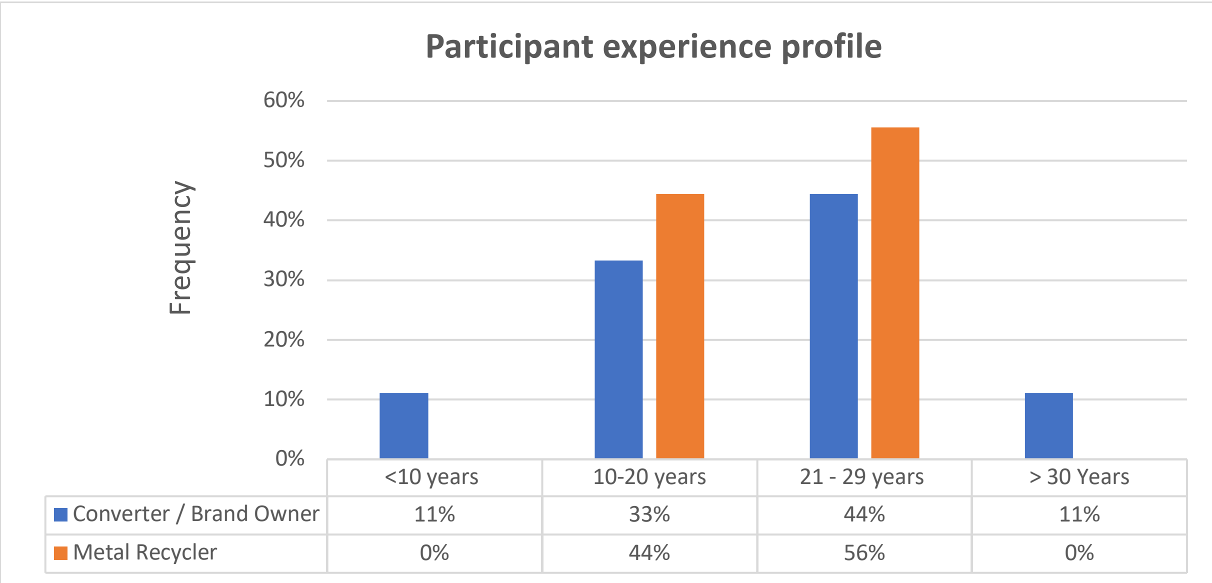


Figure 6.6: Participant experience profile

Source: Researcher's own construction

The observation that over 50% of both converter/brand-owner and metal recycler participants possess over 20 years of experience in their respective fields, underscores the industry's reliance on seasoned professionals.

This information provides insights into the distribution of experience levels which indicates the workforce composition and expertise within the converter/brand-owner and metal recycler sectors. It shows a concentration of individuals with significant years of experience in both sectors, suggesting a relatively experienced workforce in the industry.

6.5 Section B - Data analysis

According to Creswell and Creswell (2018: 291), the process of data analysis in qualitative research involves examining participant information, and typically includes the following steps that were followed in this research:

i. Initial steps encompassed organising and preparing the data, conducting an initial review of the information, coding the data on NVivo version 12, deriving a descriptive and thematic analysis from the codes;

ii. Additional steps involved using NVivo version 12 for the generation of appropriate tables, graphs, and figures, enabling logical interpretation and

iii. Two subject matter experts were used to review the data, the data coding process as well as the findings, validating the accuracy of the findings and the reliability of codes and themes that were used.

Creswell and Creswell (2018: 254) define data analysis as a series of processes and methods wherein qualitative data collected is subjected to transformations aimed at clarifying, understanding, or interpreting individuals and situations under investigation. The term "qualitative" refers to the participant’s words and observations, with the goal of interpreting the response data and expressing it in a more meaningful way (Creswell and Creswell 2018: 254).

Nowell, Norris, White, and Moules (2017: 2) suggest that thematic analysis is a systematically organised method for summarising extensive sets of data, emphasising both similarities and differences, and deriving insights from the research findings.

The following six-phase guide of thematic analysis, discussed by Byrne (2021: 1398) was used to explain the analysis of the data gathered:

i. *Familiarising oneself with the data gathered:* the purpose of data analysis is to obtain a common sense of the data. To become familiar with what the data entails, requires a thorough understanding of the data, by making notes and recordings. In this study, the researcher reviewed the converter/brand-owner and the recycler responses by repeated reading, developing a sense of the content, context, and nuances. Initial notes were made to observe any immediate correlations or patterns and these early ideas were jotted down without imposing any structure;

ii. *Generating initial codes:* In this phase the data is reduced into smaller meaningful quanta by organising it through coding. Coding is the process of linking an idea, or a portion of an idea, of a participant's response, to a particular node. The nodes are the fundamental building blocks for the themes that will later emerge. In this study, once the researcher was familiar with the data, transcription followed, and various aspects of each response, were coded to closest matching node;

iii. *Generating initial themes:* During this phase the broader themes occur therefore, an initial identification of themes is applied. Themes are described as patterns that are significant in the data and or research question. In this study, the researcher identified similar data in the groupings set out in phase number two and initial themes were generated;

iv. *Review themes:* During this phase, the themes generated in phase three are reviewed. Themes should be clear and different from each other. To generate better themes, a researcher has to consider whether the themes make sense, and whether there are sub-themes within the data. At this time, the researcher uses highlighters to identify the themes that worked in the context of the entire data set. In this study, the researcher reviewed the themes and interrogated the validity by the coded data that generated the themes. Subsequently, subthemes were identified, validated and created from the coded data;

v. *Defining and naming themes:* This phase identifies the essence of what each theme is about. The main aim is to determine what each theme represents, and, if there are sub-themes, how do they relate to the main theme? In this study, the researcher, after careful analysis, generated appropriate names for each theme and sub-theme and

vi. *Writing up the report:* The final phase entails the explanation of data once the themes have been analysed, concluded and ready for producing the final report, which is often a journal article or dissertation. In this study, the researcher extracted the key elements of each theme and sub-theme and integrated the themes into a coherent narrative, by providing illustrative examples or quotes from the participants' responses to support each theme. The findings were presented in a structured and meaningful manner, using figures, tables and graphs, considering the research questions and objectives.

Arising from the coded data, word clouds were generated separately for the converter/brand-owner and the metal recycler, to determine high level comparison and contrasts.

6.5.1 Word cloud – converter/brand-owners

Figure 6.7 reflects the key words, by frequency, arising from the interviews with the converter/brand-owners.

Figure 6.7: Word cloud - converter/brand-owner

Source: NVivo version 12

6.5.2 Word cloud – metal recyclers

Figure 6.8 reflects the key words, by frequency, arising from the interviews with the metal recyclers.

Figure 6.8: Word cloud - metal recyclers

Source: NVivo version 12

Analysing the word clouds for both the converter/brand-owner and the metal recycler the following points are pertinent:

i. The predominant words arising from the converter/brand-owner interviews were metal, packaging, recovery model, consumer, circular, waste, recycling, collection, sustainability, model and brand.

ii. The predominant words arising from the metal recycler interviews were metal recovery, energy management, operations, efficiency, processing, environmental compliance, waste, and recycling.

It is clear that both the converter/brand-owner and the metal recycler have a common interest in metal recovery and recycling, supporting a metal packaging circular economy.

The focal areas for the converter/brand-owner are packaging recovery models and environmental sustainability, whereas the focal areas for the metal recycler are processing efficiency, energy management and environmental compliance.

Moreover, the predominant words arising from the SLR were aluminium, steel, recycling, recovery, process, waste to energy, melting, circular, sustainable, DRS, system, carbon reduction, efficiency and emission and these words again complemented the word cloud derived from the converter/brand-owners, as well as the metal recyclers, demonstrating a clear triangulation of ideas within the SLR data, the converter/brand-owner and metal recycler study group data.

These observations created a platform for the thematic analysis that followed.

Arising from the data that was coded into NVivo, five main themes were identified, in alignment with the themes derived from the SLR.

Table 6.3 presents the themes and subthemes that emerged from the SLR, reinforced by the data arising out of the thematic analyses that was conducted on NVivo version 12, showing the alignment with the research questions.

Table 6.3: Themes and subthemes emerging from the thematic analysis

Research Question	Theme number and description	Subtheme number and description
1	*01* *Global best practices related to post-consumer metal packaging recovery*	1.1 Circular economy
		1.2 Global benchmarking
		1.3 Global participation
		1.4 Sustainable development goals
		1.5 Fourth Industrial Revolution
2	*02* *Effectiveness of the SA post-consumer metal packaging recovery system*	2.1 Recovery mechanism
		2.2 Recovery percentage
		2.3 Recovery reliability and sustainability
3	*03* *Accuracy and reliability of existing post-consumer metal packaging recovery system data*	3.1 Data source
		3.2 Confidence level
		3.3 Challenges
4	*04* *Commitment to post-consumer metal packaging recovery*	4.1 Triple bottom line
		4.4 Legislation
5	*05* *Alternate post-consumer metal packaging recovery system*	5.1 Potential to increase community engagement
		5.2 Potential to increase recovery
		5.3 Potential for transformation and job creation

Source: Researcher's own construction

In support of the discussion on the emerging 5 themes and 16 subthemes, relevant quotes from the data generated from the interviews were used. Data from the semi-structured interviews was transcribed verbatim, and used as such, during the discussion of the results.

The names of participants and organisations have been coded to ensure anonymity, supporting the Protection of Personal Information Act, (POPIA), Act No. 4 of 2013.

Table 6.4 presents the converter/brand-owner participant code and the corresponding job designation.

Table 6.4: Coded converter/brand-owner participants

Participant code	Job designation
CB01	Logistics Manager
CB02	Sustainability Head
CB03	Sustainability Director
CB04	Sustainability Director
CB05	Procurement Manager
CB06	Operations Director
CB07	Operations Director
CB08	Sustainability Director
CB09	Packaging Technical Director
CB10	Procurement Manager
CB11	Sustainability Manager
CB12	General Manager
CB13	Procurement Manager
CB14	Sustainability Manager
CB15	Legal Officer
CB16	Procurement Director
CB17	General Manager
CB18	Managing Director

Source: Researcher's own construction

Table 6.5 presents the metal recycler participant code, the corresponding job designation.

Table 6.5: Coded metal recycler participants

Participant code	Job designation
MR01	Technical Director
MR02	Technical Director
MR03	General Manager
MR04	Managing Director
MR05	General Manager
MR06	General Manager
MR07	Operations Director
MR08	General Manager
MR09	General Manager
MR10	General Manager
MR11	Managing Director
MR12	Managing Director
MR13	General Manager
MR14	General Manager
MR15	Managing Director
MR16	General Manager
MR17	Managing Director
MR18	Managing Director

Source: Researcher's own construction

Each of the five themes and 16 subthemes reflected in table 6.3 are discussed in the next section of this chapter.

It must be noted that the bar charts presented under the specified subthemes should be interpreted as depicting the frequency of coding for participant responses related to that subtheme. Unlike a Likert scale, which typically represents a ranked perception or agreement level, these charts focus on the occurrence of specific codes within the given subtheme. Each bar's height indicates how often a particular code or response was mentioned by participants, offering insights into the prevalence or recurrence of certain themes within the context of the subtheme. This approach provides a qualitative understanding of the data, highlighting patterns and emphasising the frequency of certain perspectives or issues raised by the participants, without assigning a quantitative ranking to those responses.

6.5.3 Theme 01: Global best practices related to post-consumer metal packaging recovery

As stated by Adewale (2020: 19), the term "global best practices" denotes specific methods, techniques, mechanisms, and practices that have been thoroughly examined and proven to yield successful outcomes on a global scale. These practices are those that have demonstrated effectiveness worldwide and, consequently, can be regarded as exemplary models and templates, setting benchmarks for others to replicate.

Figure 6.9 presents the project map for Theme 01 on global best practices related to post-consumer metal packaging recovery.

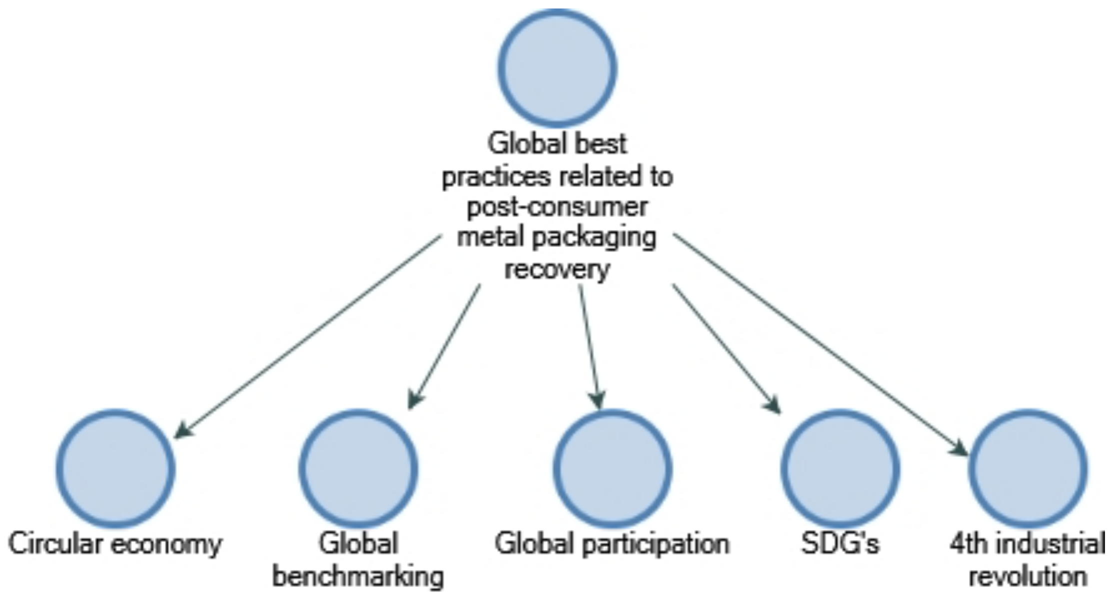


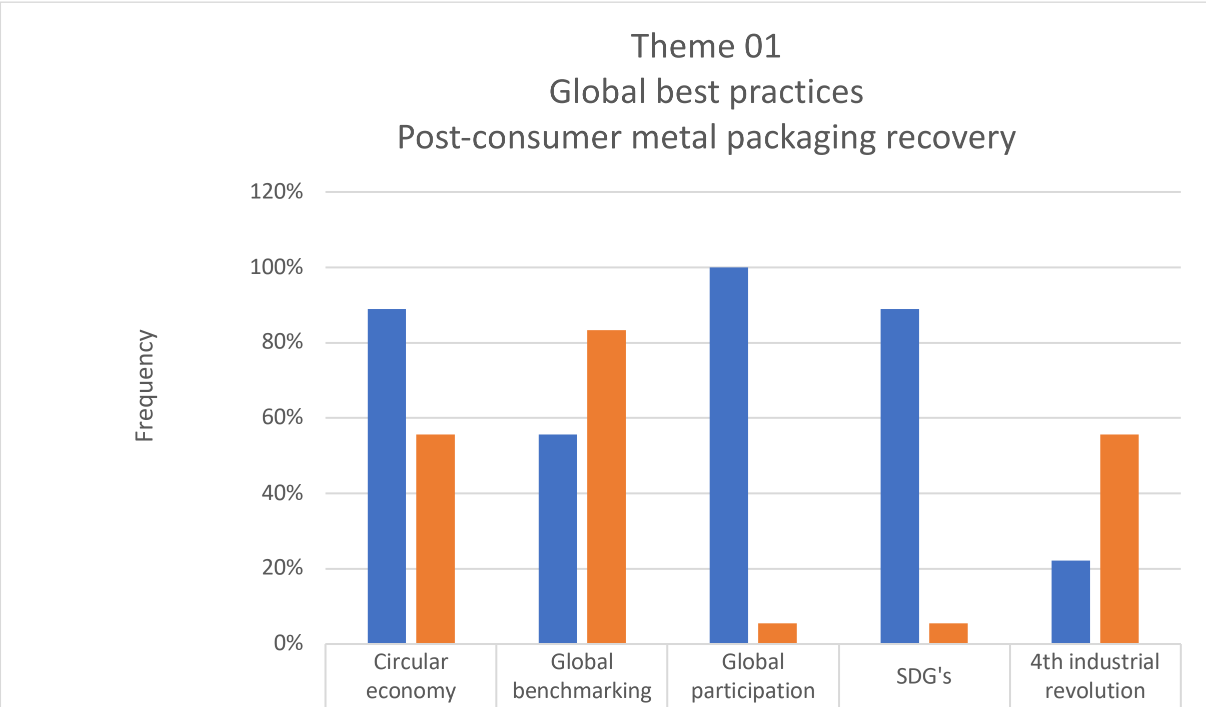
Figure 6.9: Theme 01 - Project map

Source: Construction by NVivo version 12

Theme 01 related to global best practices relating to post-consumer metal packaging recovery. Supporting this main theme were five subthemes each arising from the coded data in NVivo, as illustrated in figure 6.9.

6.10 presents the cross tabulation for Theme 01 on global best practices related to post-consumer metal packaging recovery.

It must be noted that the following subtheme bar chart illustrates the frequency of the coding of participant responses against a subtheme and not a ranked perception of the subthemes that is typical of a Likert scale.



	Circular economy	Global benchmarking	Global participation	SDG's	4th industrial revolution
Converter / brand-owner	88.89%	55.56%	100.00%	88.89%	22.22%
Metal recycler	55.56%	83.33%	5.56%	5.56%	55.56%

Figure 6.10: Theme 01 – Cross tabulation

Source: Researcher's own construction

The following sections focus on each of the five sub-themes identified within Theme 01, as depicted in the project map, 6.9. These sections explored the focal points, delved into the perspectives of the participants, and included, where required, relevant excerpts from the interviews conducted, to underscore inferences.

6.5.3.1 Theme 01 Subtheme 1.1: Circular economy

6.10 indicates that 88.89% of the converter/brand-owners made reference to circular economy as opposed to 55.6% of the metal recyclers, inferring that CE principles were driving the converter/brand-owner businesses to a greater extent.

The key CE ideas that arose from the converter/brand-owner interviews were related to forward thinking in business continuity, smart manufacturing, resource efficiency, KPI measurements, SDGs and it was clear that converter/brand-owner commitment to circularity underpinned the converter/brand-owner business principles.

The following statement by participant CB06, is indicative of this inference:

> "*The circular economy has become a part of the organisation's DNA, driving every functional area within the business towards achieving our annual sustainable development goals".*

Nonetheless the principles of CE were also embraced by the metal recyclers but more so within the manufacturing optimisation and energy utilisation areas of the business.

DNA refers to deoxy-ribonucleic acid, and is irrelevant to this study.

It was apparent during the interviews that the metal recyclers' greater focus was on process optimisation. Participant MR02 stated:

> *"Inventiveness is essential. In an effort to recover and process metal more effectively, we actively invest in and investigate alternative approaches. This entails adopting circular economy ideas and embracing technology breakthroughs, supported by chasing SDGs, measured through formal KPI's".*

6.5.3.2 Theme 01 Subtheme 1.2: Global benchmarking

The concept of global benchmarking, on the other hand, received greater attention from the metal recyclers. 6.10 reflects that 83.83% of the metal recyclers made reference to benchmarking, and it was apparent from the interviews, that benchmarking was of great importance to them, given that operationally they need to ensure that they are exploiting global best practices in metal re-melting and recovery.

Process optimisation and process efficiency remain key drivers in the global metal recovery space.

6.10 also indicated that 55.56% of the converter/brand-owners spoke of global benchmarking, and although this is a lower percentage in comparison with metal recyclers, this reflects a significant intent.

On this point, participant CB09 stated that:

> *"Nestle SA is driven by Nestle Switzerland's global benchmarks, committing to 100% renewable energy by 2025".*

6.5.3.3 Theme 01 Subtheme 1.3: Global participation

Figure 6.10 reflects that 100% of the converter/brand-owner named several other countries as examples of mature participation in CE principles and EPR systems, whereas only 5.56% of the metal recyclers made reference to global participation related to CE and EPR. This is understandable as the brand-owners in SA are global players and are acutely aware of global best practices, in a competitive TBL environment, as opposed to the recyclers who were all SA based businesses that have grown organically as a result of the need to recycle and recover used metal for local and export markets.

6.5.3.4 Theme 01 Subtheme 1.4: Sustainable development goals

A similar pattern to Theme 01 Subtheme 1.3 (global participation) can be seen in figure 6.10 for SDGs. 88.89% of the converter/brand-owner participants made reference to SDGs whilst only 5.56% of the metal recyclers referenced SDGs. Again the converter/brand-owners, given their global presence, are active with respect to committing to SDGs, whilst local metal recyclers focus on compliance with SA legislation.

6.5.3.5 Theme 01 Subtheme 1.5: Fourth Industrial revolution

With reference to figure 6.10, the fourth industrial revolution (4IR) and its influence on the recycler was clearly significant, given the need to stay abreast with global information technology, as well as supporting technical infrastructure that is needed to enhance metal collection, recycling, and re-melting.

Although 4IR technology is also crucial to the converter/brand-owner, 4IR contribution emerged as of greater importance to the metal recycling sector. This can be attributed to 4IR application in the use of the following areas within metal recycler operations (Baque-Cantos *et al.* 2023: 61; Khan, Ahmad and Majava 2023: 8; Manabe, Miyata and Ohnuki 2019: 328).

i. advanced metallurgical laboratory equipment and testing;
ii. advanced information technology (IT) systems;
iii. the use of re-melting furnaces operating at 660^0 Celsius;
iv. process losses of re-melted material,
v. carbon footprint management and greenhouse gas emissions.

The converter/brand-owner adopts 4IR technology to enhance manufacturing processes, support the D4R principles that ultimately enhances metal recovery.

6.5.4 Theme 02: Effectiveness of the SA post-consumer metal packaging recovery system.

The effectiveness of the South African post-consumer metal packaging recovery system relies on a combination of key elements. This includes the accessibility and efficiency of collection infrastructure, active participation of informal waste pickers, support from the public, through education campaigns, advanced sorting and separation technologies, well-equipped recycling facilities capable of processing recovered materials, supportive government policies and regulations, collaboration among stakeholders, and a strong market demand for recycled metals (Godfrey 2021: 3; Council for Scientific and Industrial Research 2017: i).

Success is ultimately measured not only in the quantity of metal packaging recovered in SA, but also in the positive environmental impact achieved through reduced energy consumption, lower emissions, and conservation of natural resources (Godfrey 2021: 3; Howells 2022: 1).

Figure 6.11 presents the project map for Theme 02 on the effectiveness of the SA post-consumer metal packaging recovery system.

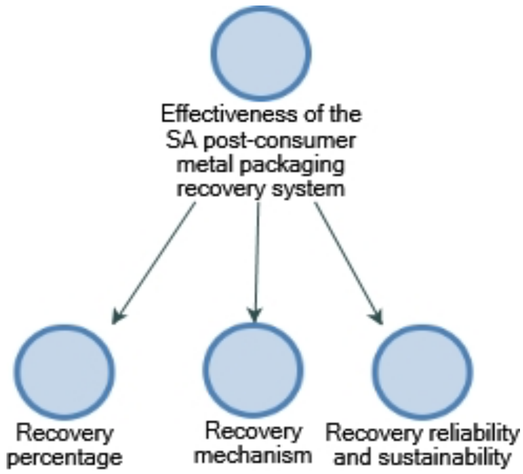
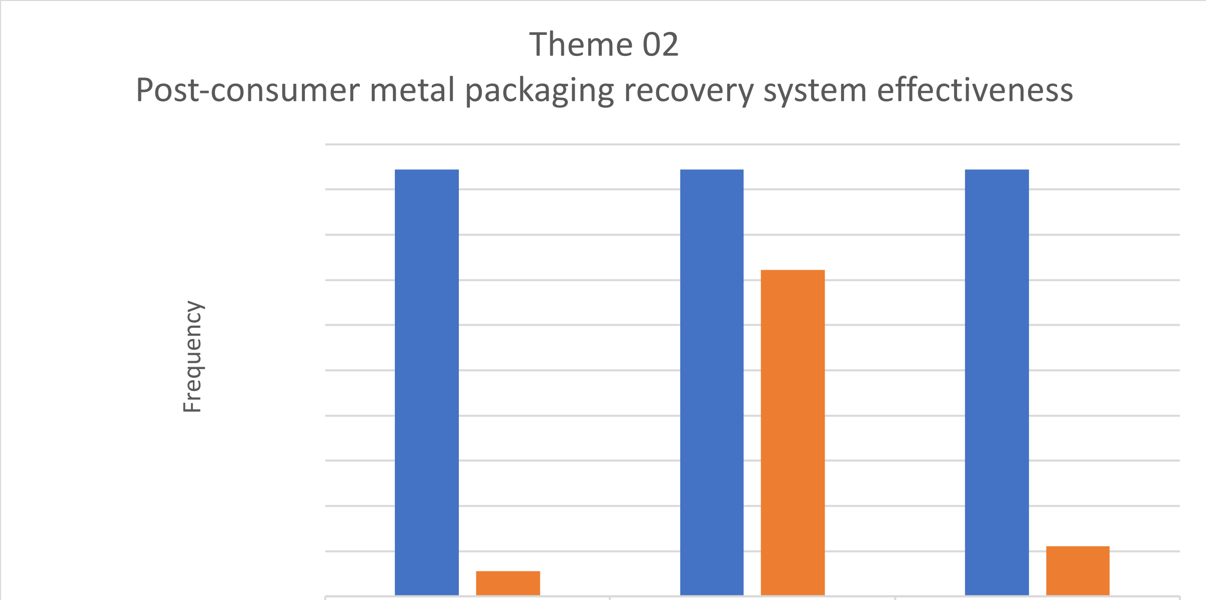


Figure 6.11: Theme 02 – Project map
Source: Construction by NVivo version 12

Figure 6.12 presents the cross tabulation for Theme 02 on the effectiveness of the SA post-consumer metal packaging recovery system.

It must be noted that the following subtheme bar chart illustrates the frequency of the coding of participant responses against a subtheme and not a ranked perception of the subthemes that is typical of a Likert scale.



	Recovery percentage	Recovery mechanism	Recovery reliability and sustainability
Converter / brand-owner	94.44%	94.44%	94.44%
Metal recycler	5.56%	72.22%	11.11%

Figure 6.12: Theme 02 – Cross tabulation

Source: Researcher's own construction

The following sections focus on each of the sub-themes identified within Theme 02, as depicted in the project map, figure 6.11. These sections explored the focal points, delved into the perspectives of the participants, and included, where required, relevant excerpts from the interviews conducted, to underscore inferences.

6.5.4.1 Theme 02 Subtheme 2.1: Recovery percentage

As illustrated in figure 6.12 it is evident that the focus on post-consumer metal packaging recovery statistics (at 94.44%) is higher amongst the converter/brand-owners than it is amongst the metal recyclers (5.56%). This is very likely as a result of the recent EPR legislation, gazetted in May 2021, that has brought significant pressure on the packaging industry, driving the metal packaging sector to ensure that post-consumer metal packaging recovery rates are measured through the metal packaging PRO, MetPac-SA (Muller 2020: 209).

To the contrary, arising out of the recycler interviews, it was clear that the metal recyclers recycle all used metal in SA, not just metal packaging, so this is not a significant measurement for recyclers.

6.5.4.2 Theme 02 Subtheme 2.2: Recovery mechanism

Metal recovery mechanisms were referenced by 94.44% of the converter/brand-owners and by 72.22% of the metal recyclers. Both sets of participants showed an interest in metal recovery systems, but from opposing vantage points.

During the interviews it was observed by the researcher that, from the convertor/brand-owner perspective, post-consumer metal packaging recovery is crucial to demonstrate EPR legislation obligations, whereas metal recovery to the metal recycler is vital as this the main raw material into their processes of metal re-melting and refining for alternate re-use applications.

Several convertor/brand-owners noted, during the interviews, that the post-consumer metal packaging recovery was reliant on the informal, waste pickers across SA, a system that was driven by unemployment, the intrinsic value of metal, coupled with other prevailing economic circumstances in SA, as opposed to a well-defined, synchronised model supporting post-consumer metal packaging recovery.

According to CB03:

> "*The recovery of metal packaging predominantly involves both formal entities and, to a significant extent, informal waste pickers who are actively participating in recovering this packaging".*

The metal recyclers require end-of-life metal to increase throughput within their operations.

Participant MR15 stated:

> "*Every individual member of the Metal Recycling Association SA, will develop their own systems to maximise yields and minimise waste, remember they are all profit generating businesses. Generally recovery yields and waste management plans, which form part of our quarterly member meeting agenda, are reviewed at these meetings"*.

6.5.4.3 Theme 02 Subtheme 2.3: Recovery data reliability and sustainability

Under this subtheme, 94.44% of the convertors/brand-owners were vocal on this area with just 11.11% of the metal recyclers expressing their views. It appears that this differential is due to the fact that the convertor/brand-owners are obligated to demonstrate metal packaging EPR compliance, whereas the metal recyclers do not fall within the ambit of the metal packaging EPR legislation and are therefore not reliant on metal packaging recovery system data (South Africa. Department of Forestry, Fisheries and Environment 2020: 7).

In support of this notion, participant MR10 stated:

> "*With respect to metal packaging, while this system functions pretty well, its success relies on the presence and co-operation of these waste pickers, scrap metal dealers and buy back centres, and if these entities could be more synergised, there would be more metal collected".*

Hence a synchronised, post-consumer metal packaging recovery model will support the converter/brand-owner quest for metal packaging EPR compliance, whilst the metal recycler yields will increase, making such a model mutually beneficial.

6.5.5 Theme 03: Accuracy and reliability of existing post-consumer metal packaging recovery system data

The accuracy and reliability of data within existing post-consumer metal packaging recovery systems are contingent on various factors such as the robustness of data collection methods, adherence to standardised reporting protocols, transparent documentation of methodologies, and the use of rigorous quality control (Griffiths and Stringer 2016: 16). Regular verification through independent audits and cross-verification with other reliable sources further enhance data accuracy (Somlai, Bullock, and Gallagher 2023: 4).

A comprehensive evaluation of these factors is crucial for stakeholders to have confidence in the accuracy of post-consumer metal packaging recovery system data, enabling informed decision-making and policy formulation (Somlai, Bullock, and Gallagher 2023: 2).

Figure 6.13 presents the project map for Theme 03 on the accuracy and reliability of existing post-consumer metal packaging recovery system data.

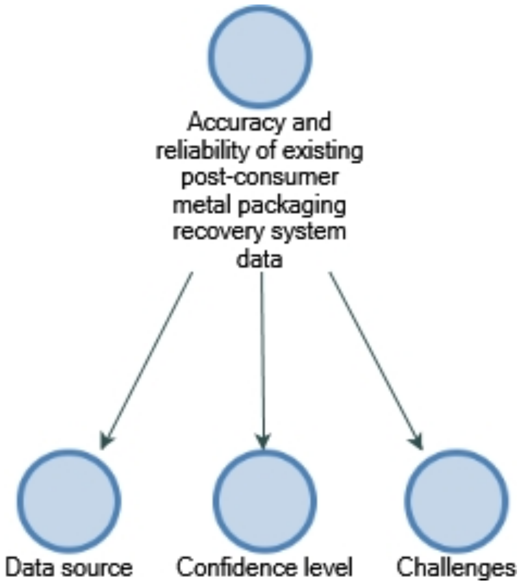


Figure 6.13: Theme 03 – Project map
Source: Construction by NVivo version 12

Figure 6.14 presents the cross tabulation for Theme 03 on the accuracy and reliability of existing post-consumer metal packaging recovery system data.

It must be noted that the following subtheme bar chart illustrates the frequency of the coding of participant responses against a subtheme and not a ranked perception of the subthemes that is typical of a Likert scale.

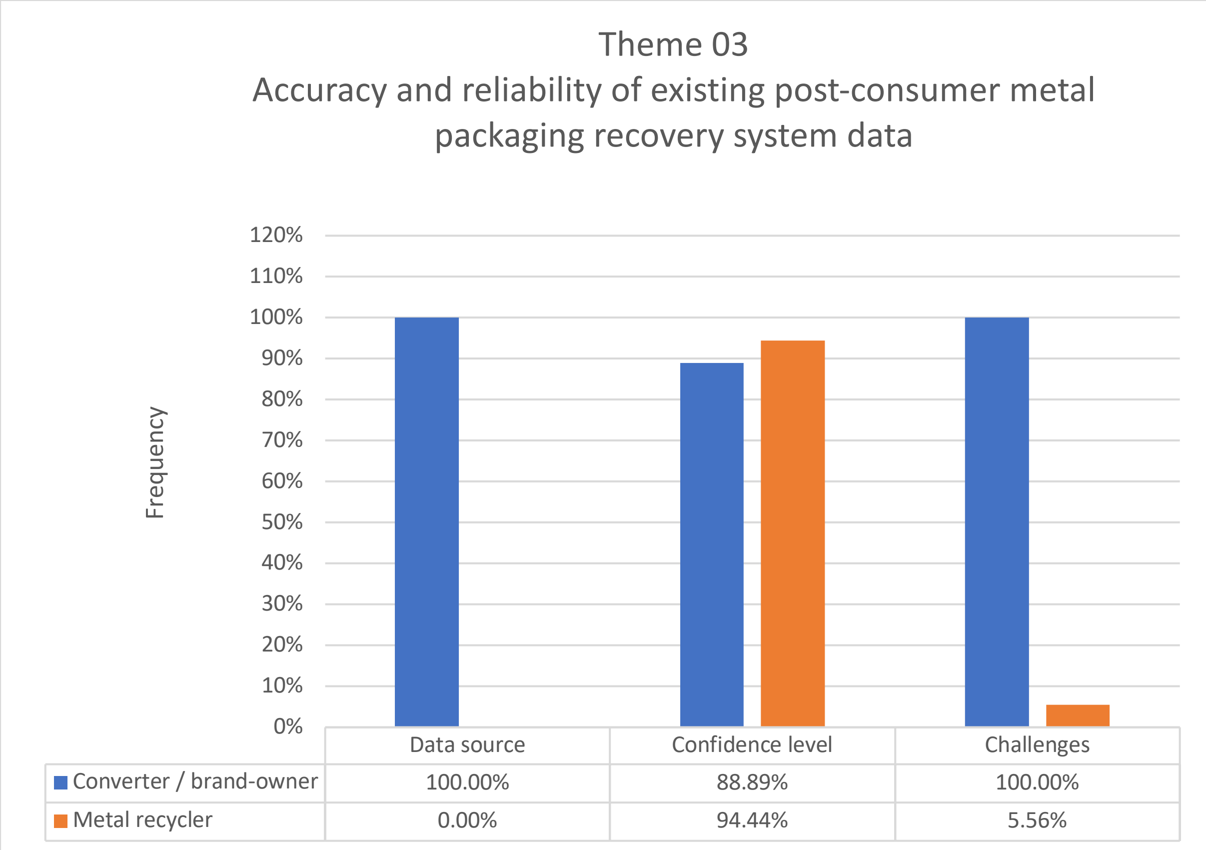


Figure 6.14: Theme 03 – Cross tabulation

Researcher's own construction

The following sections focus on each of the sub-themes identified within Theme 03, as depicted in the project map, figure 6.13. These sections explored the focal points, delved into the perspectives of the participants, and included, where required, relevant excerpts from the interviews conducted, to underscore inferences.

6.5.5.1 Theme 03 Subtheme 3.1: Data source

100% of the converter/brand-owners indicated that their source of post-consumer metal packaging recovery statistics is either MetPac-SA or BMi Research.

The annual post-consumer metal packaging recovery percentage is the total annual tonnage of metal packaging recovered by the metal recyclers, against the total annual tonnage of metal packaging placed on the SA market by converters/brand-owners (Godfrey 2021: 3).

Considering the recent EPR legislative obligations, it is clear that the converter/brand-owners have a greater interest in data source and post-consumer metal packaging recovery rates.

Given that the metal recyclers are the source of the recovery data, this explains why there is no reference to data source amongst the metal recyclers.

6.5.5.2 Theme 03 Subtheme 3.2: Data confidence level

Both the converter/brand-owners as well as the metal recyclers had similar vocal frequencies on this subject, generally expressing low levels of confidence in post-consumer metal packaging recovery statistics in SA, because of the lack of complete data and / or the potential of multiple counting of recovered packaging data by multiple streams of stakeholders such as buy back centres, material recovery facilities (MRF's), recyclers and re-melters.

A typical converter/brand-owner participant, (CB04), response on this aspect was:

> *"From the numbers I've seen, it seems like they aren't really high, I think a lot of waste metal packaging data doesn't reach us. I think that there is quite a lot of data that we are not seeing, which then means that the recovery statistics are not very accurate, and then there is the issues of double counting of data where the same data is seen at multiple catchment points in the value chain".*

A typical metal recycler participant, (MR17), response on this aspect was:

> "*Ensuring data accuracy and transparency in our metal supply chain is a top priority. We maintain meticulous records and employ robust verification methods to trace the sources of scrap metal and raw materials, ensuring transparency and reliability in our supply chain management. This is a legal requirement and we are often audited by the police. This prevents the theft of South African infrastructure".*

Hence, the dynamics between the metal recycler and the converter/brand-owner revolve around distinct vantage points, with the metal recycler primarily focused on yields and the converter/brand-owner emphasising EPR compliance.

From the interviews it became apparent that, for the metal recycler, the key metric is maximising yields, signifying the efficiency and effectiveness of the recycling process in extracting valuable metals from post-consumer packaging. This involves optimising collection, sorting, and processing techniques to enhance the overall recovery of metals.

On the other hand, the converter/brand-owners clearly demonstrated a significant emphasis on EPR compliance, reflecting their responsibility for the entire life cycle of the product, including its disposal. Meeting EPR obligations entails implementing sustainable practices, adhering to recycling regulations, and ensuring that the packaging materials are environmentally friendly.

The researcher finally notes that balancing these perspectives is crucial for creating a sustainable and mutually beneficial partnership that aligns with both economic and environmental objectives.

6.5.5.3 Theme 03 Subtheme 3.3: Challenges

Considering the recent EPR legislative obligations, it is clear that the converter/brand-owners have a greater interest relating to data integrity and post-consumer metal packaging recovery rates.

Double counting of data within the metal packaging recovery value chain is unavoidable.

Given that the metal recyclers are the source of the recovery data, this explains why there is not a significant reference to data challenges amongst the metal recyclers.

A view of a metal recycler, MR13 was:

> *"If the metal recovery model included separation-at-source and collection systems that were less dependent on informal, unemployed waste pickers in SA, there would be greater metal volumes recovered".*

6.5.6 Theme 04: Commitment to post-consumer metal packaging recovery

Figure 6.15 presents the project map for Theme 04 on the commitment to post-consumer metal packaging recovery.

The commitment to post-consumer metal packaging recovery involves a dedicated promise by individuals, businesses, and organisations to actively participate in recycling efforts focused on metal packaging that has been used by consumers and discarded (Krishnan *et al*. 2021: 1).

This commitment signifies a recognition of the environmental benefits, waste reduction, and contributions to a circular economy that result from diverting metal packaging from landfills (Didenko, Klochkov and Skripnuk 2018: 2).

By supporting the recovery process, stakeholders aim to minimise the environmental impact of metal production, conserve resources, and promote a sustainable approach to managing post-consumer waste. This commitment aligns with broader sustainability goals, corporate social responsibility initiatives, and the promotion of environmentally responsible practices (Didenko, Klochkov and Skripnuk 2018: 2).

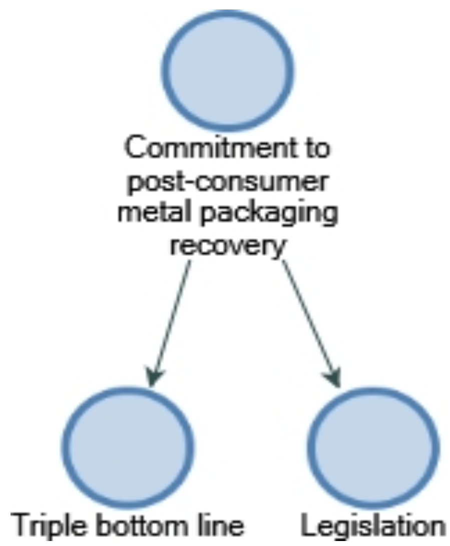


Figure 6.15: Theme 04 – Project map
Source: Construction by NVivo version 12

Figure 6.16 presents the cross tabulation for Theme 04 on the commitment to post-consumer metal packaging recovery. It must be noted that the following subtheme bar chart illustrates the frequency of the coding of participant responses against a subtheme and not a ranked perception of the subthemes that is typical of a Likert scale.

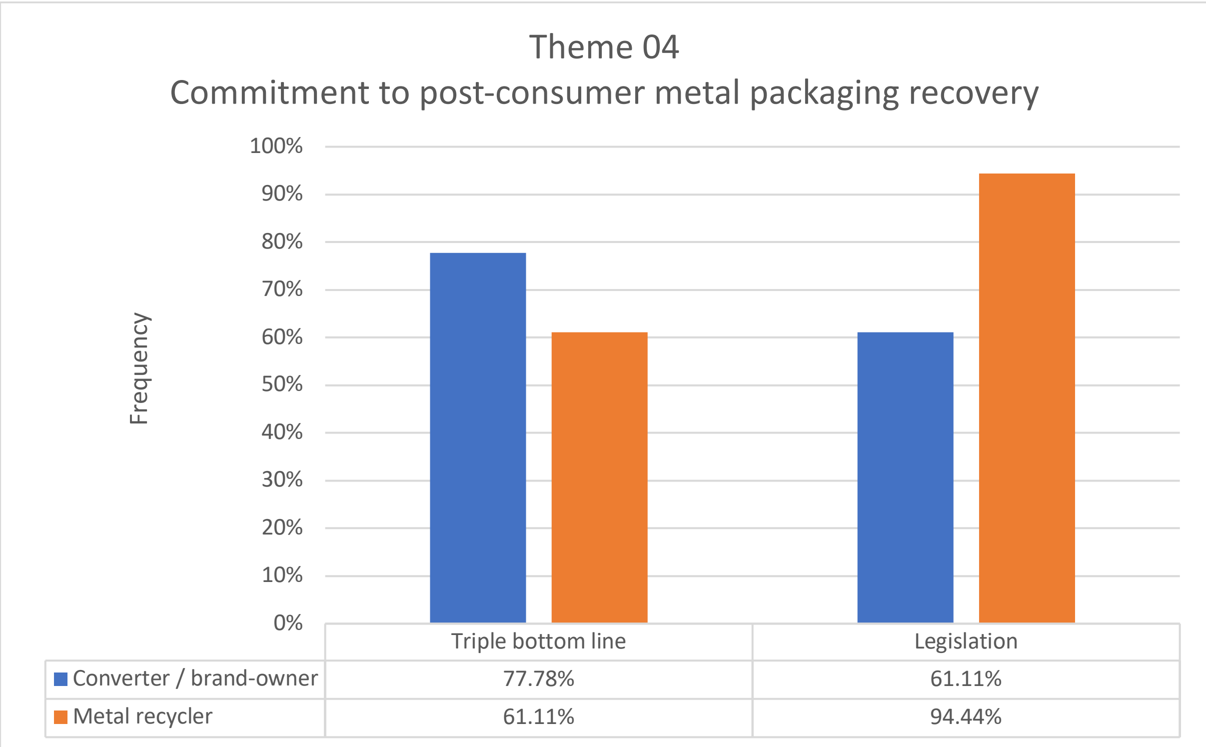


Figure 6.16: Theme 04 - Cross tabulation

Source: Researcher's own construction

The following sections focus on each of the sub-themes identified within Theme 04, as depicted in the project map, figure 6.15 These sections explored the focal points, delved into the perspectives of the participants, and included, where required, relevant excerpts from the interviews conducted, to underscore inferences.

6.5.6.1 Theme 04 Subtheme 4.1: Triple bottom line

Figure 6.16 indicates that 77.78% of the converter/brand-owners were coded by discussion on TBL whilst 61.11% of the metal recyclers were coded on this topic.

It was evident from interviews with both converter/brand-owners and metal recyclers that there was a strong appreciation for the principles embedded in TBL, that both parties have integrated CE strategies within their businesses. Specific SDGs and targets related to the environment were discussed by multiple converter/brand-owners who shared examples of annual sustainability development reports which covered energy conservation protocols, carbon footprint reduction, net zero emissions, waste to energy, design for recycling amongst others.

Specific SDGs and targets related to social and economic equity were also discussed, demonstrating a practical balanced approach to addressing people, planet and profit against a sustainable future.

A converter/brand-owner participant, CB02, proudly shared the following:

> *"Our organisation has been more than just about profit, we're into John Elkington's "triple bottom line." It's not some fancy maths, but a way of doing business that takes into account three key things: people, planet, and profit, ensuring business continuity".*

One of the metal recycler participants (MR17) had the following to say:

> *"We've implemented various initiatives and technologies to enhance energy efficiency in our metal recycling and foundry processes. Investments in energy-efficient equipment and process optimisations underscore our commitment to reducing energy consumption and associated costs, aligning with a TBL approach".*

Hence it is evident that both parties demonstrate a practical commitment to integrating a TBL approach within their businesses.

6.5.6.2 Theme 04 Subtheme 4.2: Legislation

During the interviews it was apparent that there was a strong awareness of the legislative compliance obligations of S18 of NEMWA (EPR legislation), more so with the converter/brand-owners, than with the metal recyclers, and this is very likely because the EPR legislation does not pertain directly to the metal recyclers; notwithstanding, the interviews confirmed the metal recycler support of EPR legislation in SA.

A converter/brand-owner participant, CB01, emphasised the following, during the interview:

> *"We have been closely following the development of the NEMWA, S18 based gazettes, as well as the final dates of release, which was when they became mandatory, and at Rhodes Food Group, we are fully compliant with S18 requirements".*

Demonstrating his commitment to SA legislation, a metal recycler participant, MR10, shared the following point:

> *"South Africans generate an estimated 350 kg of waste packaging per person each year. When our Collect-a-Can recycling business began 31 years ago, there was no unified EPR legislation on waste management in SA. Since then, government has given much thought and in May 2021, the new EPR gazettes have made EPR mandatory in SA".*

6.5.7 Theme 05: Alternate post-consumer metal packaging recovery system

Figure 6.17 presents the project map for Theme 05 on alternate post-consumer metal packaging recovery system.

Govindan and Hasanagic (2018: 307) assert that a post-consumer metal packaging recovery system involves the synchronised collection, processing, recycling and recovery of metal packaging that has been used by consumers and subsequently discarded.

This system aims to divert metal packaging waste from landfills and incineration, focusing instead on reclaiming valuable materials such as aluminium and steel for re-use in manufacturing (Govindan and Hasanagic 2018: 307).

The process typically includes the collection of discarded metal packaging from households, businesses, and recycling centres, followed by sorting, cleaning, and processing to prepare the materials for remanufacturing. Implementing an effective post-consumer metal packaging recovery system is crucial for reducing environmental impact, conserving resources, and fostering a circular economy where metals are continuously recycled, contributing to sustainable waste management practices and overall environmental stewardship (Didenko, Klochkov and Skripnuk 2018: 2).

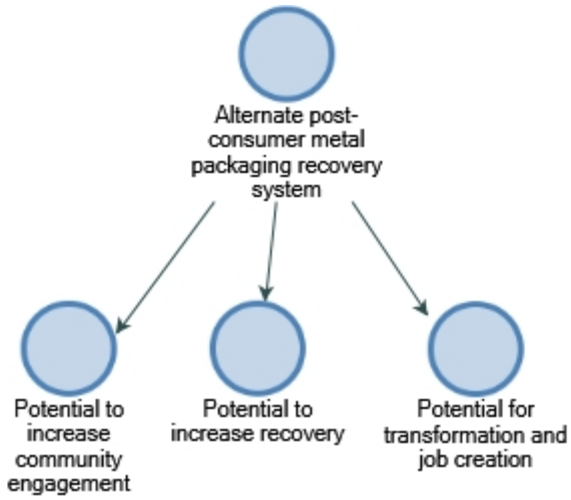


Figure 6.17: Theme 05 - Project map

Source: Construction by NVivo version 12

Figure 6.18 presents the cross tabulation for Theme 05 on the alternate post-consumer metal packaging recovery system.

It must be noted that the following subtheme bar chart illustrates the frequency of the coding of participant responses against a subtheme and not a ranked perception of the subthemes that is typical of a Likert scale.

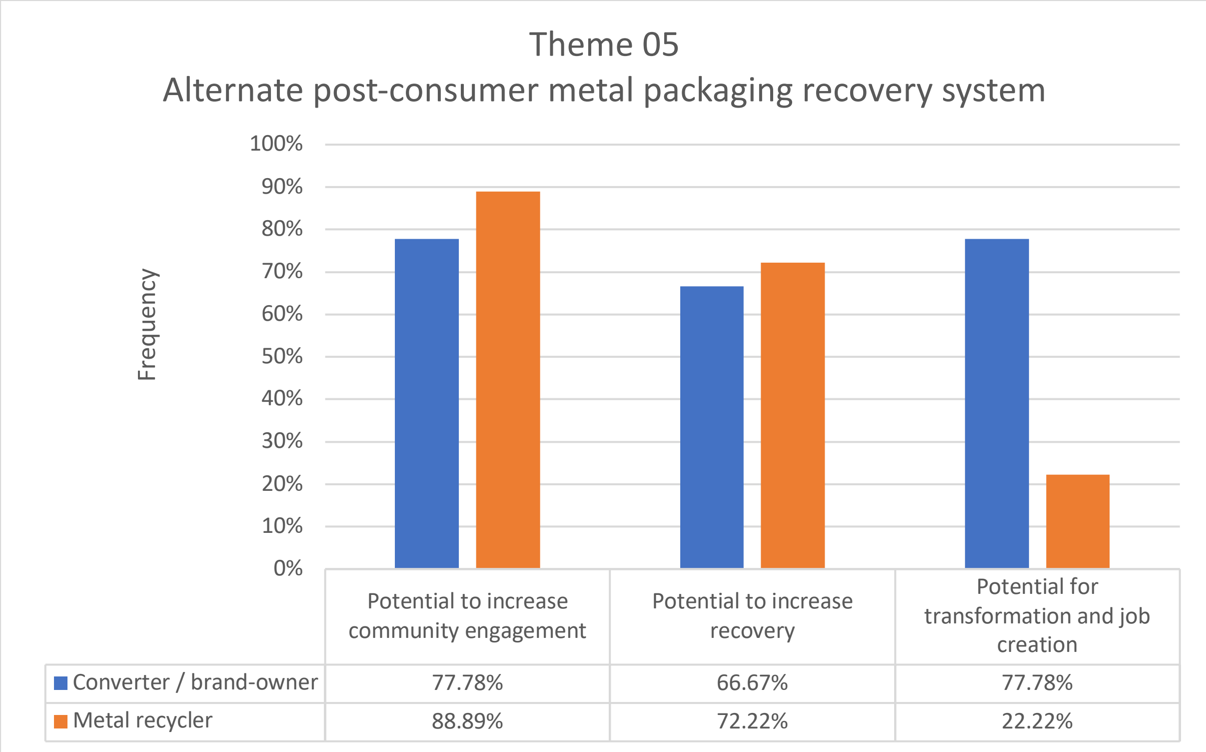


Figure 6.18: Theme 05 – Cross tabulation

Source: Researcher's own construction

The following sections focus on each of the sub-themes identified within Theme 05, as depicted in the project map, figure 6.17. These sections explored the focal points, delved into the perspectives of the participants, and included, where required, relevant excerpts from the interviews conducted, to underscore inferences.

6.5.7.1 Theme 05 Subtheme 5.1: Potential to increase community engagement.

Figure 6.18 indicates that 77.78% of converter/brand-owners voiced ideas on increasing community engagement in post-consumer metal packaging recovery, whilst 88.89% of the metal recyclers also voiced opinions on the same subtheme, inferring that both parties are aligned with respect to increasing metal recovery through an increased community engagement.

Converter/brand-owner, CB03, made the following statement on this subtheme:

> *"So, the bigger we go with recycling, the more chances for jobs, right? But, you got to have a solid plan to ensure that all the related parties are integrated. That's where a formal metal packaging recovery model*

kicks in. It's like organised chaos, but in a good way. Setting up such a formal metal packaging recovery model will help to spread the work smoothly engaging the different community stakeholders that operate within the recycling and waste management space".

6.5.7.2 Theme 05 Subtheme 5.2: Potential to increase recovery.

Figure 6.18 indicates that 66.67% of the converter/brand-owners, and 72.22% of the metal recyclers suggested the following noteworthy, practical ideas that will support an increased post-consumer metal packaging recovery rate:

i. Benchmarking against global best practices is necessary to design a post-consumer metal packaging recovery model;
ii. SA EPR compliance;
iii. Support the Paper and Packaging PRO Alliance objectives;
iv. Municipal collection system that require household separation-at-source, ensuring that wet waste is segregated from packaging waste, reducing cross contamination, yielding pristine packaging, enabling higher recovery rates;
v. Increasing community engagement will increase metal packaging recovery rate and create jobs enhancing local entrepreneurship;
vi. A DRS will potentially deliver greater recovery quantity as well as quality of used metal packaging, enabling higher re-melt yields, supporting a metal circular economy;
vii. Synchronisation of metal recovery subsystems is vital to enable circular supply chains that will hasten the return of used metal packaging, supporting a metal circular economy;
viii. Education and training is required for all post-consumer metal packaging recovery value chain stakeholders, to create awareness around sustainable development ideologies for business continuity.
ix. 4IR technology tools must be exploited to maximise the post-consumer metal packaging recovery rates;
x. The current EPR legislation must be used to sustainably drive the metal packaging recovery rates and

xi. D4R must be regulated as a pivotal discipline with the metal packaging industry to facilitate easier material recycling and recovery.

Converter/brand-owner (CB12) said:

> *"We believe that some new strategies, like 4IR technology and DRS systems, will increase metal recovery in South Africa. We, at Hulamin, installed a R30 million, state-of-the art aluminium recycling plant in our Pietermaritzburg operations around 6 years ago, with a capacity of 15 000 tons per annum to increase post-consumer aluminium packaging re-melting and recovery, aligning with CE principles".*

6.5.7.3 Theme 05 Subtheme 5.3: Potential for transformation and job creation

Figure 6.18 indicates that 77.78% of converter/brand-owners discussed ideas for transformation and job creation, by engaging women, youth and previously disadvantaged individuals, as well as the current waste-pickers, in entrepreneurial education, enabling Broad-based Black Economic Empowerment (BBBEE) in SA, supporting the element of human dignity, as embedded in SD principles.

6.6 Conclusion

In essence, the chapter delved into the data findings and outcomes, derived from the qualitative interview responses of two distinct participant groups namely, the converter/brand-owner and the metal recycler.

The qualitative interviews captured the perspectives of both the converter/brand-owner and the metal recycler regarding aspects related to the research questions. Moreover, the interview questions incorporated the six gaps identified in the SLR to enhance comprehension of the research problem.

This chapter drew upon the five main themes and sixteen subthemes elucidated in the SLR, discussed in Chapter Five, and identified the essential elements, arising out of the SLR and the qualitative analyses, that are required for the design and implementation of a post-consumer metal packaging recovery model.

Chapter Seven presents the summary of the findings and recommendations, facilitating the development of a practical model for post-consumer metal packaging recovery, including the costing of the proposed post-consumer metal packaging recovery model, and will provide a conclusion to this thesis.

CHAPTER SEVEN
SUMMARY OF FINDINGS RECOMMENDATIONS AND CONCLUSION

7.1 Introduction

This chapter presents the summary, emerging themes, recommendations, a proposed strategic post-consumer metal packaging recovery model for the SA packaging industry, including a thorough financial cost model, as well as a logical conclusion.

Such a metal packaging recovery model intends to enhance post-consumer metal packaging recovery rates, supporting a metal packaging circular economy in SA, in alignment with EPR legislation and SD principles.

7.2 Research objectives

The following objectives formed the basis of the research:

i. To ascertain the global best practices with respect to post-consumer metal packaging recovery models by conducting a systematic literature review.
ii. To evaluate the current South African post-consumer metal packaging recovery model against global best practice models by deploying two qualitative surveys.
iii. To determine the reliability of the current South African post-consumer metal packaging data acquisition and reporting systems by deploying two qualitative surveys.
iv. To determine the converter/brand-owner commitment to post consumer metal packaging recovery within SA by deploying two qualitative surveys.
v. To develop a sustainable model for the post-consumer metal packaging recovery system in SA, that supports job creation and transformation.

Each of the research objectives above was adequately examined through the execution of the SLR and the qualitative survey research instruments described in detail in Chapters Five and Six respectively.

7.3 Summary of key findings and recommendations

The following summary tables triangulate the findings arising from the SLR, the converter/brand-owner qualitative interview responses and the metal recycler qualitative interview responses, enabling a comprehensive and in-depth data comparison, aiding in the validation of research findings.

Triangulation plays a crucial role in validating data by cross-verifying information from multiple sources, as highlighted by Flick, Hirseland, and Hans (2018: 801) and Leavy (2017: 153).

According to Wilson (2016: 66), triangulation is the utilisation of multiple research methods to acquire more comprehensive and in-depth data, aiding in the validation of research findings.

Triangulation will be pointed out in discussions on the following tables, to demonstrate similar patterns or results, and to corroborate results, enhancing the reliability of the study.

7.3.1 Research question 1: *What are the global best practices relating to post-consumer metal packaging recovery?*

Theme 01 - Global best practices relating to post-consumer metal packaging recovery

7.3.1.1 Subtheme 1.1 - Circular economy

Table 7.1: Circular economy summary and triangulation of findings

Finding		
SLR	**Converter/brand-owner**	**Metal recycler**
Moving towards a CE requires well-defined and strong legislative measures and policies. These should be supported by essential performance indicators like Recovery Rates, Yield Rates, Percentage of Recycled Content, Waste-to-Energy, Life Cycle Assessment, and Energy Consumption.	The converter/brand-owner interviews revealed prominent CE concepts centred around forward-thinking approaches in business continuity, smart manufacturing, and resource efficiency. It was evident that the commitment of converters/brand-owners to circularity formed the foundational principles of their business.	Dedication to ingenuity is crucial. In the continuous endeavour to enhance metal recovery and processing, recyclers are proactively investing in and exploring alternative material recovery methods. This includes a commitment to adopting CE principles and integrating technological advancements. The pursuit of these objectives aligns with SDGs, and they assess their advancements through formal KPI's.

Source: Researcher's own construction

Recommendation

It is clear that CE is a concept that recurs amongst the output of the SLR and the two qualitative interviews, indicating a triangulation of the idea. CE requires the synchronised collaboration of all pre and post consumer packaging recovery stakeholders, however, the current EPR legislation is not inclusive of the buy-back centres, metal recyclers and metal re-melters. Therefore, it is recommended that the current EPR legislation, which is now in its third year of operation in SA, must be refined to address this deficiency, to enable an all inclusive and cohesive post-consumer metal packaging recovery system in support of CE.

Such refined and robust legislation, backed by crucial performance indicators, and effective systems, underpinned by 4IR technology, must be designed, implemented and entrenched by all related stakeholders to deliver a CE.

7.3.1.2 Subtheme 1.2 - Global benchmarking

Table 7.2: Global benchmarking summary and triangulation of findings

Finding		
SLR	**Converter/brand-owner**	**Metal recycler**
Prioritising both environmental and economic aspects during ISO 14001 implementation aligns with the principles of sustainable development and circular economies, thereby promoting a more balanced and resilient organisational strategy. It is essential to recognise the significance of distinguishing between symbolic and substantive ISO 14001 implementations to grasp their potential impact on overall organisational performance.	Benchmarking is supported because of the need to compete in an Industry 4.0 business environment.	Benchmarking is critical, given that operationally global best practices in metal re-melting and recovery is exploited. Process optimisation and process efficiency remain key drivers in the global metal recovery space.

Source: Researcher's own construction

Recommendation

The idea of benchmarking triangulates well within the SLR results and the results of the two qualitative interviews. To enhance organisational sustainability and competitiveness in an Industry 4.0 setting, it is recommended that an ISO 14001:2015 environmental management system, as a global benchmark, with appropriate SDGs and KPIs, must be designed, implemented and entrenched by packaging designers, converters, brand-owners, retailers, buy-back centres, recyclers and re-melters, as a foundation, to remain globally competitive.

7.3.1.3 Subtheme 1.3 - Global participation

Table 7.3: Global participation summary and triangulation of findings

Finding		
SLR	**Converter/brand-owner**	**Metal recycler**
Although the academic articles used in the SLR represented 39 countries, the South African practices related to metal packaging recovery were not forthcoming in the SLR.	Awareness of other countries as examples of mature participation in CE principles and EPR systems, were prolific.	Global participation knowledge of CE and EPR principles was less than that of the converter/brand-owner. Brand-owners in SA are global players, acutely aware of global best practices, whereas all recyclers are SA grown businesses arising from the need to recycle and recover used metal for local and export markets.

Source: Researcher's own construction

Recommendation

Converter/brand-owner and recyclers must constantly evaluate the South African metal recovery mechanism against global participation and global best practice to maximise post-consumer metal packaging recovery. It is clear from the SLR that SA has not significantly participated in technological advancements and sustainable development initiatives within the metal packaging recovery arena, and it is recommended that greater effort is directed to measurable process improvements, aligning with global best practices. This can be achieved by embracing the UN SDGs and other related global initiatives.

7.3.1.4 Subtheme 1.4 - SDGs

Table 7.4: SDGs summary and triangulation of findings

Finding		
SLR	**Converter/brand-owner**	**Metal recycler**
Measuring and reporting on SDGs are essential for tracking progress toward global sustainability. It provides a transparent framework to assess impacts, identify improvements, and ensure accountability, fostering collaboration and effective decision-making for shared global objectives.	Given their global presence, they are active with respect to committing to SDGs.	Local metal recyclers focus more on compliance with SA legislation.

Source: Researcher's own construction

Recommendation

Determining, measuring, tracking, actioning and reporting on SDGs are recommended to achieve metal packaging circularity. Sustainable development pillars must form the basis of strategy development and such SDG reporting must become available on organisation websites, public reports on environmental sustainability, management review minutes, AGMs and other such public domain platforms.

7.3.1.5 Subtheme 1.5 - 4th Industrial revolution

Table 7.5: 4th Industrial revolution summary and triangulation of findings

Finding		
SLR	**Converter/brand-owner**	**Metal recycler**
4IR is indispensable in advancing the circularity of metal packaging. Technologies like IoT and AI enable real-time monitoring, data-driven decision-making, and smart packaging solutions, enhancing the efficiency of metal recycling processes. This integration promotes sustainability, reduces waste, and facilitates a closed-loop system for continuous material reuse, marking a transformative shift from traditional linear production models.	4IR technology is applied to augment manufacturing processes supporting D4R principles that enhances metal recovery and recycling.	4IR and its influence on the recycler was clearly significant, given the need to stay abreast with global information technology, as well as supporting technical infrastructure that is needed to enhance metal collection, recycling, and re-melting.

Source: Researcher's own construction

Recommendation

It was evident that 4IR technology triangulated well across the SLR and qualitative analyses. To optimise metal packaging circularity, 4IR technologies like IoT and AI for real-time monitoring and smart packaging solutions are required. Implementing these advancements is recommended to support D4R principles, enhancing metal recovery and recycling processes, while staying aligned with global information technology trends.

7.3.2 Research question 2: *How effective is the post-consumer metal packaging recovery model in SA?*

Theme 02 – Effectiveness of the SA post-consumer metal packaging recovery

7.3.2.1 Subtheme 2.1 - Recovery percentage

Table 7.6: Recovery percentage summary and triangulation of findings

Finding		
SLR	**Converter/brand-owner**	**Metal recycler**
This information was not forthcoming from the SLR, given that it is unique to SA.	The focus on post-consumer metal packaging recovery statistics is higher amongst the converter/brand-owners than it is amongst the metal recyclers. This is very likely because of the recent EPR legislation, gazetted in May 2021, that has brought significant pressure on the packaging industry to measure metal packing recovery rates.	The metal recyclers recycle all used metal in SA, not just metal packaging, so this is not a significant measurement for recyclers.

Source: Researcher's own construction

Recommendation

It is recommended that metal packaging recovery statistics is acquired by the PRO from the metal packaging sector, both pre-consumer and post-consumer.

Converters and brand-owners must provide the data relating to metal packaging tonnage placed onto the South African market annually, and this must be measured against the post-consumer metal packaging tonnage recovered annualy, to generate an aggregated packaging recovery percentage that must be integrated into the annual PRO performance reports to the DFFE, against EPR targets. This KPI integrity will be enhanced and the recovery percentage will increase when the EPR legislation is refined to include buy-back centres, metal recyclers and metal re-melters.

Underscoring the critical significance of data reliability, it is recommended that the existing EPR legislation, currently in its third year of operation in SA, undergoes refinement specifically targeting the enhancement of recovery percentage. This strategic adjustment is essential to establish a comprehensive and seamlessly integrated post-consumer metal packaging recovery system.

7.3.2.2 Subtheme 2.2 - Recovery mechanism

Table 7.7: Recovery mechanism summary and triangulation of findings

Finding		
SLR	**Converter/brand-owner**	**Metal recycler**
Compaction of metal prior to remelt increases yield. DRS increases packaging material recovery. Consumer awareness in separation-at-source initiatives is essential for efficient manual sorting.	Post-consumer metal packaging recovery is crucial to converter/brand-owner to demonstrate EPR legislation obligations.	Metal recovery to the metal recycler is vital as this is the main raw material into their processes of metal re-melting and refining for alternate re-use applications.

Source: Researcher's own construction

Recommendation

Recovery mechanism is a triangulated idea across the SLR and the qualitative analyses. Implementing metal compaction practices before remelting must be adopted to enhance yield. Incorporating Deposit Return Schemes (DRS) is recommended to improve packaging material recover, and prioritising consumer awareness campaigns in separation-at-source initiatives is recommended to optimise manual sorting efficiency in waste management processes.

7.3.2.3 Subtheme 2.3 - Recovery data reliability and sustainability

Table 7.8: Recovery data reliability and sustainability summary and triangulation of findings

Finding		
SLR	**Converter/brand-owner**	**Metal recycler**
This information was not forthcoming in the SLR, given that this is unique to SA.	Post-consumer metal packaging recovery is crucial to converter/brand-owner to demonstrate EPR legislation obligations	Metal recyclers do not fall within the ambit of the metal packaging EPR legislation and are therefore not reliant on metal packaging recovery system data.

Source: Researcher's own construction

Recommendation

The recovery of post-consumer metal packaging holds vital significance for converter/brand-owners, requiring them to fulfil EPR legislation obligations. In contrast, metal recyclers, not subject to metal packaging EPR legislation, do not depend on recovery system data for their operations.

It is recommended that metal buy-back centres, metal recyclers and re-melters fall under the scope of the EPR legislation to enable greater cohesiveness in the metal recovery value chain.

Highlighting the paramount importance of data reliability, it is recommended that the existing EPR legislation, presently in its third year of implementation in SA, undergoes refinement to rectify this inadequacy. This refinement is imperative to establish a comprehensive and seamlessly integrated post-consumer metal packaging recovery system in full alignment with the principles of data reliability.

7.3.3 Research question 3: *How accurate and reliable are the South African post-consumer metal packaging data acquisition and reporting systems?*

Theme 03 – Accuracy and reliability of existing post-consumer metal packaging recovery system data.

7.3.3.1 Subtheme 3.1 - Data source

Table 7.9: Data source summary and triangulation of findings

Finding		
SLR	**Converter/brand-owner**	**Metal recycler**
This information was not forthcoming from the SLR, given that it is unique to SA.	The source of post-consumer metal packaging recovery statistics is either MetPac-SA or BMi Research.	Given that the metal recyclers are the source of the recovery data, this explains why there is no reference to data source amongst the metal recyclers.

Source: Researcher's own construction

Recommendation

4IR technology is recommended at the re-melting stage across the country to facilitate effective online system of data reporting on metal packaging recovery.

4IR presents several technologies that play a crucial role in supporting data source and integrity. Ensuring reliable and secure data is essential for informed decision-making, and these technologies contribute to maintaining data accuracy, authenticity, and confidentiality. The following 4IR technologies are recommended to support data source and integrity:

i. *Blockchain Technology:* Blockchain provides a decentralised and tamper-resistant record that ensures the immutability of data. Once data is recorded in a block, it is challenging to alter, ensuring the integrity of the information;
ii. *Artificial Intelligence and Machine Learning:* Algorithms can analyse and clean datasets, identifying and rectifying errors, inconsistencies, or missing information, thereby improving data quality;
iii. *Data encryption and confidentiality :* Advanced encryption methods protect sensitive data during transmission and storage, ensuring that only authorised users can access and interpret the information, thus maintaining data confidentiality;
iv. *Internet of Things (IoT):* IoT devices generate vast amounts of data in real-time. This data, when properly monitored and secured, contributes to maintaining the integrity of information by providing timely and accurate insights;
v. *Real-time Processing:* Processing data at the edge in real-time enhances the accuracy and reliability of information, contributing to data integrity and
vi. *Cybersecurity Measures:* Firewalls and Intrusion Detection Systems protect data sources by preventing unauthorised access and identifying potential threats that could compromise data integrity.

Adopting and integrating these 4IR technologies into data management practices can significantly enhance data source reliability and integrity.

7.3.3.2 Subtheme 3.2 - Confidence level

Table 7.10: Confidence level summary and triangulation of findings

Finding		
SLR	**Converter/brand-owner**	**Metal recycler**
This information was not forthcoming from the SLR, given that it is unique to SA.	Low levels of confidence in post-consumer metal packaging recovery statistics in SA, because of the lack of complete data and / or the potential of multiple counting of recovered packaging data by multiple streams of stakeholders such as buy back centres, material recovery facilities (MRF's), recyclers and re-melters.	Shared the same sentiments as the converter/brand-owner.

Source: Researcher's own construction

Recommendation

Industry-wide partnerships and alliances must be established to foster collaboration and synchronisation among metal packaging recovery stakeholders.

It is recommended that well defined memoranda of understanding are developed and entered into between PROs and buy back centres, recyclers, re-melters, and waste to energy stakeholders, to obtain packaging recovery data, without the risk of multiple counting across the recovery value chain.

In addition, it is recommended that rigorous, standardised and independent auditing processes must be adopted to ensure the objectivity of audit findings as well as the accuracy and reliability of reported data. It is recommended that such auditing is executed as follows:

i. First party, internal process and systems auditing, within the PRO, in accordance with annual audit schedules;
ii. Second party auditing by DFFE authority, to validate PRO processes and data acquisition systems and
iii. Third party audits by external certification bodies, interested parties, and environmental lobbyists.

Embracing cutting-edge technologies, such as IoT and blockchain, is also recommended for data security, data transparency and data confidence, throughout the recovery chain.

7.3.3.3 Subtheme 3.3 - Challenges

Table 7.11: Challenges summary and triangulation of findings

Finding		
SLR	**Converter/brand-owner**	**Metal recycler**
Collecting accurate data on metal packaging recovery systems is challenging due to fragmented information, inconsistent reporting standards, limited transparency, outdated technology, incomplete tracking, variable consumer participation, and regulatory variations.	Given the EPR legislative obligations, the converter/brand-owners have a greater interest relating to data integrity and post-consumer metal packaging recovery rates. Double counting of data within the metal packaging recovery value chain is unavoidable.	Metal recyclers are the source of the recovery data, and this explains why there is not a significant reference to data challenges amongst the metal recyclers.

Source: Researcher's own construction

Recommendation

Collaborative, synchronised efforts, standardisation of reporting practices, and increased transparency within the metal packaging recovery eco-system is recommended to overcoming these challenges. It is recommended that the data source for recovered metal packaging should be the metal re-melters, avoiding the potential of double counting of data.

7.3.4 Research question 4: *To what extent is the South African metal packaging value chain committed to post-consumer metal packaging recovery?*

Theme 04 – Commitment to post-consumer metal packaging recovery

7.3.4.1 Subtheme 4.1 - TBL

Table 7.12: TBL summary and triangulation of findings

Finding		
SLR	**Converter/brand-owner**	**Metal recycler**
The concept of the triple bottom line was introduced in 1997 and has since become a mainstream driving force for sustainable development practices.	Converter/brand-owners and metal recyclers demonstrated an appreciation for the principles embedded in TBL. Both parties have integrated CE strategies within their businesses.	Shared the same sentiments as the converter/brand-owner.

Source: Researcher's own construction

Recommendation

The TBL framework triangulated well and supports metal packaging recovery by promoting economic, social, and environmental sustainability. A TBL approach is recommended, to contribute towards cost savings and resource efficiency, social responsibility and planetary preservation as follows:

i. *Profitability:* Traditional business models primarily focus on financial profit. However, the recommended TBL approach ensures that businesses aim not only to generate profits, but also to do so in a way that is sustainable and responsible over the long term.

ii. *People engagement:* The recommended TBL approach emphasises the importance of considering the interests of various stakeholders, including employees, customers, communities, and suppliers, promoting fair wages, good working conditions, and opportunities for professional development.

iii. Environmental dimension: The recommended TBL approach will encourage businesses to adopt environmentally sustainable practices, such as reducing energy consumption, minimising waste, and using eco-friendly materials. This helps mitigate the negative impact of business activities on the environment.

7.3.4.2 Subtheme 4.2 - Legislation

Table 7.13: Legislation summary and triangulation of findings

Finding		
SLR	**Converter/brand-owner**	**Metal recycler**
Collaborative efforts between governments and industries are crucial for creating legislative frameworks that promote the growth of the circular economy, with measures like scrap steel export restrictions to ensure domestic availability and address theft concerns.	Section 18 of NEMWA communicates mandatory compliance requirements on converter/brand-owners.	The Waste Management Act and other related acts apply to recyclers

Source: Researcher's own construction

Recommendation

Not applicable, since compliance is currently being demonstrated.

7.3.5 Research question 5: *How can re-modelling the post-consumer metal packaging recovery system support job creation and transformation?*

Theme 05 – Alternate post-consumer metal packaging recovery system

7.3.5.1 Subtheme 5.1 - Potential to increase community engagement

Table 7.14: Potential to increase community engagement summary and triangulation of findings

Finding		
SLR	**Converter/brand-owner**	**Metal recycler**
Engagement of metal recovery value chain stakeholders in training and education, will provide a greater understanding of metal recovery. This will contribute to higher rates of recovery and re-use.	The engagement of women, youth and previously disadvantaged individuals, as well as the current team of waste-pickers in increasing the volume of metal packaging collection, will result in greater metal packaging circularity.	Both the converter/brand-owner shared positive sentiments with respect to community engagement.

Source: Researcher's own construction

Recommendation

It is recommended to involve women, youth, and individuals who were previously disadvantaged, along with the existing team of waste-pickers, in the development of a post-consumer metal packaging recovery system. This inclusive approach aims to enhance the collection of metal packaging, thereby contributing to higher circularity in the metal packaging life cycle.

7.3.5.2 Subtheme 5.2 - Potential to increase recovery

Table 7.15: Potential to increase recovery summary and triangulation of findings

Finding		
SLR	**Converter/brand-owner**	**Metal recycler**
D4R, waste characterisation, DRS, re-melting optimisation, understanding demand patterns, pyrolysis and material processing.	Both converter/brand-owner and the metal recycler were in agreement with the following initiatives: • Metal packaging recovery rates, recycling rates, waste to energy rates • Metal import and export knowledge • EPR compliance • D4R • DRS • Education, training and awareness • Compliance with EPR legislation • Support PP PRO Alliance	Both converter/brand-owner and the metal recycler were in agreement with the following initiatives: • Separation@source / Municipal collection • Increased community engagement • Synchronised effort within the metal packaging recycling value chain. • Exploitation of 4IR technology • Education, training and awareness • Compliance with waste management legislation • Positive stakeholder engagement

Source: Researcher's own construction

Recommendation

A post-consumer metal packaging recovery model is necessary to address the following:

i. Frequent benchmarking against global best practices;
ii. Municipal collection systems that require household separation-at-source, ensuring that wet waste is separated from packaging waste;
iii. Increasing community engagement will increase metal packaging recovery rate and create jobs enhancing local entrepreneurship;
iv. A DRS will potentially deliver greater recovery quantity as well as quality of used metal packaging;
v. Synchronisation of metal recovery subsystems is vital to enable circular supply chains;

vi. Education, training and awareness is required for all post-consumer metal packaging recovery value chain stakeholders;
vii. 4IR technology tools must be exploited;
viii. EPR legislation and the PP PRO Alliance must drive packaging recovery rates and
ix. D4R is necessary to facilitate easier material recycling and recovery.

7.3.5.3 Subtheme 5.3 - Potential for transformation and job creation

Table 7.16: Potential for transformation and job creation summary and triangulation of findings

Finding		
SLR	**Converter/brand-owner**	**Metal recycler**
This information was not forthcoming from the SLR, given that it is unique to SA.	The engagement of women, youth and previously disadvantaged individuals, as well as the current team of waste-pickers, in entrepreneurial training and education, will support BBBEE in SA, and will support transformation and job creation, improving the element of human dignity.	Both the converter/brand-owner shared positive sentiments with respect to transformation and job creation.

Source: Researcher's own construction

Recommendation

It is recommended that a post-consumer metal packaging recovery system embraces women, youth and previously disadvantaged individuals, as well as the current team of waste-pickers, in entrepreneurial education to support BBBEE in SA, improving the element of human dignity, as embedded in SD principles.

The preceding recommendations have been used as a framework for a proposed post-consumer metal packaging recovery model illustrated in figure 7.1.

7.4 Proposed post-consumer metal packaging recovery model

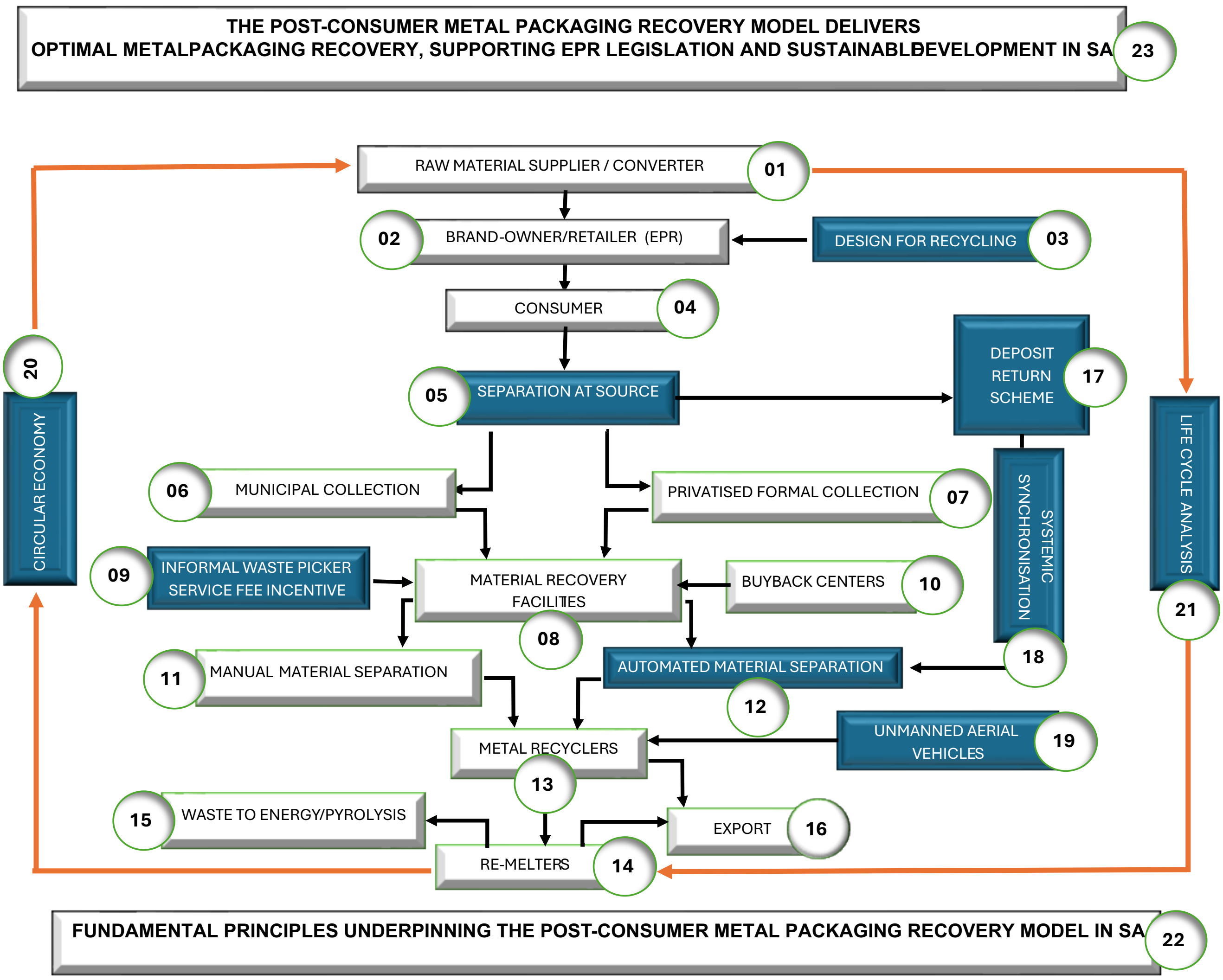


Figure 7.1: Proposed post-consumer metal packaging recovery model

Source: Researcher's own construction

Figure 7.1 illustrates the working of the proposed post-consumer metal packaging recovery model that is expected to close the gap of 9.19% between the 2024 forecast recovery figure and the DFFE target, as discussed in Chapter Two. The white descriptor blocks indicate the existing flow of post-consumer metal packaging recovery in SA. The nine blue descriptor blocks refer to additional strategic inputs into the model to create a holistic system that enhances the post-consumer metal packaging recovery.

The following discussion will sequence, against the reference numbers on each descriptor block, the post-consumer metal packaging path to recovery and re-use, demonstrating a circular economy, supported by life cycle analysis. All elements of this model are supported by literature discussed in this research.

7.4.1 Raw material/converter (01)

The metal packaging material flow begins with the raw material supplier feeding metal stock to the converter who manufactures metal packaging from the feedstock, in accordance with the brand-owner specification. All metal packaging stock that feeds into the conversion process must demonstrate a “cradle to cradle” alignment, supporting the metal LCA, which must be constantly reviewed against global best practices.

7.4.2 Brand-owner/retailer (02)

The brand-owner defines the metal packaging specification that is necessary to market the product, obtains the packaging from the supplier, fills the packaging, and places the product/packaging onto the SA market.

7.4.3 Design for recycling (03)

This is the first additional operation that is required by the proposed recovery model.

The brand-owner is ultimately accountable for the recovery and recycling of the tonnage of packaging that he/she places onto the SA market. He/she supports the recovery path that is depicted in figure 7.1, by paying an EPR fee as required by S18 of NEMWA. It is therefore in the interest of the brand-owner to design the packaging for easier recovery and recycling, adopting an “eco-modulated” approach, thereby reducing his EPR liability.

7.4.4 Consumer (04)

Consumers purchases the product in the packaging, consume the product and traditionally dispose of the packaging through municipal household waste collection systems or through privatised formal waste collection systems.

7.4.5 Separation at source (05)

This is the second additional operation that will underpin the proposed model.

With the necessary education and training on metal circularity, consumers must now separate their household waste into two bags, adopting a “two bag” system. Such a system requires the consumer to separate wet organic waste from packaging recyclables at home, hence separation at source. Such a practice will promote higher metal packaging recovery rates.

7.4.6 Municipal collection (06)

The two bags generated by the consumer will be collected on a weekly basis by either the municipality or by municipality appointed private waste collectors. Either way the waste collected is transported to material recovery facilities situated de-centrally across the nine provinces in SA.

7.4.7 Privatised formal collection (07)

The two bags generated by the consumer will be collected on a weekly basis by either the municipality or by municipality appointed private waste collectors. Either way the waste collected is transported to material recovery facilities situated de-centrally across the nine provinces in SA.

7.4.8 Material recovery facilities (08)

MRF’s are facilities that collect household waste (and other waste) from municipalities, from informal waste pickers (11), and from buy back centres (12).

7.4.9 Informal waste picker service fee incentive (09)

This is the third additional operation that will underpin the proposed model.

A service fee per kg will be paid by the industry, through the PRO, to informal waste pickers for material recovered and sold to buy back centres. This is expected to stimulate recovery rates and dignify waste picking in SA. Waste picker service fee is legislated in SA, and this is expected to become standard practice with PROs to demonstrate statutory compliance.

7.4.10 Buy back centres (10)

Buy back centres purchase material from the field and sell this onto MRF's.

7.4.11 Manual material separation (11)

Traditionally all recyclables have been manually separated.

7.4.12 Automatic material separation (12)

However, in this proposed model, a sophisticated, software driven, self-learning, artificial intelligence based 4IR machine will replace the current manual separation process. This will facilitate accurate and reliable data recording of material separated and recovered, in terms of quantity of packaging and tonnage of packaging. Data is fed digitally online, in real time, to cloud-based databases for easy access, reporting and decision making, supporting current SA EPR data legislative requirements and KPI's.

This is the fourth additional operation that pioneers a paradigm shift in material recovery in SA. This highly effective, automated, separation configuration of the proposed metal recovery model, was as a result of benchmarking against global best practices.

7.4.13 Metal recyclers (13)

All separated materials from the MRF are then transported to the respective substrate recycling operations in SA. Specifically with regard to metal packaging, the MRF will move these materials to a metal recycler closest to the MRF. Metal recyclers will compact metal into bales and move these to metal re-melters within close proximity or export the material to the highest bidder in the global market.

7.4.14 Re-melters (14)

A metal re-melter in SA, also referred to as a foundry, will accumulate metal for a full furnace load, and then re-melt the metal into ingots which are either exported or returned to the raw material supplier who will then convert these to rolled sheets ready for conversion to packaging.

7.4.15 Waste to energy/pyrolysis (15)

Re-melters in SA may convert some tonnage of metal, through pyrolysis, into high calorific gases and oils that are usable as energy sources in downstream applications.

7.4.16 Export (16)

Metal recyclers will compact metal into bales and move these to metal re-melters within close proximity, or export the material to the highest bidder in the global market.

A metal re-melter in SA, also referred to as a foundry, will accumulate metal for a full furnace load, and they re-melt the metal into ingots which are then either exported or returned to the raw material supplier who will then convert these to rolled sheets ready for conversion to packaging.

7.4.17 Deposit return scheme (17)

This highly effective DRS element, the fifth additional operation of the proposed metal recovery model, was included as a result of benchmarking against global best practices.

A DRS model, using multiple DRS reverse vending machines at all major shopping malls, across the 9 provinces, is strategically deployed as an essential part of the configuration of the post-consumer metal packaging recovery model, to ensure the return of virtually 100% of metal packaging that is placed in the SA economy, in pristine condition, due to the deposit levied on the packaging, and subsequently redeemed upon return of the packaging into the reverse vending machines.

7.4.18 Systemic synchronisation (18)

This is the sixth additional operation of the proposed metal recovery model, as a result of benchmarking against global best practices.

A DRS system will fail unless it is supported by a systemic synchronisation of all its sub-elements. Synchronisation is necessary for systems to deliver higher levels of output as a result of coherent, collective synergy. The proposed recovery model necessitates a collaborative, synchronised approach to metal recovery along the post-consumer value chain to maximise the metal recovery across municipalities, MRF's, metal recyclers, re-melters and the various DRS support structures, achieved through an intense campaign of education, training and awareness.

7.4.19 Unmanned Aerial Vehicles (19)

UAVs are the seventh new dimension that has been integrated into the post-consumer metal packaging recovery model to maximise recovery volume.

Advanced, heavy-duty drones, capable of lifting masses greater than 250 kg, can play a crucial role in supporting packaging recovery efforts in remote areas, where buy back centres and MRF's are not available. Built into the post-consumer metal packaging recovery model, is a requirement for multiple UAV usage. Through the collective effort of the multiple PROs, the country has been mapped out to reflect every remote, geographical location that is not being serviced by waste pickers and buy back centres and a plan of UAV activity is embedded into the recovery model, to complement the level of metal and other packaging substrate recovery.

7.4.20 Circular Economy (20)

CE, driving the recovery of packaging, is the eighth new dimension of the proposed model, supporting global best practices and sustainable development.

7.4.21 Life Cycle Analysis (21)

The life cycle analysis is the nineth new operation integrated into this model.

As discussed in the literature review, the LCA brings a “cradle to cradle” perspective to packaging materials ensuring optimal utility of such materials.

7.4.22 Fundamental principles underpinning the proposed post-consumer metal packaging recovery model are supported by the PRO strategy (22)

The principles that are the foundation of the proposed post-consumer metal packaging recovery model are:

i. EPR legislation;
ii. 4IR;
iii. Triple bottom line;
iv. ISO14001:2015;
v. SDGs;
vi. Global best practices and
vii. Training and education.

This proposed post-consumer metal packaging recovery model is ultimately driven by the PRO, who is funded through EPR fees that are paid by the converter/brand-owner. The PRO must encourage EPR legislation compliance across the recovery value chain, and must design systemic synchronisation across the DRS, automated material separation at MRF’s, UAV usage, through Industry 4.0 technology, enabling the synergy required to maximise metal recovery. The model is governed by the LCA to ensure that a “cradle to cradle” metal circularity is achieved as required by the ISO14001:2015 standard, which is part of the framework of this model.

7.4.23 Anticipated delivery of the proposed post-consumer metal packaging recovery model (23)

This post-consumer metal packaging recovery strategy, if executed as per the model described above, will, through the exploitation of global best practices, deliver effective post-consumer metal packaging recovery and recycling, providing accurate and reliable data for meaningful CE decision making, enabling job creation and transformation in SA.

The researcher notes that the incremental post-consumer metal packaging recovery as a result of the additional nine blue descriptor strategic inputs, is expected to approximate 20%, exceeding the current and anticipated DFFE post-consumer metal packaging recovery targets.

Such a model will also realise the SDGs that are inherent in the SA EPR legislation.

7.5 High level financial costing of the proposed post-consumer metal packaging recovery model

Although a financial cost feasibility of the proposed model is not one of the objectives of this study, the researcher felt it prudent to include such a costing exercise in this thesis.

Given that the costing of the proposed model at a national level will require extensive input from all nine provinces of SA, the researcher presents a high level cost model of Ethekwini, a metropolitan municipality in the Kwa-Zulu Natal province of SA, as an indication of the cost/benefit of the proposed model.

In addition to the several references to the South African packaging industry data and information presented in Chapter Two, the researcher also referenced a comprehensive Ethekwini Municipality Integrated Waste Management Plan (2016 – 2021) to extract actual data and information relating to Ethekwini waste collection services, material recovery facilities, operational requirements, geographical locations and distances, to support the costing exercise presented below (Ethekwini Municipality 2016: 34).

The following tables illustrate a high level financial cost/benefit of the proposed model as applicable in Ethekwini, based on logical assumptions made by the researcher.

Table 7.17 indicates the Ethekwini incremental metal recovery value as a proportion of the South African national metal packaging value. These values are based on the population ratio (14.6:1) of South Africa's national population against Ethekwini population, on the assumption that metal packaging consumption is based on population demand.

Table 7.17: High level financial costing

Benefits / Parameters	South Africa	Ethekwini	Ratio
Population - 2022	62,030, 000	4,239,901	14.6:1
Total value of SA metal packaging in 2022	R7,794,000,000	R551,738,936	14.6:1
Total tonnage of SA metal packaging in 2022	184,000	13,025	14.6:1
Rands per ton (on selling value)	R42,359	R42,359	1:1
Estimated metal cost as a %age of selling value	60%	60%	1:1
Rands per ton (on cost value)	R25,415	R25,415	1:1
Estimated additional recovery - %		20%	
Estimated additional metal recovery - tons		2605	
Estimated additional metal recovery in rands		**R63,928,657**	

Source: Researcher's own construction

Table 7.17 illustrates an additional metal recovery value of R63,928,657, generated by the proposed metal packaging recovery model, based on an anticipated 20% incremental recovery rate, which exceeds the predicted 9.19% gap in recovery rate, if no intervention was introduced, as discussed in Chapter Two. This is based on an estimated metal cost as 60% of selling value.

Table 7.18 illustrates the cost/benefit analysis per annum.

Table 7.18: High level cost / benefit analysis

Description	Value (Rands)
Additional metal recovery value	R63,928,657
Annual cost of proposed post-consumer metal packaging recovery model for Ethekwini Municipality. This figure is computed in Table 7.19.	R99,135,569
Deficit	**-R35,206,912**

Source: Researcher's own construction

The researcher notes that this calculation does not factor in further incremental metal packaging recovery volume/revenue over time, as would be expected, as the model matures, and societal behaviour adapts, nor does it compute the financial advantages of resultant economies of scale.

Additionally, the proposed metal recovery model infrastructure will benefit other packaging substrates, such as paper/board packaging, plastic packaging and glass packaging, by their own incremental recovery volume/revenue, reducing the anticipated deficit of R35,206,912 per annum, as reflected in table 7.18.

The researcher anticipates that the entire deficit may be offset by incremental recovery volume/revenue of paper/board packaging, plastic packaging and glass packaging, given that the metal packaging incremental recovery volume/revenue alone is calculated at R63,928,657.

In addition, the savings as a result of diversion of metal packaging, as well as other packaging substrates, from landfill sites in SA must be quantified and this will also significantly offset the deficit shown in table 7.18.

The researcher also points out the following soft benefits of such a recovery model which:

i. supports a triple bottom line approach endorsing SA's sustainable development principles embedded in the EPR legislation;
ii. maximises metal recovery and recycling, which is cheaper than extracting and processing raw metal from the earth;
iii. benefits other packaging substrates, promoting a circular economy across packaging substrates;
iv. promotes societal change from a linear economy towards a circular economy;
v. diverts post-consumer packaging materials from landfill, saving significant costs of maintaining such landfill sites;
vi. supports entrepreneurship and job creation in SA and
vii. embraces 4IR technology to demonstrate continual improvement.

Table 7.19 illustrates the costs of the additional strategic inputs of the proposed model. The comments explain the contribution of each of the line items as well as the costs which accumulate to the overall model cost at Ethekwini.

Table 7.19: Cost of additional strategic inputs

Additional strategic inputs to the proposed model	Recovery model descriptor block reference	Capital cost	Estimated lifespan (years)	Annual capital allocation	Annual labour and operating costs	Annual total costs	Comments
Design for recycling	03	The cost is borne by brand owners / converters. This is driven by eco-modulated fee.					
Separation at source	05				R65,235,569	R65,235,569	The major portion of the cost will be incurred by Ethekwini municipality as part of its weekly refuse removal service. This exercise attempts to quantify the incremental costs; however, the researcher has made wide-ranging assumptions due to lack of available information as it falls outside the scope of this study. Refer to Table 7.20 for the cost analysis.
Waste picker service fee	09	The cost is borne by the EPR fee.					
Automatic material separation (based on a 15-year depreciation)	12	R120,000,000	15	R8,000,000	R13,500,000	R21,500,000	Includes separation from other waste streams including glass, plastic, paper and board that will benefit from this initiative; however, these benefits, be they quantitative and qualitative, are not factored into this calculation as it is outside of the scope of this thesis. Costs are based on high-level assumptions of capital costs, labour costs and operating costs. Refer to Table 7.21 for the cost analysis.
Deposit return scheme (based on a 15-year depreciation)	17	R27,000,000	15	R1,800,000	R9,600,000	R11,400,000	DRS are planned to be located at various strategic positions within the post-consumer recovery value chains across Ethekwini. Practically, the locations that would produce the highest yield would be those having high-traffic volumes in terms of consumers / pedestrians e.g. the major metropolitan shopping malls and popular entertainment facilities such as sports stadiums, casinos / movie houses and beachfront areas. Refer to Table 7.22 for the cost analysis.
Systemic synchronisation	18	Cost is integrated into the DRS.					
Unmanned aerial vehicles	19	Unable to reliably quantify costs or impacts due to the technology being too new in an SA context. Legislative and deployment aspects are also unknown or undeveloped at this stage.					
Training & education / marketing & publicity					R1,000,000	R1,000,000	Estimated cost to cover project initiation and ongoing awareness campaigns.
Total		**R147,000,000**		**R9,800,000**	**R89,335,569**	**R99,135,569**	

Source: Researcher's own construction

Table 7.19 reconciles the additional strategic inputs of the proposed model against the descriptor block reference, and illustrates all capital cost, estimated lifespans, depreciation periods, annual capital allocation, annual labour and operating costs and the annual total costs. The comments clearly explain the basis of the estimated costs, as well as the model assumptions.

Tables 7.20, 7.21 and 7.22 provide the supporting calculations derived for separation at source, automatic material separation and deposit return schemes, that contribute to costs in table 7.19.

Table 7.20: Cost parameters - Separation at Source

	Description	Total	Per collection
Separation at source	Total no. of households in Ethekwini - 2022	1,122,738	
	Percentage on weekly refuse removal	80.70%	
	Frequency of refuse removal - per month	4	
	Annual total no. of collections	43,490,379	
	Bag cost	R43,490,379	R1.00
	Assumed additional logistics /operational costs over and above regular municipal refuse removal costs	R21,745,190	R0.50
	Collection costs - per annum	**R65,235,569**	**R1.50**

Source: Researcher's own construction

The separation at source cost derived from table 7.20 is used in table 7.19.

Table 7.21: Cost parameters - Automatic Material Separation (AMS)

	Description	Total / Annual	Cost per unit or pm	# of units	Units / facility
Automatic material separation (AMS)	AMS facilities - capital costs (Equipment)	R100,000,000	R10,000,000	10	1
	AMS facilities - logistics costs (trucks)	R20,000,000	R1,000,000	20	2
	Total annual capital cost	**R120,000,000**			
	AMS facilities - labour costs	R4,500,000	R7,500	50	5
	AMS facilities - operating costs	R9,000,000	R75,000	10	
	Total labour and operational cost	**R13,500,000**			

Source: Researcher's own construction

The automatic material separation costs derived from table 7.21 are used in table 7.19.

Table 7.22: Cost parameters - Deposit Return Scheme (DRS)

	Description	Total / Annual	Cost per unit or pm	# of units	Units / facility
Deposit return scheme (DRS)	DRS facilities - capital costs (equipment)	R20,000,000	R1,000,000	20	1
	DRS facilities - logistics costs (trucks)	R7,000,000	R350,000	20	1
	Total capital cost	**R27,000,000**			
	DRS facilities - labour costs	R3,600,000	R7,500	40	2
	DRS facilities - operating costs	R6,000,000	R25,000	20	
	Total labour and operational cost	**R9,600,000**			

Source: Researcher's own construction

The deposit return scheme costs derived from table 7.22 are used in table 7.19.

In summary, the researcher notes that the proposed model for metal recovery will not only benefit metal packaging but also improve the recycling of paper/board, plastic, and glass packaging. This enhancement in recycling is expected to generate additional revenue, potentially covering the projected annual deficit of R35,206,912. The model predicts that the increased revenue from recycling these materials, along with the R63,928,657 anticipated from metal packaging, could completely offset this deficit. Moreover, diverting these materials from landfills in South Africa will contribute further financial savings, aiding in balancing the deficit indicated in table 7.18.

7.6 Research benefits

This post-consumer metal packaging recovery model may be applicable to all packaging substrates, other than metal, resulting in the following benefits to the SA packaging industry:

i. *Environmental impact:* Understanding and implementing effective recovery models for packaging materials will have positive environmental implications, reducing waste and promoting sustainability;
ii. *Cost savings:* The implementation of this model will lead to cost savings in waste management and recycling processes, benefiting industries by optimising resource use;
iii. *Innovation and technology transfer:* Findings from this study may inspire innovations in packaging recovery technologies, potentially leading to advancements that can be applied across various industries;
iv. *Legislative compliance:* The study's recommendations may contribute to the further development of regulations and policies promoting responsible post-consumer packaging practices, enhancing compliance within the industry;
v. *Corporate Social Responsibility (CSR):* Organisations adopting sustainable packaging practices can enhance their CSR initiatives, appealing to environmentally conscious consumers, promoting a positive brand image.
vi. *Knowledge transfer:* Insights gained from this study can be shared through conferences, workshops, and collaborations, fostering knowledge transfer and collaboration within the academic and industrial communities;
vii. *Global best practices:* The research outcomes may provide valuable insights into global best practices for post-consumer packaging recovery, facilitating the adoption of successful models in different regions;
viii. *Educational resources:* This study can serve as a valuable educational resource for students, researchers, and professionals interested in sustainable packaging practices, contributing to the dissemination of knowledge in the field;
ix. *Cross-industry applications:* The recovery model's principles and recommendations may have applicability beyond the packaging industry,

potentially benefiting other sectors facing similar challenges in managing post-consumer materials and

x. *Economic growth:* Implementing this recovery model will contribute to a circular economy, encouraging economic growth by creating jobs in recycling and related industries.

By exploring these potential benefits, the study's impact can extend beyond the immediate scope of post-consumer metal packaging recovery, providing valuable insights and solutions for broader sustainability challenges.

Academic papers will be extracted from this thesis and submitted to accredited journals for publication.

7.7 Limitations of the research

The performance statistics of the packaging industry discussed in this thesis is limited to data up until the conclusion of 2022. Performance statistics for the year 2023 will only become accessible in June 2024.

The outcome of this study is applicable to the metal packaging sector of the SA packaging industry. However, recommendations arising from this study may also be applicable within other packaging substrates both locally and globally, provided that the recommendations are contextualised within the specific industry.

The financial costing as discussed earlier in 7.5 will support the planned roll out of the proposed model, limited to Ethekwini municipality in Kwa-Zulu Natal of SA, for greater control of execution costs and model management in a reduced scope of activity. Once proven viable, a phased approach is recommended to extrapolate the model to the rest of SA.

Whilst the topic of this research can be generalised across the packaging substrates prevalent in South Africa, this research focused primarily on the collection, recycling and recovery of post-consumer metal packaging in South Africa.

This thesis will be accessible locally and globally for review and decision making.

7.8 Recommendations for further studies

The proposed model will deliver against the research expectations as outlined in the research objectives. However, the following research ideas are worthwhile pursuing:

i. The scope of this study was limited to the converters/brand-owners as well as the metal recyclers across SA. Further research on the relationships between the waste pickers across SA and the self-appointed waste picker representative bodies such as ARO and SAWPA will present further insights into metal packaging recovery challenges in SA;
ii. The idea of separation at source needs to be further researched to provide a comprehensive understanding of the success factors and challenges associated with the separation at source model for waste recovery. The outcomes will contribute valuable insights for policymakers, waste management practitioners, and communities aiming to enhance their waste recovery initiatives, ultimately promoting more sustainable and environmentally friendly waste management practices and
iii. The researcher's proposed model adopts the utility of some elements of a DRS system. Implementing a full-blown DRS in a third-world economy like SA, can present several challenges due to unique socio-economic, infrastructural, and cultural factors. It is therefore recommended that a study is conducted to determine the cost/benefit analysis, the potential for success in SA, as well as the timeframe for implementation in SA.
iv. The cost/benefit analysis of the proposed model for post-consumer metal packaging recovery needs to be quantified at a national level, based on the success of the Ethekwini rolle out.

7.9 Conclusion

This chapter covered the introduction of Chapter Seven, as a continuation of the conclusion logic of Chapter Six. The research objectives, the research questions as well as the summary answers were presented to bring perspective and focus on the content of Chapter Seven. The chapter then presented all the findings that related to the triangulated research methodology to support the discussion, conclusions and recommendations arising from this research.

The researcher presented the emerging themes that arose from the results, as well the recommendations after consolidating similar themes. The overlap and convergence amongst the SLR results, the converter/brand-owner data and the metal recycler data were emphasised, drawing from pertinent research discussed earlier in Chapters Two and Three.

The chapter concludes with the researcher presenting a proposed post-consumer metal packaging recovery model which sustainably enhances the metal packaging recovery rates in SA, by integrating the key new themes derived from the research, ensuring that the SA packaging industry can meet the current and anticipated DFFE metal packaging recovery targets.

The researcher also presented a thorough financial costing of the model based on actual scenarios within Ethekwini and showed that the deficit reflected in the costing exercise, is reasonably expected to be offset by incremental recovery volumes of packaging substrates other than metal, although this has not yet been quantified, given that the metal incremental revenue alone is calculated at R63,928,657.

The researcher is of the view that such a synchronised post-consumer metal packaging recovery model will become an effective mechanism to maximise the collection, recycling and recovery of post-consumer metal packaging in SA, aligning with global best practices, supporting CE and SD principles.

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APPENDICES

Appendix 1: Turnitin report

turnitin

Digital Receipt

This receipt acknowledges that Turnitin received your paper. Below you will find the receipt information regarding your submission.

The first page of your submissions is displayed below.

Submission author:	Kishan Singh
Assignment title:	Chapters 1 - 7
Submission title:	Evaluating Post-Consumer Metal Packaging Recovery Syste...
File name:	Thesis_01_Feb_24_Turn_It_In_V2.docx
File size:	12.94M
Page count:	300
Word count:	67,286
Character count:	405,345
Submission date:	02-Feb-2024 03:23PM (UTC+0200)
Submission ID:	2283688755

1 CHAPTER ONE

INTRODUCTION

BACKGROUND AND CURRENT SCENARIO

1.1 Introduction

This study explored the challenges in post-consumer metal packaging recovery systems in South Africa (SA), against current legislation and global best practices, and reviewed the contributing factors that influence post-consumer metal packaging recovery in SA, in alignment with sustainable development theory. Post-consumer packaging refers to packaging that becomes unwanted after the contents have been used by the consumer.

"This introductory chapter presents the study context which provides the background to the research. The chapter presents the research problem, the research justification, the research aim, objectives and questions and outlines the research methodology for the study".

"This chapter also highlights the significance of the study, delimitations and limitations of the study, the conceptual and empirical frameworks, the ethical protocols and concludes with an outline of the rest of the chapters comprising this thesis".

1.2 Context of the study

This study is located within the South African (SA) packaging industry, with a specific focus on post-consumer metal packaging recovery and re-use. Annual post-consumer metal packaging recovery is the ratio of the tonnage of post-consumer metal packaging recovered after use, against the tonnage of metal packaging placed in the economy in that year (South Africa. Department of Forestry, Fisheries and Environment 2020: 10).

This study, through the lens of the SA packaging industry, was aimed at understanding current post-consumer metal packaging recovery systems, as well as the barriers to

1

Evaluating Post-Consumer Metal Packaging Recovery Systems in South Africa

ORIGINALITY REPORT

13%	10%	9%	6%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.mdpi.com Internet Source	1%
2	www.researchgate.net Internet Source	<1%
3	Dharmendra Hariyani, Sanjeev Mishra, Milind Kumar Sharma, Poonam Hariyani. "Organizational Barriers to the Sustainable Manufacturing System: A Literature Review", Environmental Challenges, 2022 Publication	<1%
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5	fastercapital.com Internet Source	<1%
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Appendix 2: Ethics clearance letter

Institutional Research Ethics Committee
Research and Postgraduate Support Directorate
2nd Floor, Berwyn Court
Gate 1, Steve Biko Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

Tel: 031 373 2375
Email: lavishad@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

5 October 2022

Mr K Singh
88 Coedmore Avenue
Yellowwood Park

Dear Mr Singh

Evaluating post-consumer metal packaging recovery systems in South Africa

I am pleased to inform you that Full Approval has been granted to your proposal.

The Proposal has been allocated the following Ethical Clearance number **IREC 112/22**. Please use this number in all communication with this office.

Approval has been granted for a period of **ONE YEAR**, before the expiry of which you are required to apply for safety monitoring and annual recertification. Please use the Safety Monitoring and Annual Recertification Report form which can be found in the Standard Operating Procedures [SOP's] of the DUT-IREC. This form must be submitted to the DUT-IREC at least 3 months before the ethics approval for the study expires.

Any adverse events [serious or minor] which occur in connection with this study and/or which may alter its ethical consideration must be reported to the DUT-IREC according to the DUT-IREC SOP's.

Please note that any deviations from the approved proposal require the approval of the DUT-IREC as outlined in the DUT-IREC SOP's.

Yours Sincerely

____
Prof J K Adam
Chairperson: DUT-IREC

Appendix 3: TRREE ethics training certificate

TRREE

Zertifikat

Certificat

Certificado

Certificate

Promouvoir les plus hauts standards éthiques dans la protection des participants à la recherche biomédicale
Promoting the highest ethical standards in the protection of biomedical research participants

Clinical Trials Centre
The University of Hong Kong

Certificat de formation - Training Certificate

Ce document atteste que - this document certifies that

Kishan Singh

a complété avec succès - has successfully completed

Introduction to Research Ethics

du programme de formation TRREE en évaluation éthique de la recherche
of the TRREE training programme in research ethics evaluation

Release Date: 2021/06/29
CID : WRJpxdqyFQ

Professeur Dominique Sprumont
Coordinateur TRREE Coordinator

FMH Continuing Education Program (5 Credits)
Programme de Formation continue (5 Crédits)

Foederatio Pharmaceutica Helvetiae FPH Programmes de formation continue

Continuing Education Programms
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[REV : 20170310]

Appendix 4: Gatekeepers Letter - Packaging SA

PACKAGINGSA
(1985/001427/08)

Postal Address: P O Box 131400
Bryanston 2021, South Africa
Telephone: +27 (0) 12 001 1914
Email: samantha@packagingsa.co.za
Website: www.packagingsa.co.za

17 August 2021

To Whom It May Concern

This is to advise that Kishan Singh (ID 630812 5192 089), a Durban University of Technology student (Student No. 19002312), will be conducting qualitative interviews with producers and brand-owners within the South African packaging industry to determine their commitment to the requirements of Section 18 of the National Environmental Management: Waste Act (NEMWA) Act 59 of 2008. Section 18 of NEMWA focusses on sustainable development and circular economy principles within South Africa. The interview also seeks to determine the challenges and opportunities that relate to the Section 18 requirements.

This is being done as part of Mr. Singh's PhD on "Modelling post-consumer metal packaging recovery in South Africa".

I understand the intention behind the PhD is to derive an economically sustainable material recovery model that supports the circular economy of metals, simultaneously driving transformation and job creation in South Africa.

I commit to fully support this initiative by communicating this research topic to the packaging industry in general and supplying him with a list of the producers and brand-owners contact details, that are members of Packaging SA.

In addition, Mr Singh will have access to Packaging SA's resource material as well as industry information as may be required in support of his academic pursuit.

Packaging SA endorses this initiative and will provide the support required as such a study will benefit not only the metal packaging industry but the SA economy in general. Packaging SA authorizes its members, producers, brand-owners to fully participate in this study.

Packaging SA also encourages metal recyclers, material recovery facilities and metal buy back centers in SA to fully participate in this study.

Shabeer Jhetam
Executive Director
Packaging SA

Appendix 5: Gatekeeper's Letter - Metal Recyclers Association

22 July 2022

To Whom It May Concern

This is to advise that Kishan Singh (ID 630812 5192 089), a Durban University of Technology student (Student No. 19002312), will be conducting qualitative interviews with metal recyclers within the South African metal recycling industry to determine their perspectives on sustainable development and metal circular economies within South Africa.

This is being done as part of Mr Singh's Doctor of Philosophy, the thesis topic is "Evaluating post-consumer metal packaging recovery in South Africa".

The intention behind the D Phil. is to derive an economically sustainable metal packaging recovery model that supports circular economy of metal, simultaneously driving transformation and job creation in South Africa.

I support this initiative by communicating this research topic to the metal recycling industry in general and supplying him with a list of the metal recycler contact details, that are members of Metal Recyclers Association SA, representing >70% of the metal recycled in SA by volume.

Metal Recyclers Association endorses this initiative and authorizes its members to support this study.

Mr Quintin Starkey
Chairman
Metal Recycler Association
Established 1942
https://mra.co.za

SAPS Accreditation No. 001/2012
Dept Labour Registration LR2/6/3/74
VAT Registration Number 4070260320
PO Box 4128 Germiston South 1401 Gauteng RSA
info@mra.co.za www.mra.co.za
Secretariat Rachelle Bezuidenhout

Appendix 6: Gatekeeper's Letter – Get Metal Group

GeT Metal
GROUP

+27 21 853 3086
info@getmetal.co.za
43 Reitz Street, Audas Estate,
Somerset West, Cape Town, 7130

22 July 2023

<u>To Whom It May Concern</u>

This is to advise that Kishan Singh (ID 630812 5192 089), a Durban University of Technology student (Student No. 19002312), will be conducting qualitative interviews with Get Metal Group to determine their perspectives on sustainable development and metal circular economies within South Africa.

This is being done as part of Mr Singh's Doctor of Philosophy, the thesis topic is "Evaluating post-consumer metal packaging recovery in South Africa".

The intention behind the D Phil. is to derive an economically sustainable metal packaging recovery model that supports circular economy of metal, simultaneously driving transformation and job creation in South Africa.

This initiative is supported by the Get Metal Group.

Mr Ebrahim Khan
<u>Executive Management</u>
Get Metal Group
https://getmetalgroup.co.za
Co-Founder & Director

Ebrahim Khan

Appendix 7: Gatekeeper's letter – MetPacSA

+27 (0) 82 880 9580
+27 (0) 33 343 2784
ceo@metpacsa.org.za
www.metpacsa.org.za

21 June 2023

To Whom It May Concern

This is to advise that Kishan Singh (ID 630812 5192 089), a Durban University of Technology student (Student No. 19002312), will be conducting qualitative interviews with MetPacSA members to determine their perspectives on the recent EPR legislation, sustainable development and metal circular economies within South Africa.

This is being done as part of Mr Singh's Doctor of Philosophy, the thesis topic is "Evaluating post-consumer metal packaging recovery in South Africa".

The intention behind the D Phil. is to derive an economically sustainable metal packaging recovery model that supports circular economy of metal, simultaneously driving transformation and job creation in South Africa.

This initiative is supported by MetPacSA and we encourage our members to give Mr Singh the support that is required.

Research Analyst

MetPacSA

Appendix 8: Letter of information

Faculty of Management Sciences
Entrepreneurial Studies and Management
17 August 2021

Letter of information

Title of thesis: Evaluating post-consumer metal packaging recovery systems in South Africa.

Principal Investigator/s/researcher: Mr Kishan Singh (Student Number 19002312)
Investigator/s/supervisor/s: Dr Manduth Ramchander

Dear Participant

My name is Kishan Singh and I am a postgraduate student enrolled on D PHIL MAN SCIENCES (BUS AD) at the Durban University of Technology. I would appreciate your participation in this research project which I am conducting as part of the requirements of my D Phil degree.

A part of this study requires an in depth understanding of the current post-consumer metal recovery systems and models in South Africa as well the brand-owner and the metal recycler views and commitment to the recent Section 18 of the National Environmental Management: Waste Act (NEMWA) (Act 59 of 2008). Section 18 of NEMWA requires an extended producer responsibility commitment from stakeholders across the metal packaging value chain in SA to demonstrate measurable year on year improvement on post-consumer metal packaging recovery.

Please be advised that the ethical aspect of the research ensures the anonymity of the participants. All information collected during the research project will be treated confidentially and will be coded so that you remain anonymous. This research project has ethics approval from the Faculty of Management Sciences Ethics Committee. The data collected will be used purely for academic purposes. Please note that participation in this research is voluntary and participants can opt out of the study at any time. The information will be presented in a written report, in which your identity will not be revealed. I do not anticipate any risks associated with participating in this research project.

This study will assist with building a model for improved post-consumer metal packaging and will therefore benefit the South African packaging industry, aligning with S18 expectations. There will be no remuneration to participants supporting this study. Other than time spent on the interview, there are no other costs to the participant.

If you have any questions about the research project or require further information you may contact the following:

Student Researcher: Kishan Singh
Telephone: 082 880 9580
Email: Kishan@gibsolutions.co.za
Student Supervisor: Dr Manduth Ramchander
Telephone: 074 400 4400
Email: manduthr@dut.ac.za
The Institutional Research Ethics Administrator on 031 373 2900

If you have any concerns or complaints and wish to contact an independent person about this research project, you may contact: **DVC: Research, Innovation and Engagement** Prof S Moyo on 031 373 2577 or moyos@dut.ac.za.

Thank you for your time,
Yours sincerely,

Telephone: 082 880 9580
Email: Kishan@gibsolutions.co.za

Appendix 9: Letter of consent

CONSENT

Full Title of the Study: Evaluating post-consumer metal packaging recovery systems in South Africa.
Names of Researcher/s: Kishan Singh

Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher, Mr Kishan Singh, about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number: IREC 112/22.
- I have also received, read and understood the above written information (Participant Letter of Information) regarding the study.
- I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.
- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.
- I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.
- I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

----------------------------------	----------------	---------------	---------------------------
Full Name of Participant	**Date**	**Time**	**Signature/Right Thumbprint**

I, Kishan Singh herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

Kishan Singh	14 March 2022	
Full Name of Researcher	Date	Signature
Full Name of Witness (If applicable)	Date	Signature
Full Name of Legal Guardian (If applicable)	Date	Signature

Appendix 10: Converter/brand-owner interview questionnaire

Converter / Brandowner

Measuring Instrument – Interview Questionnaire

Company name:	
Contact name:	
Contact job title:	
Contact telephone number:	
Contact cell phone number:	
Contact email address:	
Company website:	
Scope of Business:	National:_____ Regional:_____

1 Biometric Data

1.1 Province

- ☐ Gauteng
- ☐ KwaZulu-Natal
- ☐ The Western Cape
- ☐ The Eastern Cape

1.2 Gender

- ☐ Male
- ☐ Female

1.3 Race

- ☐ White
- ☐ Black
- ☐ Indian
- ☐ Coloured
- ☐ Other

1.4 Age

- ☐ < 30 Years
- ☐ 30 years – 39 Years
- ☐ 40 Years – 49 Years
- ☐ 50 Years – 59 Years
- ☐ 60 Years – 69 Years
- ☐ > 69 Years

1.5 Designation

- ☐ General Management
- ☐ Finance / Administration Management
- ☐ Research and Development Management
- ☐ Human Resources Management
- ☐ Logistics / Supply Chain Management
- ☐ IT Management
- ☐ Packaging Related
- ☐ Environmental Sustainability Management
- ☐ Operations Management
- ☐ Other

1.6 How long are you in current position/sector – show level of personal experience

- ☐ < 10 Years
- ☐ 10- 20 Years
- ☐ 21-29 Years
- ☐ >30 Years

Explaining the purpose of the research

Section 18 of NEMWA, through substrate specific producer responsibility organisations, requires submission of auditable post-consumer metal packaging recovery data annually. This process of enhancing post-consumer metal packaging recovery must rest, to a large extent, on the brand-owner who drives the process of packaging manufacture, filling and distributing the product in metal packaging until the consumer buys the product and consumes it. The job of ensuring the post-consumer metal packaging is recovered from the field and effectively managed by re-using the material or exporting to countries that have use for the material must be supported by the collective effort of the converter/brand-owners.

The information derived from such interviews are intended to be used to improve the recovery, reporting and re-use of post-consumer metal packaging in SA, to enable greater circular utility of such materials, aligning with sustainable development principles and SA legislation.

Research question number 1 - global best practices

1. *How does your business relate to circular economy principles?*
2. *Which countries are actively delivering against circular economy principles?*
3. *Are you constantly benchmarking with global best practices on post-consumer metal packaging recovery?*

Research question number 2 – effectiveness of post-consumer metal packaging recovery model

1. *How is post-consumer metal packaging recovered in SA?*
2. *Is this a reliable/sustainable model? Please discuss.*
3. *Can you estimate the % of post-consumer metal packaging that is recovered by informal waste pickers and the formal waste collection systems in SA?*

Research question number 3 – Reliability of post-consumer metal packaging data acquisition and reporting

1. *What is the source of your statistics (above question)?*
2. *Are you confident that these statistics are an accurate reflection of post-consumer metal packaging recovery in SA?*
3. *If not, where do you think lies the challenges in accurate data reporting?*

Research question number 4 – Commitment to metal packaging recovery and circularity

1. *Discuss the level of commitment of your business / brand to a triple bottom line strategy. Personal Answer*
2. *Are there formal sustainable development goal setting within your business? Discuss measurement and successes achieved. How do you set new targets and timelines? Test for realism and practicality.*
3. *How does your brand / business address post-consumer metal packaging recovery and recycling?*

Research question number 5 – Remodelling post-consumer metal packaging recovery.

1. *How can the implementation of a post-consumer metal packaging recovery system contribute to job creation, especially in economically disadvantaged areas?*
2. *How can such a model ensure inclusivity and transformation by providing equal opportunities for historically marginalised groups and communities?*
3. *How can community awareness and education campaigns be integrated into the recovery model to promote responsible recycling behaviour?*

Appendix 11 Metal recycler interview questionnaire

Metal recycler

Measuring Instrument – Interview Questionnaire

Company name:	
Contact name:	
Contact job title:	
Contact cell phone number:	
Company website:	
Scope of Business:	National:____ Regional:_____

2 Biometric Data

1.1 Province

- ☐ Gauteng
- ☐ KwaZulu-Natal
- ☐ The Western Cape
- ☐ The Eastern Cape

1.2 Gender

- ☐ Male
- ☐ Female

1.3 Race

- ☐ White
- ☐ Black

- ☐ Indian
- ☐ Coloured
- ☐ Other

1.4 Age

- ☐ < 30 Years
- ☐ 30 years – 39 Years
- ☐ 40 Years – 49 Years
- ☐ 50 Years – 59 Years
- ☐ 60 Years – 69 Years
- ☐ > 69 Years

1.5 Designation

- ☐ General Management
- ☐ Operations Management
- ☐ Finance / Administration Management
- ☐ Research and Development Management
- ☐ Human Resources Management
- ☐ Logistics / Supply Chain Management
- ☐ IT Management
- ☐ Sustainability Management
- ☐ Other

1.6 How long are you in current position/sector – show level of personal experience

- ☐ < 10 Years
- ☐ 10- 20 Years
- ☐ 21-29 Years
- ☐ >30 Years

Explaining the purpose of the investigation

Section 18 of NEMWA, through substrate specific producer responsibility organisations, requires submission of auditable post-consumer metal packaging recovery data annually. Metal recyclers and the MRFs that receive and sort incoming metal (packaging and non-packaging) ideally need to generate data relating to post-consumer metal packaging collected. It is currently not clear whether the information needed by the metal PROs is readily available. This study will explore what information is available, what additional information is possible and the feasibility of this information being made available to the PROs in the metal packaging sector through formal reporting systems.

Focused exploratory discussion / semi structured (90 minutes)

The questions below are based on the research objectives and the research questions. The intention of the interviews is to ascertain the views of the metal packaging recyclers with respect to S18 of NEMWA obligations that are now placed on the industry, specifically related to effective post-consumer metal packaging recovery and re-use in SA.

The information derived from such interviews are intended to be used to improve the recovery, reporting and re-use of post-consumer metal packaging in SA, to enable greater circular utility of such materials, aligning with sustainable development principles and SA legislation.

1. Research Question 1

   Benchmarking against global best practice relating to metal recovery in SA and processing (packaging and non-packaging)

How does the metal recovery and processing model in South Africa compare to global best practices?

2. Research Question 2

   Effectiveness of the SA metal recovery model (packaging and non-packaging)

How effective is the SA metal recovery systems in SA?

3. Research Question 3

   Supply Chain Transparency / Metal Recovery Model Integrity

How do you ensure data accuracy and transparency in your metal supply chain, especially regarding the sources of scrap metal and raw materials?

4. Research Question 4

   Environmental / Statutory Compliance / commitment to post-consumer metal packaging recovery

How does your facility ensure compliance with EPR legislation and environmental regulations and standards in SA?

5. Research Question 5

   Improving waste recovery models in SA

Are there alternative models to recover and process metal more effectively and more efficiently in SA?

6. Waste Management Practices

What waste management practices do you have in place to minimize the environmental impact of your operations?

7. Energy Efficiency:

Can you share information about any initiatives or technologies implemented to enhance energy efficiency in your metal recycling/foundry processes?

8. Community Engagement

What initiatives or programs do you have in place to engage with and benefit the local community surrounding your facility?

Appendix 12: SLR Web of science database query

Query Link

https://www.webofscience.com/wos/woscc/summary/4c249d75-265a-4b27-9d11-b79820189569-bce8f925/relevance/1

Search Query

"Post-consumer metal packaging" OR "Post consumer metal packaging" OR "Postconsumer metal packaging" OR "Metal packaging" OR "steel packaging" OR "aluminium packaging" OR "scrap metal" (All Fields) and **Recovery OR reuse OR "Deposit return scheme" OR "Waste to energy" OR recycling OR "extended producer responsibility" OR "circular economy" OR incineration** (All Fields)

Search results: 99 records

Appendix 13: SLR Emerald Insight database query

Query Link

https://www.emerald.com/insight/search?q=%E2%80%9CPost-consumer+metal+packaging%E2%80%9D+OR+%E2%80%9CPost+consumer+metal+packaging%E2%80%9D+OR+%E2%80%9CPostconsumer+metal+packaging%E2%80%9D+OR+%E2%80%9CMetal+packaging%E2%80%9D+OR+%E2%80%9Csteel+packaging%E2%80%9D+OR+%E2%80%9Caluminium+packaging%E2%80%9D+OR+%E2%80%9Cscrap+metal%E2%80%9D+AND+%28Recovery+OR+reuse+OR+%E2%80%9CDeposit+return+scheme%E2%80%9D+OR+%E2%80%9CWaste+to+energy%E2%80%9D+OR+recycling+OR+%E2%80%9Cextended+producer+responsibility%E2%80%9D+OR+%E2%80%9Ccircular+economy%E2%80%9D+OR+incineration%29&fromYear=2018&toYear=2023&ipp=20&fromSavedSearch=true

Search Query

Post-consumer+metal+packaging%E2%80%9D+OR+%E2%80%9CPost+consumer+metal+packaging%E2%80%9D+OR+%E2%80%9CPostconsumer+metal+packaging%E2%80%9D+OR+%E2%80%9CMetal+packaging%E2%80%9D+OR+%E2%80%9Csteel+packaging%E2%80%9D+OR+%E2%80%9Caluminium+packaging%E2%80%9D+OR+%E2%80%9Cscrap+metal%E2%80%9D+AND+%28Recovery+OR+reuse+OR+%E2%80%9CDeposit+return+scheme%E2%80%9D+OR+%E2%80%9CWaste+to+energy%E2%80%9D+OR+recycling+OR+%E2%80%9Cextended+producer+responsibility%E2%80%9D+OR+%E2%80%9Ccircular+economy%E2%80%9D+OR+incineration%29&fromYear=2018&toYear=2023&ipp=20&fromSavedSearch=true

Search results: 15 records

Appendix 14: SLR Scopus database query

Query Link

Scopus - Document search results | Signed in

Search Query

(ALL ("Post-consumer metal packaging" OR "Post consumer metal packaging" OR "Postconsumer metal packaging" OR "Metal packaging" OR "steel packaging" OR "aluminium packaging" OR "scrap metal") AND ALL (recovery OR reuse OR "Deposit return scheme" OR "Waste to energy" OR recycling OR "extended producer responsibility" OR "circular economy" OR incineration)) AND PUBYEAR > 2017 AND (LIMIT-TO (SUBJAREA , "ENVI") OR LIMIT-TO (SUBJAREA , "ENER") OR LIMIT-TO (SUBJAREA , "EART")) AND (LIMIT-TO (EXACTKEYWORD , "Scrap Metal Reprocessing") OR LIMIT-TO (EXACTKEYWORD , "Recycling") OR LIMIT-TO (EXACTKEYWORD , "Circular Economy") OR LIMIT-TO (EXACTKEYWORD , "Waste Management") OR LIMIT-TO (EXACTKEYWORD , "Life Cycle") OR LIMIT-TO (EXACTKEYWORD , "Aluminum") OR LIMIT-TO (EXACTKEYWORD , "Environmental Impact") OR LIMIT-TO (EXACTKEYWORD , "Metals") OR LIMIT-TO (EXACTKEYWORD , "China") OR LIMIT-TO (EXACTKEYWORD , "Waste Disposal") OR LIMIT-TO (EXACTKEYWORD , "Steel Scrap") OR LIMIT-TO (EXACTKEYWORD , "Energy Utilisation") OR LIMIT-TO (EXACTKEYWORD , "Life Cycle Assessment") OR LIMIT-TO (EXACTKEYWORD , "Metal") OR LIMIT-TO (EXACTKEYWORD , "Scrap Metal") OR LIMIT-TO (EXACTKEYWORD , "Metal Recovery") OR LIMIT-TO (EXACTKEYWORD , "Life Cycle Analysis") OR LIMIT-TO (EXACTKEYWORD , "Industry 4.0") OR LIMIT-TO (EXACTKEYWORD , "Aluminum Alloys") OR LIMIT-TO (EXACTKEYWORD , "Wastes") OR LIMIT-TO (EXACTKEYWORD , "Environmental Monitoring") OR LIMIT-TO (EXACTKEYWORD , "Recovery") OR LIMIT-TO (EXACTKEYWORD , "Greenhouse Gases") OR LIMIT-TO (EXACTKEYWORD , "Waste Incineration") OR LIMIT-TO (EXACTKEYWORD , "Life Cycle Assessment (LCA)") OR LIMIT-TO (EXACTKEYWORD , "Environmental Management") OR LIMIT-TO (EXACTKEYWORD , "Steel") OR LIMIT-TO (EXACTKEYWORD , "Packaging") OR LIMIT-TO (EXACTKEYWORD , "Extraction") OR LIMIT-TO (EXACTKEYWORD , "Electric Furnaces") OR LIMIT-TO (EXACTKEYWORD , "Environmental Technology") OR LIMIT-TO (EXACTKEYWORD , "Materials Flow Analysis") OR LIMIT-TO (EXACTKEYWORD , "Waste") OR LIMIT-TO (EXACTKEYWORD , "Smelting") OR LIMIT-TO (EXACTKEYWORD , "Pyrolysis") OR LIMIT-TO (EXACTKEYWORD , "Pollution") OR LIMIT-TO (EXACTKEYWORD , "Energy Efficiency") OR LIMIT-TO (EXACTKEYWORD , "Energy Consumption") OR LIMIT-TO (EXACTKEYWORD , "Manufacturing") OR LIMIT-TO (EXACTKEYWORD , "Carbon Footprint") OR LIMIT-TO (EXACTKEYWORD , "Carbon Emission") OR LIMIT-TO (EXACTKEYWORD , "Recycling Process") OR LIMIT-TO (EXACTKEYWORD , "United States") OR LIMIT-TO (EXACTKEYWORD , "Incineration") OR LIMIT-TO (EXACTKEYWORD , "Developing Countries") OR LIMIT-TO (EXACTKEYWORD , "Europe") OR LIMIT-TO (EXACTKEYWORD , "Environmental Sustainability") OR LIMIT-TO (EXACTKEYWORD , "Climate Change")) AND (LIMIT-TO (LANGUAGE , "English"))

Search results: 1 024 records

Appendix 15: Editor certificate

Dr. Maleni Thakur 43 College Road, Overport, Durban, 4091

B. Tech: Journalism, M. Phil: Quality Management 031-4645041 / 078 5442461

Ph.D. Public Admin (DUT) maleni.thakur@gmail.com

EDITING CERTIFICATE LETTER

Date: 29 February 2024

Re: Mr. Kishan Singh (Durban University of Technology)

Student Number: 19002312

Doctorate dissertation: Evaluating Post-Consumer Metal Packaging Recovery Systems in South Africa

I confirm that I have proof-read, language edited and lay-out edited the above-mentioned work by the doctorate candidate Mr. Kishan Singh.

The work was returned to the candidate with evidence of track changes and implementations to be undertaken. The correct implementation of the changes in the text and references is the responsibility of the student. The final edited version was returned to the student on 29 February 2024 via email.

I am satisfied that the editing and proof-reading of the above-mentioned work meets the post-graduate guidelines as set-out.

Sincerely,

Dr. Maleni Thakur

Editor

WLSS0581-21003/02/0008

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

Certificate of Competence

DVC (Academic)

Wits Language School

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This is to certify that

Rookmoney Maleni Thakur

from 06 September 2021 to 12 November 2021
has met the minimum requirements for competence in

Copy-editing and Proofreading

(details overleaf)

Head, Wits Language School
Date of Issue: 06 December 2021

Wits Language School

Registrar

Appendix 16: Qualitative Consultation

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STATISTICIAN LETTER

Date: 29 February 2024

Re: Mr. KISHAN SINGH

DOCTORATE DISSERTATION: Evaluating Post-Consumer Metal Packaging Recovery Systems in South Africa

I confirm that I have consulted with Mr **KISHAN SINGH** on the qualitative analyses phase of his work.

The NVIVO 12 software was used to analyse the primary data from his interview scripts.

Sincerely,

Dr. Maleni Thakur