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Sustainability through Design: A triple bottom line (TBL) approach to disposable food and beverage plastic packaging

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Plagiarism declaration

I, Minette Maritz, declare that the contents of this dissertation/thesis represent my own unaided work, and that the dissertation/thesis has not previously been submitted for academic examination towards any qualification. Furthermore, it represents my own opinions and not necessarily those of the Cape Peninsula University of Technology.

Signed: ______________________ Date: 4 November 2020

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Abstract

Since the discovery of plastics, scientists have continuously modified natural plastics to make them stronger and more durable. Today, the plastic industry has become a highly debated subject. Plastic packaging has the second highest consumption rate in the world, making it a commodity that needs to be managed properly. For this research, focus and design intent were applied to disposable polyethylene terephthalate (PET) water bottles - presently one of the largest fast moving consumer goods (FMCG) on the market. The current system surrounding PET water bottles was analysed to determine its pitfalls and opportunities. This research drew inspiration from two concepts: the first referred to the impact that the use of plastics has had on the environment and human health while the second explored the prevalence and continued increase in use of the material.

By looking at each stage of the product's life cycle, the project showcased findings from all relevant sectors and accumulated knowledge for action to facilitate a sustainable design solution. The greater understanding which was gained is applied to disposable PET water bottle design and ultimately contributes to waste management systems. By viewing the system as a holistic entity, it demonstrated how disposable PET water bottles interact with the current system.

The study showed how the systems that relate to the life cycle of a PET water bottle can be optimised through the lens of the triple bottom line (TBL) approach and Gestalt principles. Through researching the three sections within the TBL (*people, profit, planet*), the wants and needs of each section were captured and analysed. To comply with the overreaching principles of the TBL and adhere to the proposed sustainability of a circular economy, this study resulted in the design of two water bottle prototypes. A holistic intervention which met the overarching objectives of all three sections was proposed as well as two design concepts, which facilitate a critical exploration of the key factors impacting sustainable design decisions.

Key words: Sustainability, circular economy, packaging, triple bottom line, manufacturing, reuse, recyclability.

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Clarification of terms

Glossary	
Term	**Clarification**
Blow moulding	A blow moulding machine heats a preform and blows it into the desired bottle shape through the means of a mould (d'Ambrières, 2019:13)
Biodegradable plastics	Biodegradable plastics cannot necessarily biodegrade in the natural environment; it depends on the environmental conditions like temperature, microorganisms, oxygen and water (Van den Oever *et al.,* 2017:15).
Bioplastics	Bioplastics is an umbrella term used to refer to a family of different materials or processes that create bio-based, biodegradable and compostable plastics. The term bioplastics refers to an alternative plastic material that is made from 20% or more renewable materials such as corn, sugarcane, potato starch or cellulose (Van den Oever *et al.,* 2017:15).
Cavitation	Cavitation in the plastic manufacturing industry refers to the number of empty space formations in a metal mould which produces a specific amount in each press cycle (Kazmer, 2007:41).
Circular economy	A circular economy aims to capture discarded materials (plastic bottles) and re-introduce them into commerce, like recycling (MacKerron, 2015:12).
Complex plastic packaging	Packaging that contains more than one type of plastic or multiple layered materials, like juice pouches (MacKerron, 2015:8).
Composite	Composite refers to two or more constituent materials/processes that when combined, produce a new material/process which is better or more efficient (Bassill, 2016:2).

Compostable plastics	Plastics that can decompose in nature through carbon dioxide, methane, water, inorganic compounds, or biomass over a specified period (DiGregorio, 2009:2).
Crude Oil/Petroleum	Oil which is extracted from fossil feedstocks and used to produce different gasses and oils for numerous applications (Ghanta *et al.,* 2013:167).
Cracking	Cracking is defined as the process wherein complex organic molecules are broken down into smaller molecules (Corma *et al.,* 2017:1).
Cradle to grave	Cradle to grave implies that the produced product will be discarded and not be used again after its initial useful life is over (Lee & Xu, 2005:15).
Cycle time	Cycle time refers to the period that it takes to produce a certain product on a machine (Siva *et al.,* 2017:12064).
Disposable beverage bottle	A plastic bottle which contains liquid that is designed to be discarded after the contents are finished (Bø *et al.*, 2013:23).
Ergonomics	Ergonomics is the applied science of structural design, intended to maximise effectivity and consumer convenience by reducing frustration and discomfort (Papanek, 1995:113).
Flexible packaging	Flexible packaging is referred to as "mixed residues", for example juice boxes, which are made from PET and aluminium laminates that are fused together (Schweitzer *et al.,* 2018:12).
Gestalt principles	Gestalt principles are based on the theory that consumers will react to certain products or shapes based on previous experiences (Chang *et al.,* 2002:6).
Injection moulding	Injection moulding refers to the machine which is used to create a preform, through the means of melting plastic pellets and pressing it into a designed mould (Mashek *et al.,* 2017:30).

Lightweighting	Lightweighting, in the plastics industry, refers to using a lighter preform, to make the product lighter and more energy efficient throughout its entire life cycle (Schweitzer *et al.,* 2018:6).
Linear economy	A linear economy implies that raw materials are used to make a product and after its use, it is simply discarded instead of being reused or recycled (Schweitzer & Janssens, 2018:2).
Masterbatch	Masterbatch refers to the colour which is added to clear plastic pellets, to produce a certain colour (Zsíros *et al.*, 2017:1).
Microplastics	Micro-plastics are small fragments of broken-down plastic objects that seep into the environment. Micro-plastics can be any kind of plastic, but it is defined as a fragment which is less than five millimetres in length (United Nations, 2018:9).
Monomer	Monomer refers to a molecule which form the basic structure and chemical composition of polymers. Monomer chains are formed through binding them to other monomers. This is done to create different chemical structures, to give the material (in this case plastic) different properties (Hocking, 2005:637).
Natural plastics	Consists of materials originating from plants and animals and can biodegrade rapidly without human intervention (United Nations, 2018:10).
Pallet utilisation	This term refers to the number of wooden pallets you can fit into a certain amount of space (Vargas-Osorio & Zúñiga, 2016:69).
Plastic	Refers to any polymer which is flexible or malleable and is applicable to any material of which the shape can be changed or deformed (Walker, 1994:68).
Plastics	Refers to a wide range of both synthetic and natural compounds which can be moulded into solid objects (Plastics Europe, 2019:4).

Plastic pellets	Plastic pellets refer to the round plastic pellets that get melted in an injection moulding machine to form a preform (Fernandino *et al.,* 2015:326).
Plastic packaging	Any plastic product which is specifically designed to protect a product, for example; food containers, beverage bottles, etc. (Natural Capital Coalition, 2016:6).
Preform	Refers to the object that was produced from plastic pellets in an injection moulding machine. The produced plastic object is referred to as a preform, which will then be used to produce a plastic bottle with the use of a blow moulding machine (Sidorov *et al.,* 2018:14).
Readily recyclable	Readily recyclable implies that a product can be recycled as soon as it is discarded. It does not need any treatment or separation (Schweitzer *et al*., 2018:10).
Reusable bags	Reusable bag implies that it can be used more than once (MacKerron, 2015:41).
Semi-synthetic plastics	Plastics which are derived from natural plastics and modified (Macdonald & Vaughan, 2008:6).
Shrink sleeve	A shrink sleeve refers to a plastic film label which is just as large as the product. It is applied to the product using heating equipment to make it fit tightly onto the shape (Szusta *et al.,* 2018:2544)
Single use plastics	This includes any plastic which is meant to be discarded after it was used once (United Nations, 2018:15).
Solid waste	Solid waste includes garbage, refuse and other discarded materials which ends up in a landfill (Kaza *et al.,* 2018:137).
Steam cracking	Steam cracking is the process which is applied to crude oil to produce lighter fuels like Naphtha which in turn produces ethylene (Ghanta *et al.,* 2013:167).

Sustainable development	Economic and social development which meets the need of the present without compromising the ability of future generations to meet the needs of others, having implications for the entire value chain of a product (Lee & Xu, 2005:15).
Synthetic plastics	Plastics which are not derived from plants or animals, but from fossil fuels (Walker, 1994:71).
Thermal cracking	Thermal cracking refers to the chemical process through which organic materials are made into lower weight materials to produce fuels like ethane (Speight, 2003:31).
Thermoplastics	Refers to a plastic polymer that can be re-heated and moulded several times into new shapes (Bellis, 2011:1).
Thermosetting plastics	Once the plastic has set or hardened into a certain shape, it cannot be melted or reformed into a different shape (Nicholson & Leighton, 1942:303).
Virgin plastic	Virgin plastic refers to the first resin produced from crude oil, which has never been used or processed before (d'Ambrières, 2019:14).
Vulcanize	Hardening rubber (or a similar material) by treating it at high temperatures with Sulphur (Macdonald & Vaughan, 2008:6).

Abbreviations

AR	Action research
B2B	Business to business
Ca.	Circa (meaning: '*around about'* in Latin)
CAD	Computer aided design
CMM	Capability maturity model
CO_2	Carbon dioxide

CPM	Composite product map
ECMPRO	Environmentally conscious manufacturing and product recovery
EPR	Extended producer responsibility
EU	European Union
FEA	Finite element analyses
FMCG	Fast moving consumer goods
IBL	Integrated bottom line
kg	Kilogram
LCA	Life cycle analyses
LCM	Life cycle management
ml	Millilitre
mm	Millimetre
NDP	National development plan
PET	Polyethylene terephthalate
PHA	Polyhydroxyalkanoate
PLA	Bio-based polylactic acid
RPET	Recycled-polyethylene-terephthalate
TBL	Triple bottom line
TA	Thematic analysis
TPS	Thermoplastic elastomers
US	United States

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1. CHAPTER ONE: INTRODUCTION

The significance of this study is rooted in the ever-changing world of plastic packaging and the overuse thereof. This Chapter defines the parameters of what was investigated throughout this study. To understand the significance of the problem within the plastic packaging industry, the background and history thereof was studied. Through understanding the problem, the key research questions were stated. To narrow the parameters of this study, a theoretical framework was chosen which guided the study. These parameters were set to make sure that certain outcomes would be achieved, and a hypothesis could be constructed. The lens which was used to explore this topic, on a user interaction level, was also introduced and briefly discussed. The intention of the above-mentioned boundaries was set to ensure that focus will solely be placed on disposable PET plastic water bottles and the system which supports it. Lastly, the motivation and role of the researcher was discussed. This was done to place the study in an applicable realm which is unique to the researcher. This Chapter provided the framework to finally report the results and indicate what was necessary to conduct the study and to explain how the findings will present this information.

1.1. Statement of the research problem

This research drew inspiration from two concepts, which initially appear to be at odds with each other. The first referred to the impact that the use of plastics has had on the environment and human health, while the second explored the prevalence, and continued increase in use of the material.

Since the discovery of plastics in the 18th century, scientists continuously modified natural plastics to make them stronger and more durable. Currently, there are 220 million tons of plastics being produced annually worldwide (Reese & Junge, 2017:201). Most modern plastics are derived from large amounts of non-renewable fossil feedstocks which are extracted in the form of crude oil. After crude oil has been extracted, it is fragmented into natural gas, oil, coal, etc., and has many different applications (Plastics Europe, 2018: 8; Radovic & Schobert, 1997:144). The entire life cycle of plastics including its extraction, raw material processing, manufacturing, distribution, use, maintenance and disposal have an impact on the environment, as it can take up to 500 years to decompose (Lee & Xu, 2005:18). Currently, post-consumer plastic packaging will inevitably end up in a recycling program, landfills or in the natural environment, polluting urban areas and waterways (Digimarc, 2018:3). In addition to the impact of plastic on the environment, plastic has been detected in humans, posing detrimental health risks. Considering all these aspects, the production of plastics worldwide is still increasing, whilst no proper waste management policies are being implemented to curb it (Reese & Junge, 2017:201). Currently plastic packaging is designed using a linear model, which is based on planned obsolescence. Products are designed to be thrown away (United Nations, 2018:9). Short product lifecycles are causing plastic packaging to account for half of all plastic waste in the world (Schweitzer *et al.*, 2018:5).

It is, however, critical to acknowledge that it is not viable to lobby for an immediate stop in the production and use of plastics. It will take time to change to different packaging models and materials. Therefore, the design and manufacturing of plastic packaging must be reviewed, to propose design changes focused on immediate impact, while longer term solutions are implemented. It is essential for consumers to realise that plastic material is a valuable resource that can be reused instead of an invaluable commodity (United Nations, 2018:6). Successful recycling aids in building a circular economy, in which raw materials can be captured, processed and re-entered into commerce. In turn this could increase resource efficiency, reduce greenhouse gas emissions and ease economic reliance on non-renewable resources (MacKerron, 2015:12). A pivotal role is played by designers to design products that can be reused and recycled while collaborating with policy makers who are responsible for waste management systems. Currently plastic is the cheapest material (for both producer and consumer), it has the largest impact on society (job creation) and its production causes minimal emissions (greenhouse gasses) in relation to alternative materials like glass and metal (Macdonald & Vaughan, 2008:9). Plastic packaging and the production thereof need to be rethought and designed in a holistic manner, taking into consideration supporting alternative materials. To coherently view the interplay between the facets of the system, the triple bottom line (TBL) approach will be used. The TBL focuses on each part of a product system, namely; *people, profit* and *planet*. This research defines the food and beverage sector as an all-encompassing industry which includes all businesses operating in the production, processing, or retailing of food and beverage products (Natural Capital Coalition, 2016:6).

This research investigates disposable polyethylene terephthalate (PET) water bottles in relation to the growing environmental crisis, to identify its shortcomings and explore design solutions through the lens of the TBL. Even though PET plastic bottles will be the focus to explore the whole production process thoroughly, it is integral to explore the entire food and beverage industry. The PET used in the manufacturing of disposable water bottles is the same used for food packaging as they contain the same barrier properties and represent the entire food and beverage industry.

1.2. Background of the research problem

"Plastics" is an all-encompassing term used to describe a set of different materials which have a variety of properties. They are designed to meet the needs of each specific application in the most efficient way. Plastic is an organic material which is derived from either fossil fuels or other bio-based materials (Plastics Europe, 2018: 8).

The first plastics were made by using 100% natural materials. The mid-19th century saw the development of semi-synthetic and synthetic plastics. These modified polymers could be used in numerous industries as it was virtually indestructible, very affordable and lightweight. When the industrial revolution started in the 19th century, designers and innovators did not consider the possible social and environmental impact these new materials could have (Gungor & Gupta, 1999:811).

Since the 1950's, packaging waste and food waste grew simultaneously. Currently, waste produced per capita in these sectors is the highest statistics globally (Schweitzer *et al.,* 2018:4). Plastic packaging was invented as an affordable response to the consumer's need for convenience and to protect products. These flexible properties are what make plastic packaging the most desired option for the food and beverage industry (Macdonald and Vaughan, 2008:9).

Packaging would not be needed if there were no product to protect. Therefore, to understand the purpose of plastic packaging to protect the product is important. To view plastic packaging in a holistic manner, the needs of the consumer and the processing of the packaging before and after use need to be taken into consideration. This will show the effect that plastic packaging has on food waste and vice versa (Verghese *et al.,* 2013:28).

Currently, plastic packaging is the second largest form of waste in the world, surpassed only by food waste (Schweitzer *et al*., 2018:4). Plastic has become a prominent part of daily life, but the contribution to global pollution is immense. Using alternative materials such as glass, metal foils, etc. can be seen as an efficient way to reduce pollution. Concerns are, however, that glass weigh much more than plastic, consequently transportation costs are much higher, the greenhouse gas emissions will increase, and more waste will be created which will need to be disposed of (Hanekom, 2019). This reiterates the importance of creating social awareness and improving waste management systems whilst exploring alternative materials (Azzone *et al.,* 2013:142). When managed and reused properly, plastic is a valuable commodity that can help grow wealth and economy (United Nations, 2018:6).

Hammer and Pivo (2017:1) have argued that sustainable development cannot take place without recognising the necessary change of current development patterns. Carrying on with the same systems can jeopardise the environmental structure impairing both the planet and economy (Hammer & Pivo, 2017:1).

It has been proved that plastic packaging increases shelf life, which can in turn reduce food waste. To name one example; it is estimated that the plastic around a cucumber increases its shelf life from three to fourteen days (Sonesson *et al.,* 2009:16). Although this research proved that plastic shrink wrap increases the shelf life of a product, research made no mention of consumer behaviour. Thus, even though the shelf life of the product has been increased by the plastic film, the consumer might still waste it, translating to possible increased levels of both food and plastic waste (Schweitzer *et al.,* 2018:16).

It is important to consider the entire life cycle of the product to ensure that the pollution or waste is not merely shifted to a different part of the system. If the carbon dioxide (CO_2) released in food production must be compared to the production of plastic packaging, the amount of CO_2 used to produce meat is 100 times more than the plastic film used to package it (Macdonald & Vaughan, 2008:9). The benefits of plastic use in the food industry is indisputable, however since the turn of the 21st century, plastic has been increasingly criticised and rejected. It is estimated that only 9% of all the plastic ever produced globally has been recycled (United Nations, 2018:4).

In a survey done by *Which?,* a UK based consumer watchdog, 94% of respondents agreed that the amount of plastic packaging related to food should be reduced, 23% of respondents reiterated that they avoid buying products which they feel are “over packaged”. Another survey by the Industry Council for Research on Packaging proved that 79% of consumers agree that plastic is malevolent and that products are “over packaged”, considering the amount of waste that ends up in water channels and oceans every year (Schweitzer *et al.,* 2018:14).

Fast moving consumer goods (FMCG) companies are always searching for new ways to decrease the price of plastic packaging. One of the leading ways to do this is through lightweighting. Through this process, less plastic is used and consequently the carbon footprint will be minimised. Lightweighting can affect the thickness and quality of the packaging, making it less ergonomically viable for consumers which in turn reduce the product life as it can only be used once (Schweitzer *et al*., 2018:6). In the sector of FMCG where the quantities are extremely high, companies are more concerned about the price than the usability or the environmental impact of the final PET water bottle.

During the last decade, many types of new plastics have been developed, including eco-friendly, biodegradable and compostable plastics. The problem being that there is a lower demand for these plastics which translates to a higher price point (Digimarc, 2018:10). Companies like Tupperware have always tried to ensure that plastics are user friendly, sturdy, easy to use and ergonomically viable, but all these factors come at a price (Minnick, 1996:23). The more intricate the mould used to form the packaging, the more expensive the product becomes.

The initial selling point of plastics was that it is a cheap and durable material which lasts forever and was essential in the production of everyday items. Unfortunately, these strong properties are the source of the problem once these plastic items have become unusable, making plastics one of the most controversial materials in the world (Walker, 1994:82). Traditional semi-synthetic and synthetic plastics do not biodegrade; instead they break into smaller micro-plastics which seep into global waterways and food production streams (United Nations, 2018:9). Biodegradable packaging has been invented as a response to pollution, but most biodegradable plastics only biodegrade under high temperatures at incineration plants, not in the natural environment (MacKerron, 2015:21).

1.3. Research questions

This research was grounded in the following main research question:

How can a triple Bottom Line (TBL) approach shape the design of a disposable polyethylene terephthalate (PET) water bottle to produce a more sustainable option within the manufacturing process?

a) **How did the emergence of plastic packaging impact the food and beverage industry and what is the state of the global industry today?**
b) **How does the interplay of *people, profit,* and *planet* affect each other in the design of food and beverage disposable packaging?**
c) **How does a design process, with a focus on manufacturing, facilitate a focus on the TBL of PET food and beverage disposable packaging production?**

1.4. Objectives and significance of the research

The intention of this research was to propose a holistic design model which will create a platform for each stakeholder within the TBL (*people, profit, planet*) to become more efficient. To identify its short comings, plastic packaging was analysed to identify and consider efficient future development for disposable PET water bottles. This research attempted to reach four objectives: (a) contribute research to the body of knowledge associated with FMCG to support positive change in future applications, (b) generate theoretical and practical knowledge about the FMCG sector, (c) identify the relationships between stakeholders within the life cycle of a disposable PET water bottle, and (d) suggest sustainable change which can lead to development and growth (Burns, 2015:188). This research was aimed to inform action which can facilitate sustainable design options for disposable PET water bottles, and ultimately contribute to waste management systems. Through proving the significance of the TBL on each stage of the life cycle of disposable PET water bottles, this research shows the importance of all the stakeholders within the TBL and the importance of working together.

The plastic packaging industry was analysed, whilst taking into consideration the contents of the packaging to understand why packaging is a necessity. This research presented how food, packaging and waste interact with each other, by viewing the entire waste disposal system as a single entity, instead of as separate components. To understand how society perceives plastic packaging, Gestalt principles were used in this research to see how consumers perceive plastic water bottles. Thus, the final design will respond to both the physical interaction and consumer needs. This study presents a compelling opportunity to increase system efficiency of the plastic packaging economy, illustrated by examples from the packaging value chain which shows the role that plastic packaging plays in the global supply chain.

Consumers need to see plastic packaging as a valuable commodity that needs to be used according to its value in both the supply and production chain. Emphasis was placed on the rise and downfall of disposable plastic packaging whilst looking at the effects of replacing it with alternative materials. The main goal was thus to contribute knowledge and practical design to both design and plastics organizations that can add value to waste management systems within the plastic packaging industry.

1.5. Theoretical Framework

For this research, the TBL and Gestalt theory were used as the theoretical framework[1]. The TBL framework considers the social (*people*), economic (*profit*) and environmental (*planet*) dimensions of any given system to view it as one complete entity. The TBL framework aims for sustainable development that creates appropriate opportunities by looking at an entire system (Hammer & Pivo, 2017:1). The TBL supports a holistic review of the three sections (*people, profit, planet*) and argues for an integrated development plan (Sroufe, 2017:322;

[1] Both concepts are explored in more detail in Chapter 3, pages 44-48.

Sridhar & Jones, 2013:109). A key part of the design exploration in this research is to conceptualise design options that are driven by each of the three sections.

Gestalt theory is based on the principle that the consumer will react to certain products or shapes based on previous experiences, proving that consumer reaction can be biased (Chang *et al.,* 2002:6). Through using Gestalt principles, the consumer reaction can be manipulated (Papanek, 1995:38). To thoroughly understand the consumer' wants and needs, it is important that their perception of the PET water bottle is understood. This was done to ensure a holistic design was proposed.

1.6. Delineation of research

For this research, focus and design intent was placed on one of the largest FMCG products on the market, namely disposable PET water bottles. Disposable PET water bottles currently have one of the highest consumption rates with regards to plastic packaging, not only in South Africa, but across the world. This research aimed to understand how disposable PET water bottles interact with the community, financial sectors and environment. The system was analysed to show the impact that it has had on everyday life. The food and beverage sectors were defined as an all-encompassing industry including, all businesses which operate in the production, processing, or retailing of food and beverage products. The entire system of disposable PET water bottles that was analysed, included raw material extraction, manufacturing, transportation, handling, consumer interaction and disposal. This was done to understand the opportunities and complications which are associated with replacing PET bottles with alternative materials. Research yielded an understanding of the impact that effective waste management systems can have on PET water bottles to create a circular, holistic system which works together to replace the current linear model. This research showed how the system can be optimised through using the TBL approach and Gestalt principles.

1.7. Motivation of the researcher

As a young designer, I found the idea of packaging very intriguing. Packaging is part of every product that is purchased, yet once the product is removed and used, its packaging becomes redundant. Through the never-ending packaging and product cycle, I could never understand why such a resource intensive pack needs to be used to house a simple product. Through doing research on the subject, I realised that the packaging, in many cases, is what makes a product. Without packaging, the product is unrecognizable, branding has no place, the product is not protected, and the product life is decreased immensely. Just as packaging is a part of everyday life, so are plastic products. That brought me to think, how can plastic packaging be made; firstly, more efficient (upcycling or reused) and secondly, less energy intensive (throughout its production and recycling). To understand how packaging can be made more efficient, its life cycle needs to be understood as well as its user interaction, to see why it is necessary and how the system can be improved in a sustainable manner.

1.8. Role of the researcher

From the view of an industrial designer, this research had a unique insight into product and system design. Working in the corporate plastic FMCG industry, the resources and experience gained in this field added an incredible body of knowledge that is specifically applicable to this research as it focused on the entire PET plastic industry. The plastic industry is growing and changing every day, which makes it a very fascinating and fast paced industry to work in. It is important that consumers and brand leaders understand each stage of the plastic industry, to make informed decisions about the products that they choose to buy or sell. Plastics will always be relevant, therefore it is of utmost importance study it and to understand the outcomes.

Being biased in the plastic industry is easy, as there are so many views and opinions from both informed and uninformed consumers. This research was completely led by primary and secondary research, to ensure that bias was addressed and mitigated whenever possible. Data for this research were gathered through a constructivist point of view. According to Elkind (2005:334):

> *Constructivism is the recognition that reality is a product of human intelligence interacting with experience in the real world. As soon as you include human mental activity in the process of knowing reality, you have accepted constructivism.*

Through the combination of experience within the FMCG sector and the constructivism approach, this research was uniquely placed with regards to the researcher.

1.9. Thesis structure

This study has been divided into 7 Chapters, each Chapter discusses a different element of the research process. This was done to; firstly, show the progression of plastic packaging, secondly, to highlight the methods which were needed to conduct a thorough study and thirdly, to discuss primary findings and design an appropriate intervention which suit the overreaching needs within all sections of the TBL. Table 1.1. shows the Chapters which were added to this study and gives a short explanation of what each one entails.

Table 1.1: Thesis structure	
Chapter 1	This Chapter gives an outline to what can be expected throughout the study. It gives a basic outline and states why this topic is relevant within modern design circles. It also gives a basic outline of the researcher's intentions and purpose.
Chapter 2	Chapter 2 shows the relevant secondary research which has been chosen to guide the overall design of the final product. This Chapter gives an overall understanding of how the plastic industry works and all the elements involved in the before, during and after use of PET beverage bottle packaging.
Chapter 3	The relevant methodology chosen for this study is discussed in this Chapter. This Chapter also explains why this methodology is applicable to this study and explores the research methods which were used to gather primary data.
Chapter 4	Chapter 4 explores the primary data which was gathered throughout all three sections of this study; *people, profit, planet*. All the collected data was stated and grouped, to form the overreaching themes found throughout the data.
Chapter 5	The key themes that emerged through the previous Chapter, is explored in Chapter 5. Each theme was thoroughly discussed to show its significance and contribution toward the study.
Chapter 6	This Chapter established the key design parameters which were found in Chapter 5. The design response was discussed, and the final designs were described. Each design was discussed to show why certain design decisions were made. Chapter 6 also consists of the user feedback and an opinion of one stakeholder from each section; *people, profit, planet*.
Chapter 7	Chapter 7 consisted of the conclusion and recommendations which were made by the researcher. This Chapter demonstrates why each process used within this study was relevant and the outcome thereof. It also shows the significance of the study and recommends an environment where future development within this field can be achieved.

2. CHAPTER TWO: LITERATURE REVIEW

2.1. Introduction

In Papanek's 1974 book, *Design for the Real World: Human Ecology and Social Change*, the author discusses the designer's obligation to society and the environment when designing. One of the key conclusions is that designers are too preoccupied with style and aesthetics, rather than the holistic system around the product, its function, maintainability, affordability and its social and environmental impact (Papanek, 1995:265). Through his book, Papanek emphasises the importance of sustainable development to create a coherent and holistic system for design.

The report done by The World Commission for the Environment and Development (1987:15) defines sustainable development as:

> *…a morally defensible form of economic and social development that meets the need of the present without compromising the ability for future generations to meet the needs of others.*

The sustainable development of a product has implications for the entire value chain from cradle to grave (Lee & Xu, 2005:15). Plastic packaging accounts for 40% of the global packaging market, which includes both food and non-perishables (Song, Kay & Coles, 2011:295).

When creating plastics, which need strong barrier properties to protect consumable products, the three key external influences are chemical, biological and physical (Marsh & Bugusu, 2007:39). These influences affect both beverage and food packaging. Therefore, it is important to view consumable plastic packaging, to understand how both interact with its container. The same plastic is used for both food and beverage packaging (Natural Capital Coalition, 2016:6).

Currently plastic packaging, including rigid and flexible, accounts for one third of the total packaging industry, whilst food waste is the number one form of waste in the world (Foster, 2019). This shows the importance of analysing the packaging and the product to determine the best design to protect it. Plastic packaging goes hand in hand with food waste. For this reason and for this research, the two will be the cause and the effect of one another.

There have been many suggestions of what would make good replacements for modern, synthetic plastics. Consumers and critics alike want a healthier, eco-friendly planet, which is often associated with a move away from plastics. Therefore, it is critical to investigate the impact that abandoning plastics will have on the different aspects of the economy and environment.

2.2. The evolution of plastic and its influence on the packaging industry

Throughout the last decade, the term "plastic" has become a highly debated subject. Centuries ago consumers would never know the effect of plastic on modern society, as plastic was a pliable material found in nature. The first natural plastics consisted of natural polymers like keratin from animal horns, rubber from rubber trees and cellulose from bark, wood or leaves of plants (Walker, 1994:67). In the 19th century natural plastics were increasingly replaced by processed materials (Brydson, 1999:3).

In the 1840's, Charles Goodyear in the United States and Thomas Hancock in the United Kingdom independently procured patents on vulcanized rubber and produced the first semi-synthetic plastic (Macdonald & Vaughan, 2008:6). The vulcanization process made rubber strong and durable. In the 1850's it became known that rubber was a great insulator for electrical devices, which lead to the discovery and development of Latex (Plastics SA, 2018:2). Latex was made from the juice of the '*Gutta Percha'* tree, making it more malleable and flexible than rubber. This material was also used for tire manufacturing and insulating telecommunication devices (Walker, 1994:67). Natural materials, including rubber and latex, would give way to synthetic plastics.

The first synthetic plastic, called Parkensine was created by Alexander Parks; Parkensine was derived from a material named cellulose (Brydson, 1999:3). At the 1862 great international exhibition in London, Alexander Parks demonstrated and launched this new material known as thermoplastic which when heated could be moulded and cooled to retain its shape (Bellis, 2011:1). In 1868 John Wesley Hyatt created a different kind of plastic called celluloid, which is derived from cellulose and combined with alchemized camphor (Nicholson & Leighton, 1942:302). John Hyatt became the second person to alter natural and semi-synthetic plastics to make it strong and durable enough for commercial use, mainly in the photo film industry (Macdonald & Vaughan, 2008:6). After the introduction of celluloid, many countries like Germany, France and Belgium started to experiment with celluloid (Plastics SA, 2018:2).

In 1907 the first synthetic plastic was invented by a Belgian doctor called Baekeland. It was called bakelite and all present-day plastics are derived from it (Walker, 1994:71). Bakelite was the first thermosetting plastic, meaning that once it had set, it did not soften when re-heated. This unique quality made it possible to be used for almost any purpose (Nicholson & Leighton, 1942:303). Due to its revolutionary design, polystyrene (1929), polyester (1930), polyvinylchloride and polythene (1933) and nylon (1935) were born. Plastics could now be used and formed in almost any shape, form or colour (Macdonald & Vaughan, 2008:6).

During World War Two, the production of plastics developed at an increased pace as it started replacing metal parts in machinery. Plastic had many applications including for radar systems in military vehicles (Plastics SA, 2018:10). Throughout the war, petrochemical companies built plants for the exclusive production of plastic parts to service the high demand (Walker, 1994:73). After the war, these companies had to shift their focus to the consumer market to carry on with production at the plants (Nicholson & Leighton, 1942:305).

Over 90% of modern plastics are derived from large amounts of non-renewable fossil feedstocks which are extracted in the form of crude oil (d'Ambrières, 2019:13). The critical raw material needed to produce plastics is a by-product of crude oil, namely ethylene and propylene. Crude oil is a naturally occurring liquid mixture containing hydrocarbons, oxygen, nitrogen and sulphur (Radovic & Schobert, 1997:138). It is formed through a timely process of decay and chemical alteration of buried organisms, such as plants and animals. Over time, the source material is turned into kerogen, which is a solid organic material. Eventually through thermal decomposition, the kerogen is formed into gasses and crude oil (Speight, 2003:32). At an oil refinery, crude oil is broken up into many parts for instance fuels, gasoline, etc., and then used for a wide range of applications. The main reason for its extraction is to produce fuel, as shown in Figure 2.1 (Radovic & Schobert, 1997:144; d'Ambrières, 2019:13).

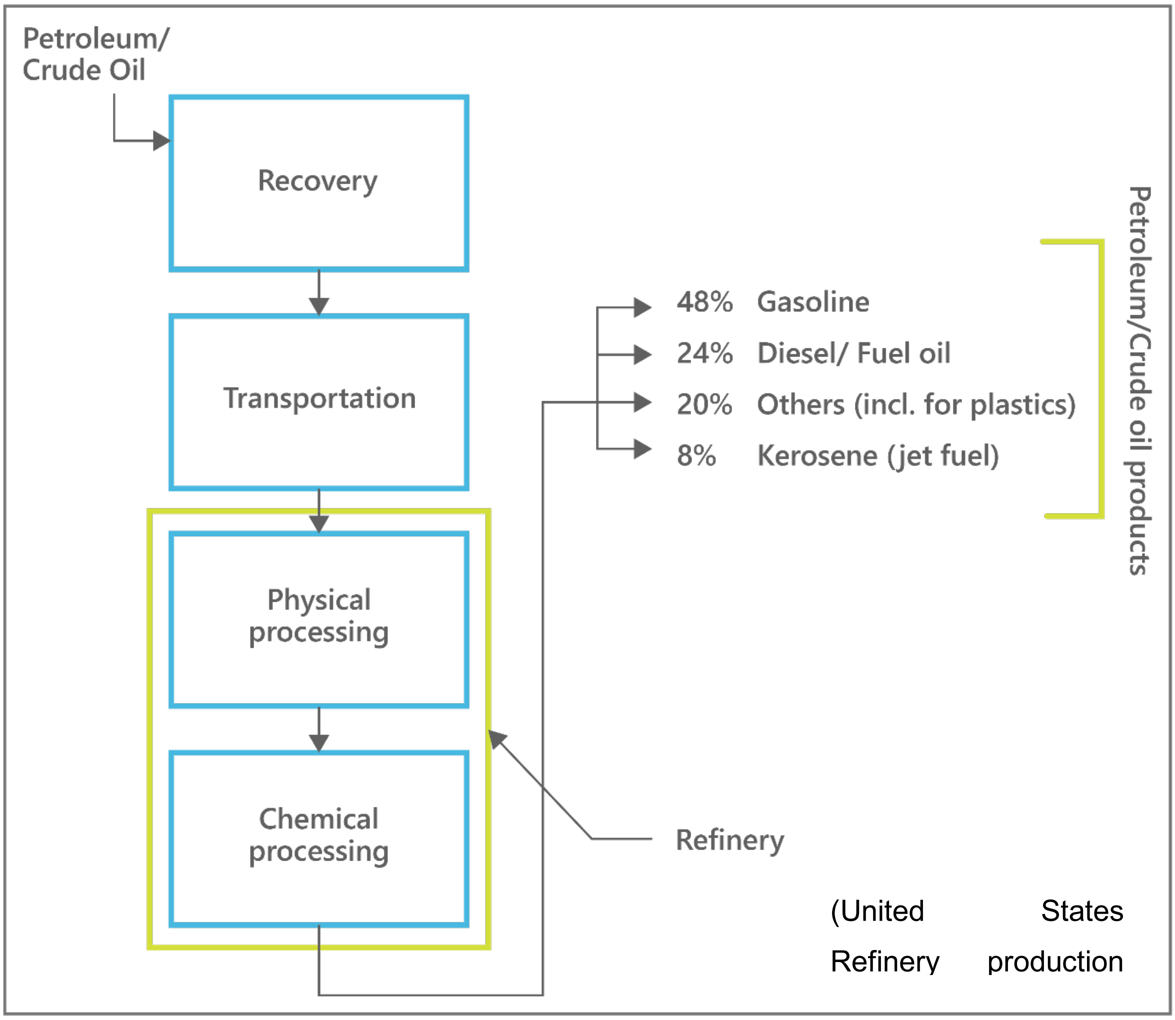

Figure 2.1: US Crude oil refining percentages

Source: Adapted from Radovic, Schobert, 1997:144; Jechura, 2018:17

Industries use two of the derives from crude oil to produce plastics and other products[2] like ethylene and propylene. Plastic production is part of the fossil fuels supply chain, making it profitable for fossil fuel companies to produce plastic resins and products (Centre for International Environmental Law, 2017:3). Fossil feedstocks are currently the most used material to produce plastics, and only 4 - 8% of all extracted fossil fuels is used in the production of plastics (OECD, 2018:4). Before plastics became a booming industry, only kerosene (used for electricity) was extracted (through the refining process) and used. All the other by-products of crude oil were discarded as waste (Radovic & Schobert, 1997:18).

The consumer market required plastics that were more malleable and were aesthetically pleasing. This led to the development of low-density polyethylene (LDPE) in England (1939),

[2] This process is further explored in section 2.3.1, pages 18-23.

high density polyethylene (HDPE) developed in Germany (1954), and poly propylene (PP) developed in Italy (1955) (Risch, 2009:8090). By the mid 1950's, plastic had become the favourite material for packaging, overtaking other materials used at the time. All plastics are given resin codes to show the different types of plastics, mostly for sorting purposes. Resin codes were first introduced in 1988 by the Society of the Plastics industry, now called Plastics Industry Association (PLASTICS). Members who form part of the "PLASTICS" association, represent the entire US plastic industry supply chain (Mashek *et al.*, 2017:12). Plastic could be used for almost any product imaginable. Table 2.1 shows the different resin code of each plastic, and its use (United Nations, 2018:4).

Table 2.1: The most common plastics and their uses

Polymer code	Product	Description	Recycled into
PET **Polyethylene terephthalate**	Bottles and jars for drinks, detergent, juice, mineral water and food packaging.	Lightweight, transparent, strong, shatter resistant, thermostable (can resist change in its chemical or physical structure at a high relative temperature), Bisphenol A (BPA) free, does not leach harmful materials into its contents, 100% recyclable (RPET).	Fibre for polyester carpeting, duvets and pillows, T-shirts, underwear, athletic shoes, sweaters, fabric for luggage and upholstery, sheeting for sandwich blisters, chocolate trays, bottles for detergents and food containers and bottles.
HDPE **High-density polyethylene**	Bottles for milk, juice and shampoo, shopping bags, household containers, crates and closures.	High impact strength, flexible, excellent corrosion and abrasion resistance, good chemical resistance, lightweight, non-toxic, safe for drinking water and low thermal conductivity.	Crates, bins, flower pots, automotive mud flaps, pallets, toys, carrier bags, traffic barrier cones, pipes, refuse bags, timber, drums, worm farms, chicken nests.

This Table continues onto the next page.

Polymer code	Product	Description	Recycled into
3 **PVC** **Polyvinyl chloride**	Clear jars and bottles for toiletries, food, medication, blood transfusion sets and cling film.	Strong, lightweight, no gas and water permeability, can produce both rigid or flexible products, flame-retardant, consumes minimal energy during production, 100% recyclable.	Shoe soles, pipes, hoses, door mats, car mats, gum boots, speed humps, traffic cones.
4 **LDPE** **Low-density polyethylene**	Bags for frozen foods, bread, garbage and toilet paper as well as milk sachets and shrink or stretch wrap.	Great insulator, very flexible, waterproof, lightweight.	Bags, dust bins, containers, bin liners, refuse bags, construction film, water pipes, irrigation pipes, furniture covers.
5 **PP** **Polypropylene**	Yoghurt and margarine tubs, ice cream containers, bottle tops and closures and clear and metallized films/wrappers for sweets.	Versatile, strong, easy to mould, tough, flexible, holds colour well, does not absorb water or seep into products.	Buckets, bowls, refuse bins, shopping baskets, coat hangers, outdoor furniture, paint tray, flowerpots, storage containers, toys.
6 **PS** **Polystyrene**	Yoghurt cups, clamshells, food trays for meat, fruit and vegetables, vending cups and take away packaging.	Low carbon footprint, lightweight, resource and energy efficient, transparent, enhances food hygiene, heat resistant, good insulator.	Hangers, picture frames, cornices, skirting's, seedling trays, cutlery, rulers, toys.
7 **Other**	In packaging it could be multi-layer materials for long-life products like cheese, processed meats, milk and sauces, filter coffee packets, toothpaste tubes, packs for butter.	Multi-layer materials are used where special barrier properties are required to protect the product and increase the shelf life. They incorporate a mix of plastic, foil and paper.	Multi-material products can only be recycled if the layers can be separated. In general, multi-layer plastics can only be recycled into plastic timber products.

Source: Adapted from Plastics SA, 2018:5-18

During the 20th century, plastics truly started taking on a commercial form (Macdonald & Vaughan, 2008:8). Tupperware company was one of the first establishments to exploit and test the limits of polyethylene (PE) to create inexpensive, lightweight food containers (Minnick, 1996:23). As the industrial revolution was booming, plastics were modified in any way imaginable, thus becoming the preferred material.

During the 21st century, society started noticing the effect that plastic has on the environment. In combination with this, oil prices increased which prompted a call for an alternative, less destructive material. All these factors contributed to designers who started to experiment with renewable materials, which lead to the adaption of bioplastics (DiGregorio, 2009:1).

The first bioplastics was invented by Brandenberger in 1912. It was a transparent sheet, made from bio-based materials including wood, cotton or hemp cellulose. It did not receive much attention, because at that time there was an abundance of cheap oil available to produce synthetic plastics (Raschka *et al.,* 2013:331). The first well-known bioplastic called polyhydroxybutyrate (PHB) was invented by Maurice Lemoigne in 1926. Even though being invented then, PHB only became widely known in the mid-1970s after the global oil crisis, which lead to crude oil becoming very expensive (DiGregorio, 2009:1). As the interest in renewable plastic materials grew, other bioplastics (made from microbes and bacteria) like polyhydroxyalkanoate (PHA) and polylactic acid (PLA) were developed and are still used today (Van den Oever *et al*., 2017:33).

- **Bioplastics** is an umbrella term used to refer to a family of different materials or processes that create biobased, biodegradable and compostable plastics (Figure 2.2). All products which are biobased are not necessarily biodegradable and vice versa, as they can have completely different characteristics and chemical compositions (European Bioplastics, 2016:1). Modern bioplastics has the same strong and durable properties that synthetic plastics have, but their energy consumption and CO_2 emissions are arguably less (Lee & Xu, 2005:29). As shown in Figure 2.2 bioplastics can either be based on renewable resources and be biodegradable or based on renewable resources but not be biodegradable or based on fossil resources and be biodegradable (European Bioplastics, 2016:2).

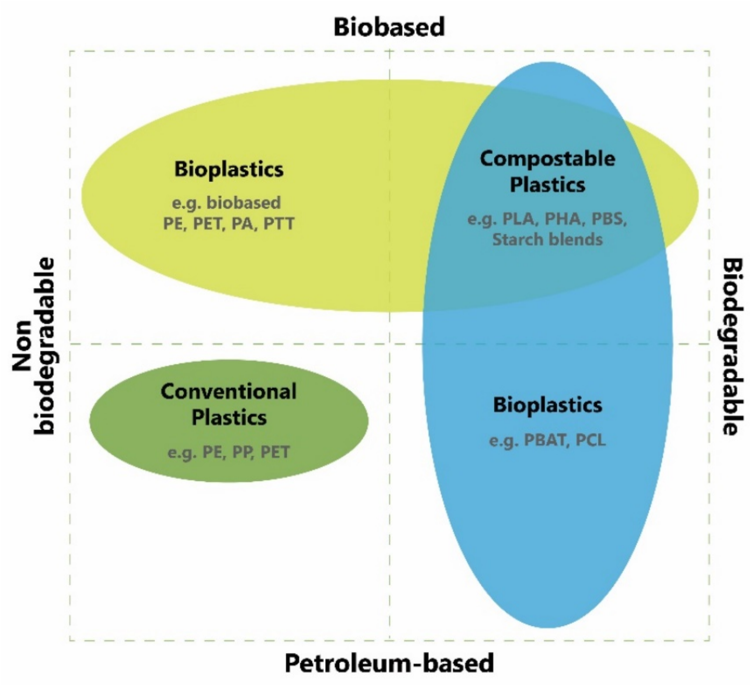

Figure 2.2: The range and nature of bioplastics

Source: Adapted from European Bioplastics, 2016:2

- **Biodegradable** implies that the product can biodegrade through the means of micro-organisms (Song, Kay & Coles, 2011:298). One of the biggest concerns regarding biodegradable plastics is that it may not necessarily biodegrade in the natural environment (United Nations, 2018:8). The biodegradability of a product depends on the environmental conditions like temperature, microorganisms, oxygen and water (Van den Oever *et al.,* 2017:15).

- **Biobased** suggests that the composition of the material is derived from bio-mass or is made exclusively from it (Song, Kay & Coles, 2011:298). Biobased materials can be made from any natural materials like wood or cotton, but it can also be made from microorganisms (Van den Oever *et al.,* 2017:15). Bio-based only refers to how the material was made, it does not mean that it can biodegrade in the environment after it was used (United Nations, 2018:8).

Currently, there are two types of compostable plastics, namely home and industrially compostable. Home compostable can degrade in a natural environment without any human intervention whereas industrially compostable products can only degrade under high temperatures at incineration plants (Van den Oever *et al*., 2017:16).

Considering these terms, there are plastic materials available like PLA, PHA & PBS (Figure 2.2) that are a combination of the two or even all three, meaning they can biodegrade or be composted, and they are made from renewable materials (European Bioplastics, 2016:2). Most current bioplastic packaging does not specify the biodegradability or compostability of the product. This may lead to uninformed consumers discarding packaging recklessly. These factors reinforce the importance for governments to apply strict labelling policies to ensure that consumers are educated and informed (United Nations, 2018:8).

2.3. The life cycle of disposable PET water bottles

Virgin plastic is sourced all over the world: America 18%, Europe 19% and Asia 50%, with China accounting for 29% of the Asian continent (d'Ambrières, 2019:14). In 2012, the greenhouse gasses produced in the transformation of crude oil to natural gasses were 400 million tons (OECD, 2018:4). The life cycle of disposable PET water bottles can be split into two phases: firstly, material extraction and conversion; and secondly, disposal to remanufacturing

2.3.1. First phase: Material extraction and conversion

Once crude oil has been extracted, it is first fragmented into heavy fuels like gasoline, diesel and kerosene (Corma *et al.,* 2017:1). The fragmentation process is done through different iterations of a process called "cracking", including "thermal cracking" and "steam cracking", which are the two main processes used in the production of ethylene and propylene (Plastics Europe, 2018: 8; Radovic & Schobert, 1997:144). Cracking is defined as a process wherein complex organic molecules are broken down into smaller molecules. This process is caused by the breaking of carbon-carbon bonds (Corma *et al.,* 2017:1).

Thermal cracking refers to the chemical process by which organic materials are decomposed into lower weight molecules (Speight, 2003:31). The process of thermal cracking is done through applying pressure and heat to physically break down the large crude oil molecules into smaller ones. Once the cracking process has taken place, distillable products are produced (Alsobaai, 2013:21). After the heavier fuels have been broken down through thermal cracking, steam cracking is applied to produce even cleaner and lighter fuels, like naphtha which in turn produces ethylene. Thermal cracking is most commonly used to produce ethane, and steam cracking to produce naphtha (Ghanta *et al.,* 2013:167). There are various steps and processes that form part of the steam cracking process. Figure 2.3 shows the entire process; from crude oil extraction, to cracking and refining, to finally produce the products needed to make plastic. Propylene is produced at the final stage of steam cracking, this becomes one of the base materials for disposable water bottles.

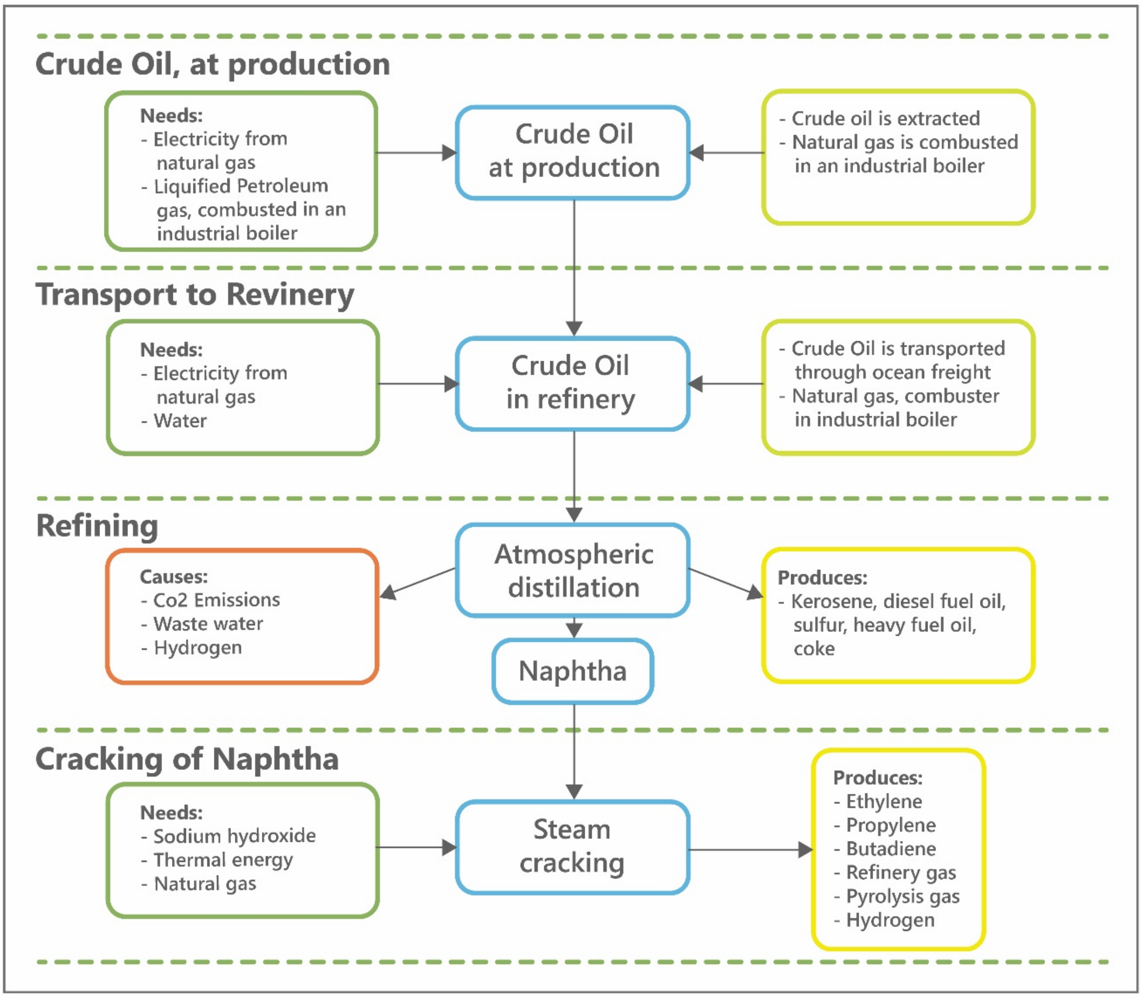

Figure 2.3: The production of ethylene from crude oil

Source: Adapted from Ghanta *et al.*, 2013:170

Energy-intensive steps associated with ethylene production from crude oil include energy required for the extraction of crude oil from reservoirs and transportation to a refinery. The transportation involves the pumping of the crude oil to the nearest seaport via pipeline, shipping to the destination, and delivery from the port to the refinery via pipeline. Then it needs additional fuel and power for the various cracking stages (Ghanta *et al.,* 2013:169).

In the process of steam cracking, heavier fuels are diluted with steam and then briefly heated in a furnace without the presence of oxygen (Rosli & Aziz, 2016:1). Steam cracking is the main process used to produce petrochemicals (Corma *et al.,* 2017:2).

Through the continuous process of cracking, some of the products that is produced include; gasoline, diesel, jet fuel and liquified petroleum gas. This is eventually refined into ethane and propane and turned into ethylene and propylene which is used to produce plastic pellets. These pellets are then sold to plastic manufacturers to produce bottles (d'Ambrières, 2019:13; Corma *et al.*, 2017:1; Alsobaai, 2013:21). Cracking both naphtha and ethane to create ethylene is a highly energy intensive processes (Ghanta *et al.,* 2013:168).

An alternative way to produce ethylene is through fermenting and distilling crops, which produces ethanol. The ethanol is obtained from renewable sources like; corn, sugarcane, cellulose or agricultural waste[3]. Once the ethanol is dehydrated, it produces ethylene (Ghanta *et al.,* 2013:167). Although it is seen as a more environmentally friendly option, it still requires many steps and processes. Ethylene production from corn is shown in Figure 2.4.

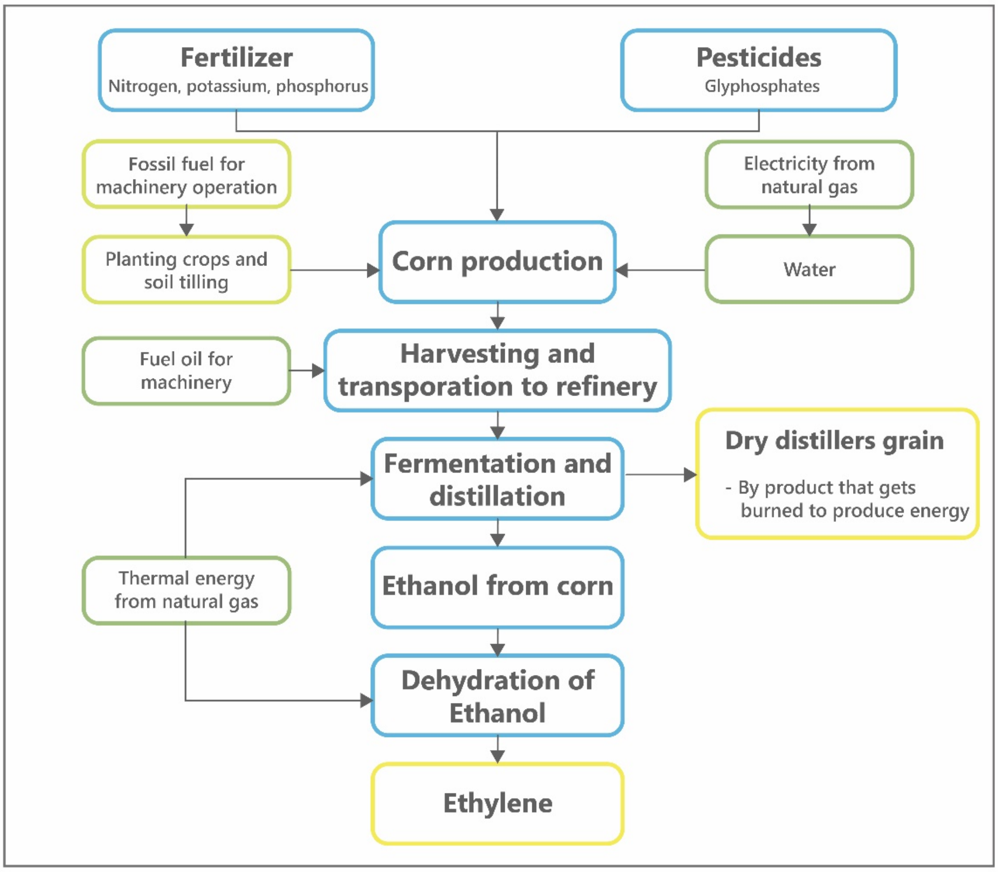

Figure 2.4: The production of ethylene from corn

Source: Adapted from Ghanta *et al.*, 2013:171

[3] This concept is further explored in section 2.6 pages 37-39.

Energy-intensive steps associated with ethylene production from corn include soil cultivation, planting, pesticide manufacture, fertilizer manufacture, application, harvesting, transportation, fermentation, dehydration and distillation to remove water from the ethanol (Ghanta *et al.,* 2013:169).

2.3.1.1. Tracing production streams

Ethylene is needed to produce polyethylene (PE), polyvinyl chloride (PVC), polyethylene terephthalate (PET), and polystyrene (PS), which combined represented approximately 65% of global plastics production by weight in 2017 (Center for International Environmental Law, 2017:2). Therefore, most plastics can be traced to the product streams of ethylene and propylene.

Before plastics became a booming industry, only kerosene (used for electricity) was extracted from crude oil for use. All the other by-products of crude oil were discarded and became waste (Radovic, Schobert, 1997:18). Since the 1980’s the demand for heavy fuels from crude oil has decreased, whilst the demand for lighter products has increased. Lighter materials are more difficult and costlier to produce as they need to go through more cracking processes (Alsobaai, 2013:21).

About 45% of all propylene is used to produce isotactic structured polypropylene (Hocking, 2005:645). A polymer structure can be isotactic, syndiotactic or atactic. The atactic nature of the polymer influences the monomer structural density of the material (Miri *et al.*, 2010:1768). This is shown in Figure 2.5.

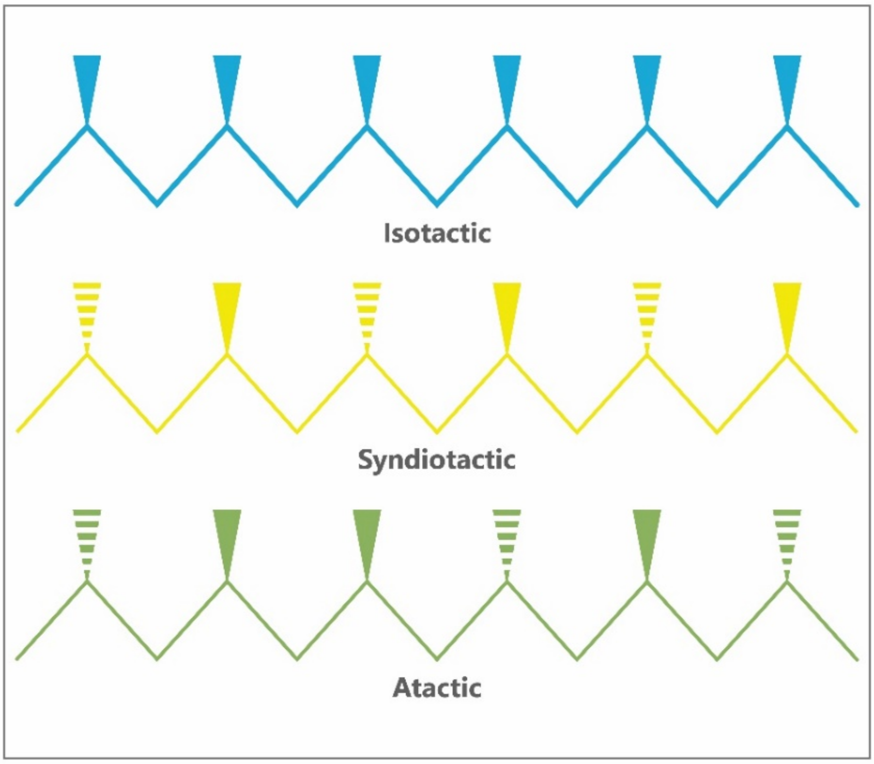

Figure 2.5: Monomer groups

Source: Adapted from Miri *et al.* 2010:1768

- **Isotactic** polypropylene is formed when the monomer adds to the polymer backbone with the pendant group on the same side as the previous pendant group. This type of polypropylene is strong and produces a hard and rigid material. Isotactic polypropylene has the highest melting point (ca. 165°C) of all three groups mentioned (Miri *et al.* 2010:1768).

- **Syndiotactic** polypropylene is formed when the monomer adds where the pendant group adds to the opposite side of the polymer backbone. This type of polypropylene has a moderate melting point of ca.155°C (Miri *et al.* 2010:1768).

- **Atactic** polypropylene is a pendent group that has no specific structure. It refers to a soft plastic like rubber and has a much lower density and melting point than other monomer groups (Miri *et al.* 2010:1768).

Monomer structures are used to understand the chemical composition of all known plastics. Through tinkering with different chemical structures, new plastics with various properties can be developed, such as; making it stronger, softer, or even more brittle (Hocking, 2005:637). To produce a water bottle, the chemical properties of the plastic used needs to adhere to certain specifications to make it a viable product that can compete in the market. The pellets used to make plastic bottles, have very specific chemical structures. Making it very important to understand different monomer groups.

After crude oil was extracted, cracked, and formed into plastic pellets with the necessary chemical composition, the pellets are sold to a plastic converter. These pellets are heated, and injection moulded to form a preform. The preform is inserted in a blow moulding machine, where it is reheated and blown into a mould, which forms it into the desired shape. The newly blown, empty bottles are then packed into large boxes and transported to a facility where they will be filled with water (d'Ambrières, 2019:13). This process can be seen in Figure 2.6.

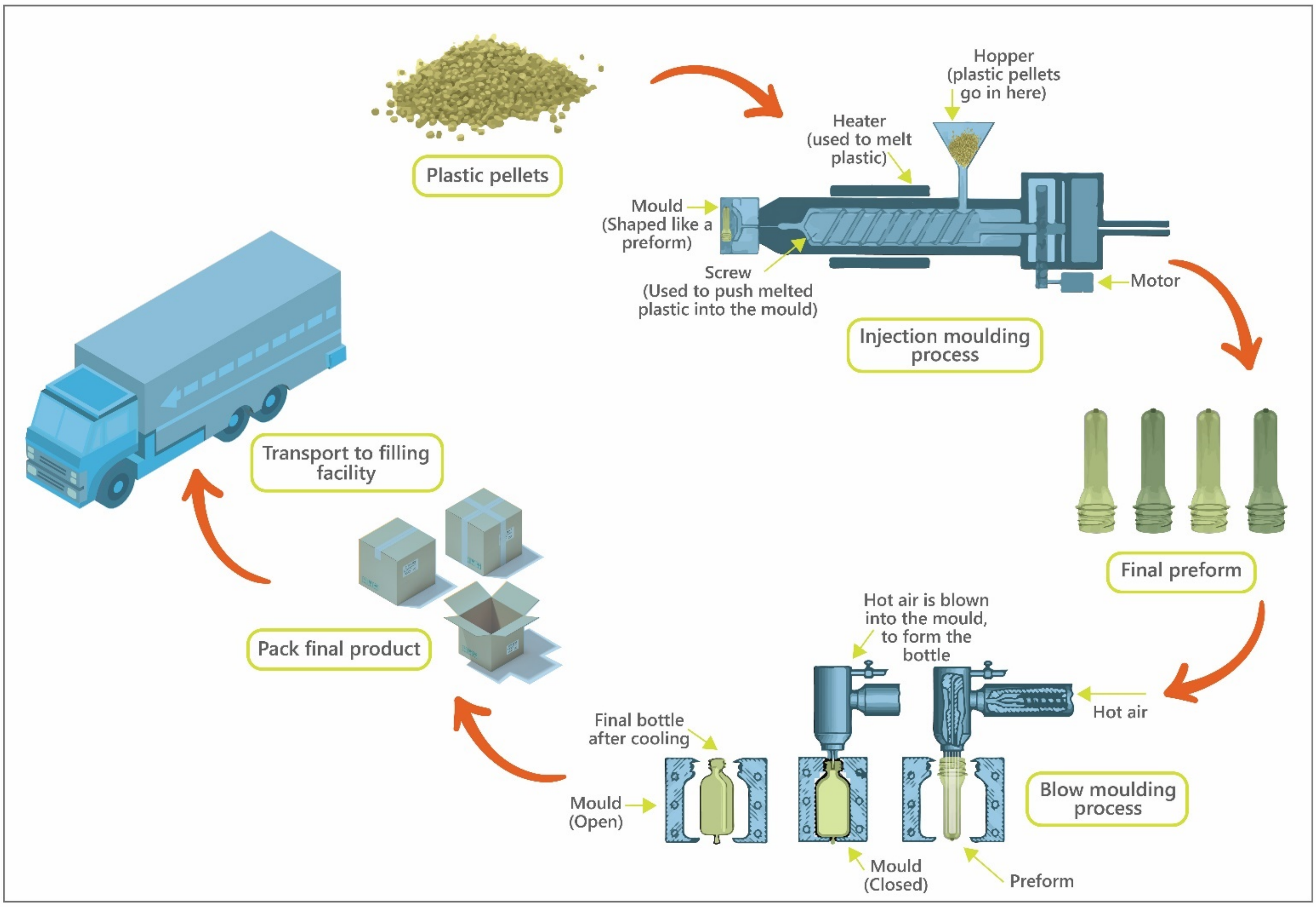

Figure 2.6: Plastic bottle manufacturing process

Source: Adapted from Mashek *et al.*, 2017:30

2.3.2. Second phase: From disposal to remanufacturing

The main purpose of recycling is to minimize the amount of product to landfill and maximise the amount of materials that can be returned into production cycles (Gungor & Gupta, 1999:824). Recycling and remanufacturing products will reduce environmental impact as fewer natural resources will be used, saving both energy, resources and reducing the greenhouse gas footprint (Arokiaraj *et al.,* 2019:38). With this in mind, it is important to evaluate and find the balance between the resources used to recycle the product and the return gained from it. The resource intensity of the recycled product must outweigh the overall cost (both money and resources) of being recycled (Gungor & Gupta, 1999:829).

It has been proven that the energy required to make recycled plastics is about half of that required to make virgin plastics (Mashek *et al*., 2017:34; OECD, 2018:6). The greenhouse gas footprint of producing recycled plastics is significantly smaller per kilogram than that of virgin plastic production. This is shown in Figure 2.7 (OECD, 2018:6).

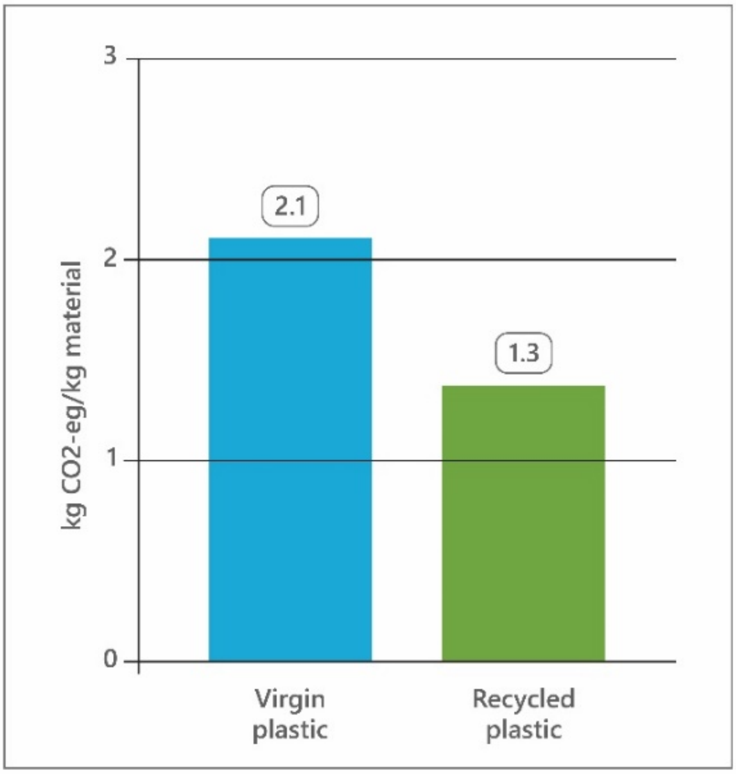

Figure 2.7: Greenhouse gas footprint: Virgin vs. recycled plastic production

Source: Adapted from Hillman *et al*., 2015:50

According to Locock (2017:17) the four major plastic types being recycled in the market is: PET (55%), HDPE (33%), PP and LDPE (4% combined). At a global level, the total recycling rates are thought to be around ca. 14 - 18%. Plastic waste is mostly being incinerated (24%). The rest (58% - 62%) is disposed of, landfilled or littered in the natural environment (OECD, 2018:8).

2.3.2.1. Recycling and landfilling

In 2018, the total amount of global plastics production was as follows: Asia (50%), Europe (19%), North America (18%), Middle East & Africa (7%), Latin America (4%), and Commonwealth of Independent States (CIS) (2%). These statistics include thermoplastics, polyurethanes, thermosets, elastomers, adhesives, coatings and sealants as well as PP-fibres (d'Ambrières, 2019:14; Plastics Europe, 2019:15). Even with plastics being more recyclable than ever, one cannot assume that consumers will recycle it. A lack of consumer knowledge and appropriate waste management systems at local government level do not contribute to the important concept of recycling. Waste management efficiency varies from country to country and is often subjected to regulations and government incentives (Di Maria *et al.,* 2018:171). There are four broad groups when categorising countries with regards to recycling: developed countries with regulations that encourage recycling, developed countries with no specific recycling regulations, developing countries with no specific recycling regulations and developing countries with little or no recycling activity (d'Ambrières, 2019:12).

- **Developed countries with regulations that encourage recycling:** These countries are marked by well-established waste management infrastructure like landfill and recycling facilities. Regulations and environmental legislation are put in place at government level, to ensure product accountability and recycling (Plastics SA, 2019:5; Di Maria *et al.,* 2018:172). Separated collection at source is enforced by government to ensure recycling efficiency. This is done by supplying residents with different bins, marked solid waste and recycling. These countries also have waste collection centres, which credit people with economic incentives in return for recyclable waste (Di Maria *et al.,* 2018:176; Gungor & Gupta, 1999:824). Specific organizations are set up to oversee recycling and are funded by government, producers, retailers and green levies. The end-of-life management is strategically planned and considered, before the product is even produced (Plastics Europe, 2018:5). In these economies, recycling relies on significant infrastructure for sorting and processing plastic waste by resin codes[4]. Additional taxes are added on traditional processing solutions like landfilling and incineration, which are a cradle to grave approach (Di Maria *et al.,* 2018:172). Countries in this category can attain recycling rates in the order of 20 - 30%, an example of such countries include Western Europe and Japan (d'Ambrières, 2019:12-14). Until 2013, approximately half of Western Europe's plastic waste was exported to China (Hesselink & Duuren, 2019:6). Although recycling rates in Europe are seemingly

[4] The resin codes can be seen in Table 2.1, page 14.

high, in 2016, Germany (only one example of a Western European country) was one of the largest exporters in the world of plastic waste to China (OECD, 2018:10).

- **Developed countries with no specific recycling regulations:** These countries have well-established waste management infrastructure, but their key focus is on traditional waste management methods like landfill and incineration. This means that recycling is underdeveloped and accounts for less than 10% of waste being recycled (d'Ambrières, 2019:15). Recycling systems in these countries are all done on industrial scale and centralised, which make it difficult for the average citizen to recycle if they do not have curb-side collection services. There is dismal to no localised collection centres (Costa-Smith *et al.,* 2017:6). Countries that fall within this category include the USA and Australia (d'Ambrières, 2019:14).

- **Developing countries with recycling activity:** These countries have marginal waste management infrastructure. Collection is systematic, although waste continues to be dumped at illegal sites and can end up in water ways (d'Ambrières, 2019:15). In these countries there is a gap between legislation and waste management policy on a governmental level (Mwanza *et al.,* 2018:687). The recycling industry in these countries is based on economic principles and relies on manual sorting centres and waste picking (Gungor & Gupta, 1999:824). Manual sorting centres and waste picking represent the informal employment sector. These countries have adequate but few recycling facilities, which are entirely funded by private owned companies and not enforced by local government (Di Maria *et al.,* 2018:177). Privately owned companies in many cases benefit from gathering and recycling both commercial and home waste (Hanekom, 2019). An example of such a country is South Africa (Plastics SA, 2019:5).

- **Developing countries with little or no recycling activity:** These countries are characterized by little to no waste management infrastructure. Collection is not systematic, and a large portion of household and industrial waste is dumped at unofficial and unregulated sites (Arokiaraj *et al.,* 2019:34). The informal recycling networks tend to be well developed and organized and are developed in reaction to local industrial demand, which leads to an income (Di Maria *et al.,* 2018:177; Gungor & Gupta, 1999:824). Infrastructure for sorting is underdeveloped and is replaced by informal networks. Countries in this category can attain recycling rates in the order of 20%. These countries recycle very little of their plastic. Ironically, these countries rely heavily on disposable water bottles for safe drinking water, even though they have no efficient means of disposing and recycling it, resulting in most plastic bottles ending-up in the ocean and landfills (Costa-Smith *et al.,* 2017:1). An example of countries that fall within this category include China, India and Brazil (d'Ambrières, 2019:15).

2.3.2.2. Recycling and remanufacturing

According to Gungor and Gupta (1999:824) the recovery of recyclables materials can be divided into two groups; recycling (material recovery) and remanufacturing (product recovery). For this research; recycling refers to recyclables being captured and sorted whilst remanufacturing refers to the material being converted, resold and returned to manufacturing streams. The market for recycled plastic products is limited due to the inconsistency of the raw material. Most manufacturers will only buy recycled pellets from verified resellers to ensure pellet quality (Shantha, 2019:9). The most important task when recycling plastics is to ensure that all contaminants are removed from the plastics to ensure food grade quality and to make it suitable for human consumption (Krehula *et al.,* 2012:443). In many cases the collection and remanufacturing of recycled products are carried out by the same parties which produced the initial product. The manufacturer takes responsibility for the recapture and reuse of their products within a closed loop system (Gungor & Gupta, 1999:828).

The easiest way to collect and sort plastics when recycling is through reading the resin code on the bottom surface of the bottle. The resin code is a number between 1-7[5] which is encircled by a small triangle. The purpose of a resin code is to inform the user which type of plastic was used to produce the bottle (Mashek *et al*., 2017:12).

Plastics recovery and recycling is driven by three aspects: economic value, market requirements and governmental regulations (Arokiaraj *et al.,* 2019:38, Mwanza *et al.,* 2018:687). The foremost issue of recycling and product recovery is the collection process, as used products originate from multiple sources (Gungor & Gupta, 1999:827). Product degradation and weathering due to sunlight exposure, water and other elements over long periods of time have an impact on the quality of the final recycled pellets (Krehula *et al.,* 2012:433). In regard to plastic recycling, there are many processes that need to take place before the final product can be sold. These processes include sorting, washing and drying, shredding and pelletising as soon as the material is collected (Shantha, 2019:9).

- **Sorting** – This is done manually or automatically to identify different plastic types. It is important that plastics are sorted and identified into the correct resin groups to provide a higher quality final product (Cook, 2015:8). If the different plastics get mixed and

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[5] See Table 2.1 on page 14.

shredded together, the structure and mechanical properties of the chosen plastic type will be compromised (Krehula *et al.,* 2012:432). The best way to manually sort is by reading resin codes on the packaging. If there were no resin codes, there are tests, like the water test or burning test, which can be done to see what type of plastic it is (Shantha, 2019:10). In the sorting process, all caps and labels are removed from the plastic product (Krehula *et al.,* 2012:430).

- **Washing and drying** – After the sorting process, the sorted plastics are washed in different chemical solutions, depending on the resin type. This is done to ensure that the chemicals do not weaken the composition of any specific plastic type (Shantha, 2019:10; Costa-Smith *et al.,* 2017:3). The duration of the washing process is dictated by the resin type and chemical composition used (Krehula *et al.*, 2012:431). Although copious amounts of water are required for this process, washing facilities usually reuse the water by installing wastewater treatment systems which constantly reuse the water during the cleaning process (Shantha, 2019:10). There are many aspects to consider when washing the plastics, including excessive heat or chemicals in the washing process, as well as residual adhesives that can compromise the structure of the final recycled pellets (Krehula *et al.,* 2012:433). The plastic products are then left outside or inside industrial ovens industrial ovens to completely dry before being shredded (Shantha, 2019:11).

- **Shredding** – A shredder is used to cut the cleaned plastic into much smaller flakes. This is done by feeding the plastics into a hopper, which is situated above a series of cutting blades. The final product is small, coarse, irregularly shaped plastic flakes (Cook, 2015:10). After the shredding process, the polymer purity and quality get tested to ensure a product of high quality and that is safe to reuse (Krehula *et al.*, 2012:432).

- **Pelletising** – Within this process, the plastic flakes are fed into an extruder, where they are heated and forced through a die to form a plastic strip. These strips are then cooled in a water bath before being chopped into standard sized pellets. After this process the pellets are dehumidified, as moisture in pellets cause inconsistent and poor pellet quality. After being dried thoroughly, these pellets are used for the remanufacturing of new products (Cook, 2015:8; Shantha, 2019:11). Plastics cannot be recycled unlimitedly as recycling reduces the quality of plastics for reuse (Costa-Smith *et al.,* 2017:3).

Currently, the cheapest sources to acquire recycled pellets are from India, China and Hong Kong (Locock, 2017:40). Due to the quality of recycled plastics that is in many cases inferior, the price of recycled plastics is often cheaper than that of virgin plastics (Hesselink & Duuren, 2019:7). There are virgin plastic manufacturers in Europe who have acquired recycling companies with the main goal to integrate recycled and virgin plastics to ensure cheaper plastic with a higher quality (OECD, 2018:14). Recycled plastics are seen as a better alternative to virgin plastics when compared to bio-plastics, because the latter often require an additional production of crops.

European legislation focuses on litter reduction rather than virgin production of bioplastics (Hesselink & Duuren, 2019:6). In the world of recycled plastics, trader (middleman) involvement is limited and the market is notorious for manufacturers (of recycled plastics) supplying pellets almost exclusively to end users. This ensures large quantities being sold (Locock, 2017:40). Recycled plastics can trade between 20% - 40% discount in relation to virgin plastics. The fluctuating oil price affects this margin as most virgin plastics are produced from oil price affects this margin, as most virgin plastics are produced from oil (Hesselink & Duuren, 2019:5).

2.4. The emergence of plastic packaging in the food and beverage industry

Since the 1950's, more than 42% of all plastics produced globally have been used for packaging purposes (Schweitzer *et al.,* 2018:4). With the emergence of plastic packaging came the convenience and availability of a wide variety of foods which are accessible all year round. This trend is endorsed by the "fast moving" culture (Risch, 2009:8091). Plastic packaging offers the necessary protection to allow smaller, more convenient servings and extended shelf life (Verghese *et al.,* 2013:10). Without plastic packaging, it can be said that the product is exposed to harsh conditions which can cause bruising and contamination, shortening self-life and limiting shelf-presence (Lee & Xu, 2005:27). Currently plastic packaging is being condemned by consumers and critics alike, based on the amount of single use plastics which seeps into the environment (Schweitzer *et al.,* 2018:14).

Single use plastic packaging is perceived as the main culprit regarding plastic pollution in the environment. For example, roughly five trillion plastic bags are distributed and consumed worldwide per year, indicating that approximately ten million plastic bags are used per minute (United Nations, 2018:6). Plastic packaging waste enters the natural environment through poor waste management systems, namely open dumping and open burning. It is estimated that a quarter of all plastic packaging waste in the EU is openly dumped (Kaza *et al.,* 2018:137). The global plastic packaging market will be worth 998 billion dollars by 2020, indicating 3.5% growth per annum (Foster, 2019). In South Africa alone, the informal job creation within the plastic packaging industry was estimated at 52 300 in 2017 (Hanekom, 2019). These statistics prove that the plastic industry plays an integral part in both the financial and social economy. This will aid in moving towards closed loop, carbon-neutral production cycles (United Nations, 2018:15).

When designing plastic packaging, all the facets of the system need to be considered, for instance marketing needs, shelf-life, logistics, transport distance, storage and handling. Above all, the environmental and economic costs need to be taken into consideration (Schweitzer *et al.,* 2018:9). To determine where the most waste takes place in the current system, all the stages of plastic packaging needs to be analysed (Hanekom, 2019).

Packaging is separated into three sections, namely primary, secondary and tertiary packaging.

- **Primary packaging** refers to packaging which is in direct contact with the product for transportation between the producer and the retail outlet. This includes; beverage bottles, containers with fresh food, and the plastic inner of a cereal box. Their main function primary packaging is to contain and preserve the product without contaminating it.

- **Secondary packaging** contains two or more primary packages and protects the primary packages from damage during shipment and storage, for example plastic shrinkwrap which bundles two or more bottles together.

- **Tertiary packaging** refers to the distribution pack; this includes boxes used for shipping and plastic bags that consumers use to transfer their goods from the store to their homes. Tertiary packaging is used to protect the product during distribution and to provide efficient handling (Verghese *et al.,* 2013:8).

Table 2.2 compartmentalises the entire packaging process at the different stages of the supply chain to indicate what needs to be considered when designing packaging.

Table 2.2: Packaging considerations for fresh and processed foods

Considerations for material selection	Material weights	Package design's dimensions, shape, ergonomics	Interaction between packaging stages (Primary, secondary and tertiary)
Mechanical and chemical characteristics of the product	Packaging line efficiency	Filling line speed	Handling efficiencies
Cube utilisation	Stack-ability	Easy to open, dispense and close	Stability and robustness throughout the supply chain
Warehousing, stocking & stacking	Inventory control (easy to see and count)	Filling, order picking, sorting and packaging	End of life waste management options
Transport mode and lengths	Infrastructure conditions	Loading and unloading operations	Change of transport modalities
Product containment	Product protection and preservation	Product convenience	Temperature and humidity control
Product quality	Product shelf life	Product safety and hygiene	Product communication
Packaging material costs	Equipment costs	Waste management costs	Marketing costs

Source: Adapted from Verghese *et al.,* 2013:11

The principle of Environmentally Conscious Manufacturing and Product Recovery (ECMPRO) needs to start at the beginning of the packaging design process. ECMPRO is driven by the increasing deterioration of the environment and it needs to be enforced by local governments (Gungor & Gupta, 1999:811).

2.5. Plastic packaging waste versus food waste in a linear economy

The most used plastics for food and beverage packaging remain PP and PET, both of which are readily recyclable (MacKerron, 2015:5). In the USA, the beverage industry (single use plastic water bottles) contributes 18% total packaging waste per annum whereas the food industry contributes 51% per annum (MacKerron, 2015:12). In the European Union (EU) ±20% of all food produced each year becomes waste. These statistics show the oversupply and undervaluation of food (Schweitzer & Janssens, 2018:2). Food wasted throughout the supply chain indicates that all natural resources used in its production dissipate. An optimised supply chain has the power to reduce food waste and improve recovery of waste in packaging and food waste sectors (Verghese *et al.,* 2013:6). Data collected in the EU show that increased plastic packaging does not lead to a reduction in food waste (Schweitzer *et al.,* 2018:4). Proper LCA's should be done to justify the use of single use plastic packaging.

Above-mentioned studies are relevant to this research, because they show the importance of looking at the product while designing the packaging for it. It has been attested that single use plastic packaging in the food industry can increase product shelf life (Sonesson *et al.,* 2009:16). This specific study was based on a life cycle analyses (LCA) to prove why plastic is needed for a longer shelf life (Schweitzer *et al.,* 2018:5). Single use packaging, like cucumber film, is justified because it increases the shelf life of certain products (Sonesson *et al.,* 2009:16). The product shelf life should not apply if the food is inevitably being wasted. Instead of having only food waste, packaging waste is also accumulated (Verghese et al., 2013:33).

The life cycle of food and beverage packaging has five stages, namely raw material production, fabrication of the packaging, distribution/transport, postconsumer disposal and recycling (Franklin Associates, 2014:5). Typically, only a few packaging and distribution methods are considered when doing a LCA. Thus, the outcome provides a choice between "bad" and "less bad" packaging and distribution methods, irrespective of the implications it can cause (Schweitzer *et al.,* 2018:12). For example, Bertoluci *et al.,* (2014:239) found that a plastic Doypack pouch (sealed plastic bag which stands upright) has less environmental impact (weight, transportation cost) than a glass jar, but reusable alternatives to the Doypack was not considered. This proves that a Doypack pouch is the better ('less bad') option than the glass alternative, even though a Doypack is very labour intensive to recycle (Schweitzer *et al.,* 2018:10). This is a bad example of a LCA, as the researcher never considered using recyclable options instead of the Doypack.

A LCA can be done on one part of a system or the entire system. For example, Boustead (1995) did a study on the eco-profile of PET polymers used for disposable bottle production. The LCA was done from raw materials extraction throughout to the production of the polymer resins. This LCA represents analysis on only one part of the PET water bottle system (Boustead, 1995:7). In contrast, Person *et al*. (1998) carried out a LCA on disposable PET bottles as part of a study on the LCA of packaging systems which compared the potential environmental impact associated with different packaging systems for beer and soft drinks. This represents a LCA done on the entire packaging system (Person *et al*., 1998:198). According to a LCA based study by Franklin Associates Ltd., recycling plastics (specifically PET and HDPE) offer significant energy saving opportunities and reduced greenhouse gas emissions (Mashek *et al*., 2017:33).

The unnecessary waste of both plastic packaging and food represent a linear economy (Schweitzer, & Janssens 2018:2). However, most studies do not include food waste when doing a LCA (MacKerron, 2015:43). For example, food waste is caused by over purchasing (bulk packs, buy-one-get-one-free) although a bulk pack consumes less plastic packaging, whereas more packaging (smaller, individually packed tubs) leads to less food waste (Verghese *et al*., 2013:22). Another important consideration when doing a LCA is to determine its end of life phase (United Nations, 2018:12). For example, a study done on the environmental impact of both recycled polyethylene terephthalate (RPET) and new PET bottles in Norway proved that the overall emissions impact of RPET bottles are 18% higher than new PET bottles. They need to contemplate the consequences when bottles are not recycled or if transportation conditions change (Bø *et al*., 2013:23). When conducting LCA's, many studies fail to consider how the product will be disposed of and that it might inevitably end up in a landfill (Schweitzer *et al*., 2018:13).

One of the biggest contributors to downstream packaging and food waste is the retail sector (Chandon & Wansink, 2012:585). Regarding the food value chain, households generate the highest amount of food waste per capita (Schweitzer & Janssens, 2018:2). Marketing by means of the secondary packaging (labels, boxes, tags, etc.) leads to both over purchasing by consumers and over packaging by retail companies (Schweitzer *et al.,* 2018:11). This emphasises the importance of acknowledging every part of the system when doing a LCA. Recycling must indicate a holistic view of the system and not solely focus on its separate parts (Azzone *et al.,* 2013:19). To make both food and plastic packaging waste efficient, it is important to move towards closed loop, carbon neutral production cycles in each industry (United Nations, 2018:15).

In a bid to reduce the amount of single use plastic bags, many countries have started taxing (Ireland, Austria, etc.) and banning (Rwanda, Kenya, etc.) the use of them (Kaza *et al.,* 2018:117). One of the first governments to implement a single use plastic bag ban and force consumers to use reusable bags was San Francisco, California State, USA. This ban showed a decrease of 72% plastic litter from 2010 to 2017 (MacKerron, 2015:41).

The South African government also implemented legislation to lessen the demand for plastic shopping bags, but banning thicker bags and charging consumers for the thinner (polythene bags > 30 μm) options had the opposite effect. Instead of reducing the number of bags being used, consumers adjusted and accepted the cost. Along with that the demand for plastic steadily increased in South Africa (Dikgang *et al.* 2012, quoted in Lam *et al.,* 2018: 345). According to the Ellen MacArthur Foundation (2019:13), there are four business-to-consumer reuse models which can address the overuse of single use plastic, namely refill at home, refill on the go, return from home, return on the go.

- **Refill at home** – This concept works on the premise that the consumer buys the container, uses the product, purchases a refill (this can be done through e-commerce or in store) and finally refill and reuses the same container. This will aid in the reduction of transportation, packaging and product cost (Ellen MacArthur Foundation, 2019:15).

- **Refill on the go** – Firstly, the consumer buys the container. Secondly, the product is used. Thirdly, the consumer refills the container on the go. This model requires a physical store or dispensary point. Benefits of this model includes: consumers have access to the exact quantities they desire, intelligence (for business owner) can be gathered at refill point of consumer preferences, transportation and packaging cost will be reduced and consumers will benefit from improved access (Ellen MacArthur Foundation, 2019:17).

- **Return from home** – This model is only suitable in areas where e-commerce is viable and works as follows: consumer subscribes to a product service, business delivers the product to the consumers door, consumer uses product, business collects (at door) used product and swaps it for a new product, and finally the business cleans and refills the used product. This model improves the entire system through optimising and standardising logistics and packaging. Another benefit includes consumers not having to keep track of their stock at home, as the subscription systems allows the business to auto-replenish when necessary (Ellen MacArthur Foundation, 2019:19).

- **Return on the go** – This model is based on substituting single use plastics and has four phases: consumer purchases product, said product is used by consumer, consumer returns the packaging at a designated drop-off point, the business cleans and refills the product. This model incentivises consumers to return their product by means of a rewards scheme, set up by the specific business. This can lead to the optimisation and standardisation of logistics, packaging, drop-off points and cleaning networks across brands (Ellen MacArthur Foundation, 2019:21).

To pursue sustainability within packaging design, alternative materials should be researched, awareness raised among consumers, plastic products must be properly labelled, and the design of packaging reviewed.

2.5.1. Case study: Effects of single use plastic bag ban on consumers

In 2011, a study was done in both California and Arizona State, USA, to investigate the effect that the single use plastic bag ban had on the consumer. The study focused on the potential cross contamination of reusable or washable cloth grocery bags. Researchers chose 28 - 30 randomly reusable or washable cloth grocery bags from consumers in grocery stores across these states. The individuals were also interviewed about how often they use, clean and store the bags. These bags were then sampled and tested for possible bacteria (Williams *et al.*, 2011:509). Up to 97% of users indicated that they never wash their bags. Bacteria were found in 99% of the bags and coliform bacteria were found in 51% of all the bags tested. Cross contamination when using non-plastic options can be detrimental to consumer health (Williams *et al.,* 2011:512). In both California and Arizona, there was a marked increase of emergency room visits and deaths related to the coliform bacteria during the period that using single use plastic bags became illegal (Klick & Wright, 2012:15). Emergency room visits increased by between 25% - 33%, and deaths related to this bacterium spiked by 50% after the plastic bag ban was implemented (Klick & Wright, 2012:20). There are many forms of reusable bags to consider which are stronger than the above-mentioned reusable or washable cloth bags, which is only one example.

Since 2004, as the number of reusable bags increased, the average weight of single use plastic packaging in the EU has dropped (Azzone *et al.,* 2013:142). Reusable bags can be produced from materials that add extra strength and durability. This effectively means that these bags consist of different components, for instance material for the handle another material for the bag (Schweitzer *et al.,* 2018:13). Thus, many reusable bags end up in landfills after their useful life is over, purely because of the labour-intensive process required to recycle it (United Nations, 2018:8).

Multilayer or flexible plastic packaging (e.g. juice boxes, sachets, pouches) cannot be readily recycled and is waste intensive (Schweitzer *et al.,* 2018:10). Flexible packaging is currently being driven by the high demand for convenience foods. It provides moisture and oxygen scavengers which allow extended shelf life (Foster, 2019). Flexible packaging is referred to as mixed residues, which means that they will inevitably become littered or incinerated as they cannot be easily reused, or recycled (Schweitzer *et al.,* 2018:12). An example is flexible packaging, like juice packs, which are made from PET and aluminium that are fused together.

To recycle this product, PET and aluminium need to be mechanically separated which is both costly and time consuming (MacKerron, 2015:29).

Another aspect that hinders recycling is contaminated packaging. An example of contaminated packaging is oily pizza boxes or milk containers which have not been rinsed. These products need to be cleaned before it can be recycled (United Nations, 2018:9). In a bid to make flexible packaging more sustainable, some packets have been designed to provide a longer useful life or to serve a secondary function (Foster, 2019). Examples of steaming packets and resealable packets can be seen in Figure 2.8.

Figure 2.8: Flexible packaging with a secondary function

Source: Adapted from Mondi Group, 2020

It is important for governments to start reducing plastic waste and enacting policies which introduce a circular model to reduce the amount of plastics being used. Before such policies are implemented, governments should asses the available resources and alternatives in their community before enforcing policies. This will aid to ensure both efficient recycling and reuse (United Nations, 2018:6-7). Plastic packaging is increasingly being designed for recycling but cannot be recycled due to the lack of infrastructure (Foster, 2019). It has been proved that PP produces 45% less greenhouse gas emissions during production than PET, but has not been widely adopted as the recycling infrastructure is not suited for it. Only 72% of the US population currently has access to PP recycling whereas 94% has access to PET recycling, which make PET the more widely used material (MacKerron, 2015:15).

Shortening food supply chains are a critical part of creating a closed loop system. Short supply chains will contribute to less packaging being used, as long shelf lives are not required (Schweitzer *et al.,* 2018:3). Less packaging and time will be needed for transportation throughout the food supply chain by facilitating better transportation and reducing distribution losses (MacKerron, 2015:6).

In developed countries, packaging accounts for around 3% of waste in landfills. National waste statistics in South Africa estimates that packaging waste accounts for a maximum of 6% of waste to our landfills (Packaging SA, 2017:3). In 2017 Plastics SA did research to show the progress that has been made from 2016 to 2017 in the recycling of plastic packaging. According to the results the total amount of plastic packaging collected for recycling was 43.7%, recyclables which went to landfill dropped by 5.2%, and domestic virgin consumption dropped by 1.7% (Hanekom, 2019).

The managing of food and packaging waste should be considered as a single entity, rather than being viewed separately. A holistic model needs to be developed to approach waste management (Azzone *et al.,* 2013:19). The poor perception of plastics needs to be reformed and seen as a valuable resource which can be harnessed for its strength and durability, not as a commodity which is only good for single use and waste (United Nations, 2018:5).

It is important to understand what impact natural materials and semi-synthetic materials have on the natural environment. Each produces waste at different stages of life cycle (United Nations, 2018:16). Without stepping back and viewing the entire production cycle, focus is placed on the 'worst' part of the system, which in this case is plastic packaging.

2.6. Alternative materials and the implications

One of the most widely used strategies to reduce the current plastic packaging footprint is by lightweighting or reducing material to lessen the overall weight of the packaging (MacKerron, 2015:16). Currently, bioplastics are being investigated and trialled in almost any way possible to find the best possible alternative for crude oil-based plastics (Risch, 2009:8091). In the sector of plastic packaging, it is integral for consumers to understand what they are buying and the implications thereof. The terms biodegradable and biobased packaging is commonly mistaken that it can break down naturally and quickly in the natural environment. Most biodegradable plastics only biodegrade under high temperatures at incineration plants (United Nations, 2018:8). This will allow uninformed consumers to discard biodegradable packaging into the natural environment.

There have been many suggestions for alternatives to plastics, but they also introduce a range of new consequences. Currently biodegradable plastics which show the best alternatives to synthetic based single use plastic packaging include polylactic acid (PLA), polyhydroxyalkanoates (PHA) and thermoplastic elastomers (TPS) (United Nations, 2018:15).

Although they are notable alternatives, they can only be recycled with industrial composting or anaerobic digestion facilities. This means PLA, PHA and TPS are only viable in a closed loop system where the packaging waste is well managed, otherwise they will end up in landfills and the ocean (United Nations, 2018:15). Another concern regarding these materials is that they contaminate current recycling systems, as they look like normal PET or PP packages. This can cause an uninformed consumer to sort and dispose of PLA the same way as PET (United Nations, 2018:15).

In 2013, Coca-Cola started developing a fully recyclable PET plastic bottle, called "PlantBottle". By 2016, this bottle was made from 100% plant-based materials instead of petrochemicals. The "PlantBottle" PET bottles are made from sugarcane bagasse, a by-product which is produced after juice has been extracted from sugarcane (MacKerron, 2015:29). When considering plant-based alternatives, it is important to analyse the materials according to their resource (agricultural, economically) intensity and effect on pollution during production (Schweitzer *et al.,* 2018:12). Biobased PLA is a plant-based material that is an alternative to plastics and has a reduced environmental impact. Although this product is plant-based, it is important to consider the effect that using renewable sources (corn-starch, sugarcane) will have on the environment, waste management cycles and recycling (MacKerron, 2015:21).

Many bioplastics are produced from organic materials like maize. The agricultural production of maize (any natural alternative) has many aspects that need to be considered before becoming a viable replacement to crude oil-based plastics, for example space (crop size), water, fertilizer, and biocides (Hanekom, 2019). All these natural resources are needed to cultivate maize fields. The social and economic benefit of large-scale maize production as an alternative will be immense, but the environmental degradation and impact will be far greater (United Nations, 2018:11). Biomass waste needs to be used instead of actual crops (Hanekom, 2019).

When considering alternative materials, it is important to look at all the types of packaging, namely primary, secondary and tertiary[6] (Verghese *et al.,* 2013:16). Primary packaging has a big impact on plastic packaging waste. The reason for this is packaging restrictions and pre-determined, which regulates if produce is suitable or desirable for both the retailer and consumer (Schweitzer *et al.,* 2018:7).

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[6] Explained in section 2.4, page 29.

An alternative for primary, single use plastic packaging is reusable crates in the transportation and processing phase of the business to business (B2B) sector. It will only be viable in short supply chains as the product is possibly more exposed (Jepsen *et al.,* 2014:13). In this scenario the product-service model is used, which means the reusable crates are rented by the retailer and the products are then distributed between producers, suppliers and retailers. These crates are then sent back to the supplier for refilling (Schweitzer *et al.,* 2018:10). A French company used this model and it was proved that increased ventilation in the crates ensured less bruising with the result that both packaging and food waste were reduced (Schweitzer *et al.,* 2018:10).

It is important to evaluate the positive and negative effects that both natural materials and semi-synthetic materials have on the natural environment before recommending a viable alternative to plastics. Each sector produces its own waste at different stages of its life cycle, thus proving the importance of a thorough LCA (United Nations, 2018: 16).

2.7. The importance of the PET beverage bottle in the packaging industry

The first commercial plastic bottles started being sold in the late 1940's, after it was proven that PET was not harmful to human health (Abdulkarim & Abiodun, 2011:58). Currently, plastic bottles and jars represent by weight 75% of all plastic containers in the world (Mashek *et al.*, 2017:11).

In 2017, a study done on the global market for disposable water bottles, valued the four main categories of water (carbonated, flavoured, still and functional) at 198.50 billion US dollars. Across the globe one million plastic bottles are being purchased per minute. By 2021 it is estimated that the consumption will increase by another 20%. The growth in consumption is driven by the fast moving consumer culture which demands convenience (Ballantine *et al.,* 2019:1). Currently, the manufacturing of bottled water is the world's fastest growing industry. PET is now the preferred material by water and carbonated drinks industries around the world, because of its strong barrier properties (Abdulkarim & Abiodun, 2011:59).

Market research done in the US by the Beverage Marketing Corporation in 2018 showed that within the US beverage sector, PET bottles represented 69.7% of the total market share of all water bottles. PET bottled water also represented the strongest overall growth in 2018 with a 6.8% increase from the previous year (IBWA, 2019:14-15). Fewer than half of all beverage bottles produced are collected and less than 7% is currently being recycled. The remainder of beverage bottles ends up in landfills, at incinerators plants, or as trash on land and in streams, rivers, and oceans (Ballantine *et al.,* 2019:2).

The consumption of carbonated drinks, beverages and food items packaged in PET is increasing annually (Abdulkarim & Abiodun, 2011:56). A study done by the International Bottled Water Association (2018), showed that consumers associate bottled water with "healthy living" as the calorie intake is so much less than carbonated drinks. This attraction to disposable water bottles has started creating a global trend of increased demand for PET water bottles (IBWA, 2019:11).

The exponential growth of PET beverage bottles is driven by: lighter packaging, consumers who desire portable packaging that is easy to handle, design for recycling (Mashek *et al*., 2017:21). First world countries generate more PET bottle and packaging waste. This is due to their high per capita consumption of different PET packaged products. This is due to the fast-paced consumer culture (Abdulkarim & Abiodun, 2011:58).

Within the last decade, manufacturers have been implementing procedures to lessen the amount of PET water bottles that seep into the environment. In 2017, 37% of disposable PET water bottles were being recycled, which was double the amount recycled a decade ago. Between 2000 and 2014, the average weight of a disposable PET beverage bottle declined by 51% (Mashek *et al.,* 2017:28).

2.8. Plastic industry within the South African context

Globally the plastic packaging industry is a vast field. New studies on the effect and usage of plastics are being developed each day. In turn, the legislation around the usage and disposal of plastics is ever changing. Many international policies have been used to influence South African policies, regarding the environment and plastic packaging. In 2016, South Africa signed the Paris agreement. The Paris agreement is a legally binding framework set out by the United Nations. It is an internationally coordinated effort aimed at tackling climate change. Each country which signed the document is obligated to prepare, communicate and maintain successive nationally determined contributions (Adoption of the Paris Agreement, 2015).

Plastics SA is the umbrella body which represents the entire value chain of the South African Plastics industry. On 5 September 2018, Plastics SA published an Extended Producer Responsibility (EPR) Plan. The EPR plan promotes waste minimisation, reuse, recycling and recovery of all plastic waste (PETCO, 2016). This development plan is completely on par with the current goals of the Paris agreement, showing SA's willingness and continuous research to move towards sustainable plastic packaging.

In July 2019, Plastics SA announced the formation of the South African Alliance. Its main goal is to end plastic pollution in the SA environment. The South African Alliance is comprised of a group of plastics industry role players. Their main goal is to increase the plastics recycling rate, and ultimately contribute to the National Development Plan (NDP) together with the objectives of the EPR plan (Plastics SA, 2019). The NDP was released by the South African Department of Social Development in 2015. The key objective of the NDP is to create an outline for the industry in which people suffering from disabilities can contribute to the growth of South Africa's economy, thus creating jobs. Through appropriate intervention and legislation, the NDP aims to raise per capita income and increase the employment rate from 13 million in 2010 to 24 million in 2030 (Department of Social Development, 2015).

When considering the impact of a disposable bottle on the environment, it is critical to analyse the entire bottle and its development. Considerations include the PET bottle, the label, the marketing strategies, trends and consumer behaviour associated with the life cycle of the product (Sherwood *et al.,* 2016:48). Design interventions are needed to facilitate better experiences and infrastructure, which would allow the consumer to rethink the way they look at plastic packaging. A new holistic approach needs to be introduced, which encompasses the issues not only of cost, shelf-life, safety and practicality, but also of environmental sustainability (Siracusa *et al*., 2014:152). Within South Africa, the plastics recycling industry is based on economic principles. This is in contrast with Europe, where recycling is based on environmental legislation which is enforced by the local government. South Africa relies on manual labour and waste picking, whereas in Europe the entire system is automated (Plastics SA, 2017). The importance of creating sustainable recycling systems which are tailor-made for different countries are shown in Table 2.3.

Table 2.3: Differences in SA and EU recycling climate

South Africa	Europe
Recycling is based on financial principles	Recycling is based on environmental principles
Accurate recycling output tonnages	Accurate waste collection data
Waste pickers collect recyclables from curb-sides and landfills	Recyclable waste is obtained from separation at source process
Community will only do it if incentivised by money	Community is involved, because it is the right thing to do
Less than 5% of collected recyclables is shipped to processors outside South Africa	Up to 2018, the bulk of the recyclables were shipped to third world countries
64% of South Africans have access to waste management	Landfill restrictions for recyclables in at least 10 European countries
Manual sorting of recyclables, excluding PET bottles	Recyclers utilise optical sorting
PE-LD films have an output recycling rate of 35%	Very low recycling rates for flexible packaging
Manual sorters have no problem identifying black items	Black products are unrecyclable due to optical sorting
Input recycling rate in 2018 of 46.3%	Input recycling rate in 2017 of 31.1%
Many South Africans live below the breadline and are fighting for survival	The average European is valuing its national heritage and lifestyle

Source: Adapted from Plastics SA, 2019

In Europe, the user interaction stops after the packaging has been discarded. The post-consumer waste is collected by formal waste management companies (United Nations, 2018:8). In South Africa, there are two user interaction phases: consumer and post-consumer interaction. The postconsumer interaction is defined by informal waste pickers and manual sorting centres. Waste pickers represent individuals who are unqualified or unable to find a job. This is where the NDP becomes applicable. The manual sorting and waste picking culture in SA, creates jobs for differently abled people. Waste pickers represent the informal employment sector of SA. In 2017, 74% of all plastic materials that were recycled, originated from landfill and post-consumer sources (pickers). In 2017, ±313780 tons of plastic were collected for recycling whilst in 2018 ±519370 tons were collected and recycled. This indicates a growth of 6,7% from 2017 - 2018 (Plastics SA, 2019). Plastic recycling in SA is continually growing, and has significant financial gain for pickers, as can be seen in Figure 2.9.

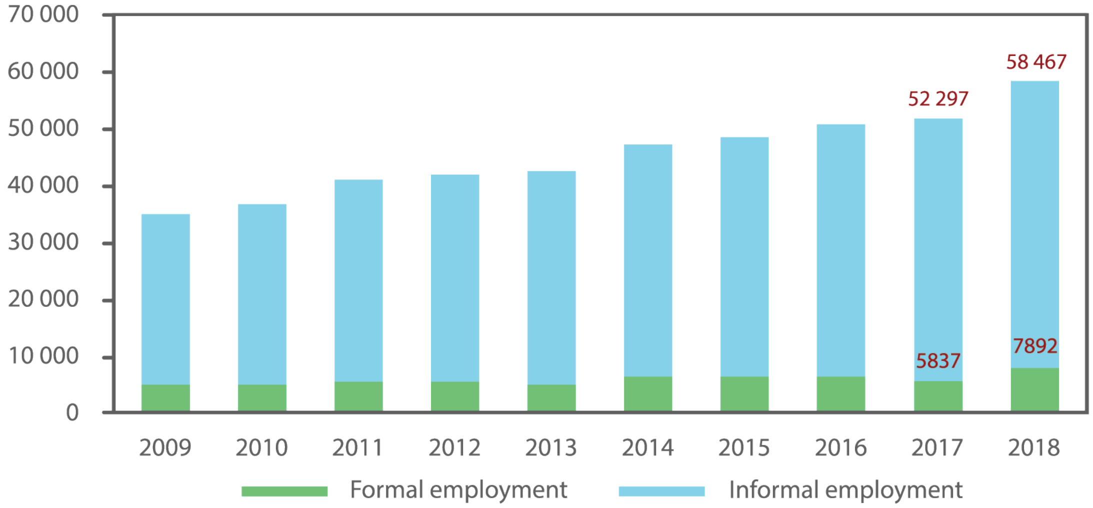

Figure 2.9: Formal & Informal employment in SA plastic packaging

Source: Adapted from Plastics SA, 2019; Hanekom, 2019

An example of the importance of tailor making waste management systems according to specific geographical location or region is black plastic containers. In 2015, one of Europe's largest recycling companies, "Waste Management" confirmed that their equipment generally cannot process black plastic due to equipment limitations. Black plastic is a favourite to use for many quick service restaurants (QSR), and as a result, this causes major concern (MacKerron, 2015:21). Whereas in SA, the waste picking culture (informal employment) creates the perfect solution as it can be easily sorted and recycled (Plastics SA, 2019). In the EPR plan published by Plastics SA in 2018, they emphasised the importance of the user factor within the plastic packaging economy to ensure sustainable development. To safeguard that the ERP plan can reach sustainable development goals, they made use of the Ellen MacArthur

Foundation’s circular economy model. This model can be seen in Figure 2.10. Figure 2.10 divides the circular economy into three spheres: biosphere, humansphere and technosphere.

- **Biosphere** refers to the natural capital that is used in the production of plastic products. This includes, material extraction, farming practices and cultivation.
- **Humansphere** shows the impact that the consumer has within the production of plastic. The humansphere is highlighted as being the centre of the system, showing the importance of taking user behaviour into account when designing.
- **Technosphere** refers to the processes which happens after the PET bottle was used. It shows the processes involved in the recapture and remanufacture of the packaging.

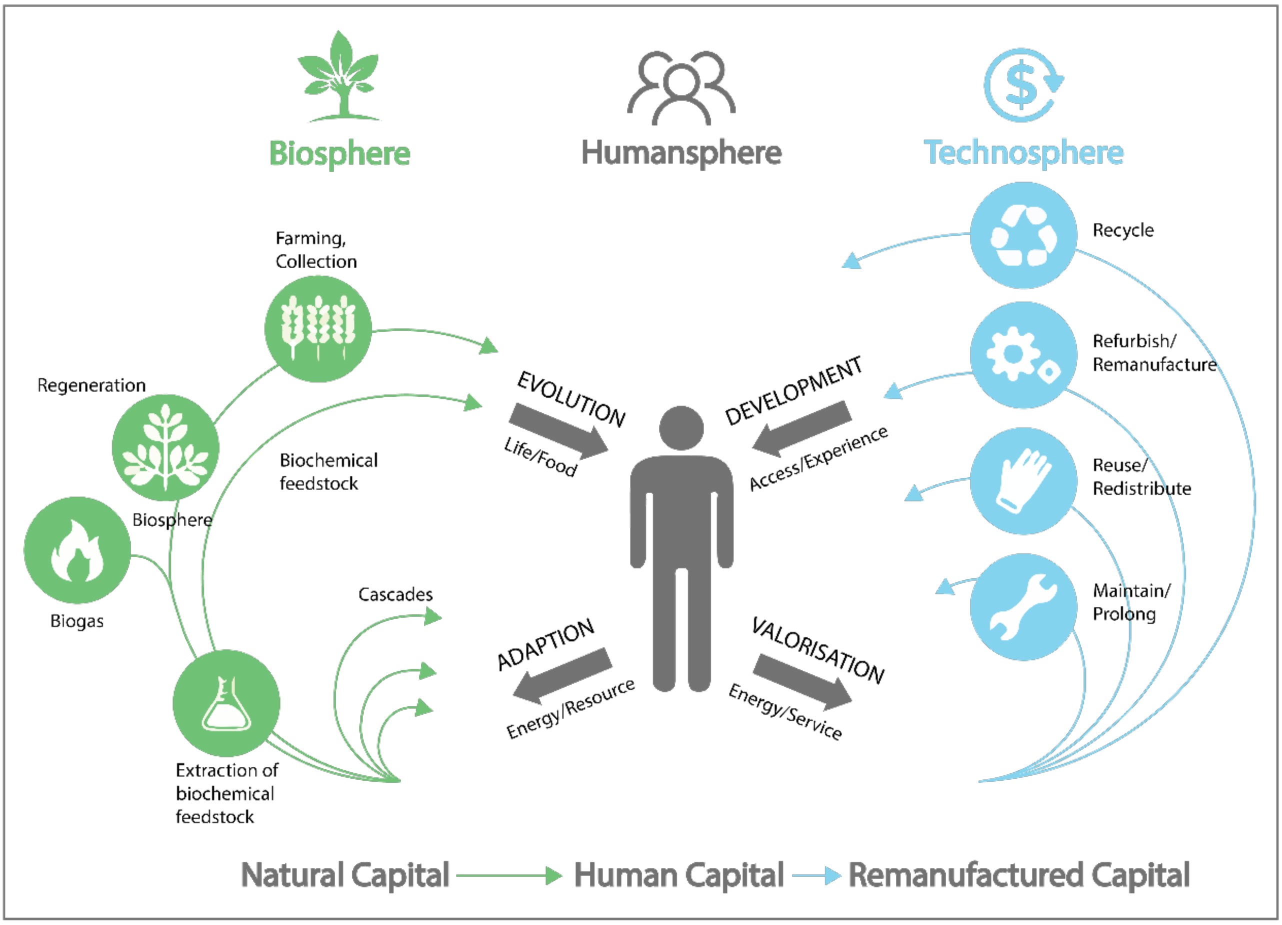

Figure 2.10: Circular economy model

Source: Adapted from Ellen MacArthur Foundation, 2013:24; Plastics SA, 2019

The key goal of a circular economy is to turn used products back into reusable resources at the end of their life cycle, this would lead to closed loop systems within industrial ecosystems and minimise the amount of waste seeping into the environment (Valavanidis, 2018:2).

The use of recycled products like plastic supports the ideal of a circular economy, which reuses raw materials with the potential to reduce the amount of virgin plastic used (MacKerron, 2015:22). According to the Ellen MacArthur Foundation, the circular economy can be divided into five key principles:

- **Design out waste** – This principle refers to designing with the intent of disassembly or refurbishment. The product must be designed in such a way, that the materials can be reused, using minimal energy (Ellen MacArthur Foundation, 2013:22).

- **Build resilience through diversity** – Through using natural systems as a model, this principle proposes that any product should be designed to be versatile and adaptive. This in turn means that the product or system must be suited for more than one application (Ellen MacArthur Foundation, 2013:22).

- **Rely on energy from renewable sources** – This principle proposes that whilst designing it is important to consider renewable options. The energy involved in the production of a product should be analysed throughout its life cycle, to ensure that it is optimised at each stage of production (Ellen MacArthur Foundation, 2013:23).

- **Think in systems** – Thinking in systems relies on the ability of the designer to understand all the parts within a system, and the influence that each part has on each other. That is why it is important to consider all the sections of daily life (social, financial, environmental), when designing. This principle emphasises the flow and connection of each process over time, to make the project more efficient in the long term (Ellen MacArthur Foundation, 2013:23).

- **Waste is food** – To reintroduce products back into the system, each component of a product must be analysed to recognise the best way it can be reused. This, in turn, leads to the product, or its parts, to be reintroduced into the economy. Thus, being the final step within the circular economy model (Ellen MacArthur Foundation, 2013:23).

The circular economy aims to keep resources in use for as long as possible by extracting maximum value from them whilst in use. This is done to recover and regenerate products and materials at the end of each product’s life.

2.9. Sustainability through design in South Africa

Within the South African context, there are two types of innovation which occur; incremental innovation and radical innovation. Incremental innovation is defined as utilising existing technology to increase the value of a product or system (Lewrick, *et al.*, 2015:240). Radical innovation is defined as the creation of new knowledge to produce novel products or ideas which are successful within a current system (Lewrick, *et al.*, 2015:240).

An example of incremental sustainable innovation in South Africa is an incentive given by the PET Recycling Company NPC (*PETCO)*, who represent the South African PET plastic industry. *PETCO* incentivises PET recyclers who collect bottles and process them into RPET, to eventually produce new products. The incentives given by *PETCO* includes both contracting and financing PET recyclers. Their main goal with this incentive is to ensure long term sustainability within the plastic packaging economy. This incentive will assist to sustain the interest in PET recycling, develop new end-use markets and inevitably reduce the amount of post-consumer PET going to landfill (PETCO, 2019:26). *PETCO* is a privately held company which is funded by the ERP[7] fee which is collected from manufacturers and importers of virgin PET material.

An example of radical sustainable innovation in South Africa includes a company called *Waste plan*. They were the first SA based company (privately held – nongovernmental) which introduced the concept of waste reduction, instead of waste disposal. Their mission is to reduce waste to landfill, through introducing on-site separation services. Through countering the amount of waste which goes to landfill, and then re-distributing it to recycling facilities, *Waste plan* aims to counter both transportation and the carbon footprint of waste by introducing proper waste management at the source. This ensures that all waste is separated efficiently and distributed to the correct facilities (Lourens, 2019).

Both *Waste plan* and *PETCO* are aiming to drive life cycle management within the South African context, although their approach is different. *Waste plan* aims to reduce waste at the source and *PETCO* gives financial incentives with the aim to get producers to recapture and recycle their waste.

In June 2020, the EPR plan was amended to include section 18. Section 18 allowed industry to raise, manage and disburse EPR fees themselves (Department of environment, forestry and fisheries, 2020:6). The aim of this amendment was to extend producer responsibility for

[7] See Chapter 2, section 2.8. for more information on the ERP plan.

their products along the entire value chain. The amendment placed responsibility on Producer Responsibility Organisations (PRO’s). The PRO’s must drive waste minimisation, manage funds to promote material reduction for re-using – recycling – recovering waste, whilst driving awareness and innovation to reduce the impact of their products on the environment (Plastics SA, 2020:1-2). To date, only a draft of section 18 has been published. Failure from any company that forms part of the ERP plan to comply with the new draft amendment will be a punishable offence. The noncompliance to the amended draft section 18 of the ERP plan can lead to; a fine, up to 15 years imprisonment, or both (CDH, 2020:4).

To ensure sustainable design within the South African packaging climate, two models can be used, namely; the life cycle management model and the capability maturity model. The life cycle management model (LCM) (development – introduction – growth – maturity – decline) is used to consider the impact of a product from cradle to grave. This model uses tools like a LCA to manage all the different aspects within a product system (NCPC, 2020:3). The capability maturity model (CMM) (initial – repeatable – defined – managed – optimised) is used to assess the effectiveness of a product or system and what is needed to improve its performance. This model originated from improving existing maturity models, meaning that this model is often used in combination with other models like a LCA and LCM (Hilmer, 2019:19).

An LCM can be applied to many different areas within a company to make it more efficient, including; management, production, sales and distribution, procurement, marketing, and product development (NCPC, 2020:3). The *Belgotex flooring solutions* case study demonstrates how the LCM model was applied to a South African business, to reduce their environmental impact and improve the company performance (NCPC, 2020:17). The key mission of *Belgotex* is to design, manufacture and deliver quality flooring to both commercial and residential markets. The key achievements that were found through using the LCM model within their company included:

- Raw materials used in the production of the flooring included post-industrial and post-consumer waste (NCPC, 2020:18).
- Through using solar photovoltaic panels to provide a percentage of their energy, they have minimised their energy usage and carbon emission during production (NCPC, 2020:18).
- By using a solution-dyed yarn process and rainwater harvesting plant, they have minimised their municipal water usage (NCPC, 2020:18).

- They have implemented a waste management system, to sort waste at the source, and to ensure efficient disposal (NCPC, 2020:18).

Through applying the LCM as a key business model, *Belgotex* is one example of a leading sustainable establishment within South Africa.

The use of the CMM model within South Africa is minimal. A study done in 2019, showed that only one out of 11 participants, from multiple universities, preferred to use the CMM model as their methodology (Hilmer, 2019:57). Most researchers prefer to use the CMM in combination with other models. For example, the case study mentioned above for the LCM, used a CMM together with a LCM to prove its findings (Hilmer, 2019:19). Thus, the application and use of the CMM on its own is currently being underutilised in South Africa.

2.10. Conclusion

The food and beverage industry include all businesses operating in the production, processing, and retailing of food and beverage products. Ultimately the problem with disposable plastic packaging is one of design within all sectors, namely manufacturing, distribution, consumption and trade systems. The main goal of disposable plastic packaging is to provide a container to protect consumable products, like beverage and food products. It is integral that the material used for plastic packaging provides barrier properties which adhere to all health and safety standards of all consumable products.

Once crude oil has been extracted and converted into pellets, there are different scenarios that can take place after its disposal. Packaging is increasingly being designed to be recycled and reused, but despite efforts to encourage and support recycling, landfills are becoming filled with valuable plastic refuse. When the entire ecosystem is understood, the potential of product design interventions, technologies and new developments in areas such as biobased materials, become apparent. Even with plastics being more recyclable than ever, one cannot assume that consumers will recycle them. A lack of consumer knowledge and appropriate waste management systems at local government level, impacts this.

To pursue sustainability within packaging design, it is important that: alternative materials should be researched, awareness should be raised among consumers, plastic products must be properly labelled, and the design of packaging reviewed. Design intervention is needed to facilitate better infrastructure, which would allow the consumer to rethink the way they look at plastic packaging. A new holistic approach needs to be introduced which encompasses social, economic and environmental consideration.

3. CHAPTER THREE: CASE METHODOLOGY

3.1. Introduction

The aim of the methodology Chapter is to state which research methods were used in this study. To understand all three sections of society (*people, profit, planet*), the TBL was used as the primary theoretical framework. This Chapter discusses why this methodology is applicable to this study and how it will be used to strengthen the hypothesis. In addition, this Chapter also explored a secondary framework which would be used to assist in the field research that was done. Both the primary and secondary theoretical framework was discussed and explained. To understand the best way to conduct field research within this specific study, AR was also explored, to prove its relevance to this study and why it is an appropriate methodology. Finally, this Chapter discussed the field research methods which were best suited for this study to prove its hypothesis.

3.2. Theoretical framework: Triple Bottom Line and Gestalt Theory

3.2.1. The “Triple Bottom Line”

Figure 3.1: The triple bottom line

Source: Adapted from Australian Government, 2016:5

In this study the TBL framework was used to divide the production of disposable PET water bottles into three sections, namely *people, profit, planet* (Figure 3.1). This can be referred to as “triple value adding” (Roberts & Cohen, 2002:129).

The TBL was developed to view a system by looking at innovation and development that should be applied to current systems while creating opportunities for generations to come.

The TBL framework was devised in 1994 by a business consultant named John Elkington (Elkington, 2004:1). Traditionally, this framework is used in accounting and government sectors to calculate profit margins and growth opportunities. The social and environmental dimensions of this framework make it applicable to many other fields, including design.

This framework was used to evaluate each section in the system of disposable PET water bottles. The interaction between the three sections were done to show how each section effects the other one’s life cycle. Research was done on: the public perception of plastic, challenges within the current system, why suitable alternative material is not necessarily a better option and how these problems can be addressed within the current system (Alhaddi, 2015:8).

Within the TBL framework, the three sections revealed different outcomes. These outcomes were used to guide the best options regarding *people, profit* and *planet*, which in turn, provided guidance on the social, economic and environmental outcomes that disposable PET water bottles must have to contribute to sustainable change. The objectives for triple bottom line assessment of disposable PET water bottles were:

- **Social:** Production of disposable water bottles creates jobs at each facet of the system, which allows for a higher standard of living. Communities with enough and reliable waste management systems have a range of intended purposes, including domestic, recreational and cultural use which defines the social aspect involved in the production of PET water bottles.

- **Economical:** To provide an opportunity which is economically viable for governments, producers and consumers. Costs that had to be considered included: cost of raw material, manufacturing, transportation, handling, consumer interaction and disposal. Once the production is efficient, a resilient system can aid in the economic future for all parties associated with the life cycle of disposable PET water bottles assuming that all financial aspects had been taken into account.

- **Environmental:** To propose a system that will reduce the current environmental footprint of PET water bottles. The effect that disposable PET water bottles have on the environment throughout its life cycle needs to be analysed. This includes studying how the product interacts with the environment throughout its life cycle.

By using the TBL principle, the social, financial and environmental aspects of disposable PET water bottles were highlighted and assessed (Figure 3.2):

Figure 3.2: The triple bottom line explained
Source: Adapted from Australian Government, 2016:7

- *People* defines the social aspect involved in the production of disposable PET water bottles. The production creates jobs, which in turn creates a higher standard of living (Hanekom, 2019). With the manufacture of said packaging, it is important to educate society on the importance of proper disposal, which can lead to value adding and opportunities (United Nations, 2018:8). *People* is also defined by the physical aspect of the product. The shape and size of the physical product need to fulfil the purpose which it has been designed for whilst being ergonomically viable. The purpose, intent and interaction of the product need to be clear as well as being comfortable and easy to use (Verghese *et al.,* 2013:28).

- *Profit* defines the financial aspect associated with the life cycle of disposable PET water bottles. Financial growth can only be achieved if the entire cycle of production is efficient (Alhaddi, 2015:4). All the facets of the life cycle need to be considered, including the cost of raw material, manufacturing, transportation, handling, consumer interaction and final disposal (MacKerron, 2015:39). Specific analyses will be done on each of these costs to see exactly what the financial implications are and what affect it has on the manufacturer, the producer and the consumer.

- *Planet* defines the effect and interaction that disposable PET water bottles will have on the environment throughout its life cycle (United Nations, 2018:5). Research will be done into the raw materials needed to produce PET and possible ways to make the current system more efficient. Increased pollution prevention and improved waste management systems will rely on educating society (MacKerron, 2015:20).

It is important to understand why consumers behave in a certain way as well as understanding the wants and needs of producers. By making use of significant data, a common middle ground can be found between the consumer and the producer (Schweitzer *et al.,* 2018:10). Production and manufacturing systems need to be viewed holistically, instead of looking at all the different stages of the process as separate entities (Verghese *et al.,* 2013:31). This relates to more contemporary versions of the TBL, such as the integrated bottom line (IBL) (Sridhar & Jones, 2013). The IBL is an extension of the triple bottom line concept. Although the TBL considers *people, profit* and *planet* to be critical to the development of any business or strategy, the IBL suggests that all three should be considered in unison and not as separate entities. The social, financial and environmental elements all have an impact on one another, thus it should be considered as a single entity (Roy, 2011:331).

The TBL was an appropriate theoretical framework for this study as it addresses social concerns, while simultaneously supporting financial growth and environmental conservation. The aim of this study was to create an appropriate intervention which observes each section of everyday life; social, financial, environmental. The TBL is the most accurate tool to measure all three sections simultaneously. This tool measures the physical realm which relates to a certain product or system.

3.2.2. The importance of Gestalt theory in design

Gestalt principles are applicable to this research, as it attempts to understand why and how certain user behaviours can be triggered through appropriate patterns and intervention (Wagemans *et al.,* 2012:1219). Although there are many variations of Gestalt theory, the most common laws are; similarity[8], proximity[9], continuity[10], closure[11] and prägnanz[12] (Chang *et al.,* 2002:5).

Gestalt refers to a coherent form or a structured unified whole (Wagemans *et al.,* 2012:1219). It shows the subconscious relationship between consumer expectation and the designed product. This will aid in gaining a holistic perspective. The Gestalt principles used in this research are some of the lesser known principles, including: isomorphic correspondence, prägnanz and focal point.

- Isomorphic correspondence – This principle refers to how the user interprets what he or she sees. It is based on the idea that the user will define the object, based on previous experiences (Chang *et al.,* 2002:6).

- Prägnanz – This principle is based on simple design with good form. It suggests that the user prefers simplistic structures which is easy to comprehend. In many cases these shapes are symmetrical (Wagemans *et al.,* 2012:1225).

- Focal point – This principle is based on the idea that the user is persuaded to see something specific due to the product which was designed with a carefully placed focal point (Chang *et al.,* 2002:6).

Gestalt principles were used in this study to understand why consumers react to products and systems in a certain way and how designers can intervene in this process. Through research and testing, a possible intervention that can facilitate all three sections (*people, profit, planet*) within one product is proposed in Chapter 6. Each section was critically investigated to understand what makes each one unique and why all three sections are equally important to suggest a suitable design intervention.

Gestalt theory was chosen as the applicable theoretical framework for this study as it aids in describing the user experience before, during and after use of the disposable PET water bottle. Through using the Gestalt theory principles of isomorphic correspondence, prägnanz and focal point, it helped to explain why consumers make certain purchasing and disposal decisions. Gestalt theory is centred around the idea of how consumers perceive visual elements. Whilst the TBL focuses more on the scientific side of why consumers make certain purchasing decisions, based on cost and environmental principles, Gestalt focuses on the

[8] Similarity implies that items which look the same, will be grouped together.
[9] Proximity implies that the user will subconsciously group items that are closer together.
[10] Continuity implies that the eye instinctively follows the direction of the visual.
[11] Closure assumes that the human mind perceives open shapes as incomplete and will naturally fill the gaps.
[12] Prägnanz implies that the user subconsciously prefers simple design with good form above intricate shapes.

psychological effect that a physical bottle with specifically designed elements can have on the consumer's purchasing decision. Through using both Gestalt theory and the TBL as the theoretical framework for this study, both the physical and psychological realm within consumer decision-making could be explored.

3.3. Research design and the methodology

Action research (AR) was used as the methodology for this research. Figure 3.3 illustrates AR as structured around the systematic investigation of social situations and interactions. The goal of AR is to promote sustainable change through collaborative participation by all parties involved, which can in turn create a holistic system (Burns, 2015:187).

Figure 3.3: Action research

Source: Adapted from Zuber-Skerritt, 2001:2

AR is described as a programme for change in a social situation. Even though it has been applied mostly to teaching practices, its social principles and similarities between the AR process (plan – act – observe – reflect) and the design process (research – analysis – synthesis – evaluation) make it equally appropriate in the field of design (Swann, 2002:55).

Ortrun Zuber-Skerritt (2001:2) divides action research into four sections, namely plan (problem analysis and strategic planning), act (implementing a strategic plan), observe (evaluating the action through appropriate methods), and reflect (reflecting on the result of the evaluation, leading to identification of a problem).

Throughout this research the social, economic and environmental stakeholders involved in the consumption of disposable plastic water bottles were analysed. The life cycle or a PET plastic water bottle has an influence on all the stakeholders. Action research requires that the research process must be made visible. It demands public accountability and visible self-evaluation, an issue that assumes increasing importance for current professional design practice (Swann, 2002:57). Anne Burns describes the role between the problem and the stakeholders in AR as:

> *Typically, the situations that participants wish to investigate are those they perceive to be 'problematic'. Rather than suggesting that the participants or their behaviours are the 'problems', the term problematic reflects a desire on the part of participants to 'problematize', that is question, clarify, understand and give meaning to the current situation. The impetus for the research is a perceived gap between what exists and what participants desire to see exist (Burns, 2015:188).*

This makes AR even more applicable to this research, as this research does not propose immediate change. It will rather attempt to propose how certain parts of the system can be optimised to ensure sustainable social, economic and environmental growth.

AR was used as the methodology for this study, as it allows for both quantitative and qualitative research to take place through action and reflection (second and fourth research stage). As the name states, "action research" is meant to help the researcher gain knowledge through a chain of actions (plan – act – observe – reflect), which would eventually lead to a certain hypothesis. The mixed method structure of "method triangulation" which is applied to AR research was applicable to this study, as different methods were used to conduct the research, for example; survey's, personal accounts, interviews and product journey mapping. Another mixed sampling group, "data source triangulation" was also used in this study, which allowed the researcher to collect data from different types of people. These triangulation methods made AR a suitable choice for this study.

Within the context of this research, AR was used as a tool to weigh the research outcomes to enable choosing the best option. These outcomes were used to guide the best options regarding *people* (social), *profit* (economic) and *planet* (environment). AR requires several cycles to be reviewed, amended, adapted, and refined before a solution is proposed and executed (Swann, 2002:56). The research used AR to reach the above-mentioned, as can be seen in Table 3.1.

Table 3.1: AR cycles in relation to the research and design phases[13]

AR Cycle	**Corresponding action/ task within this research project**
Plan	The literature review was re-analysed to choose appropriate sampling groups for each section; *people* (social), *profit* (financial), *planet* (environmental). *People* – The sampling group included all ages, ethnicities and genders. Both quantitative and qualitative research was done with sampling groups of 42 and 6 respectively. *Profit* – The sampling group included experts in the plastic manufacturing industry and consisted of three qualitative interviews. *Planet* – This sampling group consisted of one key individual, with knowledge of the entire plastic value chain. All questions were set up with critical data gathered in Chapter 2 in mind. A map was constructed to thoroughly understand the user interaction at each stage of the life cycle.
Act	After the sampling group was chosen and surveyed, interviews were set up and data collection started. All participants were informed of their rights and what was required of them. The *people* section consisted of written answers and voice recordings, which had to be collected. Both the *price* and *planet* sections consisted of one-on-one interviews.
Observe	After the data were collected, the interview sections were transcribed. The data coding process consisted of three phases. Firstly, the data collected within each section were analysed to find the sub themes within each section. The sub themes were then individually discussed. Secondly, through the Thematic analyses (TA) process, the key themes which are applicable to all sections, were constructed. Thirdly, the key themes were discussed to find critical design solutions.
Reflect	The critical design solutions found through the TA were then used to design a holistic solution which is applicable to all sections.

This study took the basic outline of AR for its main structure, but made a few additions to make it suit the research questions completely. Figure 3.2. illustrates the research design, as applied to this study.

[13] When a secondary source is not listed for a Table, the Table was produced by the author, using content generated by the author.

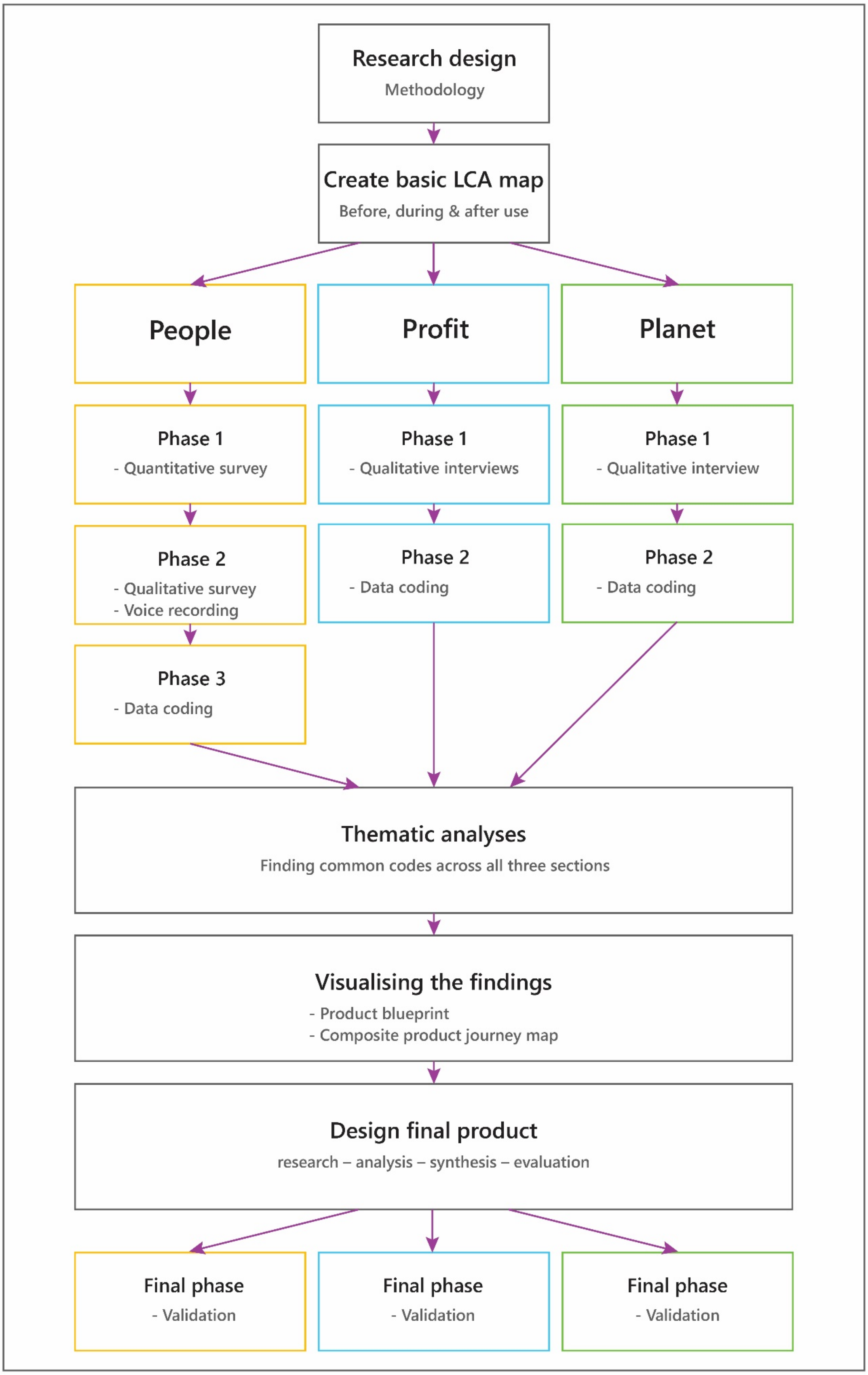

Figure 3.4: Research design

3.4. Sampling group

The sampling group for this study consisted of participants from each section of the TBL; *people, profit, planet*. This study did not aim to target only one part of the economic society, but rather targeted each individual section within the TBL. The sampling group for each section had its own requirements.

People – There were two key sampling requirements for *people;* firstly, each participant had to form part of the consumer economy (meaning they must be 18 years or older and be making their own purchasing decisions) and secondly, each participant had to purchase or carry bottled water on a regular basis. Participants sampled in this section included all ethnicities and genders.

Profit - The sampling group for *profit* only included participants which worked within the FMCG sector. It was important that all participants understood the financial processes and implications which form part of the everyday cycle within the disposable PET plastic market. Restricting this sampling group, ensured that the data was accurate and appropriate to the specific product, a disposable PET water bottle.

Planet – For this section of the study, only one key witness was needed. The purpose of this witness was to validate the entire life cycle of the PET water bottle manufacturing process and its before and after use cycle.

3.5. Research methods

Research was done to find and report credible solutions to problems which are grappled with every day. Thorough research can minimise error and improve product and system life cycles. Ethically, this research aimed to be accurate and reliable. To gain ethical clearance for this study, a research proposal had to be presented to the post graduate design board of CPUT. The proposal included a short summary of the researcher's intentions and the field research which would have to be conducted. After the proposal was accepted, an ethical clearance certificate was issued. Although the certificate was issued, no ethical approval number was added.

The significance of the research was measured by the participant reaction (Fox, 1998:2). Research methods are used to show the significance of a study within a real world environment. To understand the context and significance of this specific research, research methods included: interviews, surveys and product journey mapping (Whitehead, 2005:6). In this research surveys and interviews were employed as the main data collection methods. The findings were analysed using a thematic analysis (TA) approach. Supporting the data collection and analysis processes, mapping was used to provide additional insights.

Before the surveys and interviews were set up, the entire life cycle of a plastic water bottle was mapped and simplified to understand the first interaction point of each section. Once each section was understood and broken up into before-and-after-use, a basic map (Figure 3.4) was constructed. The goal of the basic map was to understand the requirements and restrictions of each section and to set up adequate questions for the data collection process.

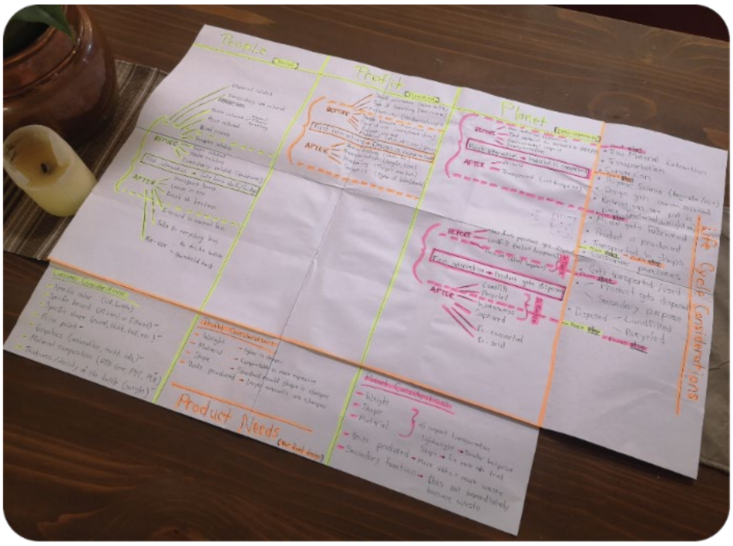

Figure 3.5: Basic map[14]

After gaining a better understanding of the data needed, the necessary consent forms were drafted[15], and the interviews[16] were constructed. The data collection method for each section was as follows: *people* consisted of both quantitative survey and qualitative interviews, *profit* consisted of structured interviews with the addition of voice recordings and *planet* consisted

[14] When a secondary source is not listed for a Figure, the Figure was produced by the author.
[15] Please see appendix A.
[16] Please see Appendix B-E.

of one expert interview which contained both structured and open-ended questions. The transcribed data sets under each section can be seen in Figure 3.5.

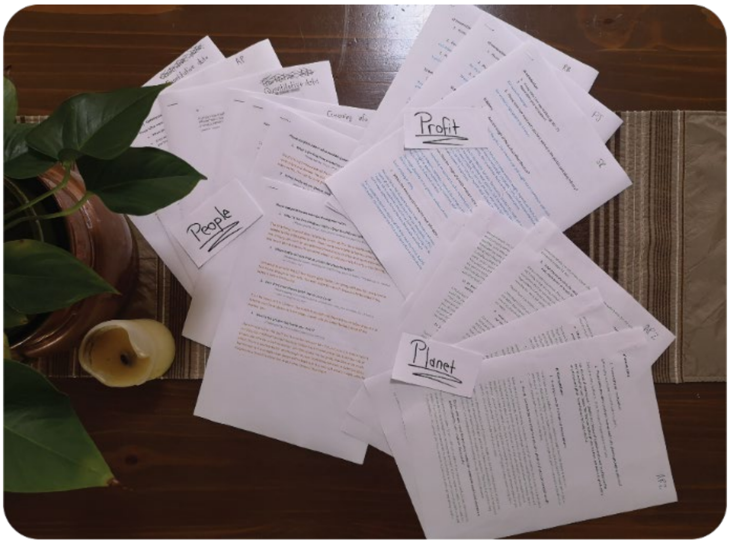

Figure 3.6: All data sets

3.5.1. Survey

The surveys conducted were mainly quantitative and related to the *people* (or social) principles of the TBL framework. The reason why a survey was used for the quantitative research part of this study, was to gain a broad understanding of what the general consumer's wants and needs were. There were 42[17] consumers that completed the survey (Appendix B). Questions in the survey were set up to gain insight regarding the decisions that consumers make when they choose a bottle from the shelf and what they take into consideration. This data was mainly used to assist in the physical design of the bottle (discussed in Chapter 6).

3.5.1.1. *People*: Investigating insights and perceptions

Qualitative data relating to the *people* (social) TBL principle were collected through a survey with four participants. Each participant was given a questionnaire (Appendix C) with two sections; a write up and voice recording. The first section of the survey comprised of a write up which had seven questions. The aim of this first section was to gain insights into the participants' perceived idea of a PET water bottle. By completing a written survey, the participants need to think of an appropriate answer, before they write it down.

In the second part of the survey there were eight questions. To answer these questions the participant needed to visit the local grocery store to decide which water bottle to purchase. The goal of the voice recording was to gain insight into the participant's immediate response

[17] Although 42 people participated in the questionnaire, only 38 participated in the qualitative question.

when seeing the available water bottle options on the shelf. A conscious decision was made by the researcher to do surveys instead of interviews. Through using surveys instead of interviews in this section, the researcher was not present during the required participant action. It was the intention of the researcher to create a comfortable environment for the participant, to ensure that the participant did not feel the need to give a biased answer based on what he/she thought the researcher would like to hear. The key subcategories found within both the qualitative and quantitative data can be seen in Figure 3.6 and 3.7. Figure 3.6 includes: design, price (cheapest), design and reusability, as well as, design and price. Figure 3.7 includes: design, reusability and price (more expensive).

Figure 3.7: Quantitative –
People data set themes

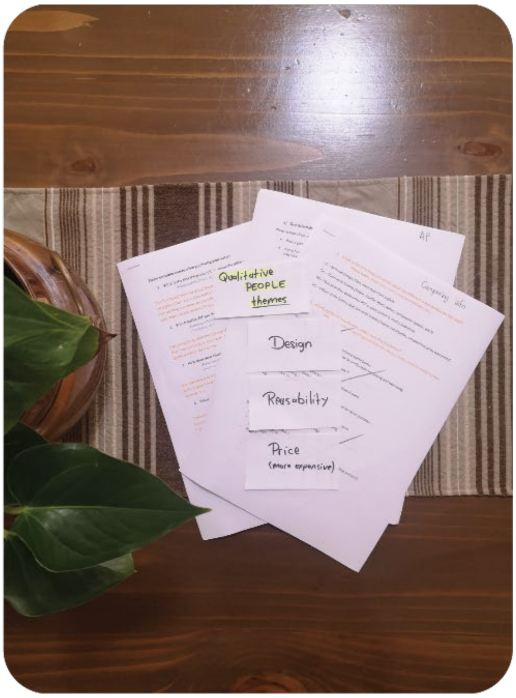

Figure 3.8: Qualitative –
People data set themes

3.5.2. Interviews

Interviews are defined as a discussion between the researcher and one or more parties. These discussions are based on a list of pre-set questions that relates to a certain topic which is in this case the life cycle of a PET water bottle (Driscoll, 2011:154). The purpose of the research method was to gather detailed information about a specific object or system (Driscoll, 2011:163). This research included semi-structured and structured interviews for an overall understanding and impression of the holistic system of a PET water bottle.

Semi-structured interviews were completed to allow for a more participatory model. The interviewer prepared the questions beforehand whilst allowing the participant to express their views and opinions freely. Semi-structured interviews were based on an open-ended approach to elicit answers from the view of the participant (Newton, 2010:3). The purpose of selecting a semi-structured approach was to remove as much research bias as possible and to allow the interviewees to lead the direction of the conversation

3.5.2.1. *Profit*: Investigating economics

Data collection of insights into the *profit* principles of the TBL were also achieved through interviews. The aim was to understand what processes had an impact on the price of the disposable water bottle. This became critical as price was identified as a consumer consideration in the *people* section of the research in both the quantitative and qualitative findings. This research focused on one interaction phase that *profit* has with the water bottle, namely design requirements to transportation of final product.

This part of the research comprised of three key semi-structured interviews (Appendix D) which consisted of open-ended questions. The data set was comprised of interviews with two key account managers and one senior CAD designer with respectively 11, 13 and 30 years' experience in the plastic FMCG industry. The key subcategories found through the third data set can be seen in Figure 3.8. It includes: price, design, consumer perception, client perception and environmental concern.

Figure 3.9: *Profit* data set themes

3.5.2.2. *Planet*: Environmental concerns and considerations

The final interview allowed for the collection of insights which relate to the *planet* (environmental) principle of the TBL. The aim was to understand how the disposable water bottle impacts the environment throughout its entire life cycle. For this part of the research, a polymer scientist with 31 years of experience in the field was interviewed. A polymer scientist is uniquely qualified to offer insights regarding this section as they have a unique view of the entire life cycle of a specific material, in this case plastics. They are involved in both raw material analyses as well as recycled material analyses. The key aspects identified during the interview can be seen in Figure 3.9 and include: consumer perception, key problems, facts, solutions and design.

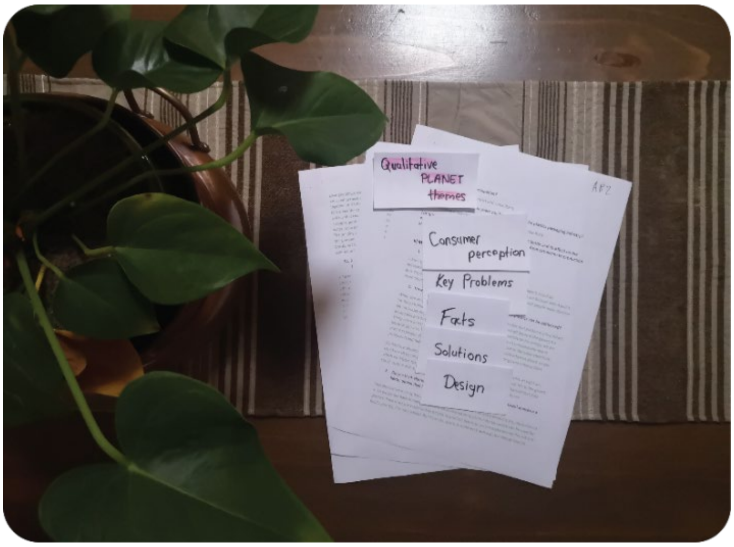

Figure 3.10: *Planet* data set

3.5.3. Composite product journey mapping

Composite product maps (CPM) are based on the customer journey map model. The main goal is to capture and inform how the customer perceives and interacts with a given product or system (Adaptive Path, 2013:4). These maps are designed to improve the overall experience by solving problems at each point of interaction with a product or system. By building a journey map, the researcher can gain invaluable knowledge of how the product or system is perceived throughout its life cycle. A map provides a holistic view of the proposed system (Silvertech n.d.:10).

A customer journey map is used to determine how an individual group interacts with certain products or systems. The goal is to change a product (if necessary) to make it user friendly (People Metrics, 2017:2). A product journey map looks at each stage of a products life cycle:

before use, during use and after use. The goal is to map, analyse and present the interaction (Bassill, 2016:2). This map shows the difference between the product and customer desires. Ultimately it shows how the product can be modified to become more efficient (Sawtooth Software, 2004:2).

Within the product journey mapping model, the map is typically driven by user perceptions or preferences. Perception data driven maps are easy to interoperate as they are based on user ratings and descriptions of products. They convey user insights, although they cannot predict user preferences. Preference driven maps can better account for user preference, because of the assumption that the user has an ideal direction or space for a desired product (Sawtooth Software, 2004:2). Within the CPM, both preference and perception mapping were used (Bassill, 2016:2).

As the generated product map focused on human behaviour and the physical interaction between the end user and the PET water bottle, the *people* (social) sections of data were used to develop the map. This CPM made it possible to look at individuals' interaction with the disposable water bottle. Table 3.2 shows the considerations that were applied to map all three stages of the *people* interaction with the PET water bottle life cycle.

Table 3.2: Product journey considerations

Before use	During use	After use
- Has price affected their choice? - What environmental logos did they consider? - Did overall design affect their decision? - Did material composition affect their decision?	- Will the consumers immediately use their bottle? - What was the purpose of purchasing a disposable water bottle? - How long will they use the water bottle? - How will the consumers transport the product? - How will the consumers dispose of the product?	- Where did they dispose of the bottle? - How did they dispose of the bottle? - Did they reuse the bottle before disposing of it? - What did they use the bottle for after its initial use was over?

3.6. Thematic analyses

In this research, thematic analysis (TA) was used to analyse and process primary data. TA is traditionally used to identify patterns within qualitative data. It describes the data that have been collected and interprets all the relevant aspects of the topic to form relevant patterns (Braun & Clarke, 2006:79). This tool captures possible themes and complexities that represent important meanings or responses within the research. There are six phases to conducting a TA, namely becoming familiar with the data, generating codes, searching for themes, reviewing themes, defining and naming these themes as well as producing a final report (Braun & Clarke, 2006:82).

This data analysis method is applicable to this report as it is used to find patterns in themes, and to code the collected data. These were the six phases of TA has been applied to this research:

- **Familiarization** – This stage included transcribing all interviews, creating statistics and grouping quantitative data as well as summarising quantitative interviews. Through this process, all participants were given user codes to ensure their anonymity.

- **Generate codes** – During this process, preliminary codes within each section of research were named, to loosely describe the basic outline of what has been found. These codes included snippets of information, like: design, price, usability.

- **Search for themes** – After all the data were coded patterns of sub themes started showing throughout the research. By identifying umbrella themes which connected all sections, the key themes were recognised. As part of this phase six initial themes were identified, namely overall design, product price point, both customer and client perception, reusability and recyclability.

- **Review themes** – This stage reviewed whether the initial key themes chosen overlapped. Through the reviewing process, the initial six themes were examined to review content and whether there was conceptual overlap between themes. After the review overlap was discovered and themes collapsed, four final themes were identified and refined. The themes were: multi-response design, making the complexity of disposable bottles visible to all stakeholders, context driven consumer cost expectation and emotional response to plastics.

- **Define themes** – In this section, the themes were discussed to define and showcase the most important data found throughout the entire report. To strengthen these chosen themes, secondary data collected in Chapter 2 were also used as additional evidence to show its significance.

- **Produce report** – After the data were gathered, coded and defined, the final design process started. As this research proposed a final, holistic water bottle design, throughout the TA process, a list of design considerations and requirement were also set up. Together with the design requirements for the physical bottle and data gathered on creating sustainability through design, the final report was produced.

3.7. Data management

The data gathered through this research are both in the form of physical papers (completed surveys) and electronic data (voice recordings). To ensure that all data will be thoroughly protected and can be accessed if necessary, all hard copies were scanned and saved with the electronic data on a cloud-based (google drive) platform and an external hard drive, which are all password protected. The original paper copies of the data, as well as the consent forms will be stored in a safe at the researcher's home office. Data have only been seen by the researcher and the project supervisors. Redacted copies of data are available.

3.8. Ethics

Ethics relate to the professional practice of the researcher. The researcher is expected to behave in a professional manner throughout the entire process, without making the participant feel uncomfortable or influencing them to give a biased opinion to skew the data (Krishnamurthy, 2011:4).

The field research done for this thesis was set up in a manner, not to cause harm or potential risk to any of the participants or stakeholders involved. The goal was to represent the data as honestly as possible. The identities of all participants were, and still are, kept confidential. No deceptive practices were used, and all participants had the right to withdraw from the research at any point. At each stage of the research process, the participants were made aware of their rights and what they could expect from the research activities.

The consent forms were given to all participants[18], as an agreement between the researcher and the research participant. The consent form was an outline of what was expected as well as the roles and the responsibilities of both the researcher and participant. Each interview and questionnaire were set up with an introduction which stated the aim of the part of research.

[18] Please see Appendix A.

Only after the introduction, did the participants complete the consent form. The introduction form was used in addition to a verbal communication from the researcher about what the research entailed and what was asked from the participant. This way, the participant could both hear and read what they were agreeing to, before completing the consent form.

The consent form was signed by both parties. An example of the consent form can be viewed in Appendix A. Information shared with the participants included: contact details of the researcher, the purpose of the research, the methods that were used, the possible outcomes, and the associated demands, discomforts, inconveniences as well as risks that the participants may have faced

4. CHAPTER FOUR: RESEARCH FINDINGS

This Chapter explores the research findings in relation to the three key sections discussed throughout this paper: *people, profit* and *planet*. The data that have been collected within each section will be discussed separately to highlight the key concerns within each one. To map the life cycle of the PET water bottle, each section has been broken up into subcategories: before use, first interaction and after use. The participant codes for this research can be seen in Appendix F. In these subcategories human experience was central to the discussion and findings were collated under each of these subcategories. The only section that has two 'first interaction' points is *planet*. Table 4.1 visualises the first interaction point of each section and provides a general overview of the finding's discussion in the Chapter.

Table 4.1: First interaction point of each section

Bottle life cycle	***People***	***Profit***	***Planet***	
Raw material extraction				First interaction
Transportation				
Conversion				
Design requirements are put in place				First interaction
Design is commissioned				
Mould is made				
Bottles are produced and filled				
Bottles are transported to shop				
Consumer makes purchase				First interaction
Bottle is transported or used				
Disposal				Second interaction
Recycling				

After the findings were described, all three sections were cross referenced, and the data sets analysed using a TA approach. Themes identified through this analysis formed the discussion points explored in Chapter 5. The findings overview can be seen in table 4.2.

Table 4.2: Overview of findings

Category	Data	Findings
People	Quantitative survey	• Design • Price (cheapest) • Design and reusability • Design and price.
	Qualitative survey	• Design • Reusability • Price (expensive)
Profit	Key interviews	• Price • Design • Consumer perception • Client perception • Environmental concern.
Planet	Expert interview	• Consumer perception • Key problems • Facts • Solutions • Design

4.1. PEOPLE

People was the first part of the research to be conducted. The aim was to understand how the disposable water bottle is perceived through the eye of the consumer and how the consumer interacts with it after its primary use is over. This research analyses the interaction phase that *people* has with the water bottle, namely consumer purchase to disposal.

4.1.1. Findings from quantitative survey with consumers

There were two main consumer considerations that stood out throughout the first data set: price and design. The other consumer considerations that were found were in direct correlation with one of the main themes, namely design. The key themes can be seen in Figure 4.1.

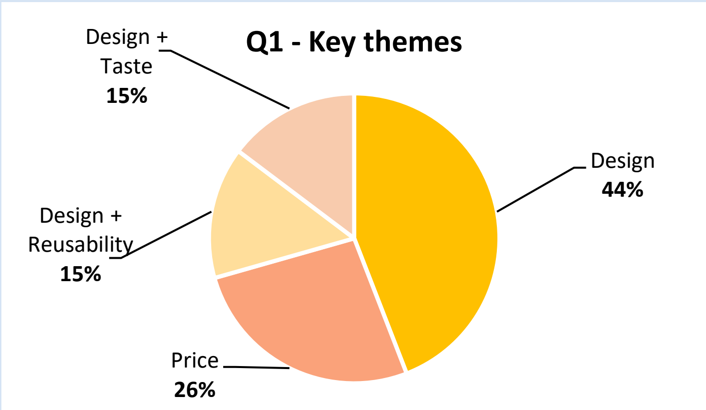

Figure 4.1: *People* – Q1 – Key themes

Price – Throughout this process, it was found that consumers would purchase almost any bottle, if the price point is low. Out of the 42 participants, 24 (57%) agreed that the price point of a bottle is important to very important.

Design – Of all the participants, 74% agreed that design on its own or in combination with taste or reusability is the most important consideration when making a purchase. Design restrictions and preferences that have been found include: a straight simplistic bottle, a strong and sturdy bottle, a twist cap opposed to a sipping cap and a larger bottle with a capacity between 500 - 750 millilitres. This is shown in Figure 4.2.

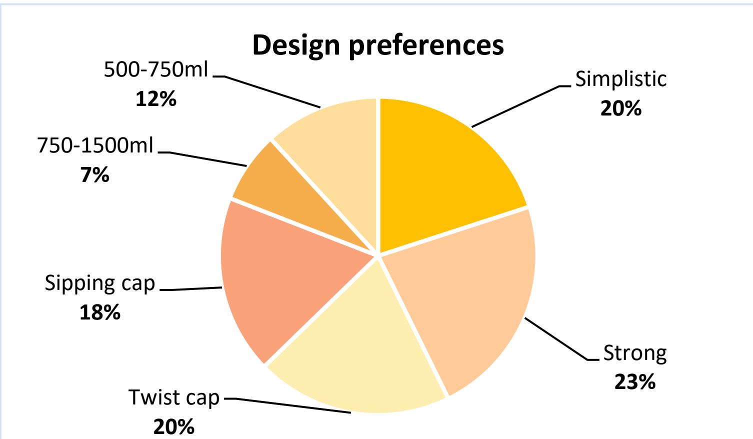

Figure 4.2: *People* – Design preferences

Recyclability – Another key concern for consumers was the recyclability or reusability of the bottle as 22 out of 42 participants (52%) indicated that they reuse their bottle after they have bought it. The recycling logo on a bottle is also one of their key concerns. They will always look out for the recycling logo on a bottle and if it is present, they are more likely to buy it. This is shown in Figure 4.3.

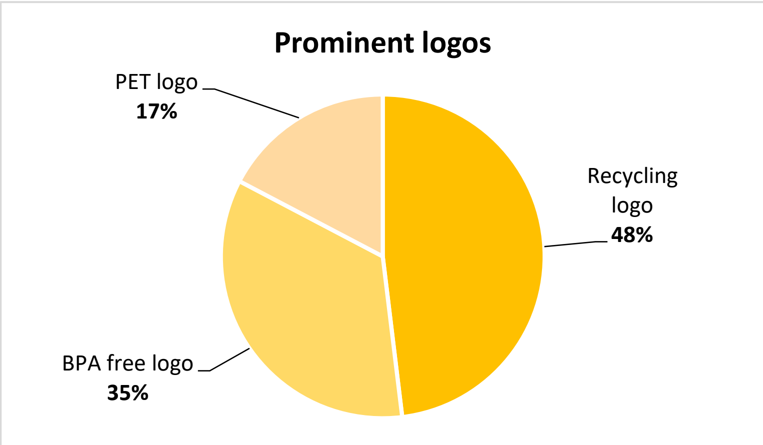

Figure 4.3: *People* – Prominent logos

4.1.2. Findings from qualitative interviews with consumers

The three main consumer considerations found through the second data set were: price, design and recyclability. Other, less prominent considerations included: solutions and perceptions. These have a strong correlation with findings from the quantitative data set within the same section. This can be seen in Figure 4.4.

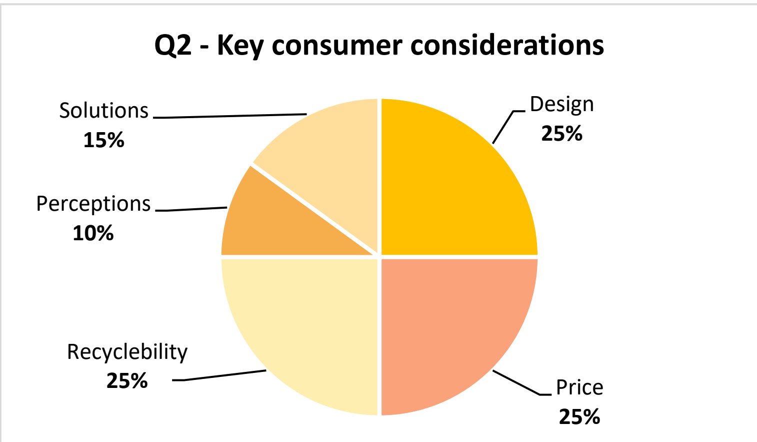

Figure 4.4: *People* – Q2 Key consumer considerations

Price – Opposed to the first data set where a low price point was the main consideration, the outcome was different in the second data set. Data set two indicated that the consumers did not mind paying more for water if the bottle was strong, reusable and aesthetically pleasing.

Design – Data set two provided many of the same design specifications as data set one, with a few additions. Design restrictions and preferences included: all participants agreed they prefer a minimalist design which is strong and sturdy, they also favour a larger bottle capacity of between 750 - 1500 millilitres. In addition to these restrictions, participants agreed that they purchased bottled water for on-the-go purposes and when there is no other option available, they also require the bottle to fit into their car cup holder. All participants indicated that they only buy bottled water when they do not have their refillable bottle or flask at hand.

Recyclability – All participants agreed that they reuse a bottle at least once before recycling or disposing of it, although they indicated that they are more likely to reuse a glass bottle and rather recycle a plastics bottle. Consumer access was a large concern for participants. In this data set they indicated that they do not necessarily have access to either clean water or recycling bins. This forces them to purchase bottled water and use traditional disposal methods, although they do recycle when they have the opportunity. Even though not all participants have access to recycling facilities, they make a conscious decision to choose a bottle which is recyclable[19]. Two out of four participants indicated that they understood the importance of re-entering their plastic waste into the recycling stream to produce new bottles or other products. Only one participant mentioned the importance of looking at the recyclability of the label, cap and bottle before making a purchasing decision.

Solutions – Using reusable options like a metal flask or glass bottle were one of the main themes with regards to solutions, as it causes less waste. Only one participant believed that those options are less sustainable (with regards to material extraction, transportation and recycling) than a disposable plastic bottle. Even the participants that do not prefer purchasing plastic bottles, agreed that to make a more informed decision, they would like to be educated about the impacts of plastic versus glass. Other solutions that were proposed include: increased availability of recycling stations, central recycling centres close to their workplace or general grocery stores, and common refilling stations to lessen the number of disposable bottles being purchased.

[19] 2 out of 4 participants agreed that disposable bottles are an absolute necessity in areas where clean tap water is not available.

Perceptions – In addition to 75% of participants believing glass would be a better option, one participant alleged that glass is biodegradable and can break up in nature. Another participant claimed that recycling causes more emissions in its overall process than simply landfilling the bottle after its useful life is over.

4.2. PROFIT

Profit was the second section explored. In this section of research, the terms "client" and "consumer" are discussed. "Client" refers to the company who is commissioning a new design, and "consumer" refers to the individual buying the commissioned product from a local grocery store.

4.2.1. Findings from qualitative data set: Expert interviews

All participants agreed that there are three main concepts that cause the price of plastic bottles to fluctuate: material use, cycle time or cavitation and overheads. The two main *profit* factors that were found through the second data set were: price and design. Secondary factors included: perceptions and the environment. This can be seen in Figure 4.5.

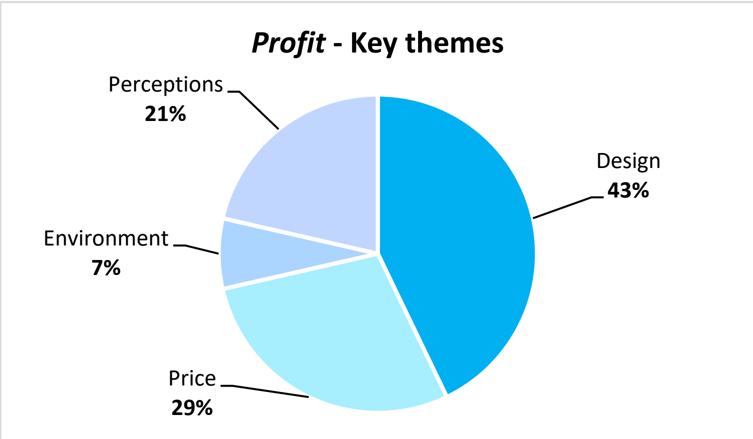

Figure 4.5: *Profit* – Key themes

Price – Findings indicate that the South African plastic industry does not set the price for plastic polymers, as the raw material needed to produce PET pellets are not produced in SA but are imported. The price of plastics in SA is based on global trends and demand. Thus, the material price of PET in the South African context is not fixed. Currently, PET is the cheapest plastic material available due to high demand. Participant SR001 explains:

> *…the rand per kg price of PET is the most expensive, but PET is stronger than both HDPE and PP. This means that less PET is used to produce a bottle than bottles made from PP and HDPE, causing the weight of the PET bottle less and the*

PP/HDPE bottle heavier. So, in the end, the PET bottle is either cheaper or the same price as the PP and HDPE. The price of plastic polymers depends on crude oil prices and global supply and demand. The price is determined by over or under supply: the more there is, the less it will cost and vice versa.

The price of PET increases once demand drops or any additives are added. Additives are added to make the bottle more resistant to certain conditions like extreme heat or cold. Participant PJ002 explains:

PET has no barrier protection. Additives can be added to PET to extend the shelf live, but it pushes up the price tremendously. Colouring is also expensive, it adds about 0.1% to price.

Another general additive that can increase the bottle price is colour. The masterbatch[20] is not very expensive, but the colour change-over on the machine causes the machine to be offline for a while, which leads to overall extended cycle times for a specific product.

Other aspects that influence the price which the SA plastic industry does not have control, is: mould cavitation, cycle time and transportation. The more cavities there are in a mould, the more bottles and caps a machine can produce over a shorter cycle time. The mould can take a certain number of cavities, depending on the final design, which in turn has an impact on the pallet utilisation and transportation.

Participant SR001 and PJ002 agree the more product that can fit onto a pallet, the less the transportation cost would be, as the company needs to load less pallets per truck. Participant RB003 explains:

Weight has an effect: the heavier the product, the more expensive the petrol will be. The bigger the product is, less will fit onto a pallet, making fewer products go into one truck.

Another impact on the overall price of the product is the transportation: the further the product needs to be transported, the higher the cost. Quality tests are also done on all products throughout the production process. The cost of quality tests is included in the overall price of the commissioned product, although it does not influence it as quality tests are standard procedure on most products. The factors that affect the fluctuation of product price the most include:

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[20] This refers to specific additives or pigments which are added to clear pellets to get the desired colour.

- Material weight
- Raw material cost
- Pallet utilisation
- Whether they use a generic preform
- Transportation
- Demand

Design – Design plays in integral role in keeping the cost of a bottle down. Not only does the design have an impact on the cavitation of the mould, but certain design aspects can cause a lighter preform to be used. Participant SR001 explains:

> *…a client wanted to redo their current 90ml bottle shape – so we priced them five cavities on the mould, but the new design and shape, only allowed for four cavities, so the designer slim lined the bottle, to run more cavities on the mould and save money.*

When considering what preform to use, it will always be cheaper for the client to specify using a generic preform[21], as it is much costlier to import a new preform or to create a new injection set to make a new preform. Participant SR001 explains

> *…a new PET mould has two parts; a preform mould and the blow shells. The cost breakdown for this is 70% preform and 30% blow shell. When using a non-generic preform, the client needs to purchase both parts. If the client uses a generic preform, then they only pay for the blow shell and not a new preform as it is cheaper to use a generic preform and cap.*

Design aspects that can cause a bottle to be cheaper and easier to produce include: additional ribbing[22], round bottles and clear bottles. The reason why round bottles are cheaper to produce, is because it is blown and removed from the mould more easily, decreasing overall cycle time. Even though a round bottle is cheaper to produce as opposed to a square bottle, a square bottle is better for pallet utilisation which in turn has an overall cost saving with regards to transportation. Another unique feature of a round bottle, as opposed to a square bottle or bottle with many flat panels[23], is its resilience to panelling. According to all participants, panelling occurs when a bottle is transported to and from higher to lower altitudes (for example from Johannesburg to Cape Town). A bottle needs to be designed with filling

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[21] The term generic preform is used to refer to a preform which is owned and produced by a certain company.
[22] Ribbing in this context refers to the indents and grooves on a plastic bottle.
[23] Refers to a bottle with flat panels which have no radius for added strength.

location, altitude and heat fluctuations in mind. Precautions that can be done to ensure that a bottle has little to no panelling include:

- Ribbing
- Radius on straight panels
- Producing a round bottle

A key consideration in bottle design is shelf height and presence. All participants agreed that shelf height and presence is very important to the client as it dictates whether the prospective consumer will see and buy it. Increased shelf presence will lead to more bottles being sold. If the bottle is much higher than its competitors, it will be placed either on the bottom shelf or top shelf, causing that the consumer do not see it. Participant SR001 explains:

> *… this jar used to be in the form of a flat bag on the bottom shelf. Once the bag was converted to a jar and displayed in a better position, the units sold increased from 200 000 to 3000 000 per year.*

The decoration of the bottle is also very important. Two out of three participants agreed that shrink sleeving a bottle is cheaper than an adhesive label as less parts are used. When adding a shrink sleeve, there are certain design specifications that need to be adhered to. Specifications include:

- Stretch ratios need to be considered
- No sharp edges
- The bottle must have a small indent at the bottom (so the sleeve can tuck and won't pull up).

Perceptions – All participants agreed that the target market (consumer) and market leader bottles dictate the overall design and weight of the bottle. Participant PJ002 explains:

> *Consumer perception; both bottles are the same size, but the taller bottle contains more. Markets are driven by consumer perception with regards to height and width. Leading brands never have short bottles for big quantities. Bottles are designed to maximize space on shelf which is eye catching.*

The final product weight is based on historical data. If a product is converted from glass to plastic, the consumer wants the same product feel, so the client will prefer a heavier preform to retain the same exclusive feel. Participant RB003 explains:

Certain consumers refuse to buy products which were originally sold in glass packaging and converted to plastic, for example tomato sauce and chutney. As a plastic bottle is much lighter than a glass bottle, consumers prefer the heavier bottle, as they perceive it as being of a better quality.

It was indicated that clients may believe that the consumer does not mind which weight, shape or material the bottle is. Rather clients maintain that the product quality should stay the same at the cheapest price point. Consumers may be weary of change, so clients will always try and keep the consumer happy to ensure their products get chosen. It was indicated that clients may believe that the consumer is more drawn to the cheapest price point of the product than the weight, shape or material of the bottle. Clients will always try to keep the consumer happy to ensure their products get chosen. If the bottle is wider or taller than that of its competitor, the consumer perception would be that the wider bottle has a larger content, even though it is the same amount.

Environment – All participants indicated that a lighter bottle has an inferior feel than a thicker, heavier bottle. With regards to bottle decoration, both shrink sleeving and labelling has its advantages and disadvantages which affect the overall price of the bottle, as can be seen in Table 4.3.

Table 4.3: Advantages and Disadvantages

Adhesive label		**Shrink sleeve**	
Advantages	**Disadvantages**	**Advantages**	**Disadvantages**
Easy to apply	Many off cuts	Easy to separate during recycling	Uses expensive equipment to apply
Cost more than a shrink sleeve label	Hard to separate during recycling	Less wastage	Uses additional energy to apply
	Can contaminate recycling stream	Cost less than an adhesive label	
	Uses glues		

Source: AP2004; SR001

Although both options have advantages and disadvantages, it depends on client preference and means. Participant PJ002 explains:

> *For shrink sleeving, the equipment cost is high, but to produce the product is cheap. Shrink sleeving has no scrap and uses less labour and processing, so you save cost. You have a premium product with a higher output, so you serve a bigger market. Variation on products is also smaller than with labelling.*

4.3. PLANET

Planet was the third section of research that was conducted. *Planet* is the only section that has two interaction points throughout the life cycle of the water bottle: raw material extraction to production and disposal to recycling.

4.3.1. Findings from qualitative data: Expert interview

Plastics are produced from a by-product of the petroleum industry, and if it is not used it becomes waste and is burned, which in turn causes large amounts of CO_2 being emitted into the environment. Participant AP2004 explains:

> *Before the Middle East started making plastics, at night you could see all the oil wells emitting light. It was because they needed to set fire to the gasses which emit from the oil wells, because those gasses are dangerous. Then they learned that they could capture and use these gasses to make something else, like plastics for instance. So now if you look at the Middle East at night, it is dark.*

According to AP2004, claims are being made about the sustainability of plant-based plastics and how it is better for the environment. Going plant-based seems like a good solution, but it requires large amounts of water, pesticides and energy to cultivate crops. According to the key AP2004, the only way that plant-based options are viable is if crop waste materials are used, instead of cultivating new crops with the sole purpose of turning it into plastics. There are two main themes found throughout this data set: solutions and design. The two sub themes include: problems and perception, as shown in Figure 4.6.

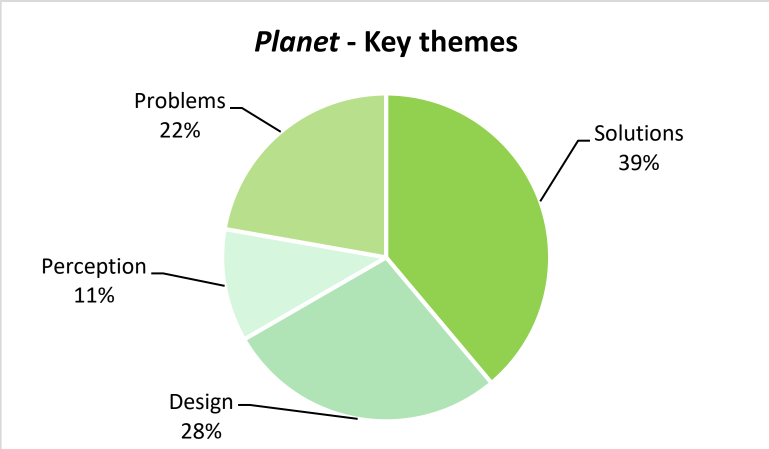

Figure 4.6: *Planet* – Key themes

Solutions – Before the energy problem within the plastic industry can be solved, the social issues connected to it need to be addressed. In rural areas financial incentives are given to informal waste pickers. Informal recycling is one of the largest recycling businesses in SA, and it is done by pickers who pick plastic waste and resell it to converters. Currently, a large problem in SA is intercepting plastics before it gets to landfill. Once the plastics have been in the landfill, it requires extra energy, money and resources to clean before it can be converted and reused. Cleaner material will optimise the recycling process. That is also what makes PET such a durable material as it is the only plastic polymer that can be continuously repurposed and is safe to have food contact after recycling. The only aspect that changes over a long period of continuous recycling is the clarity of the material. Once that happens, it can be reused and turned into fibres for mattresses, pillows, etc. According to AP2004, all raw materials needed to produce PET in SA is currently being imported. Thus, the continuous loop of recycling ultimately uses less energy and requires less raw materials to be imported, making PET recycling in SA efficient.

Consumers need to be educated about plastics and held accountable for cleaning and recycling their bottles. Two possible solutions are: return systems and recycling hubs.

- Return systems refer to a where consumers could return their used bottles before buying a new one.
- Recycling hubs refer to centralised recycling centres which are close to consumer routes.

Marketing teams need to properly label their products to ensure that consumers know how to recycle them. One of the main solutions mentioned by AP2004 is that plastic companies and brand managers need to be held accountable for the products they produce. If they can track their plastic products, it will be easier to recapture it, before it gets to landfill. Companies and different sectors need to work together to ensure a fully recyclable final product. How to optimize the industry:

- Address social concerns
- Capture products before landfill
- Capture all PET
- Return used bottles
- Inform consumers
- Better labelling practices

Design – The bottle must be as light as possible and be able to do the job it was made for. Resource beneficiation is key, for example:

> *A two-litre bottle uses a 32 gram preform, water can be transported, used safely and it can be reused. In contrast to a glass bottle which weighs 250 grams that uses more resources and energy in its production and transportation. If the bottle does its job, it can be as light as possible (AP2001).*

Bottled water is a necessity in rural areas where there are no other clean water sources available. The bottled water needs to be transported over a long distance to these areas, making a lighter bottle a better option, as it will cause less CO_2 emission and in turn have a smaller environmental footprint.

Geographical location and context in design is very important. For example: in Europe bottles are designed with an attached lid, the reason being to capture both parts (lid and bottle) to be recycled together. In contrast to SA, where recycling companies prefer that the bottle and the lid are separated as it goes into two different recycling streams. Product design can aid in choosing the right material, design and decoration, which suits any recycling stream. Another key design factor that needs to be considered is the decoration and labelling of the bottle. The label is critical as it informs the consumer what type of bottle has been purchased and how it can be recycled. Labels also need to be designed to suit the available recycling equipment. It works well to put a PP shrink sleeve on a PET bottle, because the PP is lighter than the water. During the recycling separation stage, the PP will float, making it easy to remove and optimise the sorting process. Shrink sleeve labels are a better option than an adhesive label or a print-on-bottle option. The adhesive label requires additional glues to attach the label to the bottle, and the print-on-bottle option requires ink to be imbedded onto the bottle surface. Both these options will contaminate the recycling process, which in turn results in the recycled PET not being clear. Critical design considerations include:

- Labelling
- Geographic location
- Context
- Lightweighting[24]

Problems – The most expensive part of recycling is getting the bottle back from the consumer. Once the bottle has been taken to recycling, plenty of energy and money is needed to clean and wash PET bottles before it can be recycled. If it is not washed and separated properly, it can contaminate recycling streams which can, in turn, only produce coloured plastics. Consumers want an alternative material to plastic, but even if the consumer has an alternative option and does not dispose of it properly, it can still contaminate the natural environment. According to AP2004:

> *Plastic waste is less of a problem if it is well managed. But at the end of the day, if it is laying in the field, any waste is problematic.*

It is critical for consumers to be educated and to understand what happens to their waste and how they can help to reduce it. Plastic companies and brand owners are desperate to keep clients, so they are willing to do anything to keep them happy, despite knowing that they are subjected to a poor choice, AP2004 gives an example;

> *…a blue bottle requested by a major South African dairy manufacturer. The company producing the bottle may know that it is not a highly recyclable option, but they can't afford to lose one of the biggest dairy manufacturers and distributors in South Africa as their client.*

Some of the biggest concerns regarding the environment are:

- Capturing bottles
- Incorrect information
- Waste management

Perception – Consumers make decisions regarding plastics based on emotion and not on facts. Just because plastic waste can be seen, they have a skewed perception. They think that paper, cardboard and glass are better options than plastics, because it can't be seen in the natural environment. This is mainly due to these options being heavier, so they sink into the ground and waterways much more easily than plastics. AP2004 believed the problem lay

[24] Lightweighing, in the plastics industry, refers to using a lighter preform, to make the product lighter and more energy efficient throughout its entire life cycle.

with consumers and brand owners who do not want to be held accountable for their waste. They want to put it curb-side, and never think about how they can reduce their usage. The same is true for plastic companies and brand owners who should not try and live up to consumer perceptions and expectations.

4.4. Establishing emerging themes from the findings

Throughout the field research, critical data were gathered which were aimed at designing a sustainable solution. The TA process, as described in the Methodology Chapter, was used to identify the key themes, which emerged from the findings. The TA process was iterative, allowing for the review of codes and themes throughout the process. This allowed the researcher to review themes to ensure they were not formed through bias. Once the findings were documented and extensively reviewed, the first two steps (familiarisation and generation of initial codes) of the TA process were completed. The initial search for themes took the form of a mapping exercise, during which umbrella concepts were identified. Umbrella concepts connected the various sections, bringing similar findings positioned across sections together. Once this was achieved, five themes emerged. Once the initial themes were identified, the review phase of the TA process was completed. The themes and processes were reviewed to ensure that the decisions made were grounded in the findings. During the review phase it was found that the content within two themes overlapped, and instead of being two separate themes the findings presented a single, more complex theme.

From this review phase the final four themes were established and named:

- *Multi-response design*, this refers to the design elements which brings *people, profit* and *planet* together
- *Making the complexity visible to all stakeholders*, this refers to the complexity of both consumer and client education
- *Context driven consumer cost expectation*, this refers to what consumers and brand owners in the industry are willing to pay
- *Emotional response to plastics*, this refers to the perceptions that consumers and brand owners have about the environmental impact of plastics

The key themes that were found through the TA process is applicable to the three key sections of this research: *people, profit* and *planet*. Thus, these five themes will form the foundation of the discussion Chapter. The final discussion of the themes, and the reporting of what was identified leads to the final step in the TA process – reporting. The TA process facilitated in the composition of a final list of design considerations and requirements. This list will aid to propose a final, holistic physical water bottle design. As creating sustainability through design was the main goal of this research. The design requirements for the physical bottle and the gathered data will be used in unison to produce the most efficient final design and recommendations.

5. CHAPTER FIVE: DISCUSSION WITH RESPECT TO THE RESEARCH OBJECTIVES

In this chapter the themes identified during data analysis in Chapter 4 are discussed. The themes included: the need for a 1) multi-response design, 2) making the complexity visible to all stakeholders, 3) context driven consumer cost expectation, and finally addressing the 4) emotional response to plastics. The discussion of findings helps to define and showcase the most important data in relation to literature, which provides insights and highlights the significance of what was found. The overreaching similarities and contradictions found between both the primary and secondary data will be discussed.

To further contextualise the data and visualise the relationships, mapping was used as an organisational tool. Mapping took the form of a product blueprint and a composite product journey map. The origin of these mapping techniques is explored when they are introduced later in this Chapter. The process of mapping allowed for a deeper engagement with the data. The maps included did not generate new data, but provided an opportunity to visually explore the interconnectedness of data within the themes identified.

In addition to a discussion of findings, this Chapter explored the various design requirements that emerged throughout primary research and those from existing literature. For each key section of this research, the design requirements differ immensely: design for *people* is driven by consumer perception, design for *price* is determined by overall production cost and design for *planet* is regulated by both what is best for the environment and what works best within current recycling streams. Even though they all have a different main requirement, similarities exist across all sections: *people, profit* and *planet*.

5.1. Multi-response design

There are several design elements which bring findings from *people, profit* and *planet* together. These took the form of both insights as well as design restrictions which were identified throughout the collected data. A key theme was lightweighting. It has been proved that lightweighing will aid in the overall *price* to be lower, its environmental (*planet*) impact will be less (through CO_2 emission during transportation and production), but it would cause consumers (*people*) not to reuse it.

As mentioned by Schweitzer *et al.* (2018:6), lightweighting affects the thickness and quality of the packaging, which would make the bottle feel weaker for consumers, so they won’t reuse it and the bottle is then only used once. The importance of the consumer (*people*) factor within the plastic economy is emphasised by the circular economy model produced by the Ellen MacArthur Foundation (2013:24), putting the consumer at the centre of the entire system[25].

According to Mashek *et al.* (2017:21) the increased use of PET water bottles is driven by: lighter packaging (easy to transport and cheaper) and consumers who desire portable packaging and design for recycling. This is echoed by both the quantitative and qualitative research findings, namely that consumers prefer a larger (750 - 1500ml) reusable bottle with a twist-on cap which they can carry with them during their normal day. Throughout the *people* data sets (both the quantitative and qualitative), participants agreed that they are drawn to uncluttered designs which are strong and sturdy. This is contradicted by the *profit* and *planet* data sets (all qualitative), which both imply that a lighter bottle is cheaper and faster to produce whilst creating less CO_2 emission throughout its life cycle. A study done by Mashek *et al.,* (2017:28) proved that the average weight of disposable PET water bottles has declined by 51% between 2000 and 2014. Even though a lighter bottle is better for both *price* and *planet*, additional factors like ribbing and no flat-panels (adding a small radius to a flat surface) could be used to make it feel stronger for the consumer (*people*). Within the *profit* data sets, it was found that a round bottle is better for faster cycle times (it gets extracted from the mould faster), but a square bottle is better for pallet utilisation (more product can fit onto a truck). According to participant AP2004, a square bottle is the best option for *planet*, simply because its pallet utilisation is more efficient, so less transportation means that the overall CO_2 emission of the product will be lower. The square bottle is also a good option for *people*, as it can be designed with uncluttered design principles in mind.

Both Siracusa *et al.* (2014:152) and the Ellen MacArthur Foundation (2019:13) agree that design interventions are needed to facilitate better infrastructure which would allow the consumer to rethink the way they look at plastic packaging and consequently be convinced to reuse it. Through the *planet* qualitative research findings, AP2004 shared the view that consumers both need to be educated and incentivised to recycle their products. AP2004 believes that setting up bottle return hubs would get users to recycle their bottles. This idea is echoed by a participant AP001 from the *people* qualitative research findings, who believes that if there were recycling hubs on their main routes, they would be more inclined to recycle it. The Ellen MacArthur foundation (2019:13) proposes four business-to-consumer reuse models to address this problem: refill at home, refill on the go, return from home and return on the go. This data emphasises the importance of designing a product which is suited to its geographic location (Plastics SA, 2017). Geographic location refers to a specific country or

[25] This model is explained in Figure 2.10, page 44.

area within a country[26]. This fact is reiterated by AP2004, which indicated that recycling systems in different countries and inner regions differ immensely. Another design consideration which is affected by position is shelf height. The market leader bottle dictates the height of product shelves in a grocery store. According to all participants in the *profit* data set, a new bottle should be the same height as the market leader bottle, to ensure good product placement and visibility. Another design consideration for consumers is that they prefer mineral water above sparkling water. This effectively means they prefer a bottle which has a flat bottom (a non-petaloid bottle base), although this design factor will also differ according to location. Abdulkarim and Abiodun (2011:58) agree that geographical location should be one of the biggest design considerations.

Sherwood *et al.,* (2016:48) emphasises the importance of considering both the bottle and its label whilst designing to ensure that the entire pack is more recyclable. This sentiment is echoed by participant AP2004, who believes that the label should be considered to ensure it can be separated easily within recycling streams. Labels are also critical to convey the product properties to the consumer. According to the United Nations (2018:8), it is critical for governments to apply strict labelling policies to ensure the consumer is informed about how they should recycle the bottle. AP2004 believes that using shrink sleeve labels is a better option, because it has minimal offcuts and only requires heat for application. Even though the *profit* data stipulate that shrink sleeving equipment is more expensive, it also showed that in the long term, it is less costly than using adhesive labels as it produces fewer offcuts and no glues are required in its application. Sherwood *et al.,* (2016:48) and Siracusa *et al.,* (2014:152) agree that it is important to analyse all the parts (material used, label, cap, marketing) of the disposable water bottle to ensure a sustainable product.

Physical design requirements that relate to a multi-response design approach, noted from participant input throughout the various data sets (*people, profit, planet*) include:

- Round bottle which predominately has a circular shape (SU19-SU41, AP001, GM002, RB003, RO003, SR001)
- Square bottle which has four panels of equal length (SR001, PJ002, AP2004).
- Clear bottle that has no additional additives added to the plastic pellets to change the colour, making the bottle perfectly clear (SR001, PJ002, RB003, RO003, AP2004).
- A bottle with ribbing which refers to having indents and patterns which are embossed into the bottle surface to make the it stronger (SR001, PJ002, RB003).

[26] Please refer to Chapter 2, heading 2.8, page 40 for an example of geographic location.

- No-flat-panels, each panel of the bottle should have a small radius to increase its overall strength and top load[27] abilities (SR001, PJ002, RB003).
- Twist-on bottle closure, the user prefers a closure that must be screwed off to consume the drink. This is in contrast with a sipping spout which allows the user to drink from the bottle, without having to remove the closure (SU01-SU22, GM002, RO003).
- Shrink sleeve label refers to a plastic film label which is applied to the product using heat (SR001, PJ002, RB003, AP2004).
- The bottle must have a flat base, this concept refers to a centralised inward bulge on the bottom of the bottle, making the bottom appear flat at its base. This is in contrast with a petaloid-base, which has 5 - 8 petal shapes at the bottom of the bottle (SU01-SU28, AP001, GM002, RO003).
- Content of 750 - 1500 millilitres (SU01-SU018, SU30-SU38, AP001, GM002, RO003).
- The bottle must be the same height as the market leader product, the bottle must not be shorter or taller than the most famous beverage brand bottle that has the same quantity. If it is shorter or taller, the product will be placed on either a higher or lower shelf (SR001, PJ002, RB003).

According to Papanek (1995:265), it is important for designers to consider a product's function, maintainability and affordability to ensure a holistic product that will have a sustainable social and environmental impact. These design considerations prove that the designer plays an integral role in the plastic industry for the social, financial and environmental economy (United Nations, 2018:15).

5.2. Making the complexity of disposable bottles visible to all stakeholders

This theme highlights the complexity associated with the design process, with the goal being to educate the consumer and the client. Azzone *et al.,* (2013:142) believes that creating social awareness and improving waste management systems is critical whilst designing. Through both the quantitative and qualitative *people* data sets, participants agreed that they always consider the recycling logo on the bottle, not mentioning that they understand what it means or know where to dispose of it. Seventy-five percent (75%) of participants agreed that glass bottles is better for the environment than plastic bottles. One participant believed that recycling uses more energy throughout its life cycle than the production of a new product (GM002). In

[27] Top load refers to the amount of weight which is applied to the top of the bottle when stacking pallets in a truck.

a research done by Mashek *et al.,* (2017:34) it has been proven that recycled plastics use about half of the energy required to make virgin plastics. This shows that even though consumers know some principles of reuse and recycling, they do not understand the holistic process associated with recycling it. This is echoed by the *planet* data set, which states that consumers need to be made aware of what happens to their waste after they have disposed of it.

Both DiGregorio (2009:1) and Walker (1994:82) did research (independently) in which they discussed how consumers started calling for an alternative, less destructive material in the 21st century. According to Schweitzer *et al.* (2018:14), plastic packaging is being condemned by consumers, based on the amount of single use plastic seeping into the environment. In 2018, the United Nations (2018:8) emphasised the importance of good labelling policies to inform the user about the material used and whether it is biodegradable or compostable and under which conditions. This proves that it is integral that consumers be educated about the plastic packaging industry. Good labelling policies can aid in consumer education. Throughout the qualitative *people* data set, all participants agreed that they would like to be more informed about the entire system and life cycle of plastics.

AP2004 explains that the most expensive part of recycling is getting the bottle back from the consumer, separating it and cleaning it. If the consumers were educated on this issue, they might start to consider the end-of-life if the product, as it is critical for consumers to know what happens to their waste after it has been discarded.

Through the *profit* data collected, PJ002 alleged that product weight is based on historical data. The consumer would not purchase a product which was converted from glass to PET if it is not as heavy as the glass. This is in contrast with the consumers (*people*) who do not want to use plastic bottles, because of its effect on *planet.* A heavier bottle has a larger CO_2 footprint. Through the data collected in the *profit* section, it was also been speculated that consumers do not mind buying plastic products as long as the content tastes the same and the price stays the same or decreases. Another interesting finding in the *profit* data set, was that consumers would rather buy a bottle which looks bigger than its competitor, although it contains the same quantity. This indicates that the consumers who contributed to this study did not mind the packaging size, if they think they are paying less and getting more.

Alternative materials have been proven to be more expensive than traditional plastics. This is supported by both the *profit* and *planet* findings. According to Macdonald and Vaughan (2008:9), plastic has the biggest social impact (*people*), it is the cheapest material to use (*profit*) and it causes minimal CO_2 emissions (*planet*) in relation to alternative materials. Yet, it is the material that causes the most devastation in the natural environment.

Consumer education is the largest overreaching theme found throughout both the primary and secondary research. Throughout all three sections (*people, profit, planet*) the key design requirements, which emerged to make the complexity of disposable bottles apparent to all stakeholders included:

- Consumer must be educated to understand the benefits of plastic and how they can help drive the overall recyclability of it (AP2004).
- Both consumers and companies must be held accountable to ensure that they are less wasteful about the product waste which they produce and buy (AP2004).
- PET plastic needs to be recaptured after it has been used and returned to the plastic economy by means of recycling (RB003, RO003, AP2004).
- Brand owners and marketing companies need to implement good labelling policies which explicitly show product information, like material type and how to dispose of it, to educate the consumer on good disposal practices (AP001, RO003, SR001, PJ002, AP2004, GM002).

To show all the interconnecting facets of the plastic industry, a blueprint was constructed to visualise the data that was found throughout the primary and secondary research. A service blueprint is a service design tool, used predominantly in the user experience design field. The goal of a service blueprint is to show the different roles within a service delivery system, showing how all participants interact with each other to understand and manage customer service expectations (Hossain *et al.,* 2017:920). A service blueprint is centred around the user experience of a system. In this research the blueprint observed the user interaction with a specific product, instead of an entire system. Even though this blueprint is focused on a disposable PET water bottle, it uses the same principles and guidelines as a traditional service blueprint. The aim of the product blueprint was to show the complexity of the different facets of the water bottle and how they are connected throughout its entire life cycle. The blueprint shows how the different parts of the product life cycle influences each other. The product blueprint can be seen on page 91: Figure 5.1.

The product blueprint, as described by Hossain *et al.,* (2017:921), comprises of:

- *Physical evidence* refers to all physical components that were used in the production of the disposable PET bottle.
- *User interaction* is the stage where the active user was involved, showing how they interacted with the product.
- *Front stage* shows the employee actions which the customer can see and is aware of, but does not have an active part in.
- *Back stage* refers to all the support processes that were associated with the product, which the customer did not see.
- *Support processes* refer to all processes which support the product being mapped.

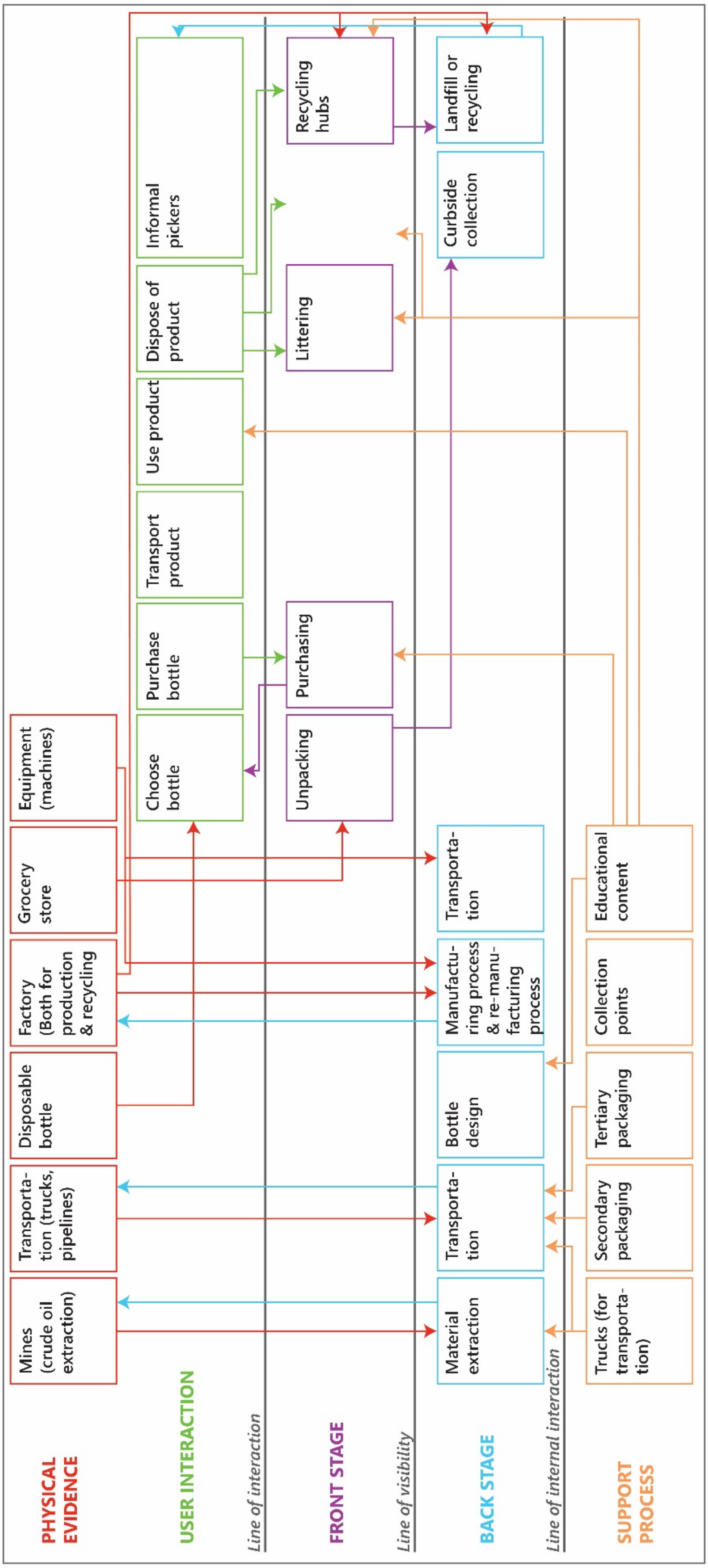

Figure 5.1: Product blueprint

On the documented findings (product blueprint) map from this study (Figure 5.1), the red lines indicate the physical equipment needed to do multiple tasks throughout the manufacturing process. It also shows the financial and environmental cost (*profit* and *planet*) of the manufacturing process. The environmental cost includes: CO_2 emission from transportation, manufacturing and crude oil extraction as well as bad disposal practice like landfilling. The financial cost includes: overall cost of manufacturing, transportation, machines, material and factory space.

The green lines (Figure 5.1) show the user interaction with the product. The product gets chosen, used, transported and disposed of. This process shows the consumer (*people*), financial (*profit*) and environmental (*planet*) cost of a product. The consumer cost includes: consumers not knowing which disposal method to follow. The financial cost includes: needing waste pickers and additional collection methods to recapture PET. The environmental cost includes: disposable water bottles ending up in landfills and waterways.

The purple lines (Figure 5.1) show the impact that front stage action has on both user and back stage interactions. The product gets unpacked from the secondary or tertiary packaging that it was transported in, purchased and then the secondary or tertiary packaging gets disposed of. This process has a social (*people*), financial (*profit*) and environmental (*planet*) cost. The consumer cost includes: the consumer will make a purchase decision with regards to how and where the product has been unpacked and displayed. The financial cost includes: by using smart packing and promoting methods, the employee will pack the bottles to make maximum profit. The environmental cost includes: the secondary and tertiary packaging which gets disposed and might end up in landfill or the environment.

The blue lines (Figure 5.1) show the impact that back stage action has on user interaction and physical equipment. Once the crude oil was extracted, refined and turned into plastic pellets, it gets manufactured and transported to its selling location: a grocery store or local super market. The next interaction phase is when it gets disposed of after it was sold. This stage has both a financial (*profit*) and environmental (*planet*) cost. The financial cost includes: the overall manufacturing, transportation and recapturing (by formal recycling systems and informal waste pickers) of the product. The environmental cost includes: the CO_2 emissions throughout its entire life cycle and bad disposal practices like landfilling and littering in the natural environment.

The orange lines (Figure 5.1) represent the effect that support processes has on the front stage actions, back stage actions, and the user interaction actions. The support processes influence all three sectors: social (*people*), financial (*profit*), and the environment (*planet*). The consumer influence includes: educational content that informs the user about recycling and material usage. This can be conveyed through informative labelling practices. The financial influence includes: the overall cost of the bottle, packaging (secondary and tertiary), transportation and educational content via website advertising or television commercials. The environmental influence includes: the overall CO_2 emission of the life cycle of packaging design.

This product blueprint (Figure 5.1) mapped the entire life cycle of a disposable PET plastic water bottle, showing how each stage, namely: extraction, transportation, conversion, design, construction, packaging, selling and disposal affects one another. Through visualising the entire process, the interconnectedness of all sections can be visually represented to see its overall impact on all stages of the product life cycle. The blueprint showed the importance of considering each phase of its production when making design decisions. It also proved the importance of using the TBL strategy, as the life cycle of a PET water bottle has equal (be it bad or good) effect on all three sections: *people, profit, planet*. By viewing the blueprint through a product lens (as opposed to a system lens), the physical interaction between all sections of the entire holistic system of a disposable PET water bottle could be viewed and understood.

5.3. Context driven consumer cost expectation

This theme explored the financial views of consumers and brand owners in the plastic packaging industry and highlights what they are willing to pay. According to Macdonald and Vaughan (2008:9), plastic packaging was designed in response to the consumer need for affordable, convenience products which are easily accessible. Through the qualitative findings in the *people* data set, it was shown that consumers are most likely to buy the cheapest product. This was in contrast with the qualitative *people* data, as these participants said that cost is not their primary driver when purchasing bottled water. The coherent theme in both *people* data sets was that consumers only purchase bottled water if there is no other option available, proving that it is a convenience item which they only purchase when it is a necessity. This sentiment is echoed by AP2004, who explained that plastic bottles are critical in areas where clean drinking water is not readily available. If it was not for consumers purchasing water out of necessity, *profit* would not even be a variable. Ballantine *et al.,* (2019:1) agree, the overall growth in consumption of disposable plastic bottles is driven by convenience and fast-moving culture. All participants from the *profit* data set agreed that currently PET plastic is the cheapest material available due to high demand.

SR001 explained that the price of PET plastic pellets in South Africa is always fluctuating, because the raw material needed to produce all plastics need to be imported at a higher cost.

In 2019, the amount of plastics which were recaptured and recycled was 43.7% and the amount of virgin plastics that was consumed dropped by 1.7% (Hanekom, 2019).

According to PJ002, the price of PET starts to fluctuate once any additives are added to make it: stronger, coloured or have better barrier properties. Marsh and Bugusu (2007:39) explain that there are three key influences that packaging needs to protect a product from, namely: chemical, biological and physical. That is what makes PET a durable and cost-effective material. AP2004 explained, PET plastic is the only plastic polymer that can continuously have food contact, even after it has been recycled. The participants from the *people* data set agreed that they prefer cost effective products, making PET the best option currently.

The 21st century marked the start of the plastic crisis, which contributed to scientists experimenting with alternative materials, such as bioplastics (DiGregorio, 2009:1). In a research done by Digimarc (2018:1), the problem with the new eco-friendly, biodegradable and compostable plastics proved to be its much higher price point. This accentuates the emphasis made by all *profit* participants that demand drives the price of plastics. Through the quantitative *people* data set, participants agreed that they do not want to pay a lot for disposable plastic bottles. Consumers are not willing to pay more for a product which can be accrued cheaper. In the *planet* data, AP2004 also mentions how consumers prefer the idea of plant-based plastics, not realizing the impact it has on the environment or their pocket. This is echoed by a study done by Hesselink and Duuren (2019:7), they hypothesised that recycled plastics are often cheaper than virgin plastics.

Throughout the *profit* data set, all participants agreed that material used, cycle time[28], cavitation[29] and overheads are what drive the price of plastic packaging. The faster a PET bottle can be manufactured, the cheaper it will be for the consumer. Minnick (1996:23) reiterates this fact by stating that more intricate shapes take longer to produce, making it more expensive.

Another key factor that raises the price of a product is transportation. SR001 explained that transportation cost is lower if you can distribute a higher quantity and through lightweighting the bottles with one trip. All participants in the *profit* data set agreed that the further a product needs to travel, the more expensive it would be. AP2004 stated that in many cases, filled disposable water bottles need to be transported over long distances to rural areas where clean

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[28] Cycle time refers to the period that it takes to produce a product on a machine.
[29] Cavitation refers to the number of empty space formations in a metal mould which produces a specific amount in each press cycle.

water is not readily available. MacKerron (2015:39) states that transportation will always be one of your biggest factors which increases the overall price of a product.

Standardising production lines is another way to reduce overall product cost. All *profit* participants agreed that using a generic preform will always be cheaper than designing and manufacturing a new preform. This sentiment is echoed by the Ellen MacArthur Foundation (2019:16) who believes that creating central returning hubs can lead to better product recapturing. If all return systems are standardised, it will be easier to recycle and recapture similar products. Both *people* data sets also agreed that the bottle needs to have a simple, non-intricate shape and be affordable, meaning no elaborate new shapes are required as long as they can get clean drinking water and easily.

Before the energy problem within the plastic industry can be solved, the social problem (poverty and uneducated consumers) need to be addressed. According to AP2004, this can be done through financial incentives. A report published by Plastics SA (2019), proved that approximately 74% of all plastics recycled in South Africa, were associated with informal waste pickers. This is echoed by the *planet* participant AP2004, who seconded the motion that informal recycling is one of the largest businesses in South Africa. The value of plastics should not be underestimated as it can contribute to the growth of wealth and the economy if managed properly (United Nations, 2019:6).

The physical and system design that drive consumer cost expectation noted throughout the data set, include:

- Consumer convenience, consumers solely purchase PET water bottles for convenience or necessity when there are no other options available (AP001, GM002, RO003, RB003, SU26, SU37, AP2004).
- Financial incentives will help consumers to understand the value of a plastic bottle and drive an overall increased willingness to recycle (AP2004).
- The importance of recycling needs to be made clear to consumers, because they need to *"...understand that within the SA climate, if PET is recycled, less raw material to produce PET pellets will need to be imported which will cost less and lead to less CO_2 emissions"* (SR001, PJ002, AP2004).
- The effectiveness of PET (regarding cost and food safety) and how consumers need to value PET for its resource efficiency and low cost (SR001, AP2004).
- Alternatives are not cheaper, bioplastics are not necessarily cheaper than crude oil-based plastics (SR001, PJ002, AP2004).

- Producing products fast is important, the longer the cycle time of a machine indicates that less products can be produced in a certain amount of time. In the plastic industry, time equals money (SR001, PJ002, RB003).
- Transportation can increase or decrease the price, the further a product needs to travel the more expensive the transportation cost would be (SR001, PJ002, RB003, AP2004).
- Using a generic preform is better, because it will always be cheaper to purchase a standard preform than designing and manufacturing a custom one (SR001, PJ002, RB003).

5.4. Consumer perception and emotional response to plastics

The perceptions that consumers and brand owners have regarding the impact of disposable plastic packaging is a key theme in this research. Macdonald and Vaughan (2008:5) have argued that plastics have an impact on each sector of daily life and is a necessity. Both the *profit* and *planet* data sets agreed with this sentiment, but participants from the *people* data are still wary about its use. According to Schweitzer *et al.* (2018:6), the FMCG sector is more concerned about the product's price than the usability or the environmental impact. This motion is echoed by AP2004, who believes that plastic companies will design any bottle (even if its environmental impact is bad), to keep both the consumer and client happy and make the profits larger.

There was consensus among those who contributed to the *people* data set that they always consider the reusability and recyclability of a product, before they purchase it. This view does not, however, necessarily translates into them recycling it. In many cases, participants noted that it was due to not having access to recycling facilities, meaning that their intention was to recycle, but it was not always possible. This was shown in a research by Di Maria *et al.,* (2018:171), in which they assume that even though plastics are recyclable, the consumer would not necessarily recycle it. AP2004 believed that if consumers could clean and properly recycle their bottles it can have an impact on social, financial and environmental aspects. If recycling was more efficient, it would: create jobs and financial incentives to consumers, cost less money, and produce energy to recycle so that less waste would seep into the environment. Foster (2019) argues that plastics are being designed to be recycled, but the lack of infrastructure causes it to not happen. Fifty percent (50%) of *people* participants understood the necessity of recycling and re-entering plastic into the system instead of creating new plastics, but only one participant mentioned the importance of looking at the entire bottle (bottle, cap, label) when making a purchasing decision. Sherwood *et al.,* (2016:48) also believes it is critical to consider the entire bottle throughout its development process. This shows that current consumers are uneducated about recycling and the details thereof.

All *profit* participants agreed that bottle labelling practice is very important when considering the recyclability of the bottle. A shrink sleeved bottle is better to recycle as it is easier to separate the label from the bottle without contaminating the recycling stream. Krehula *et al.,* (2012:443) reiterated the importance of ensuring no contaminants enter the recycling stream, as this will compromise the quality of the recycled plastic. Shrink sleeve labels tend to be larger and cover the entire surface of the bottle, there is more space to inform the user of the properties of the bottle and it (the shrink sleeve label) is recyclable. AP2004 accentuated the importance of good labelling practices by brand owners. Good labelling policies will help to educate consumers on how to recycle or to return a product into the plastic economy (United Nations, 2018:8).

In research done by Radovic and Schobert (1997:18), they argued that before synthetic plastics were discovered, only kerosene was extracted from crude oil, leaving the other by-products to be burned and become waste. Today these by-products are used for plastic production. AP2004 argued that if all the by-products of crude oil had to be burned, a valuable resource would be lost, and large amounts of CO_2 would be released into the atmosphere as well.

People participants agreed that using reusable glass bottles or metal flasks is better than purchasing disposable water bottles. At the Propak Africa Conference 2019, Hanekom explained how turning away from plastics and using alternative materials (glass, metal foils) can be detrimental, because it can increase CO_2 emissions four-fold (Hanekom, 2019). The AP2004 believes that a water bottle does not need to be heavy, it simply needs to do its job, which is transporting clean water. This may be in contradiction to consumer perceptions as the consumer is constantly confronted with the negative impact of plastics and may thus be wary of plastic waste. Since glass is so much heavier than plastic, it sinks and becomes submerged into the environment without consumers even noticing it.

Gungor and Gupta (1999:827) believe a key issue with plastic packaging is the recovery and collection process. According to AP2004, companies need to be held accountable for the waste of the products they produce. Companies and brand owners need to track their waste to successfully recapture it. If a product is not captured and left to degrade in the natural environment, the quality would drop, compromising its use for future recycling (Krehula *et al.,* 2012:433). Once a product has gone to landfill, it requires extra energy to be recaptured and washed, making product recovery critical to ensuring an efficient recycling stream.

Schweitzer *et al.,* (2018:11) believes that packaging reduction will aid in reducing the wasteful practices within the plastics industry. This is echoed by AP2004, who argues that if *people* were made aware of their consumption, they would use less. Di Maria *et al.,* (2018:171) argues that a lack of consumer knowledge and waste management at governmental level can have a large impact on product recovery and recycling. This makes it critical for governments to tailor make recycling systems for the resources available.

In a research done by Hesselink and Duuren (2019:6), they believe that recycled plastics are a better alternative than bio-plastics, because of the additional production of crops required to produce bio-plastics. AP2004 seconds this motion and believes that plant-based plastics are only viable if it is produced from crop waste. The energy used in the plastic production from crops is just as much, if not more, than that of virgin plastics (Ghanta *et al.,* 2013:169).

MacKerron (2015:21) argues that biodegradable plastics were invented as a response to pollution, but it only biodegrades at incineration plants and not in the natural environment. This brings us back to the importance of good labelling practices and consumer education, as current recycling streams are being contaminated by biodegradable plastics which look like PET (United Nations, 2018:15).

Throughout the data set the following requirements for the physical design of the bottle, and the production system, were noted:

- Recycling hubs need to be placed in centralised locations which are on a consumer's normal route ("en route" to the local grocery store and "en route" to work) allowing the customer to recycle the plastic bottles easily and conveniently (AP001, GM002, AP2004).
- Consumers need to be educated about the importance of understanding the true facts surrounding plastics: how it can be repurposed and used as a valuable resource (RO003, AP2004).
- Good labelling practice is needed to show the importance of communicating to the consumers what their responsibilities are and what they should do with the bottle after they have used it (AP001, GM002, RO003, SR001, PJ002, AP2004, SU1-SU25).
- The entire system around the product (bottle, cap, label, marketing, user behaviour) must be considered when designing. This refers to the importance of consumers and brand owners to consider the holistic design process of all components to ensure efficient recycling practices (RB003, RO003, AP2004).
- Both companies and consumers need to be held accountable for their waste and understand where it goes after its useful life is over (AP2004).

- Tailor made recycling systems will aid in creating geographically accurate recycling streams which are best suited for its location (AP001, AP2004).

To gain a deeper understanding of the human aspect of the plastic industry, a CPM[30] was constructed to visually show the consumer journey when making purchase decisions and the possible solutions that can enhance their experience. CPM's are based on the customer journey map model and is predominantly used as a tool in the user experience design field. As opposed to the service blueprint, the CPM places focus on the customer experience whilst interacting with a service[31] (Adaptive Path, 2013:4). For this research, the CPM looked at how the user interacted with the product and not the entire system. The CPM can be seen on the next page: Figure 5.2.

[30] Composite product journey map.
[31] For more information on a CPM, see Chapter 3, subheading 3.5.3 pages 63-64.

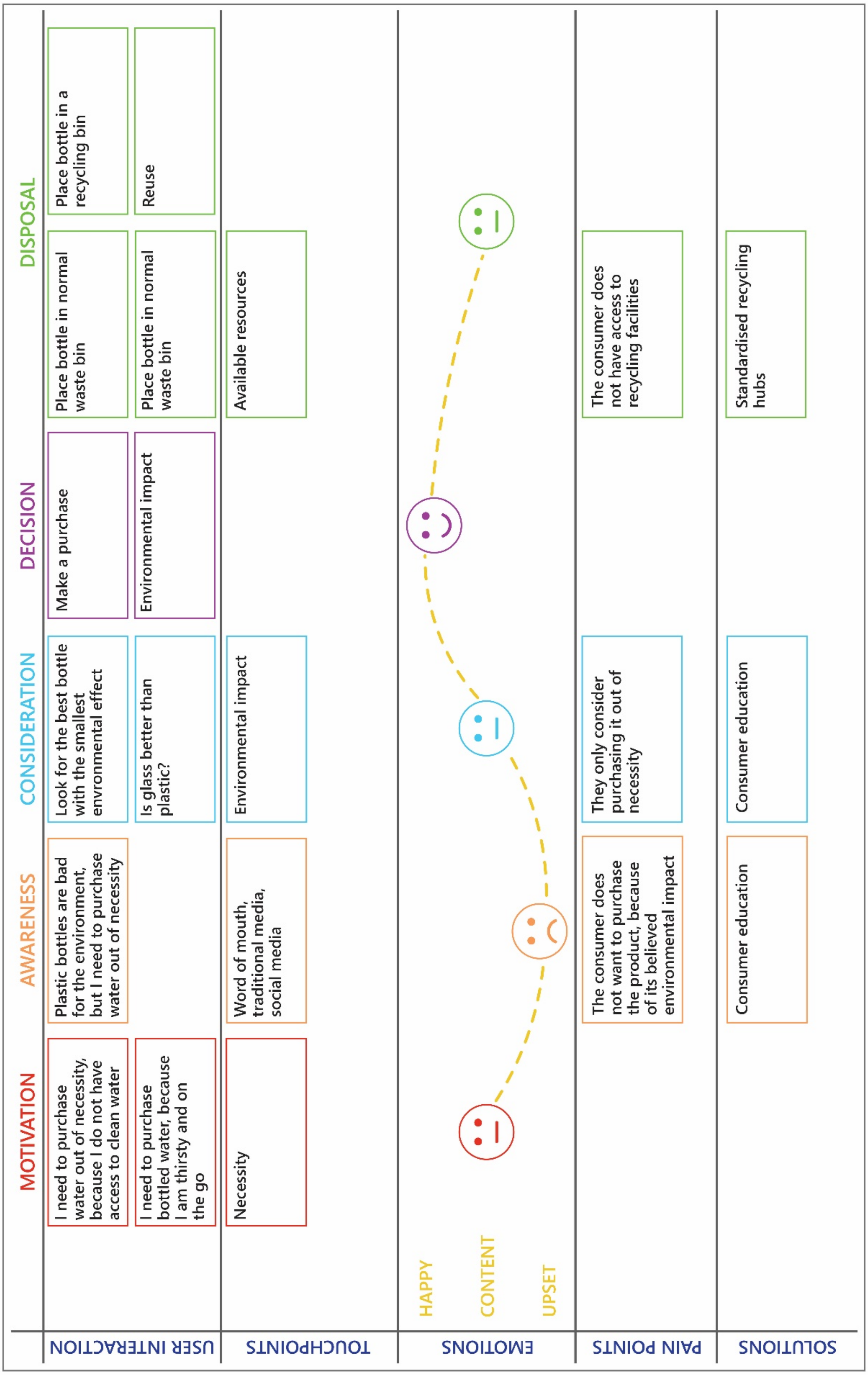


Figure 5.2: Composite product journey map

The CPM is divided into five spheres which tracks the consumer behaviour: motivation, awareness, consideration, decision and disposal. The aim of these spheres is to understand the user behaviour and emotions throughout the decision making and purchasing process.

- *Motivation* describes why it is necessary for the consumer to purchase bottled water.
- *Awareness* shows the consumer perception about the disposable plastic bottle which they needed to purchase. It also shows where the consumer gained insight about disposable PET water bottles.
- *Consideration* focuses on the process of choosing a physical bottle and aimed to track the thought process of the consumer.
- *Decision* refers to the final product which the consumer has purchased.
- *Disposal* shows all the avenues (that was found through primary and secondary research) which can be followed when discarding of the product.

To thoroughly track consumer behaviour, the gathered research was divided into a further five points: user interaction, touchpoints, emotions, pain points and solutions.

- *User interaction* refers to both the physical and mental interaction that the consumer has with the disposable water bottle.
- *Touchpoints* show the consideration and why the consumer would make certain purchasing decisions.
- *Emotions* reflects how the consumer feels about each of the five spheres.
- *Pain points* indicate why the consumer would feel a certain way about purchasing a disposable water bottle.
- *Solutions* refers to how the pain points can be addressed.

This CPM showed a clear visual representation of the emotional wariness that consumers have about disposable PET water bottles. Through having visualised the primary data with the focus being placed on the consumers, it showed the constant awareness that they had when making purchase decisions and how they did not know how to dispose of their plastic waste. The map helped to gain insight into the lack of consumer education and the lack of recycling facilities in their immediate area. By knowing the consumers emotional response and their misunderstanding of plastic water bottles, the problem became clear: consumers are not educated about plastic waste and do not necessarily have access to recycling centres. This map showed consumer willingness to recycle, emphasising the importance and impact that well-structured educational information can have on their ability to understand waste management and recycling systems.

6. CHAPTER SIX: DESIGN

Once the themes, which emerged from the gathered data, were established the final design process started. This research proposes a final, holistic water bottle designed according to a list of design considerations and requirements that were set up throughout the TA process. The list of requirements included parameters that have been set up to support the design of a viable product. The final design is a consolidation between the three sections of the TBL: *people, profit, planet*. To conceptualise a viable solution which fits all three sections, the final product represents the findings from both the primary and secondary data. By combining the three sections of the TBL, a holistic design which contained specific requirements from each section was proposed. It is important to have specific requirements in place to guide the design process. This way, the final design will adhere to social, financial end environmental norms. Together with the design requirements for the physical bottle and data gathered on creating sustainability through design, the final product was designed.

To make it easier for the reader to understand the design parameters and how it relates to each section, a list of design features can be seen in Table 6.1.

Table 6.1: List of design features

	People	***Profit***	***Planet***
Round bottle	✓	✓	✓
Square bottle		✓	✓
Clear material, content visible	✓	✓	✓
Ribbing		✓	✓
Radii panels	✓	✓	✓
Twist closure	✓	✓	✓
Flat base	✓		
Shrink sleeve label		✓	✓
Height comparative to industry standards		✓	
Eye catching branding	✓	✓	

6.1. Establishing design parameters

The research showed that two bottles needed to be designed. The design process which was used in this study included; research, analyse, synthesise and evaluate. The design specifications that led to this decision was divided into the key three sections: *people, profit, planet*.

People – For *people*, the overall aesthetics was the main concern. *People* preferred a round, clean shape which looked like a traditional, round glass bottle. All *people* participants agreed that they prefer a bottle between 750ml - 1500ml. As there was such a large volume difference between the two, the extreme points of the values were used for the proposed solutions. Thus, proving that two bottles had to be designed. Concept 1 would have a volume of 1500ml and Concept 2 would have a capacity of 750ml. Another key design requirement that was found was user education. *People* data showed that consumers are more willing to reuse, return or recycle the bottle if they know how to properly dispose of it. Thus, a shrink sleeve would be a good solution, as it is large and has more space to communicate important information like recyclability and compostability.

Profit – The two key aspects that affected *profit* were overall cycle time and pallet utilisation. Both aspects have a direct impact on overall manufacturing and transportation cost. According to SR001, to increase cycle time on the blow moulding machine, a round bottle is the best option as it extracts easier and faster from the mould. This is in contrast with pallet utilisation: to increase overall pallet utilisation, a square bottle is the more efficient option, as it fits perfectly into boxes (tertiary packaging) and more units can fit onto a pallet. Thus, showing that two bottles need to be designed: a round and a square option. The square bottle was designed with a capacity of 750ml and the round bottle with a capacity of 1500ml. Another key design aspect that was mentioned by PJ003 was that using a shrink sleeve is more profitable in the long run. Although the initial equipment cost is higher for a shrink sleeve label than an adhesive label, the overall price of the sleeve is cheaper, and it also has fewer off cuts, thus producing less waste.

Planet – The key concerns for *planet* were that the new proposed bottle should have lower CO_2 emissions whilst being efficient in current recycling systems. To ensure a decrease in both transportation cost and overall CO_2 emissions, good pallet utilisation is the key response. Thus, a square bottle was the better option for planet. The shrink sleeve is also the best option as explained by participant 50. AP2001 explained that polypropylene (PP) is lighter than water, meaning that at the separation plant the shrink sleeve will float and the bottle will sink which make a shrink sleeve very viable within current recycling streams. Thus, showing that a shrink sleeve is the best option for the new concept bottles.

Apart from overall uncluttered design, another aspect that forms an integral part in captivating consumer attention is the branding and colour used on the label. The colour used for the label of both concept bottles was chosen to be eye catching, yet clean and uncluttered. The clean, translucent nature of the label speaks to the *people* data, who prefers a design with fewer elements, but stands out among the rest.

The biggest divergence in the designs is between the round and square shape. To ensure final user testers would have options to discuss, the decision was made to have two final designs which can both fit the three sections requirements. After the user feedback was gathered, the two designs were critically compared to prove why both are necessary and will fit into current manufacturing, transportation and recycling streams.

The physical design requirements that were collated for the two design options are included in Table 6.2:

Table 6.2: Physical requirements informing the design

Bottle concept 1	**Bottle concept 2**
Round bottle	Square bottle
Capacity of 1500ml	Capacity of 750ml
Clear material, content visible	Clear material, content visible
Ribbing	Ribbing
Radii panels	Radii panels
Twist closure	Twist closure
Flat base	Flat base
Shrink sleeve label	Shrink sleeve label
Height comparative to industry standards	Height comparative to industry standards

A key parameter that emerged through the *profit* data set was the importance of height and width having to be approximately the same as current market leader bottles. A report published by Technavio named: Bottled Water Market in South Africa 2016-2020 (Technavio, 2016:49), reported that the projection for the leading water bottle South African brands in 2020 will be:

- aQuellé
- Valpré (Coca-Cola company)
- Bonaqua (Coca-Cola company)
- Nestlé

As the new design needs to adhere to market standards and brand leaders, the 750ml and 1500ml bottles of each brand were analysed to see its different heights, widths and weights. This was done to ensure that the proposed bottle can compete in the current market. The measurements, as measured by the researcher of the current market leader bottles can be seen in Table 6.3.

Table 6.3: Current market leader bottles

	aQuellé	**Valpré**	**Bonaqua**	**Nestlé**
750ml height	240 mm	262mm (1 litre)	210mm	242mm
750ml width	75mm	82mm (1 litre)	80mm	72mm
750ml weight	24g	26g (1 litre)	25g	24g
1500ml height	292mm	295mm	299mm	319mm
1500ml width	95mm	94mm	94mm	88mm
1500ml weight	34g	36g	35g	31g

As shown in Table 6.3, the market leading brands all have generally the same height and width. Valpré was the only brand that does not have a 750ml option, so for this research, their one litre bottle dimensions were used. For visual reference, the 750ml and 1500ml bottles can be seen in Figure 6.1 and Figure 6.2 respectively.

Figure 6.1: 750ml market leader bottles

Figure 6.2: 1500ml market leader bottles

As seen in Figure 6.2, the overall height, width and shape of the 1500ml bottles are very similar. This is in contrast with the 750ml bottles in Figure 6.1, where the overall shapes and sizes differ immensely.

The design specifications for the new concept bottles took into consideration the data of current market leader bottles (aQuellé, Valpré, Bonaqua, Nestlé) when establishing a viable height, width, and weight. This was done to ensure that the proposed two concept bottles would have a competitive advantage in the current market. Another factor to consider when standardising the dimensions is that the new bottle will be able to fit into current filling lines and recycling streams. The proposed new bottle design specifications can be seen in Table 6.4.

Table 6.4: New bottle specifications

	Height	Width	Weight
750ml	230mm	75mm	31g
1500ml	295mm	91mm	39g

6.2. Conceptualising a design response

The intention of the proposed design was to visually capture the collected data in a physical way. This will allow the reader to better understand the physical aspects which are necessary to make a bottle which is viable throughout all three sections of the TBL. Thus, the purpose of the designs was not to produce something novel. The final design was constructed with the intention to communicate complex design problems and to show in a visual way how they could be solved.

6.2.1. Concept one: 750ml PET bottle discussion

The first proposed bottle has a square shape with a capacity of 750ml. The specific height of this concept was chosen (230mm), because it is approximately between the height of both the shortest and tallest 750ml market leader bottles. Another reason why the 750ml concept needs to be shorter is because of its square shape. The volume of a square, with the same overall dimensions of a circle, will always have a higher volume. Choosing this height would allow the proposed bottle to be placed on the same shelf as the current market leader bottles.

The specified width of the new bottle will be the same as the market leader bottle, namely aQuellé. By choosing this width, the new bottle will be able to fit into current packaging and filling streams, as it is not larger nor smaller than the largest and smallest market leader bottles.

For the new design, the same neck finish which is used by all the market leader bottles will be used: 28mm PCO1881 neck. Using the same neck will ensure changeability throughout all brands, to aid in decreasing overall manufacturing needs. Manufacturing needs in this instance refers to bottle caps. The weight of the preform (which includes the neck), will be 31g. The smaller 28mm radius neck is also easier for sipping purposes.

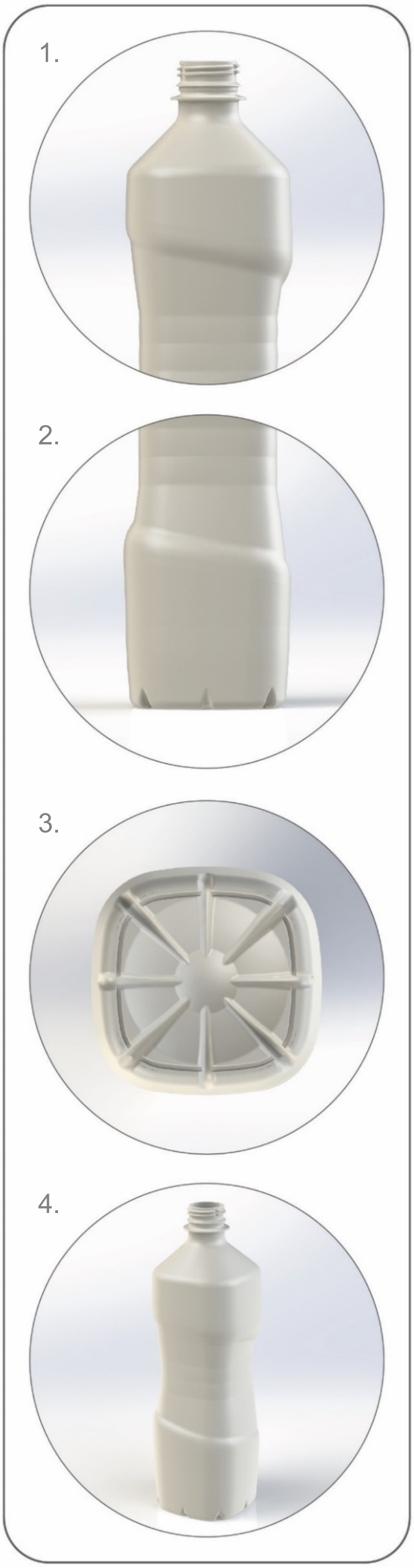


Figure 6.3: 750ml design

Image one and two of Figure 6.3, shows the sweeping rib, which wraps around the bottle in a cylindrical shape. This design decision was made to increase the overall strength of the bottle. The midsection of the bottle contracts inward to allow for a better grip. Although this bottle is square, it has no straight or flat panels. The square shape is better for packing and pallet utilisation, adhering to both *profit* and *planet* requirements.

In both image one and two, notice how the sweeping rib is convex and the middle section concaves. This was done to ensure overall strength of the bottle whilst also indicating how the bottle should be held for optimum comfort. All panels on this design have a small radius, to increase overall top load strength.

Image three shows the base design. All current market leader bottles for still water have a similar base design, the new base was designed with the same elements. The increased number of ribs on the base will decrease the overall weight of the bottle. The deeper rib groove, seen in image three, is to ensure better grip for the shrink sleeve.

Image four shows the overall design of the new concept bottle. The square shape would allow this bottle to look different. This speaks to the *people* data. The new proposed bottle will thus stand out next to its competitors as all current market leader bottles are round. The overall shape also speaks to the Gestalt principle of “focal point”[32], which will lead the consumer to see specifically designed focal point, in this case, a square shape.

[32] This principle is discussed in Chapter 3, heading number 3.2.2, page 53.

6.2.2. Concept two: 1500ml PET bottle discussion

The second concept is a rounded bottle, with a 1500ml capacity. The reason why this height (295mm) does not correlate with the tallest market leader bottle (Nestlé), is because of the large difference between the Nestlé bottle and the other three market leader bottles. There is a 20mm height difference between Nestlé and Bonaqua, whereas the height difference between Bonaqua, Valpré and aQuellé was a dismal 1mm. Thus, the mean height between the three market leader bottles was chosen to ensure a competitive shelf appearance.

The maximum width of the new concept bottle (91mm) will be less than all the market leader bottles. When designing this bottle, clean and uncluttered design was considered. The overall shape of the 1500ml bottle concept was based on the appearance of glass bottles, as that is what primary data found that *people* prefer. As the new concept shape looks completely different from the market leader bottles, which have many more ribs, it could be understood why it was necessary to decrease the overall width of the concept bottle. Fewer ribs would also cause this new concept bottle to be made using a heavier preform than its competitors.

For the 1500ml bottle, the same neck that was used for the 750ml bottle was used: 28mm PCO1881 neck. The only difference is that the 1500ml bottle needs to be heavier to ensure a strong bottle, as the 1500ml bottle is both taller and wider. The weight of the preform (which includes the neck), will be 39g.

The overall shape of the base for the 1500ml bottle will be the same as the 750ml bottle, apart from being round. The same lightweight principles were applied to both the 750ml and 1500ml bottles.

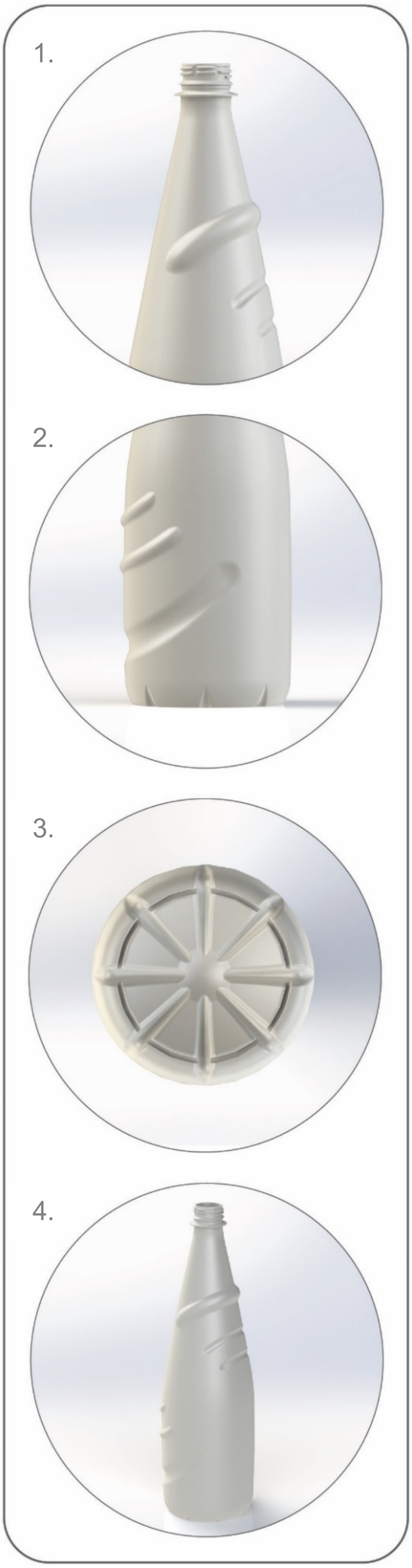


Figure 6.4: 1500ml

As seen in both image one and two of Figure 6.4, the proposed bottle will have an asymmetric rib pattern at both the top and bottom of the bottle. The top will consist of one large convex rib and two, smaller ribs which concave. The top part of the bottle is very elegant and smooth, following the shape of a glass bottle. What makes this concept different is the radius that was added to the side panels, to increase strength and add volume.

Image two shows the bottom part of the bottle. The rib pattern on the bottom has the opposite rib profile to the top: one large rib which concaves and two, smaller ribs which convex. These rib profiles were added to increase the overall strength of the bottle without the ribs being too noticeable. The straight edges on the bottom of the bottle also have a small radius, for increased strength.

The base design for the 1500ml bottle can be seen in image three. Like the 750ml concept base, this base also has eight ribs. Increasing the amount of ribs in the base, allows the bottle to be made with a lighter preform. Like the 750ml design, this concept has a deeper rib groove, which will allow the shrink sleeve to snugly shrink into the cavity for better grip.

Image four shows the overall design of the new concept bottle. The cone shape would allow this bottle to look different from its competitors. This design was based on the prägnanz[33] Gestalt principle, as it is an uncluttered design which is easy to comprehend.

[33] This principle is discussed in Chapter 3, heading number 3.2.2, page 53.

6.2.3. Finite element analyses

To ensure that the two proposed concepts are viable in current transportation streams, two finite element analyses (FEA) tests were conducted to calculate overall stress and displacement[34] of the two bottles. An FEA is a computer simulation, done to solve possible mechanical problems that the bottle might have, before it is put into production. For this specific test, a 20kg top load weight was placed onto each bottle, to calculate how the bottle will behave under extreme pressure. This is important as it will show whether the bottle is strong enough to be transported on pallets. According to RB003, 20kg top load is the general weight that is used to test the market leader bottles and jars.

The stress test was done to see where the weakest points in the bottles were, when a top load of 20kg is placed on top of it. In Figure 6.5 and 6.7, notice the rainbow coloured margin on the left. The dark blue end of the margin indicates little to no stress: meaning that the blue parts will be the strongest parts of the bottle, with no crushing or bending taking place. The opposite side of the margin, which is red, indicates the maximum level of stress showing that there is a big chance that the bottle will crush or bend in those areas.

The displacement test was done to see how much the bottles might displace when a top load of 20kg is added. In Figure 6.6 and 6.8, the rainbow margin indicates the maximum (red) and minimum (blue) displacement amounts in millimetres. Figure 6.5 and 6.6 shows the computer simulated top load tests for the 750ml bottle.

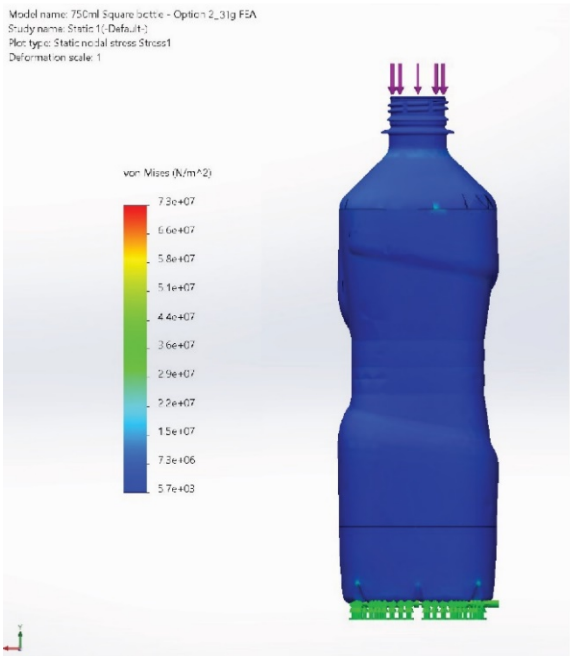


Figure 6.5: 750ml stress test

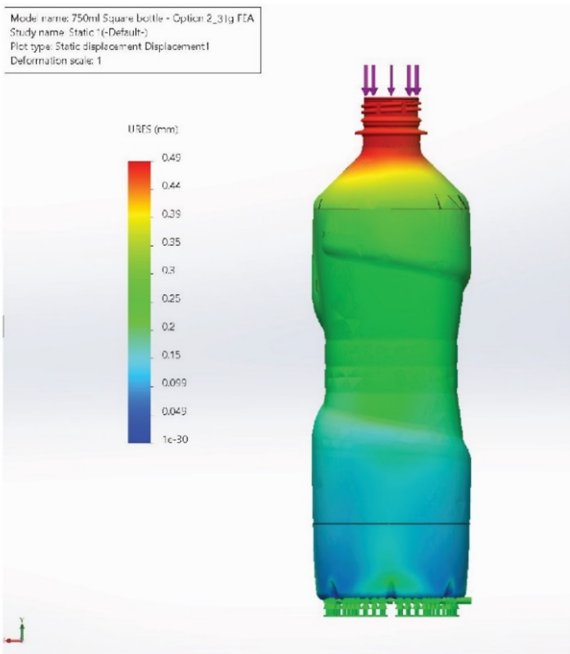


Figure 6.6: 750ml displacement test

[34] Displacement in this context refers to the bottle pressing outward when weight is placed on top of it.

Figure 6.5 indicates that the 750ml bottle essentially has no stress points. The weakest points of the 750ml bottle can slightly be seen at the bottom (light blue), where the base ribs are situated. Figure 6.6 indicates that at its weakest point, the 750ml bottle merely has a displacement of 0.49mm. According to RB003, historically the neck of a bottle is always its weakest point. As the stress analyses of the bottle showed no stress at the neck of the bottle, one can assume that the displacement will also be less as the bottle is structurally sound.

Figure 6.7 and 6.8 show the computer simulated top load tests for the 1500ml bottle.

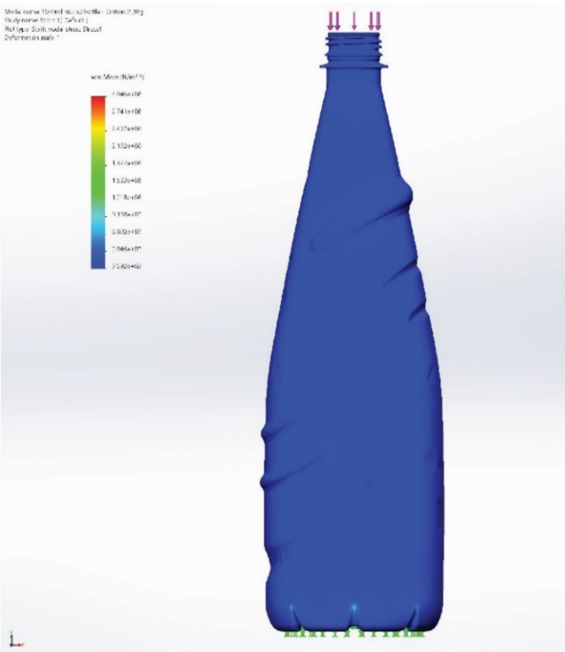


Figure 6.7: 1500ml stress test

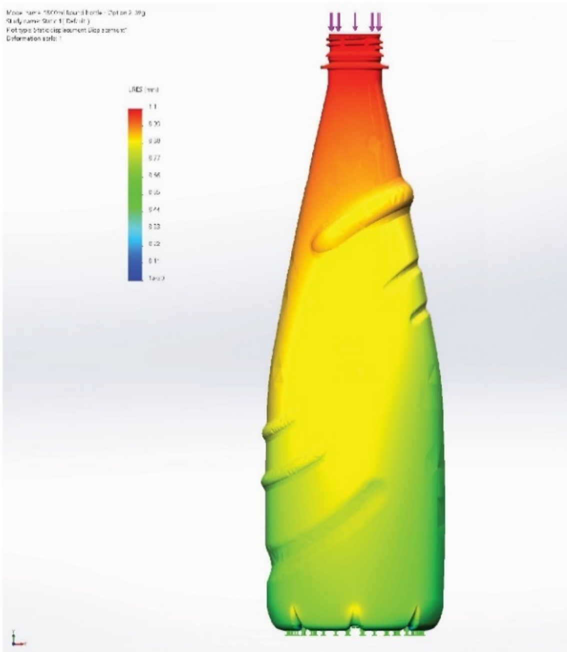


Figure 6.8: 1500ml displacement test

Figure 6.7 proves that the 1500ml bottle is strong and has almost no stress points. As with the 750ml bottle, the area with the most stress on the 1500ml bottle is the base ribs. Figure 6.8 shows that the 1500ml bottle is not as strong as the 750ml bottle, but only has a displacement of 1.1mm at its weakest point which is also in the neck. The 1500ml bottle has almost no stress and little displacement, indicating that the bottle will be structurally sound and viable in high quantity production streams.

6.2.4. Shrink sleeve label

Throughout the primary research, consumer feedback on education regarding PET plastic packaging disposal proved lacking. All participants agreed that if they understood why it is important to recycle and had the means to do so, they would. The importance of brand owners to communicate the material used and disposal methods of the bottle became apparent. This was clearly shown in the data gathered throughout all three sections: *people, profit, planet*.

Another critical design specification that became apparent through both the *profit* and *planet* sections was that a shrink sleeve label is a better option than an adhesive label. Another reason for choosing a shrink sleeve label is that it covers the entire bottle. This implies that there is more space to convey critical information to the user. Thus, for the new bottle concepts, a shrink sleeve label was designed.

This label design is merely used as a tool to show the reader the importance of conveying product information and disposal methods on their label, in this case: a shrink sleeve label. Even though the focus of this research was to showcase two concept designs that communicated the findings of the study, it was critical to showcase a complete product during final user feedback sessions. Thus, it was important to design a label to convey a complete product that can be discussed at the user feedback stage. The most important design aspects of this label included: branding (name and logo) and disposal instructions. The final, translucent label can be seen in Figure 6.9.

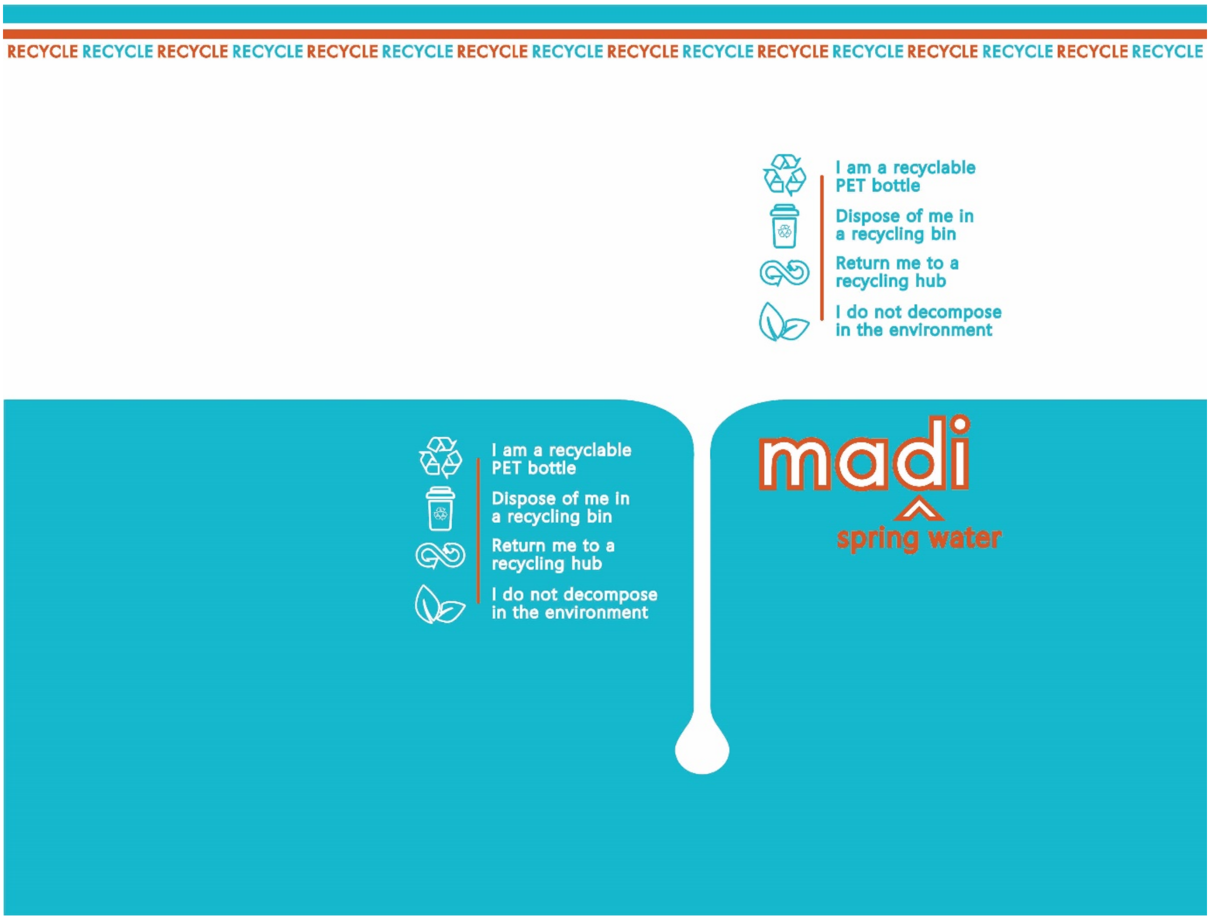


Figure 6.9: Final shrink sleeve label

The name of this new concept bottle is Maḓi. This name was chosen as it indicates geographical location. Maḓi is a Venda word, meaning water. Venda is one of the 11 official languages in South Africa, so the name of the bottle already indicates geographic location.

To promote consumer education, the opportunities presented by the packaging could be leveraged. It is important for the consumer to understand the material that the bottle is made of, and how the bottle needs to be recycled. The label is the perfect medium to convey this information. The Maḓi bottle label clearly shows: the material that the bottle is made of, how to recycle it and its decomposability. On this proposed label, the disposal instructions are large, allowing the consumer to read it as easily as reading the logo.

Through considering all the design aspects that were found throughout the primary and secondary data, the final design was constructed. Although this specific bottle was designed to fit into the South African context, the overreaching principles applied to the design can be applied in any country. Figure 6.10 shows the undressed bottle, with no material or label added. The final, dressed designs can be seen in Figures 6.10 – 6.13.

Figure 6.10: Madi front view - undressed

Figure 6.11: Madi front view

Figure 6.12: Madi top view

Figure 6.13: Madi isometric view

6.3. User feedback on the design concepts

For this phase of the research, a participant feedback form[35] was set up and sent to one participant of each section: *people, profit, planet*. The form included images of both bottle concepts and short descriptions of the design decisions that was made and the reason therefore. Each participant was asked to state their individual views of the two bottle designs, considering their respective sections: *people, profit, planet*. The goal of the form was to get an accurate representation of how each section would respond and interact with the two new proposed concepts.

The participants who took part in this phase included: RO003, RB003 and AP2004[36]. The goal of the participant feedback was to see how the participants from each section understood the new design and if it met their various and sectional expectations. Their feedback, as it relates to the concepts of *people, profit* and *planet*, was as follows:

People

- RO003 appreciated the overall shape and design of the 750ml bottle, as the square shape is different from what is normally seen on the shelves: "…*it has immediate appeal since it is fresh and different*". This participant also liked that the square shaped 750ml bottle concaved in the midsection, as it would have good grip and not easily slip out of their hand. RO003 relished in knowing that the square shape of the bottle will optimize pallet utilisation and in turn have a smaller carbon footprint. RO003 liked that the 1500ml bottle was round and not square, as RO003 believes that a square shaped bottle of that size could feel very bulky and tough to hold. This participant also enjoyed the round shape of the bottle and the ribbed side panels: "… *the round edges give it an understated, sleek look. The ribbed side panels look comfortable to hold onto*". RO003 believes that it is important for such a large, heavy bottle to have features, like the ribbed side panels, which make the overall grip better. This participant liked the idea of having an interchangeable neck size, as RO003 believed it could lower overall manufacturing cost.

Profit

- RB003 appreciated that both bottles use a standard neck size: "…*from a production side, I'm pleased to see that both bottles use a standard 28mm PCO neck finish, that*

[35] The participant feedback form can be seen in Appendix G.
[36] The participant codes can be seen in Appendix F.

way we wouldn't need specialised capping machines and they both use existing standard PET preforms". With regards to overall structure, this participant believed that both bottles would perform well in a blow moulding machine: "…*there aren't any sharp corners which the PET would struggle to get into*". RB003 also liked the ribbing and radii panels on both bottles: "…*both bottles would perform well when it comes to panelling, due to internal vacuum pressure*". This participant also recognized that shrink sleeving would work well on both bottles and is better for overall manufacturing.

Planet

- AP2004 thought that the shrink sleeve was a good choice for both bottles, as it adheres to good recycling and separation practices. With regards to the 750ml bottle, this participant believes it will attract attention as the shape is different from the bottles that is currently on the shelves. AP2004 prefers the smaller middle of the 750ml bottle, as it will make gripping and carrying easier. This participant also appreciated the overall appearance of the bottle: *"…with a shrink label that is well applied, it will still have a neat and tidy appearance*". This participant was wary of the fact that the shrink sleeve might not suit the 1500ml bottle, as the labelling surface is small, and the sleeve might not shrink neatly onto the surface. Although the 1500ml bottle is bigger, AP2004 believes that the thin, streamlined neck with the additional ribs at the top will ensure a steady grip: *"…I love the opposite ribs – the two opposite sides and the in and out design of them"*.

Generally, all participants agreed that both bottles are functional and would fit well into current manufacturing and recycling streams. Through this user feedback, the most important aspects of each section were reiterated: people prefer an aesthetically pleasing bottle which is comfortable to hold and has a smaller carbon footprint, profit will always prefer a bottle which can fit into current production and manufacturing streams to the point where aesthetics does not matter, and planet likes any bottle as long as it fits into current recycling and separation streams.

6.4. Towards a consolidated design

The ways in which plastic packaging is being used is ever changing. It is therefore critical to continue researching and optimising the design thereof. This research has shown that through critically analysing the three sections of the TBL, it is possible to produce a consolidated product which considers each section. Although, the data has shown that not all three sections can be equally important.

Through these two concepts, both bottles have more important and lesser important factors from each section which are incorporated. The 750ml, square bottle is perfect for optimal pallet utilisation (good for both *profit* and *planet*), but it will have an increased cycle time (bad for *profit*), meaning it would take longer to produce the square 750ml than the 1500ml bottle. This shows that *profit* and *planet* are at odds with each other. A critical design decision that was made was using a heavier preform than the market leader bottles (aQuellé, Valpré, Bonaqua, Nestlé). This design decision is good for *people,* as it would allow for a stronger bottle which has clean lines and fewer ribbing patterns which would cause *people* to want to reuse the bottle. Although a heavier preform was a good decision for *people*, it is bad for *profit*. The argument for *planet* becomes intricate, as a reusable bottle would cause less waste (good for *planet*), but it would also cause heightened CO_2 emission during the transportation phase (bad for *planet*). The overall design of both concepts is good for *people*, as it complies with their need for simple, clean aesthetics which is easy to hold and stands out between the other market leader bottles.

6.5. Conclusion

Currently, the hypothesis found throughout both the primary and secondary data is that the most important section to consider is *people*: the only ever-changing variable within the three sections. The consumer (*people*) is the driving force between both the financial viability of the product and the recyclability thereof. Without the consumer, there would not have been a need for the product, consequently meaning that there would also not have been a product to recycle. The design process that was used in this study included;

- Research – This included all the primary and secondary data that was gathered throughout the literature review and field research phases.
- Analyse – The findings of both the primary and secondary data were analysed to find possible themes throughout both which could be used to design the final product.
- Synthesise – At this stage the final designs were produced, and the design decisions were stated to prove the reasoning behind each design choice.
- Evaluate – Finally, the designs were evaluated by one participant from each section of this study (*people, profit, planet*), to ensure that it was a relevant design.

Future considerations would include using a lighter preform, with unique rib profiles which do not make the bottle cluttered. Optimised bottle shapes need to be researched to ensure a stronger bottle which uses a lighter preform. This research has shown that a square bottle is stronger than a round bottle, thus researching different bottle shapes is critical to ensure the continued growth and efficiency of the PET water bottle design industry.

7. CHAPTER SEVEN: CONCLUSION AND RECOMMENDATIONS

Chapter 7 explored the final conclusions and recommendations of this study. It also included answering the four main research questions, which were stated in Chapter 1. This research aimed to identify the everyday challenges associated with the design and manufacturing of disposable PET water bottles, considering all sections within the TBL: *people, profit* and *planet*. Throughout all three sections, the requirements differed immensely: *people* were based on consumer reaction, *profit* relied on overall production and manufacturing, *planet* was driven by recycling systems.

Furthermore, it demonstrated the complexity of the global issue within the plastic industry and the importance of creating recycling systems which are tailor-made to a geographic location. The complexity is highlighted by uncertain plastic recycling legislation and the need for a united response from both governments and plastic manufacturing companies to the current plastic crisis. This research showed that there is not one simple solution to complex problems, but the entire system within the industry needs to be reviewed and optimised.

It is critical to acknowledge that within the current consumer environment of easily accessible packaging, neither glass nor plastic packaging is the best option with regards to the circular economy. Developing a new material which encompasses all the industry needs will take time. Currently, there is no better alternative to PET plastic packaging. It is important to note that the current problem within the plastic packaging industry is not the material itself, but rather its overuse and lack of efficient recapturing, recycling and reuse strategies. All stakeholders within the plastic packaging industry, including manufacturing companies and end users are part of the solution.

By studying and understanding user behaviour, systems can be designed to suit their reaction towards both the use and disposal of plastics. The intricacies associated with all three sections of the TBL were explored, to find coherent ideas and requirements which affect them all. The importance of all stakeholders within the plastic value chain was shown and possible interventions were introduced.

While this research focussed on the manufacturing of PET packaging within the South African context, the tools and themes that were used in this research can be applied to many different businesses and industries. Beneficiaries of this study include any businesses who aim to lessen their carbon footprint through using LCA and circular economy practices. This research model can be applied to any product or system which aims for sustainable development. Users who would gain directly from this study include packaging manufacturing companies, governmental agencies, waste management facilities and the general consumer.

7.1. Responding to the research questions

a) How did the emergence of plastic packaging impact the food and beverage industry, and what is the state of the global industry today?

Currently, the increased use of PET water bottles is driven by consumers who desire portable packaging which is easy to get on-the-go and to transport. Mismanaged PET packaging can have a detrimental effect on all sections of the TBL, but if it is managed properly, it can improve each section and make it more efficient. Currently, packaging systems are not efficient, because not enough LCA's are done to explore the advantages and pitfalls of each section: from raw material extraction to final recycling. To make the system more efficient, each stage must be researched, as part of a holistic and strategic review, to find opportunities within the life cycle, and how it can be optimised.

Today, *people* are calling for alternative materials, with the same properties as plastics. Consumers want a material that will have equal or the same usability as plastic, but with a smaller environmental footprint. Even though consumers are at odds with using plastics, it is currently being used more than ever. Plastics have become a necessary everyday object, and although consumers are trying to fight against using it, it is an inevitable part of daily life. To change consumer views, they need to be made aware of why plastic is a good alternative to glass and the positive effect that plastics can have if it is disposed of and recycled properly. Through educating consumers on the importance of plastics and their responsibility within the circular economy, they will start to see the benefits thereof. One way in which consumers can be educated is by means of an informative product label. Thus, it is key to emphasise the importance of having good labelling policies which can educate consumers on the impact that they can have if plastics are disposed of and recaptured properly.

Findings from this research suggest that the key concerns within the current disposable PET bottle market include: more lightweight packaging solutions, faster cavitation times, optimised pallet utilisation, recapturing of plastics and consumer education. Currently, one of the key problems is lightweight packaging. It is good for the environment (*planet*), but extreme lightweight packaging causes the consumer (*people*) to have a lesser view of the bottle. Extreme lightweighting will cause consumers not to reuse the packaging and they are more likely to discard of it recklessly. A lighter pack will have less CO_2 emissions than its heavier counterpart. It is therefore crucial to establish a golden midway: a pack that is light enough to cause minimal emissions, but strong enough for consumers to reuse it.

It was found through the primary research that both fast cavitation time and pallet utilisation is driven by overall design and bottle shape. The opposite of each is true: a round bottle is best for cavitation and a square bottle is best for pallet utilisation. Although it was found that these two options are currently the best for their intended usages, further research should be done on the effects of different shapes on both cavitation and pallet utilisation.

Another concern that was addressed included using shrink sleeve labels instead of adhesive labels. Shrink sleeve labels are better for *planet*, as they have little to no offcuts, require no additives like glue, and they are easy to separate at separation plants for recycling. A well-designed shrink sleeve label can communicate crucial information about the recyclability, compostability, and disposal methods of the bottle, thus addressing user education. To ensure good labelling policies, governments should apply legislation which forces plastic manufacturing companies and brand owners to be held liable for the waste that they produce.

b) How does the interplay of *people, profit and planet* affect each other in the design of food and beverage disposable packaging?

Throughout both the primary and secondary data, it became apparent that the plastic packaging industry has an immense impact on all three TBL sections: *people, profit, planet*. Disposable plastic packaging design interacts with all sections of the system: social needs, financial limitations and environmental concerns. It has been found that when designing the system around a product, all three sections of the TBL are not equally considered. Within current extraction, manufacturing, transportation, waste management and recycling streams, it is not likely for all three sections to be viewed as equally important. Without current systems being revised and changed to practically aid the other, one section will always have to be inferior to the other.

To a large extent, *people* and *profit* drives the manufacturing of plastic bottles. The consumer need for a low-cost product which is efficient will always prosper above a more expensive bottle which can do the same thing. This study did not explore food packaging, yet the same principles that was found in this study of disposable water bottles could be applied to the food packaging industry, as they have the same extraction, manufacturing and recycling needs.

The holistic analysis that was completed as part of this research considered the three sections as equally important. Through the analysis, one aspect that each section had in common was consumer behaviour. This research found that uninformed consumers have a harmful effect on the entire plastic economy, concerning both the financial and environmental aspects of everyday life. Consumers need to be informed about the importance of plastics, the importance of recycling and the entire life cycle thereof. Even though they all have a different main requirement, similarities exist across all sections.

c) How does a design process, with a focus on manufacturing, facilitate a focus on the TBL of PET food and beverage disposable packaging production?

Once the TBL was analysed, it became clear that *people, profit* and *planet* should be used as guidelines to any design process which aims to create holistic change or awareness. The challenges and responsibilities of designers, brand owners, plastic manufacturing companies, recycling facilities, governments and consumers in a world with ever growing environmental and social concerns were highlighted through this research. The design process used in this research included: research, analysis, synthesis and evaluation. The TBL was present in every step of the design process:

- Research – throughout both the primary and secondary research it was found that two bottles had to be designed to comply with both *profit* and *planet* needs.
- Analysis – the analysis done on all three sections of the TBL proved that the problems within the current debate around plastics is more complex than anticipated at first. There is no one perfect solution to wicked problems within the plastic manufacturing industry. Only once the entire system of plastic extraction, manufacturing, transportation, disposal and recycling systems is viewed as one, the different parts can be optimised to equally reach the standards of all three sections of the TBL.
- Synthesis – this part included comparing the results of the primary and secondary research with the user feedback of the final design. It proved that one part of the TBL will always be more important than the other, in this case *people* and *profit*.
- Evaluation – the evaluation stage proved that it is possible to produce a consolidated product between all three sections of the TBL. It is important to note, within current manufacturing systems, that both concept bottles inevitably included more and lesser important factors from each section.

Looking at the design process through the TBL lens, it proved that current systems need to be reviewed, improved and optimised throughout the entire manufacturing process of plastics, namely before, during and after use. This research aided in an overall understanding of the FMCG industry, proving the importance of plastic manufacturing companies and their responsibility towards the social and environmental sectors.

7.2. Contributions to knowledge

Due to climate change, issues of the environment are more prominent than ever. A key driver that has been cited, throughout many publications and reports (see literature review), as one of the largest forms of waste which pollutes the environment is plastic packaging. Plastic packaging is currently the second largest form of waste globally. This critical information is what drove this study, the current design trend is moving towards creating a circular economy which will undoubtedly impose future sustainable developments. This new research area was the key driver of this study. The two disposable PET water bottle prototypes which were produced during this study, were merely to show how sustainable development can be cultivated through using a holistic approach (the TBL) in a physical, measurable format. The key research findings of this study can be applied to any design field where holistic development within a system or surrounding products is the final goal.

Through using non-traditional theoretical frameworks within a design study, this research differs from other design studies, as it had a different approach. The data was collected in such a manner, so as to show that no one part (social, financial, environmental) can be reformed without considering its counterparts, as all are equally important. This study aimed to find similarities across disciplinary fields to advocate for sustainable change. This study also builds on other research studies (cited in Chapter one), like LCA's and the circular economy. Although it uses the same guideline as an LCA and the circular economy approach, it also considered all the stakeholders which are involved in the system around a single product. The aim of the researcher was to design a physical bottle, but also to end up with a model which could be applied to any system or product.

The key research concepts of validity, reliability and generalizability were used to assess this study. Each is outlined below.

- Generalisability was used to measure the results found through this study against a larger group of different people and situations. The generalisability of this study is broadly applicable to different people and fields. For example, the concept of a circular economy and LCA can be applied to any field, regardless of geographical location and culture.
- Reliability was used to measure the consistency of the data which was gathered. This study only made use of internal consistency (across items), to measure the consistency of the data across all three sections; *people, profit, planet*. To measure consistency over time (test - retest reliability) and different researchers (inter - observer reliability), would require additional time.

- Validity was used to measure whether this study has real world application. The validity was tested by going back to the consumers, showing them the designed product and getting their feedback. The positive user feedback on the proposed water bottles proved the validity of this study.

7.3. Contributions to the theoretical framework: TBL and Gestalt theory

Traditionally, the TBL is a theoretical framework used within economic spheres and is not usually applied as a design framework. In accounting, this framework aims to view the social and environmental bottom line as just as important as the profit bottom line. This is to ensure sustainable growth within the company. The TBL as applied to this research, gained a holistic view of the disposable PET water bottle design industry. Although the TBL looks at the three sections as separate entities, this research grouped them together, to gain a holistic perspective. Through using the TBL as a design tool, the entire system around the water bottle was viewed as one, instead of as separate entities. This adheres to the principles of a circular economy, where all sections within a system is studied and understood before a product is designed. For future design studies, it is recommended that TBL be applied to any product or system designs, where the goal is to find a holistic solution to intricate design problems. By viewing the entire system as one, the opportunities and points of friction (even small ones) between each section become apparent.

Gestalt principles are rooted in social sciences and user behaviour. In this research they were used as tools to view how consumers would react to certain shapes, according to previous experiences. Gestalt principles proved to be a useful tool to study user behavioural patterns within design. It is important to note that Gestalt is a very powerful tool to help instigate certain user behaviour and reactions, thus it has many uses. Gestalt was not used to its full potential in this research as there was very little user interaction. In this research, Gestalt was merely used as a tool to justify certain design decisions. Gestalt principles allow the designer to make certain hypotheses without having actual user interaction. For future design studies, Gestalt will come to its full potential if it is used in prototype analyses or interviews where designed artefacts are present. This way, the researcher can gain critical knowledge about what triggers certain user interactions and behaviour.

7.4. Methodological considerations: Action research within the sustainability space

Action research is traditionally rooted in the social sciences. AR was suitable to this research as - just like AR - this study does not propose immediate change. This research attempted to propose how each section of the TBL could optimize the entire manufacturing process of disposable PET water bottles throughout its life cycle. The steps followed in AR research (plan – act – observe – reflect) are very similar to the design process (research – analyse – synthesise – evaluate), making cross-disciplinary research between design and the social sciences viable.

The goal of AR is to create a simple, practical, repeatable process of iterative learning, evaluation, and improvement. The systematic approach worked well for this research, as there are so many parts within the plastic manufacturing cycle to consider. To better understand the AR process within the manufacturing context, a map was constructed to show exactly what was needed to conduct the full AR cycle. Thus, the life cycle of disposable PET water bottle manufacturing was mapped to show each stage of its cycle: before, during and after use. Through using the mapping tool in combination with AR, the interview and survey questions became clear. What makes AR different to other methodologies is that it is less formal, but still structured. Its main goal is to address practical issues, instead of only theorising about a singular problem. The structure of AR made it easy to introduce other tools, like product journey mapping and product blueprints. The way in which AR was used in this research was to view the system around a product, not merely the product itself.

The open nature of the AR cycle is a good choice for research studies where the choice in methodology is not clear from the beginning. As the AR cycle is so vast, it is easy to weave different tools into the process whilst still staying within the AR boundaries. AR is a great methodology to use in studies where the main goal is to gain practical knowledge. For theoretical studies, the AR cycle might be too vast.

7.5. Recommendations for future research

To conclude the study, it is suggested that further research be conducted on ways to improve each part of the manufacturing process of the plastic industry, from raw material extraction to final recycling and re-entrance into the circular economy. This point was clearly raised by a participant who noted that the energy used within each section of the production of plastics should be studied and optimised (AP2004). This is true for the entire life cycle of plastics.

It is also critical to research and review new plastic recovery systems, user educational methods and apply psychological models to see the most efficient way to educate consumers. Once consumers are educated, recycling systems will consequently become more efficient and recapturing statistics will inevitably rise. It is important to realise that all parts of the system are connected and must therefore be analysed as a whole instead of viewing each process as an individual part. Sustainability and the circular economy are relatively new concepts. Research and opportunities for improvement and better integration into all three sections (*people, profit, planet*) should be analysed and encourage.

LIST OF REFERENCES:

Abdulkarim I.A. & Abiodun, A.O. 2012. A Study of problems associated with PET bottles generation and disposal in Kano metropolis. *Academic Research International. Nigeria*. 3(2), pp.56-65.

Adaptive Path. 2013. *Adaptive Path's Guide to Experience Mapping*, San Francisco: Adaptive Path, pp.3-28.

Adoption of the Paris Agreement. (2015). *In: Framework convention on Climate Change.* [online] Paris: United Nations. Available at: https://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf [Accessed 7 Nov. 2019].

Alhaddi, H. 2015. Triple Bottom Line and Sustainability: A Literature Review. Business and Management Studies, 1(2), pp.6-10.

Alsobaai, A. 2013. Thermal cracking of petroleum residue oil using three level factorial design. *Journal of King Saud University* - Engineering Sciences. 25. 21–28, DOI 10.1016/j.jksues.2011.06.003.

Arokiaraj, D., Thangavel, Y. & Sankriti, R. 2019. Recover, Recycle and Reuse, An Efficient Way to Reduce the Waste. *International Journal of Mechanical and Production Engineering Research and Development*, 9(3), pp.31-42, DOI: 10.24247/ijmperdjun20194.

Azzone, G., Borzatta, P., Ferrari, D. & Savona, P. 2013. *The excellence of the plastics supply chain in relaunching manufacturing in Italy and Europe*. The European house Ambrosetti, pp.13-170.

Australian Government. 2016. The triple bottom line framework: A method for assessing the economic, social and environmental outcomes of the sustainable diversion limits for the northern basin. Canberra: Murray–Darling Basin Authority, pp.5-21.

Ballantine, P., Ozanne, L. & Bayfield, R. 2019. Why Buy Free? Exploring Perceptions of Bottled Water Consumption and Its Environmental Consequences. *Sustainability*, 11(3), pp.757.

Bassill, S. 2016. *Should You Be Using Product Journey Mapping to Drive Innovation?* 20/20 Vision for Marketing Breakthroughs. QDI Strategies, pp.2-5.

Bellis, M. 2011. The History of Plastics. *About. com Inventors*.

Bertoluci, G., Leroy, Y. & Olsson, A. 2014. Exploring the environmental impacts of olive packaging solutions for the European food market. *Journal of Cleaner Production*, 64, pp.234-243.

Bø, E., Hammervoll, T. & Tvedt, K. 2013. Environmental impact of refillable vs. non-refillable plastic beverage bottles in Norway. *International Journal of Environment and Sustainable Development*, 12(4), pp.2-25.

Boustead, I. 1995. *Eco-Profiles of the European Plastics Industry, Report 8: Polyethylene Terephthalate (PET)*, Association of Plastic Manufacturers in Europe Technical and environmental Centre, Brussels, pp.7.

Braun, V. & Clarke, V. 2006. Using thematic analysis in psychology: Qualitative Research in Psychology. Bristol. 3 (2), pp.77-101.

Brydson, J. 1999. *Plastics Materials*. 7th ed. Oxford: Butterworth-Heinemann, pp.1-18.

Burns, A. 2015. Action Research. In: J. Brown and C. Coombe, ed., *The Cambridge Guide to Research in Language Teaching and Learning*, 1st ed. Cambridge: Cambridge University Press, pp.188-202.

Center for International Environmental Law. 2017. Fossils, Plastics, & Petrochemical Feedstocks. *Fueling Plastics*. [online] Washington, DC: CIEL, pp.2-3. Available at: <https://www.ciel.org/wp-content/uploads/2017/09/Fueling-Plastics-Fossils-Plastics-Petrochemical-Feedstocks.pdf> [Accessed 22 April 2020].

Cliffe Dekker Hofmeyr (CDH), 2020. *Extended Producer Responsibility – The "New Approach" Under Our Circular Economy to Achieve the Elimination of Waste Generation.* Environmental alert. [online] Johannesburg: Cliffe Dekker Hofmeyr (CDH), pp.4. Available at: <https://www.cliffedekkerhofmeyr.com/export/sites/cdh/en/news/publications/2020/environment/Downloads/Environmental-Alert-3-July-2020.pdf> [Accessed 23 January 2021].

Cook, A. 2015. 'Plastic Recycling', in *Case studies for developing globally responsible engineers*. GDEE (eds.), Global dimension in Engineering Education, Barcelona.

Corma, A., Corresa, E., Mathieu, Y., Sauvanaud, L., AlBogami, S., Al-Ghrami, M. S. & Bourane, A., 2017. *Crude Oil to Chemicals: Light Olefins from Crude Oil.* Catal. Sci. Technol, pp.7, 12−46.

Costa-Smith, L., Maltzer, I. & Martino, J. 2017. "Poly Pelletizer: Recycled Pet Pellets from Water Bottles". *Mechanical Engineering Senior Theses*, pp.70.

Chandon, P. & Wansink, B. 2012. *Does food marketing need to make us fat? A review and solutions*. Nutrition Reviews, 70(10), pp. 571-593.

Chang, D., Dooley, L. & Tuovinen, J.E. 2002. Gestalt Theory in Visual Screen Design — A New look at an old subject. In: Not Set ed. *Selected Papers from the 7th World Conference on Computers in Education (WCCE'01),* Copenhagen, Computers in Education 2001: Australian Topics. Melbourne: Australian Computer Society, pp. 5–12.

Department of environment, forestry and fisheries, 2020. *Consultation on The Proposed Regulations Regarding Extended Producer Responsibility*. Pretoria: Department of environment, forestry and fisheries. No. 43481, pp. 6.

Department of social development. 2015. *The National Development Plan 2030: Persons with disabilities as equal citizens.* Pretoria: Department of Social Development, pp.6-8.

d'Ambrières, W. 2019. Plastics recycling worldwide: current overview and desirable changes. *The journal of field actions*, (19), pp.12-21.

Di Maria, F., Lovat, E. & Caniato, M., 2018. Waste management in developed and developing countries: The case study of Umbria (Italy) and the West Bank (Palestine). *Detritus*, In Press (1), pp.171-180, DOI 10.31025/2611-4135/2018.13690

Digimarc. 2018. *The state of Packaging today*. The history of Packaging. [online] pp.1-12. Available at: https://www.digimarc.com/docs/default-source/default-document-library/state-of-packaging-today.pdf?sfvrsn=6a3af137_4 [Accessed 25 Jan. 2019].

DiGregorio, B. 2009. Biobased Performance Bioplastic: Mirel. Chemistry & Biology, 16(1), pp.1-2.

Driscoll, D. 2011. Introduction to Primary Research: Observations, Surveys, and Interviews. In: C. Lowe and P. Zemliansky, ed., *Writing Spaces: Readings on Writing*, 2nd ed. Indiana: Parlor Press, pp.153-173.

Ellen MacArthur Foundation. 2013. *Towards the Circular Economy: Economic and Business Rationale for an Accelerated Transition.* [online] Available: https://www.ellenmacarthurfoundation.org/assets/downloads/publications/Ellen-MacArthur-Foundation-Towards-the-Circular-Economy-vol.1.pdf [Accessed 7 November 2019].

Ellen MacArthur Foundation. 2019. New Plastics Economy. Reuse: Rethinking packaging. [online] Ellen MacArthur Foundation, pp.13-21. Available at: <https://www.ellenmacarthurfoundation.org/publications> [Accessed 5 September 2020].

Elkind, D. 2005. Response to Objectivism and Education. *The Educational Forum*, 69(4), pp.328-334, DOI: 10.1080/00131720508984706.

European Bioplastics. 2016. What are bioplastics? Fact sheet. Berlin: European Bioplastics, pp.1-4.

Elkington, J. 2004. *Enter the triple bottom line*. London: Earthscan, pp.1-16.

Fernandino, G., Elliff, C., Silva, I. & Bittencourt, A. 2015. How many pellets are too many? The pellet pollution index as a tool to assess beach pollution by plastic resin pellets in Salvador, Bahia, Brazil. Revista de Gestão Costeira Integrada, 15(3), pp.325-332, DOI: 10.5894/rgci566.

Foster, J. 2019. International flexible packaging trends and sustainability. *Proceedings of the 2019 Propak Africa conference*, Johannesburg, 12-15 March 2019.

Fox, N. 1998. Trent Focus for Research and Development in Primary Health Care: *How to Use Observations in a Research Project*. Trent Focus, pp.1-29.

Franklin Associates. 2014. Impact of plastics packaging on life cycle energy consumption & greenhouse gas emissions in the United States and Canada - Substitution Analysis. pp.5-16.

Gungor, A. & Gupta, S. 1999. Issues in environmentally conscious manufacturing and product recovery: a survey. *Computers & Industrial Engineering*, 36(4), pp.811-853.

Ghanta, M., Fahey, D. & Subramaniam, B. 2013. Environmental impacts of ethylene production from diverse feedstocks and energy sources. Applied Petrochemical Research, 4(2), pp.167-179, DOI 10.1007/s13203-013-0029-7.

Hammer, J. & Pivo, G. 2017. *The Triple Bottom Line and Sustainable Economic Development Theory and Practice.* University of Portland State & University of Arizona, Research Paper, pp. 1-12. Available at SAGEPUB:

Hanekom, A. (2019). Replacing plastic: blessing or curse? *Proceedings of the 2019 Propak Africa conference*, Johannesburg, 12-15 March 2019.

Hilmer, T., 2019. *A Strategy for Improving the Maturity Levels of IT Service Management in Higher Education Institutions In South Africa*. Nelson Mandela University, Port Elizabeth, pp.19-56.

IBWA, 2019. *The People's Choice: Bottled Water*. [online] International bottled water association, pp.11-15. Available at: <https://issuu.com/ibwa/docs/bwr_jul-aug_2019_final> [Accessed 4 August 2020].

Jechura, J. 2018. *Petroleum refining overview*. https://inside.mines.edu/~jjechura/Refining/01_Introduction.pdf [Accessed 10 Jan. 2020].

Hesselink, T. & van Duuren, E. 2019. *The Plastic Recycling Opportunity an Industry Ready for Consolidation.* Realizing value series. Netherlands: KPMG.

Hillman, K., Damgaard, A., Eriksson, O., Jonsson, D. & Fluck, L. 2015. *Climate Benefits of Material Recycling,* DOI doi.org/10.6027/TN2015-54

Hocking, M. 2005. Petrochemicals. *Handbook of Chemical Technology and Pollution Control*, pp.637-668, DOI 10.1016/B978-012088796-5/50022-3.

Hossain, M., Enam, F. & Farhana, S. 2017. Service Blueprint a Tool for Enhancing Service Quality in Restaurant Business. American Journal of Industrial and Business Management, 07(07), pp.921. DOI: 10.4236/ajibm.2017.77065

Jepsen, D., Vollmer, A., Eberle, U., Fels, J. & Schomerus, T. 2014. *Development of tools to prevent food waste*. Environmental Research Plan of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, pp.1-22.

Kaza, S., Yao, L. Vhada-Tata, P. & Van Woerden, F. 2018. *What a Waste 2.0 A Global Snapshot of Solid Waste Management to 2050.* Urban development series. Washington: International Bank for Reconstruction and Development, pp.1-178.

Kazmer, D. 2007. Injection Mould Design Engineering, DOI: 10.3139/9783446434196

Klick, J. & Wright, J.D. 2012. *Grocery Bag Bans and Foodborne Illness*. University of Pennsylvania & Institute for Law & Economics, Research Paper No. 13-2. Available at SSRN: https://ssrn.com/abstract=2196481 or http://dx.doi.org/10.2139/ssrn.2196481.

Krehula, L., Siročić, A., Dukić, M. & Hrnjak-Murgić, Z., 2012. Cleaning efficiency of poly (ethylene terephthalate) washing procedure in recycling process. Journal of Elastomers & Plastics, 45(5), pp.429-444, DOI: 10.1177/0095244312457798.

Krishnamurthy, P. 2011. *An Introduction to Ethic*s. SSRN Electronic Journal, DOI: 10.2139/ssrn.1781502

Lee, S.G. & Xu, X. 2005. *‘Design for the environment: life cycle assessment and sustainable packaging issues*. Int. J. Environmental Technology and Management, Vol. 5, No. 1, pp.14-41.

Lewrick, M., Omar, M., Williams Jr., R., Tjandra, N. C., & Lee, Z. 2015. *Radical and Incremental Innovation Effectiveness in Relation to Market Orientation in the Retail Industry: Triggers, Drivers, and Supporters*. In E. Pantano (Ed.), Successful Technological Integration for Competitive Advantage in Retail Settings, pp.239-268. IGI Global. doi:10.4018/978-1-4666-8297-9.ch011

Locock, K.E.S. 2017. *The Recycled Plastics Market: Global Analysis and Trends*. CSIRO, Australia.

Lourens, B. (2019). Waste reduction vs waste disposal: Reducing your carbon footprint. *Proceedings of the 2019 Propak Africa conference,* Johannesburg, 12-15 March 2019.

Macdonald, A. & Vaughan, A. 2008. *Fantastic Plastic*. 1st ed. London: Gatsby Science Enhancement Programme, pp.1-55.

MacKerron, C. 2015. Waste and Opportunity 2015: Environmental Progress and Challenges in Food, Beverage, and Consumer Goods Packaging. Natural Resources Defense Council, pp.4-58.

Marsh, K. & Bugusu, B. 2007. Food Packaging? Roles, Materials, and Environmental Issues. *Journal of Food Science*, 72(3), pp.39-55.

Mashek, W., Holmes, K., Southworth, G., Martin, K. & Stoney, A. 2017. *Plastic bottles today: Innovating to reach today's consumer*. Bottling plastics market watch report. Washington: Plastics industry association, pp.9-51.

NCPC, 2020. *Life Cycle Management Tools and Guideline for Manufacturing Industry in South Africa.* [online] Pretoria: National cleaner production centre, pp.3-18. Available at: <http://www.ncpc.co.za/files/Guides/LifeCycle-Management-Guideline-2020_1.pdf> [Accessed 25 January 2021].

Minnick, M. 1996. Guide to the Earl S. *Tupper Papers*. [Papers] Smithsonian Archives Centre, Miri, M., Pritchard, B. & Cheng, H. 2010. A versatile approach for modeling and simulating the tacticity of polymers. *Journal of Molecular Modeling,* 17(7), pp.1767-1780, DOI 10.1007/s00894-010-0880-8

Mwanza, B., Mbohwa, C. & Telukdarie, A., 2018. *Strategies for the Recovery and Recycling of Plastic Solid Waste (PSW): A Focus on Plastic Manufacturing Companies*. Procedia Manufacturing, (21), pp.686-693, DOI 10.1016/j.promfg.2018.02.172.

Natural Capital Coalition. 2016. “Natural Capital Protocol – Food and Beverage Sector Guide”. (Online) Available at: http://www.fao.org/fileadmin/templates/nr/sustainability_pathways/docs/NCC_FoodAndBeverage_WEB_2016-07-12.pdf.

Newton, N. 2010. [The use of semi-structured interviews in qualitative research: strengths and weaknesses]. Academia. (Unpublished paper)

Nicholson, J. & Leighton, G. 1942. Plastics come of age. *Harper's Magazine*, (185), pp.300-307.

OECD. 2018. Improving Plastics Management: Trends, Policy Responses, And the Role of International Co-Operation and Trade. *OECD Environment policy paper* no.12, DOI 10.1787/23097841.

Packaging SA. 2017. *Common Myths/Misconceptions about Packaging*. Gauteng: Packaging SA, pp.1-12.

Papanek, V. 1995. *Design for the real world: Human ecology and social change*, Thames and Hudson, London, pp.38,256.

People Metrics. 2017. [eBook]. *Introduction to Customer Journey Mapping.* People Metrics incorporated, pp.1-10. Available at: http://cdn2.hubspot.net/hub/221727/file-33376447-pdf/PDFs/Introduction_to_Customer_Journey_Mapping_ebook_PeopleMetrics.pdf [Accessed 18 May 2019].

Person, L., Ekvall, T. & Weidema, B.P. 1998. *Life Cycle Assessment of Packaging Systems for Beer and Soft Drinks*, Technical report 6: disposable PET bottles. Ministry of Environment and Energy, Denmark, Danish Environmental Protection Agency, Miljøprojekt No. 405, pp.198.

PETCO. 2016. *Minister calls for Industry Waste Management Plans - PETCO.* [online] Available at: https://petco.co.za/section28/ [Accessed 7 Nov. 2019].

PETCO, 2019. *Designing for The Environment*. The essential how-to guide for all those involved in the development, design, marketing and procurement of packaging on how to design PET plastic packaging that works for your product and for our planet. [online] Johannesburg: PETCO, pp.1-25. Available at: <https://petco.co.za/wp-content/uploads/2019/08/PETCO_Design-for-Recyclability_Guideline-Document_2019_FINAL.pdf> [Accessed 23 January 2021].

Plastics Europe AISBL. 2012. *Plastic Packaging: Born to protect*. [online] Brussels: Plastics Europe, pp.1-17. Available at: https://www.plasticseurope.org/en/resources/publications/112-plastic-packaging-born-protect [Accessed 15 Jan. 2019].

Plastics Europe. 2018. Plastics – the Facts 2017, an analysis of European plastics production, demand and waste data. Brussels: Plastics Europe, pp.3-41.

Plastics Europe. 2019. An Analysis of European Plastics Production, Demand and Waste Data. Plastics – *the Facts 2019*. Düsseldorf: Plastics Europe.

Plastics SA. 2018. [eBook] *All about plastics.* pp.1-24. [online]. Available at: http://www.plasticsinfo.co.za/wp-content/uploads/2018/06/All-About-Plastics-May2018.pdf [Accessed 25 Feb. 2019].

Plastics SA. 2019. *End Plastic Pollution – South African Alliance.* [online] Available at: https://www.plasticsinfo.co.za/wp-content/uploads/2019/03/PLASTICS-SA-ANNOUNCES-POLLUTION-ALLIANCE_FINAL-2019.pdf [Accessed 11 Nov. 2019].

Plastics SA. 2019. *National plastics recycling survey 2018: Recycling is the realization of the plastics circular economy*. [online] Available at: https://www.plasticsinfo.co.za/recycling/ [Accessed 1 Nov. 2019].

Plastics SA, 2020. *The Development of a Section 18 ERP Plan.* Important industry update. [online] Plastics SA, pp.1-2. Available at: <https://www.plasticsinfo.co.za/wp-content/uploads/2020/07/ANTON_LETTER_EXPLAINING_EPR_SECTION_18_8.pdf> [Accessed 23 January 2021].

Radovic, L.R. & Schobert, H.H. 1997. *Energy and fuels in society: analysis of bills and media reports*. New York, McGraw-Hill. Chapter 8. www.ems.psu.edu/~radovic/Chapter8.pd

Raschka, A., Carus, M. & Piotrowski, S. 2013. Bio-Based Plastics. United Kingdom: John Wiley & Sons Ltd, pp.331–345.

Risch, S. 2009. Food Packaging History and Innovations. *Journal of Agricultural and food chemistry*, 57(18), pp.8089-8091.

Roberts, B. & Cohen, M. 2002. Enhancing sustainable development by triple value adding to the core business of government. *Economic Development Quarterly*, 16, pp.127-137.

Rosli, M. & Aziz, N. 2016. Simulation of ethane steam cracking with severity evaluation. *IOP Conference Series: Materials Science and Engineering*, 162(1), pp.1, DOI:10.1088/1757-899X/162/1/012017.

Roy, A. 2011. 'Integrated bottom line', in Cohen, N & Robbins, P (eds), *Green business: an a-to-z guide,* The SAGE References Series on Green Society: Toward a Sustainable Future, SAGE Publications, Inc., Thousand Oaks, CA, pp. 331, DOI: 10.4135/9781412973793.n93.

Sawtooth Software. 2004. Technical paper series. *The CPM System for Composite Product Mapping*. Washington: Sawtooth Software, Incorporated, pp.1-18.

Schweitzer, J.P. & Janssens, C. 2018. Overpackaging. Briefing for the report: *Unwrapped: How throwaway plastic is failing to solve Europe's food waste problem (and what we need to do instead)*. Institute for European Environmental Policy (IEEP), Brussels. A study by Zero Waste Europe and Friends of the Earth Europe for the Rethink Plastic Alliance, pp.2-4.

Schweitzer, J., Gionfra, S., Pantzar, M., Mottershead, D., Watkins, E., Petsinaris, F., Brink, P., Ptak, E., Lacey, C. & Janssens, C. 2018. *Unwrapped: how throwaway plastic is failing to solve Europe's food waste problem (and what we need to do instead).* Institute for European Environmental Policy (IEEP), Brussels. A study by Zero Waste Europe and Friends of the Earth Europe for the Rethink Plastic Alliance, pp.1-22.

Schweitzer, J.P., Petsinaris, F. & Gionfra, C. 2018 *Justifying plastic pollution: how Life Cycle Assessments are misused in food packaging policy*. Institute for European Environmental Policy (IEEP), Brussels. A study by Zero Waste Europe and Friends of the Earth Europe for the Rethink Plastic Alliance, pp.3-16.

Shantha, A. 2019. *Project Proposal for Post-Consumer Plastic Recycling Project*, DOI: 10.13140/RG.2.2.27442.04805.

Sherwood, J., Clark, J.H., Farmer, T.J., Herrero-Davila, L. & Moity, L. 2017. Recirculation: A new concept to drive innovation in sustainable product design for bio-based products. *Molecules,* 22(1), pp. 48.

Sidorov, D., Kolosova, E., Kolosov, A. & Shabliy, T. 2018. *Analysis of the preform blowing stage when obtaining a polymeric product using the extrusion blow moulding method*. Eastern-European Journal of Enterprise Technologies, 2(1 (92), pp.14-21, DOI: 10.15587/1729-4061.2018.126015

Silvertech. (n.d.). *Whitepaper: Mapping the Customer Journey*. Manchester: Silvertech incorporated, pp.4-21.

Siracusa, V., Ingrao, C., Giudice, A.L., Mbohwa, C. & Dalla Rosa, M. 2014. Environmental assessment of a multilayer polymer bag for food packaging and preservation: An LCA approach. *Food Research International*, 62, pp.151-161.

Siva, R., Naveed khan patan, M., Lakshmi pavan kumar, M., Purusothaman, M. Pitchai, S. & Jegathish, Y. 2017. Process improvement by cycle time reduction through Lean Methodology. *IOP Conference Series: Materials Science and Engineering*, 197, pp.12064.

Sonesson, U., Davis, J. & Ziegler, F. 2009. *Food Production and Emissions of Greenhouse Gases*. An overview of the climate impact of different product groups. Sweden: Swedish Institute for Food and Biotechnology, pp.1-21.

Song, J., Kay, M. & Coles, R. 2011. Bioplastics. In: R. Coles and M. Kirwan, ed., *Food and Beverage Packaging Technology*, 2nd ed. London: Blackwell Publishing Ltd, pp.295-319.

Speight, J.G. 2003. Thermal Cracking of Petroleum. In: Ikan R. (eds) Natural and Laboratory-Simulated Thermal Geochemical Processes. Springer, Dordrecht, DOI 10.1007/978-94-017-0111-2_2

Sridhar, K. & Jones, G. 2012. The three fundamental criticisms of the Triple Bottom Line approach: An empirical study to link sustainability reports in companies based in the Asia-Pacific region and TBL shortcomings. *Asian Journal of Business Ethics*, 2(1), pp.109.

Sroufe, R. 2017. Integration and organizational change towards sustainability. *Journal of Cleaner Production*, 162, pp.322.

Swann, C. 2002. Action Research and the Practice of Design. *Design Issues*, 18(2), pp.49-61.

Szusta, J., Tomczyk, A. & Karakaş, Ö. 2018. *A New Method for Estimating the Clamping Force of Shrink Sleeve Labels.* Materials, 11(12), p.2544, DOI: 10.3390/ma11122544.

United Nations. 2018. *State of plastics: World Environment Day Outlook 2018*. [online] United Nations, pp.3-13. Available at: https://www.unenvironment.org/resources/report/state-plastics-world-environment-day-outlook-2018 [Accessed 25 Feb. 2019[.

Vargas-Osorio, S. & Zúñiga, C. 2016. *Una revisión literaria del Problema de Carga del Pallet.* Lámpsakos, (15), pp.69, DOI: 10.21501/21454086.1790.

Wagemans, J., Feldman, J., Gepshtein, S., Kimchi, R., Pomerantz, J., Van der Helm, P. & Van Leeuwen, C. 2012. *A century of Gestalt psychology in visual perception: II. Conceptual and theoretical foundations*. Psychological Bulletin, 138(6), pp.1218-1252.

Walker, A. 1994. Plastics: The Building Blocks of the Twentieth Century. *Construction History, 10*, 67-88.

Whitehead, T. I. 2005. Basic classical ethnographic research methods: Secondary data analysis, fieldwork, observation/participant observation and informal and semi-structured interviewing, ethnographically informed community and cultural assessment research systems (EICCARS) Working Paper Series, *CEHC Cultural Ecology of Health and Change*, pp.2-24.

Williams, D., Gerba, C., Maxwell, S. & Sinclair, R. 2011. Assessment of the Potential for Cross-contamination of Food Products by Reusable Shopping Bags. *Food Protection Trends*, 31(8), pp.508–513.

World Commission on Environment and Development. 1987. *Our Common Future*. [online] New York: United Nations, pp.15. Available at: <https://digitallibrary.un.org/record/139811?ln=en> [Accessed 4 October 2019].

World Watch Institute. 2011. Online publication on *Bottle water consumptions and PET bottles.* (Online) Available at: www.worldwatch.org/node/5475.

Valavanidis, A., 2018. *Concept and Practice Of The Circular Economy*. Athens: National and Kapodistrian University of Athens, pp.2-7.

Van den Oever, M., Molenveld, K., Van der Zee, M. & Bos, H. 2017. *Bio-based and biodegradable plastics – Facts and Figures*. Wageningen: Wageningen Food & Biobased Research, pp.15-65.

Verghese, D., Lewis, D., Lockrey, S. & Williams, D. 2013. *The role of packaging in minimising food waste in the supply chain of the future*. Melbourne: RMIT University, pp.6-45.

Zsíros, L. Török, D. & Kovács, J. 2017. *The Effect of Masterbatch Recipes on the Homogenization Properties of Injection Moulded Parts.* International Journal of Polymer Science, 2017, pp.1-7, DOI: 10.1155/2017/5745878.

Zuber-Skerritt, O. 2001. Action Learning and Action Research: Paradigm, Praxis and Programs. In: S. Sankara, B. Dick and R. Passfield, ed., *Effective Change Management through Action Research and Action Learning: Concepts, Perspectives, Processes and Applications*. Lismore, Australia: Southern Cross University Press, pp.1-20.

Appendix A – Participant consent form

Participant Consent Form

“Sustainability through Design: A triple bottom line approach to disposable food and beverage plastic packaging”

I………………………………………………..… voluntarily agree to participate in this research study.

- I understand that even if I agree to participate now, I can withdraw at any time or refuse to answer any question without any consequences of any kind.
- I understand that I can withdraw permission to use data from my interview within one month after the interview, in which case the material will be deleted.
- I have had the purpose and nature of the study explained to me in writing and I have had the opportunity to ask questions about the study.
- I understand that participation involves giving my honest and unbiased opinion on disposable water bottles and all the circumstances surrounding it.
- I understand that I will not benefit directly from participating in this research.
- I agree to my interview being audio-recorded.
- I understand that all information I provide for this study will be treated confidentially.
- I understand that in any report on the results of this research my identity will remain anonymous. This will be done by changing my name and disguising any details of my interview which may reveal my identity or the identity of people I speak about.
- I understand that disguised extracts from my interview may be quoted in the researchers’ dissertation, conference presentation, published papers or interviews.
- I understand that signed consent forms and original audio recordings will be retained on the researchers’ laptop, to which only she has access to.
- I understand that a transcript of my interview in which all identifying information has been removed will be retained for the duration of the researchers’ study.
- I understand that under freedom of information legalisation I am entitled to access the information I have provided at any time.
- I understand that I am free to contact any of the people involved in the research to seek further clarification and information.

Researcher Contact details:

Name & Surname: Minette Maritz

Cell phone number: +27 71 861 7356

Email address: minettemaritz747@yahoo.com

Signature of research participant

--- ----------------

Signature of participant Date

Signature of researcher

I believe the participant is giving informed consent to participate in this study

-- ----------------------

Signature of researcher Date

Appendix B – People: Quantitative survey

Considerations when purchasing bottled water.

Thank you for taking part in my survey. This survey is completely anonymous, and the data collected will specifically and only be used for the fulfilment of my master's thesis. This survey has been set up to view how the user interacts with disposable plastic water bottles, to show their preferences and needs.

1. Bottled water is either mineral water (water from a mineral spring) or filtered water (water which is cleaned using a chemical or biological process). Which type of water do you prefer? You can choose more than one.

    a) Still - Mineral
    b) Still - Filtered
    c) Sparkling - Mineral
    d) Sparkling – Filtered

2. Which drinking method do you prefer?

    a) Twist cap
    b) Sipping spout

3. Do you consider any of these logos when purchasing bottled water? Please select which ones.

    a) Plant bottle
    b) BPA free
    c) Bioplastic
    d) Compostable plastic
    e) Recyclable
    f) PLA plastic
    g) RPET plastic
    h) PET plastic
    i) None

4. How important is the price of the bottled water?
   a) Extremely important
   b) Very important
   c) Somewhat important
   d) Not so important
   e) Not at all important

Please explain why?

____

5. Which shaped bottles do you find the most desirable? Please select a maximum of four:
   a) Dumbbell shape
   b) Thin gripped shape
   c) Curved shape
   d) Fat gripped shape
   e) Straight shape
   f) Square shape
   g) Long neck shape

6. Describe in your own words: What do you look for when purchasing disposable water bottle and why do you find certain bottles or shapes more appealing than others?

____

7. Which volume of water do you prefer to purchase for everyday use?
   a) 250ml
   b) 500ml
   c) 750ml
   d) 1 litre
   e) 1.5 litre
   f) Other

If other, please specify the amount?

____

8. What are the most important features of the bottle that would make you purchase it? Please select a maximum of four:
   a) Usability
   b) Design
   c) Price
   d) Brand
   e) Taste
   f) Must fit into the car cup holder
   g) Popularity
   h) Other

Please specify why?

____

9. What happens to your water bottle after it has been used?
   a) Lay's in the back of my car
   b) Gets thrown in any garbage bin
   c) Gets thrown in a recycling bin
   d) I refill it
   e) I use it for gardening
   f) I use it for other tasks around the house
   g) Other

If other, please specify why?

____

10. Does the strength of the bottle bother you? Do you prefer a thinner or thicker bottle consistency?
   a) Thick and strong bottle
   b) Thin and weak bottle

Appendix C – People: Qualitative survey and voice recording questions

Field research interview: **PEOPLE**

Thank you in advance for taking part in this research.

This research is an investigation into the design and sustainability of disposable water bottles throughout the manufacturing process and its entire life cycle. The aim is to understand how the disposable water bottle is perceived through the eye of the consumer (**people**), its financial implications (**profit**) and how it affects the environment (**planet**). In conclusion, a solution which considers the interplay of all these aspects within the sphere of disposable water bottles will be proposed.

This research requires the participant to complete two sets of questions: firstly (a), written questionnaire, and secondly (b), they need to record a two-part voice file in which the participant answers an additional questionnaire.

The **first questionnaire** (write up section) contains six questions. The participant is required to complete this section as thoroughly as possible within the space provided. If the participant is unsure how to answer the question, please read the grey information underneath each question for guidance.

The **second questionnaire** (voice file) contains nine questions which is split into two parts. For the first part of this section, the participant is asked to visit a store which sells disposable water bottles, and record a voice note. In the voice note, the participant is asked to describe their thought process about how and why they decide to purchase a specific plastic water bottle.

In the second part of this question, the participant is asked to create an additional voice note. For this part, the participant is not required to be in the shop, but can answer these questions at any time. The participant is asked to explain what happens to the bottle after the bottle has been used.

If you agree to take part in this research, please complete and sign the consent form on the following page.

a) Questionnaire: WRITE UP

Please follow these steps carefully when completing this questionnaire:

- Please give a detailed answer to each question
- If you have any other comments or recommendations, please feel free to add them after you have answered the question

1. Please specify your age bracket? (**Please specify:** 20-24; 25-29; 30-34; etc.)

____

____

2. Why do you purchase bottled water? (**Please specify:** What causes you to make the decision; health benefit, warm day, don't drink tap water, etc.)

____

____

3. Do you think there is an alternative to disposable plastic water bottles? (**Please specify:** Why do you think so and what would you suggest)

____

____

4. When purchasing water, do you drink the water immediately or take it somewhere? (**Please specify:** If not drinking it immediately, where are you taking it and why?)

____

____

5. Do you consider whether the bottle is recyclable before choosing it? If yes, which factors do you consider? (**Please specify:** does it have sustainable logos at the back; compostable, biodegradable, etc.)

____

____

6. Please elaborate on question 5, what caused you to consider whether it was recyclable or not? (**Please specify:** Why did or didn't you find it important)

---

7. How do you decide which water bottle to choose? (**Please specify:** Price, taste, material composition, shape, etc.)

Additional Notes:

---

b) Questionnaire: VOICE NOTE

Please follow these steps carefully when creating your voice file:

- When making the voice note, please read the question number and question carefully, followed by your answer
- Please give a detailed answer to each question
- If you have any other comments or recommendations, please feel free to add them after you have answered the question

Please complete instore when purchasing your water:

1. What is the first thing you notice about the different water bottles on the shelf? (**Please specify:** Shape, colour, brand, material composition, etc.)
2. Which bottle did you choose, please describe the bottle (**Please specify:** brand, sparkling/mineral/filtered, shape of bottle, thick/thin bottle, number of millilitres, etc.)
3. How does your chosen bottle feel in your hand? (**Please specify:** Is it strong or does it collapse when you press the sides, does it have a smooth or rough finish, etc.)

4. What is the price of the bottle you chose? (**Please specify:** Did this affect your choice and why?)

Please complete when you have a moment to yourself:

5. Your water bottle is now empty, what will you do with it? (**Please specify:** Do you leave it in the car, refill it, reuse it at home, dispose of it)
6. Please refer to question 5, what caused you to make this decision? (**Please specify:** Why did you not do it differently?)
7. Please refer to question 6, do you normally follow the same pattern? (**Please specify:** Do you sometimes do one thing and other times another. If so, please explain what you do and why)
8. What would cause you to make a different decision regarding the disposal or reusability of the bottle? (**Please specify:** Would you change your behaviour if you knew it was bad or if there was a better alternative? Please explain how and why)

Appendix D – Profit: Interview questions

Field research interview: **PROFIT**

Thank you in advance for taking part in this research.

This research is an investigation into the design and sustainability of disposable water bottles throughout the manufacturing process and its entire life cycle. The aim is to understand how the disposable water bottle is perceived through the eye of the consumer (**people**), its financial implications (**profit**) and how it affects the environment (**planet**). In conclusion, a solution which considers the interplay of all these aspects within the sphere of disposable water bottles will be proposed.

This section of field research has three sets of interview questions. Section A will be introductory questions regarding the interviewee. Section B consists of questions which is applicable to the before stage of the design process of the disposable water bottle. Finally, section C will focus on what happens once the bottle is finally produced.

If you agree to take part in this research, please read and sign the consent form on the following page.

a) Introduction:

1. Please state your occupation?
2. Please state how many years you have worked in the plastics packaging industry?

b) Before:

1. How does the weight of the product affect the price?
2. Do you think the weight of a bottle makes it more exclusive?
3. What is the most expensive and the most affordable materials? Why?
4. How does the shape of the plastic bottle/jar affect the price?
5. Does the number of units ordered affect the price?
6. How important is shelf presence to a customer? (**Specify:** placement etc.)
7. Do you think the shelf presence affects the number of products being sold?

c) After:

1. Through what tests does the bottle go after production? (**Specify:** drop/leak test etc.)
2. Does the different kind of tests come at a cost?
3. How does the transportation of the product affect the cost?

4. What is the difference in price between long and short haul trips?
5. Is it cheaper to label or sleeve a bottle? Why would you say that?

Do you believe that there are any additional questions that should be asked regarding the subject, and is there anyone you can recommend that has expertise in this area whom I should also interview?

Appendix E – Planet: Interview questions

Field research interview: **PLANET**

Thank you in advance for taking part in this research.

This research is an investigation into the design and sustainability of disposable water bottles throughout the manufacturing process and its entire life cycle. The aim is to understand how the disposable water bottle is perceived through the eye of the consumer (**people**), its financial implications (**profit**) and how it affects the environment (**planet**). In conclusion, a solution which considers the interplay of all these aspects within the sphere of disposable water bottles will be proposed.

If you agree to take part in this research, please complete and sign the consent form on the following page.

Introduction:

1. Please state your occupation?
2. Please state how many years you have worked in the plastics packaging industry?

For this part of my research, I divided the lifecycle of a plastic bottle and its effect on the environment into two phases. The first interaction phases are from extraction to production and the second phase, from disposal to being recycled.

b) Main questions:

1. What is your take on the *single use plastics* debate?
2. How do you think the extraction to production phase of plastics can be optimised?
3. Do you think alternatives like producing plastics from renewable plant-based sources is a better option than from crude oil? Please clarify?
4. What is your opinion on the disposal and recycling of plastics and its effect on the environment?
5. Do you think there is a future for plastic recycling in South Africa?
6. How could *circular economy* be the solution to dealing with this challenge?
7. What would you say are the biggest issues in the value chain of recycling plastics?
8. What role do you think the consumer plays in the recycling of plastics? And how can they be made more aware to recycle it?
9. What is your take on PET bottle weights? It makes it more profitable to recycle, but if it is not recycled, then its environmental footprint is much larger.

10. Do you think the recycling process can be optimised? If so, how?
11. Do you think a bottle can be designed to help consumers understand the need for change in the industry? If so, please specify?
12. Do you believe there is something beyond the *Circular Economy* that we are yet to innovate and achieve? If so, what do you think this will be?
13. How should a packaging business respond to the threat of consumer pressure and *single use packaging* legislation?
14. Do you think that product design can aid to ensure a smaller environmental footprint throughout the entire life cycle of plastic bottle production? If so, how?

Do you believe that there are any additional questions that should be asked regarding the subject, and is there anyone you can recommend that has expertise in this area whom I should also interview?

Appendix F – Participant codes

Participant	Participation in Data Collection Method 1	Participation in Data Collection Method 2 (if applicable)	Assigned code	Additional comment
Participant 1	Survey	N/A	SU01	Participated in qualitative question.
Participant 2	Survey	N/A	SU02	Participated in qualitative question.
Participant 3	Survey	N/A	SU03	Participated in qualitative question.
Participant 4	Survey	N/A	SU04	Participated in qualitative question.
Participant 5	Survey	N/A	SU05	Participated in qualitative question.
Participant 6	Survey	N/A	SU06	Participated in qualitative question.
Participant 7	Survey	N/A	SU07	Participated in qualitative question.
Participant 8	Survey	N/A	SU08	Participated in qualitative question.
Participant 9	Survey	N/A	SU09	Participated in qualitative question.
Participant 10	Survey	N/A	SU10	Participated in qualitative question.

Participant 11	Survey	N/A	SU11	Participated in qualitative question.
Participant 12	Survey	N/A	SU12	Participated in qualitative question.
Participant 13	Survey	N/A	SU13	Participated in qualitative question.
Participant 14	Survey	N/A	SU14	Participated in qualitative question.
Participant 15	Survey	N/A	SU15	Participated in qualitative question.
Participant 16	Survey	N/A	SU16	Participated in qualitative question.
Participant 17	Survey	N/A	SU17	Participated in qualitative question.
Participant 18	Survey	N/A	SU18	Participated in qualitative question.
Participant 19	Survey	N/A	SU19	Participated in qualitative question.
Participant 20	Survey	N/A	SU20	Participated in qualitative question.
Participant 21	Survey	N/A	SU21	Participated in qualitative question.
Participant 22	Survey	N/A	SU22	Participated in qualitative question.

Participant 23	Survey	N/A	SU23	Participated in qualitative question.
Participant 24	Survey	N/A	SU24	Participated in qualitative question.
Participant 25	Survey	N/A	SU25	Participated in qualitative question.
Participant 26	Survey	N/A	SU26	Participated in qualitative question.
Participant 27	Survey	N/A	SU27	Participated in qualitative question.
Participant 28	Survey	N/A	SU28	Participated in qualitative question.
Participant 29	Survey	N/A	SU29	Participated in qualitative question.
Participant 30	Survey	N/A	SU30	Participated in qualitative question.
Participant 31	Survey	N/A	SU31	Participated in qualitative question.
Participant 32	Survey	N/A	SU32	Participated in qualitative question.
Participant 33	Survey	N/A	SU33	Participated in qualitative question.
Participant 34	Survey	N/A	SU34	Participated in qualitative question.

Participant 35	Survey	N/A	SU35	Participated in qualitative question.
Participant 36	Survey	N/A	SU36	Participated in qualitative question.
Participant 37	Survey	N/A	SU37	Participated in qualitative question.
Participant 38	Survey	N/A	SU38	Participated in qualitative question.
Participant 39	Survey	N/A	SU39	Did not participant in qualitative question.
Participant 40	Survey	N/A	SU40	Did not participant in qualitative question.
Participant 41	Survey	N/A	SU41	Did not participant in qualitative question.
Participant 42	Survey	N/A	SU42	Did not participant in qualitative question.
Participant 43	Interview (*people* focused)	Survey (*people* focused)	AP001	N/A
Participant 44	Interview (*people* focused)	Survey (*people* focused)	GM002	N/A
Participant 45	Interview (*people* focused)	Survey (*people* focused)	RO003	N/A

Participant 46	Interview (*people* focused)	Survey (*people* focused)	RB003	N/A
Participant 47	Interview (*profit* focused)	N/A	SR001	Key account manager in FMCG with 13 years' experience
Participant 48	Interview (*profit* focused)	N/A	PJ002	Key account manager in FMCG with 30 years' experience
Participant 49	Interview (*profit* focused)	N/A	RB003	Senior CAD Designer in FMCG with 11 years' experience
Participant 50	Interview (*planet* focused)	N/A	AP2004	Polymer scientist with 31 years' experience

Appendix G – Participant feedback

User feedback: **PEOPLE**, **PROFIT**, **PLANET**.

Thank you in advance for taking part in the final, user feedback section of this research.

Final bottle design

Through analysing and coding both primary and secondary data, two final bottles were designed: a 750ml and 1500ml.

The bottle specifications for the 750ml bottle include:

- Height: 230mm
- Weight: 31g
- Width: 75mm

The bottle specifications for the 1500ml bottle include:

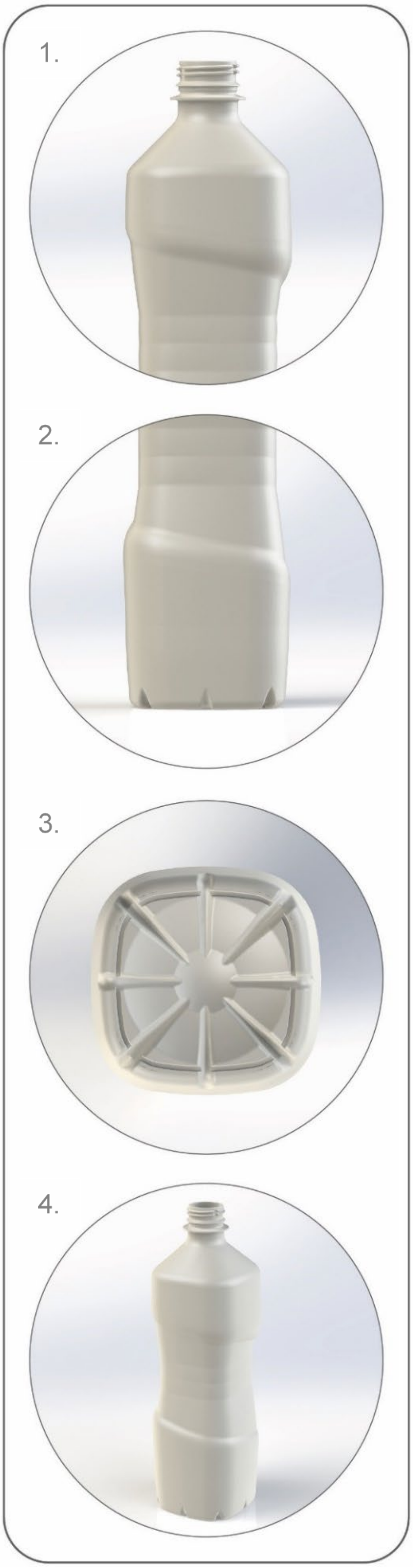
- Height: 295mm
- Weight: 39g
- Width: 91mm

Both bottles use the same neck finish which are used by all market leader bottles: 28mm PCO1881 neck. Using the same neck will ensure changeability throughout all brands, to aid in decreasing overall manufacturing needs.

On the next two pages, you will find the design specifications for both the 750ml and 1500ml design. The third page includes pictures of the final bottles, with a shrink sleeve label.

Action:

After thoroughly looking at the images, please state your opinion of the two bottle designs. Please wright a minimum of two sentences about each bottle, describing your thoughts and comments about it.



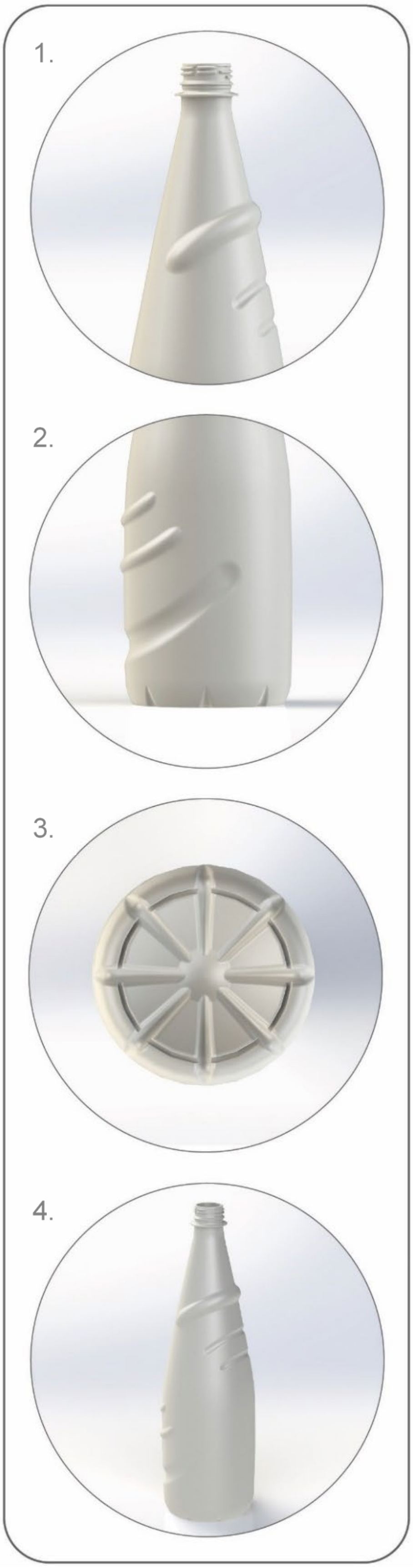
750ml design

This first image shows the sweeping rib, which wraps around the bottle is a cylindrical shape. This design decision was made to increase the overall strength of the bottle. The midsection of the bottle contracts inward to allow for a better grip. Although this bottle is square, it has no straight or flat panels. The square shape is better for packing and pellet utilisation, adhering to both *profit* and *planet* requirements.

In both image one and two, notice how the sweeping rib is convex and the middle section concaves. This was done to ensure overall strength of the bottle whilst also indicating how the bottle should be held for optimum comfort. All panels on this design has a small radius, to increase overall top load strength.

Image three shows the base design. All current market leaders for still water has a similar base design, the new base was designed with the same elements. The increased number of ribs on the base will decrease the overall weight of the bottle.

Image four shows the overall design of the new concept bottle. The square shape would allow this bottle to look different. This speaks to the *people* data. The new proposed bottle will thus stand out next to its competitors as all current market leader bottles are round.



1500ml design

The proposed bottle will have an asymmetric rib pattern at both the top and bottom of the bottle. The top will consist of one large convex rib and two, smaller ribs which concave. The top part of the bottle is very elegant and smooth, following the shape of a glass bottle. What makes this concept different is the radius that was added to the side panels, to increase strength and add volume.

The rib pattern on the bottom has the opposite rib profile as the top. These rib profiles were added to increase the overall strength of the bottle without the ribs being too noticeable. The straight edges on the bottom of the bottle also has a small radius, for increased strength.

Like the 750ml concept base, this base also has 8 ribs. Increasing the amount of ribs in the base, allows the bottle to be made with a lighter preform.

Image four shows the overall design of the new concept bottle. The cone shape would allow this bottle to look different from its competitors. Another feature that would make this bottle stand out among its competitors is its asymmetric rib profiles.

750ml and 1500ml designs: