REVERSE LOGISTICS FRAMEWORK FOR PET BOTTLES

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Abstract
Reverse logistics (RL) is an engineering strategy used by manufacturing companies to develop environmental sustainability through recycling. The result of not having appropriate legislation and frameworks in Zambia, specific to RL for plastic bottles, huge volumes of Polyethylene Terephthalate (PET) bottles are dumped on the Environment. Only 30% of the waste generated, in Zambia, is collected for disposal in dumpsites and the remaining 70% is not recovered. Of the 30% waste collected, there is no data to indicate the exact amount of PET bottles disposed.

This paper focuses on analyzing RL activities performed by beverage manufacturing companies in conjunction with community involvement. Examining the regulations set by the regulatory bodies in monitoring waste management issues. Three separate questionnaires are issued, one for the beverage companies, one for the regulatory body and one for the municipality. Structured interviews and direct observations were also used. The results indicate that, RL of PET bottles is not practiced by the beverage companies. However the companies recognize the importance of recycling PET plastic bottles and have printed symbols of recycling on their bottles. Measures taken to protect the environment indicate regulations from the regulatory body are in place though not effectively enforced on PET plastic waste This paper focuses on analyzing the data collected via the three tier questionnaires and providing some insights into options to implement RL, within the Zambian constraints. A Container Deposit logistics Refund Legislation (CDRL) framework was developed and proposed for use in the recovery of PET bottles and any other recyclables

Keywords
Reverse Logistics, PET Waste Bottles, Recycling, Waste Management

Introduction
Several million tonnes of plastics produced every year are used for packaging materials and almost any type of consumer product (Papong, Malakul, Trungkavashirakun, Wenunun, Chom-in, Nithitanakul, 2014; Blanco, 2014). Post initial use, packaging material (PET bottles) become waste which is later disposed to the environment. With the global consumption of Polyethylene Terephthalate (PET) packaging forecasted to reach 19.1 million tonnes by 2017, with a 5.2% increase per annum between 2012 and 2017 (Smithers Pira organization, 2012). Bottles for water, carbonated soft drinks, and other beverages account for 83–84% of global PET resin demand (Information Handling Services, 2012). The huge increase in plastic consumption, has led to various issues such as environmental pollution, health concerns for scavengers and low utilization for this reclaimed waste (Michiko, 2004). According to Rubio, Chamorro & Miranda (2008), research on strategic aspects of reverse logistics is scarce. Besides, very few attempts in the supply chain research area are conducted to study reverse and recycling supply chains (Wong 2010). Formigoni and Rodrigues (2009), and Coelho (2011) studied the recycling collection system and found that PET bottles in Brazil are entirely recycled by informal sectors, and that the main problem of the reverse chain is selective collection. Zhang and Wen (2014) studied the consumption and recycling of collection system of PET bottles and find that, 90% of the post consumed PET bottles were collected by the informal collectors and were reprocessed by small factories and the main problem was merging the two sectors (informal and formal) into the formal sector. The Smithers Pira organization (2012) report, which forecasted global PET packaging usage in 2017, found that collection and recycling are key issues along the PET supply chain even though there seems to be a lack of emphasis and research on the management of the End of Life (EoL) of disposable soft drink plastic bottles (WRAP,

2009c). With such limited research on PET bottle recycling and reverse logistics, it was imperative to conduct such a study in Lusaka, Zambia.

Zambia is a developing nation with a growing consumer market for PET bottles. However, despite having a number of legislations, there are no specific laws or regulations determining responsibility for manufacturing, collection, recycling and final deposal of plastic waste. According to GTZ/CWG (2007) only 9% of the waste generated in the city of Lusaka (Zambia) is recovered while the remaining 91% is unrecovered. Further, World Bank (2012) reported that in Africa only 4% of the waste generated is recycled while, 47% is dumped in the open. The increase in the amount of unrecovered waste for recycling and final disposal has greatly contributed to land pollution (**Exhibit 1**). This study analyses in an integrated manner, the best alternatives to improve the recycling system by examining the beverage PET bottling industry reverse logistics system. Existing environmental and waste management legislations and regulations are also be examined. The following research questions are be addressed: (1) Are companies in the beverage industry practicing RL? (2) What are the different types of plastic (PET) recycling processes? (3) What effective RL frameworks can be used by beverage manufacturing companies to promote PET recovery? (4) What are the drivers to implementing RL? (6) Are there any measures taken to reduce environmental degradation caused by PET bottles?

Exhibit 1. Land and Visual Pollution caused by PET Plastic waste (Lusaka, 2015)

Literature Review

PET Plastic Waste Recycling

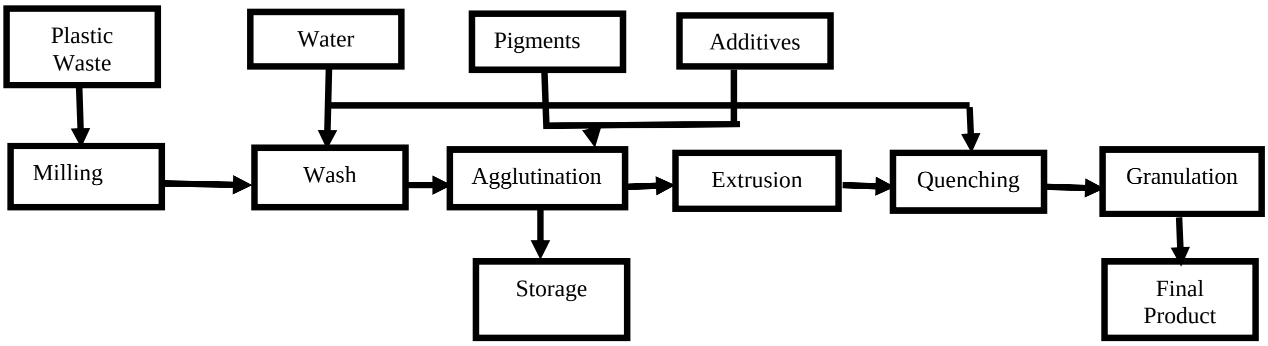
Plastic waste recycling is recommended as a means to sustainable waste management. The primary aim is to lessen environmental damage and achieve environmental sustainability. Recycling can save energy, conserve resources, reduce emissions from incinerators and prolong life spans of the landfills (Tsai, 2008). Polyethylene Terephthalate (PET) bottles have experienced rapid growth since the 1970s when the technique of blow moulding was introduced (Glenz, 2007). In the area of waste recycling, PET recycling has continued to receive considerable attention due to the main environmental benefits which are acknowledged throughout the world and make it one of the most successful and cleanest waste-recovery processes (Badia, Strömberg, Karlssonb & Ribes-Greus, 2012). Recycling PET has become a well-established system with its own logistic chain including bottles collection, flake production and pellet production (Shen, Worrell and Patel, 2010).

Two types of recycling processes are in use, (Manzini and Vezzoli, 2005); closed loop recycling and open loop recycling. In closed loop recycling, recovered materials are used in place of virgin materials to make the same products whereas in open loop recycling the product is different from the recovered material. In the case of PET bottles, closed and open loop recycling processes can be used. Whether the open-loop or closed-loop recycling system is used, PET plastic recycling begins with PET collection.

Technically four categories of recycling processes exist, primary (mechanical reprocessing into a product with equivalent properties), secondary (mechanical reprocessing into products requiring lower properties), tertiary (recovery of chemical constituents) and quaternary (recovery of energy), (Hopewell, Dvorak & Kosior, 2009)

According to Al-Salem, Lettieri & Baeyens, 2009, primary recycling focuses on re-introducing scrap or single polymer edges and parts to the extrusion cycle in order to produce products of the similar material. Mechanical recycling can only be performed on single-polymer plastic thus the more complex and contaminated the waste, the more difficult it is to recycle it mechanically (Al-Salem, Lettieri & Baeyens, 2009). Despite this, a number of products found in our daily lives come from mechanical recycling processes. **Exhibit 2** depicts the processes involved in mechanical recycling.

Exhibit 2. Mechanical recycling steps (Aznar et al. 2006)



Reverse Logistics

Reverse logistics has become an important source of opportunity for companies to improve visibility and profitability and lower costs across the supply chain (Chiou, Chen, Cheng, & Chung, 2012; Frota-Neto, Bloemhof-Ruwaard, Van Nunen & Van Heck., 2008). Wong (2010) explains that since the 1990s, there has been an increasing effort to examine the best ways to reduce congestion, conserve resources, reduce emission, and recycle in logistical activities. With this scenario in mind, companies have developed concern for waste generated from their post-consumption products, whose return needs to be considered to enable them provide a business opportunity through reverse logistics.

Rogers and Tibben-Lembke (2001) define reverse logistics as “the process of planning, implementing, and controlling the efficient, cost-effective flow of raw materials, in-process inventory, finished goods, and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal.” While Dekker, Pappis, Stavros & Tsoulfas, (2003) defined it as “the process of planning, implementing and controlling flows of raw materials, in process inventory, and finished goods, from a manufacturing, distribution or use point, to a point of recovery or point of proper disposal”. In these definitions, the perspective on RL keeps the essence of the definition as put forward by Rogers and Tibben-Lembke (2001). Tibben-Lembke (2002) further stresses that, many companies are beginning to understand the importance of reverse logistics and how to best manage it as its goal is to recapture waste and unwanted or unusable products and as such logistics systems may generate cost savings for companies (Schwartz 2000, Shear 1997). The essence of RL is to ensure smooth flow of materials and therefore this process should be sustainable as it deals with much more important issues than simple returns. Understanding and applying the concepts of RL in the Zambian context particularly in the PET beverage industry would add value to the EoL PET waste and contribute to sustainable resource recovery.

Types of RL Systems

The goal of RL frameworks is to propose a basis for implementing or reviewing a RL system. There are two types of RL systems classified on the basis of the degree of the openness in its network, open-loop and closed-loop systems (Singh, Singh & Walia, 2011).

In closed-loop logistics the used products return back to the original producer. It is a key component of world class recycling and sustainability initiatives. **Exhibit 4** illustrates the closed-loop RL system. In open-loop logistics used products is be recovered by other parties. **Exhibit 3** illustrates the open-loop RL system

Considering the recycling activities in Zambia, studying the RL systems contributes to the development of the appropriate type of RL in the Zambian contest. Therefore studying the two types of RL systems is relevant as the information obtained is be used in the development of an effective RL system.

Exhibit 3. Open-Loop System (Singh, Singh and Walia, 2011)

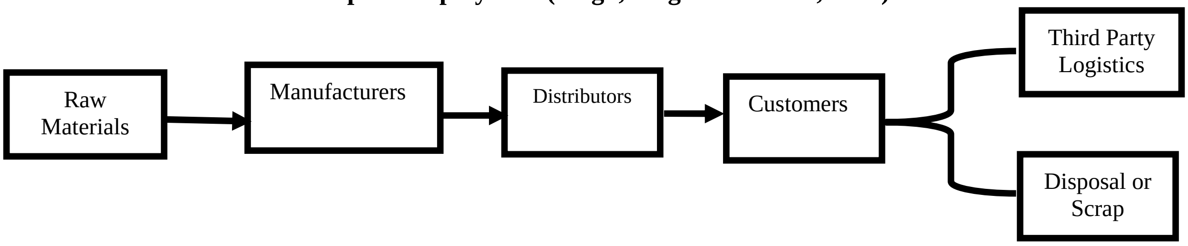
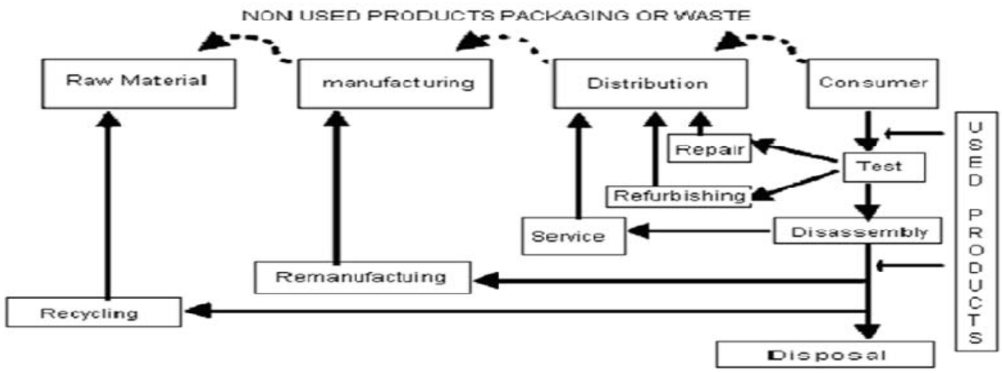


Exhibit 4. Closed- loop System (Singh, Singh & Walia, 2011)



Drivers in Reverse Logistics

According to Srivastava (2008), RL has three drivers and these are government legislation, economic value to be recovered in the returned product and environmental concerns. These driving forces differ in each country of application but the relevance is the same. In most developed countries with strict government regulations, application of RL has been successful. Japan with the highest recycling rate of PET bottle among developed countries established CPBR in 1993 (Zhang and Wen (2014. Extended producer responsibility has become a key element of public environmental policy in several countries. In this approach, manufacturers and customers are obliged to take back and recover their products after use in order to reduce volumes of waste disposal.

Economic factors act as the second motivation for implementing RL (Lambert, Riopel & Abdul-Kader, 2011). Fleischmann, Krikke, Dekker, Flapper, (2004) eludes that product flows in today's supply chains do not end once they have reached the customer. Many products lead a second and even third or fourth life after having accomplished their original task at their first customer. Consequently, a product may generate revenues multiple times, rather than a single time. Capturing this value requires the broadening of the supply chain perspective to include new processes, known as 'Reverse Logistics (RL)', as well as multiple interrelated usage cycles, linked by specific market interfaces. It represents one of the largest and most overlooked opportunities to facilitate and return profits to a company. Currently, very few companies are doing a good job in addressing this issue in the beverage industry and Zambia is an example.

Methods and Materials

The propositions in this paper was investigated using a qualitative research approach. Descriptive research design was aimed at determining the status of the companies and the local authorities in terms of regulation, legislation and current practices. Research data was collected using structured questionnaires and direct observations.

Questionnaires

Three types of questionnaires were designed; for the beverage bottling industries, for a regulatory body (Zambia Environmental Management Authority) and for Lusaka City Council (LCC). Separate questionnaires were used as the research concerns for beverage companies, regulatory bodies and LCC were different.

Purpose of the Beverages Companies Questionnaire. The questionnaires distributed to the beverage companies focused on determining the following; whether the beverage companies were practicing RL; Quantity of production volumes of PET packaged products; the type of plastic (PET) production or recycling system used; and what drove these companies to practise R.L. The purpose of determining whether the beverage companies were practicing any form of RL was to further determine how it was practiced, the drivers behind practicing and the type of RL system used. There are many reasons why products are returned and why companies engage in reverse logistics. Some of the reasons are; economic profits from direct gains such as; input materials, cost reduction, value added recovery and indirect gains such as; market protection, green image, improved customer/supplier relations; legislations; corporate citizenship and other products are returned because they do not function properly or because their function is no longer needed. All these reasons were assessed in the questionnaire in order to determine why the companies practiced or did not practice RL. The type of RL systems used was also assessed. For those companies that practiced RL, the researchers assessed the factors that influenced them to practice RL. The sole purpose of determining the type of plastic production or recycling system, was to understand the type of raw materials used in the production of PET and who the major suppliers of those raw materials were. It was necessary to determine the type of PET production or recycling system in order to understand where RL aspects fitted in. The existence of environmental and waste collection policies in the companies under study was also investigated.

Purpose of Regulatory Body (Zambia Environmental Management Agency, ZEMA) Questionnaire. For the regulatory body (ZEMA), the researchers questioned whether the current Producer Responsibility Measures Clause in the Environmental Protection and Pollution Control Act applied to the producers of PET bottled products or there were separate regulations or laws that compel producers of beverage products to be responsible for their EoL PET products. The researchers further investigated the challenges facing the regulatory body to fully implement the laws and whether application of RL could contribute to the alleviation of the many problems facing the body especially environmental degradation caused by illegally disposed of PET plastic waste.

Purpose of the Lusaka City Council (LCC) Questionnaire. For LCC, the researchers assessed the waste collection methods used, whether the scavengers or waste buyers were part of the waste collection system. Further RL was explained to LCC in order for the researchers to determine whether LCC could support RL systems.

Direct observations

These were conducted to observe the surroundings in Lusaka city and how the recyclers collected their PET bottles.

Sampling and Methodology

The sample size of the beverage bottling companies was determined using purposive sampling and seven (7) companies were selected. Purposive sampling was used based on the fact that the companies selected provided a good representation of the population.

A total of 7 beverage manufacturing companies were sampled out of 28. A sampling intensity of 25% was used as it minimizes the sampling error. According to Struwig & Stead (2010), 25% sampling intensity is recommended and acceptable for selecting samples from each population. The representative sample was based on Boyd formula, equation (1) is shown below.

$$\frac{n}{N} \text{ X } 100 = C \qquad (1)$$

Where;

C = Represents a figure greater or equal to 5% of the target population.

N = Overall population

n = Sample size

Determined Sample size:

$$n = 28 \text{ X } 25/100$$
$$n = 7$$

Out of the nine institutions which comprised of two regulatory bodies and seven companies, two regulatory bodies responded while only five companies responded positively by allowing plant visits. 66.7% was the response rate from the questionnaires.

Results and Discussion

Results from Company Questionnaire

Production Volume of PET Bottles. The beverage companies were categorized into large-scale, medium-sized and small-sized companies. Categorization of the companies into large, medium and small was based on the volume of production. From the number of companies that were investigated, only 5 companies responded positively. Two large companies, two medium sized companies and one small company.

Exhibit 5 below illustrates the production volume and mass of PET bottled beverages from the categorised beverage companies that participated in the research. The results in the table below illustrates that, 17 103 166 liters of PET bottled beverages are produced for consumption on a monthly basis from the five companies. In a period of one year, 205 237 992 liters of PET bottled products are produced. According to the Incom Company, 1 tonne is equal to 40 000 PET bottles in Beijing (unpublished results). Using this figure, we can estimate the amount of PET bottles on the market to be 8 209 519 680 PET bottles per year in Lusaka. However there are limitations when estimating the consumption of PET bottles. The figure (8,209,519,680 PET bottles) was calculated based on data from only five companies and if the researchers were able to obtain data from all the beverage companies in Lusaka, the figure would increase. The researchers did not consider all the companies and also not consider the number of returns. Despite the limitations, the results provides preliminary insights into the amount of PET bottles available for recycling.

Exhibit 5. PET Bottled Beverage Production Volume (Liters) (Company Records, 2015)

Category	Production Volume (liters)	
	Daily	Monthly
Large	469 079	12 196 056
Medium	176 735	4 595 110
Small	12 000	312 000
Total	657 814	17 103 166

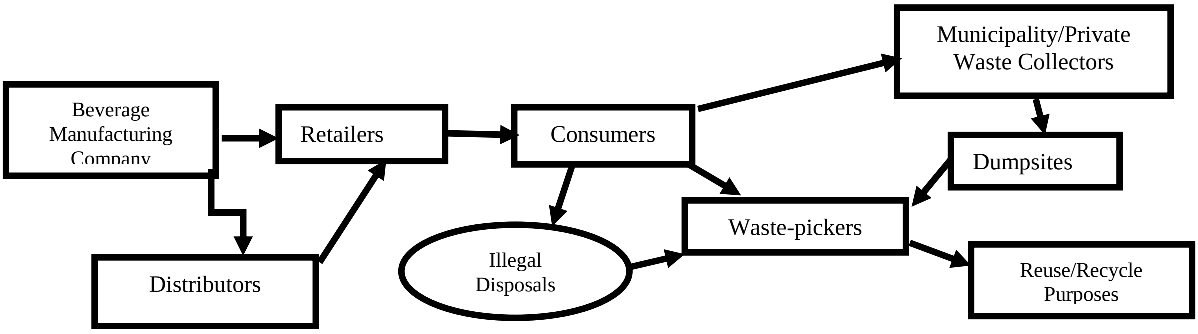
RL Practices by Beverage Companies. Results from the large companies indicated that, closed loop reverse logistics is practised on returnable glass bottled products. The glass bottles returned are mechanically recycled by washing them in machines at temperatures not higher than the melting temperature of the bottles. However, PET bottles are not recovered as the companies do not have recycling facilities for plastic.

High emphasis on quality management results in product returns on damaged or expired products of both plastic and glass packages. Large companies do not practise reverse logistics on EoL PET bottles but have printed recycling symbols on their products to enable other waste recyclers collect the bottles easily for recycling.

Medium and Small companies do not practise RL of PET bottled products. The companies in this category only handle product returns. One of the major reasons indicated for not practising is, companies do not have the machinery to recycle. **Exhibit 6** illustrates the current flow of PET bottles. Manufactured PET bottled products flow from the manufacturer to the distributors (third party distributors) to the retailers and then to consumers. After EoL, these bottles become waste and are then collected for disposal by the municipality or private waste collectors or if illegally disposed or not, waste pickers collector these bottles and sell them for reuse or recycling purposes. There is no form of RL practised by these companies.

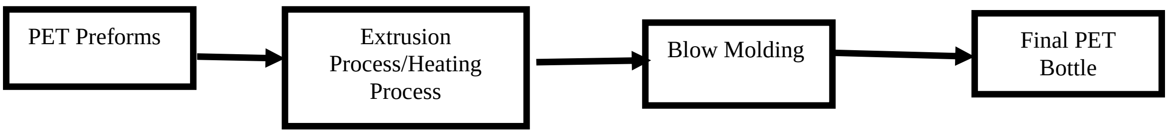
The researchers then analysed two types of RL models (**Exhibit 3 and 4**) reviewed in literature, the closed loop and the open loop systems. The closed loop system is considered practical by those companies dealing in recyclable plastic bottles. In the case of open loop reverse logistics, the PET plastic waste bottles do not return to the original manufacturers or suppliers. The products are taken away by third party logistics for the purpose of reuse, resale or recycling. Therefore, considering the results from the companies, the researchers proposed an open loop reverse logistics system in order to facilitate recycling activities. **Exhibit 8** illustrates an effective reverse logistics framework developed called the Container Deposit and Refund Legislation (CDRL).

Exhibit 6. Current flow of PET Bottles in the System



Production of PET Bottles. Currently, the sampled (5) beverage bottling companies in Zambia import all the raw material needed for production of PET bottles. Preform PET bottles are imported from South Africa by most of these companies except for one medium beverage company were some 40% of PET bottles are produced in-house using granules from South Africa. The preforms are heated and blown to required shapes and sizes before filling them. **Exhibit 7** illustrates the current stages involved in the production process of PET bottles.

Exhibit 7. Current stages involved in the Production Process of PET Bottles



Results from the ZEMA and LCC Questionnaire

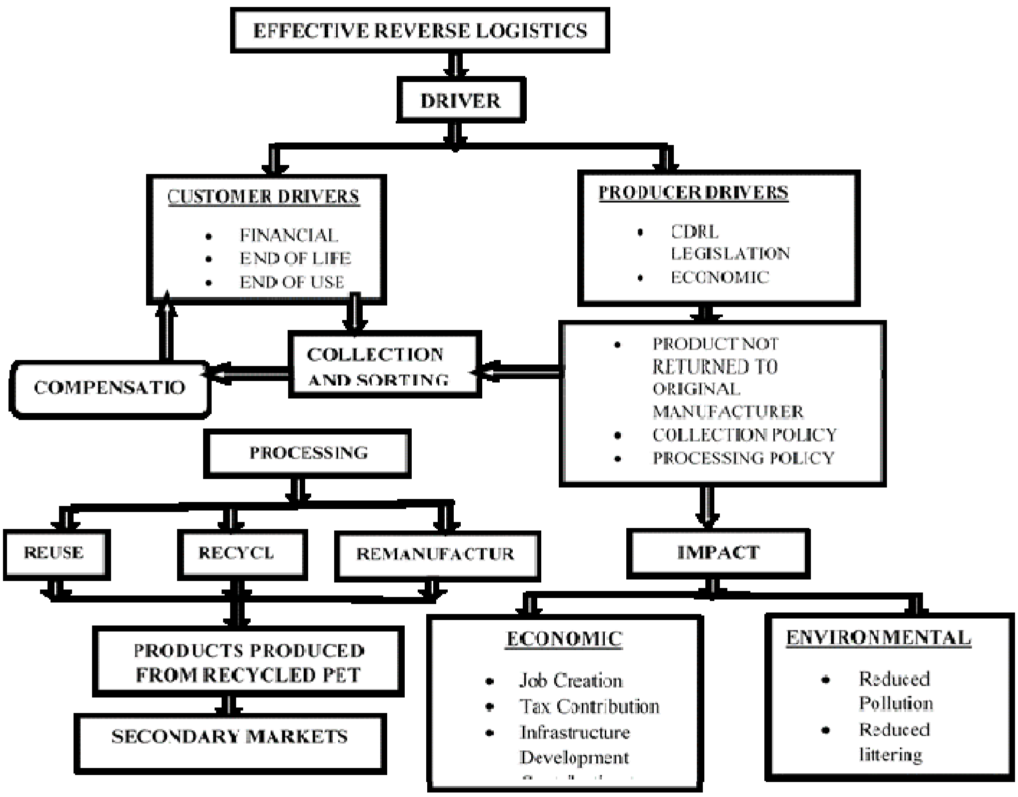
The authors investigated the measures that have been put in place to protect the environment. Zambia environmental management agency (ZEMA) being an autonomous body and plays the role of regulating and coordinating environmental management was investigated. According to ZEMA, there are no environmentally related regulations on PET waste management in Zambia although a new legislation known as Polluter Pays has been proposed. The legislation compels all PET bottle manufactures to pay for pollution. It also promotes the principle of recycling to enhance material recovery. However the regulations that compel manufacturers to be responsible for their EoL and EoU products are enshrined under the waste management regulations. Although, these regulations are under waste management, ZEMA is still responsible for the enforcement of these regulations. A number of challenges prevent the proper enforcement of these regulations. Established gaps that hamper environmentally sound management of plastic wastes are categorized as follows: policy planning; legal aspects including enforcement, key stakeholders, their roles and coordination; capacity building and training, public awareness and lack of effective RL systems.

LCC is overseen by ZEMA and has been given the mandate to enforce environmental regulations. Despite been given the mandate, it also faces similar challenges as ZEMA. The results suggest that, introduction of a RL framework would optimize PET bottle collection for the waste recyclers and also reduce on the amount of waste collected for disposal by LCC. According to LCC, only 30% of the waste generated in the city is collected for disposal at the local dumpsites. The remaining 70% is left uncollected. To overcome the challenges of uncollected waste, LCC engaged private waste collectors. Currently there are 9 companies responsible for primary waste collection. They provide waste collection for households, commercial and industrial areas for a fee that varies depending on the area density. At the dumpsites a form of waste collection for recycling purposes occur, any material that can be reused or sold are collected. The collection activity is performed by an informal sector dominated by family and micro private enterprises. LCC hasn't always allowed waste picking performed at the dumpsites by private actors but due to the increasing environmental awareness regarding recycling it is now allowing them.

Proposed RL Framework

The Container Deposit and Refund Legislation (CDRL) framework (**Exhibit 8**) is a legislation that can lead to the creation of a committee or an agency to act as the producer responsibility monitoring body. The committee may comprise representatives from the Zambia Environmental Management Agency (ZEMA), the Lusaka City Council (LCC), the beverage manufacturers and importers. CDRL can be a form of Extended Producer Responsibility (EPR) where manufacturers are be legally obliged to share responsibility with consumers for the costs of recycling the products they produce. The main objective of CDRL is to ensure that used beverage PET plastic containers are collected and recycled. Currently the majorities of used plastic bottles go to landfill (at a cost to local government), are burnt, or become litter with associated pollution. The proposed CDRL framework is directed towards making manufacturers and importers add a compulsory deposit of a prescribed percentage for every beverage produced. The funds collected are paid into a revolving fund account of the managing committee which in turn maintain funds from the deposits collected from beverage manufacturers and importers and used to pay out refunds to collectors and processors for the returned bottles. The customer that consumes the beverage and returns the used containers to licensed collectors or collection points is be able to claim back a refund of deposit of up to a specified percentage. The type of collection was designed to reward a prescribed deposit of a stated percentage of the selling price awarded to customers who have bought and consumed the product at the point of sale. The collection centers were designed to implement either a volume based or a mass based system. The volume based can consider buying plastic bottles in specified quantities. On the other hand, the mass based system may need to weigh the bottles and pay based on the weight

Exhibit 8. Container Deposit and Refund Legislation (CDRL)



Under CDRL, companies that produce or import beverages is required to obtain a beverage container permit from ZEMA or LCC. The CDRL does not act as a cost to soft-drink producers because the funds to be generated from the sale of recycled plastic can provide revenues. This proposed framework is not to be viewed as a constraint by producers as they are to be part of the CDRL committee or agency. The economic aspect of implementing the CDRL is that, it can act as a cost reduction tool as it can enhance the remanufacturing of PET performs using recycled plastics. Implementing the CDRL framework leads to the involvement of different stakeholders such as the private sector partnering with the local communities in plastic waste management thus job creation. To enhance PET plastic waste collection, informal and formal collection is to be incorporated. To reduce the cost of sorting, the collection centers may implement a policy that it is only to buy cleaner bottles with labels already removed and sorted according to color. This can act as a mechanism of passing the cost of removing labels and preliminary cleaning to the sellers.

Conclusion

The researchers concluded that, PET reverse logistics is not practiced by the beverage bottling companies in Lusaka, Zambia as it is considered a non-value adding process and can therefore be very costly from the financial point of view. However, scavengers collect PET for reuse purposes. According to Zhang and Wen (2014), informal sector play a vital role in the recycling collection process of PET and therefore incorporating them in the RL framework system contributes to sustainable collection of PET bottles for recycling.

The research established that closed-loop RL system exists on the glass bottles. With the involvement of third party logistics, waste pickers, enforcement of regulations and extended producer responsibility on plastic manufacturers an open-loop RL can be implemented for the purposes of recycling. Therefore the researchers developed the CDRL framework as an engineering management strategy and if properly implemented can optimally facilitate the recovery of these PET bottle plastic wastes and therefore promote recycling for sustainable waste management.

Analysis of the regulatory bodies revealed a number of drawbacks faced by these bodies hence enduring proper implementation of the regulations. The established CDRL incorporates drivers of RL that would contribute and lessen the challenges faced by these regulatory bodies.

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