Extended Producer Responsibility: A Management Option for E-Waste Management

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Abstract
The management of e-waste by Original Equipment Manufacturers (OEM) in Gauteng Province was investigated by exploring their involvement in the management of the end-of-life electronics through the Extended Producer Responsibility (EPR) take back schemes. The study also investigated the general e-waste management situation in South Africa by establishing and assessing the underlying aspects of EPR in e-waste management in the Information and Communication Technology (ICT) sector. Literature and applied information on e-waste and EPR were used, and special focus was paid on end-of-life computers. Despite the challenges in e-waste management, stakeholders strive towards holistic sustainable e-waste management. Policy directions based on the gaps identified in the current e-waste management strategy were recommended. It is recommended that e-waste management policies and regulations guided by the EPR principles as highlighted in the waste management legislation be implemented. In addition, knowledge transfers from developed (with working EPR schemes) to developing nations is recommended. EPR has been identified as an effective tool in the management of e-waste. The research outcomes will be instrumental in the identification of enhancement options for the implementation of the EPR principle.

Keywords
Extended Producer Responsibility, E- waste Management, Original Equipment Manufacturers, Sustainability

1. Introduction
Modern technology has witnessed the rapid increase in electronic equipment with Information and Communication Technology (ICT) networking infiltrating and affecting present day life. Moreso, the current digital revolution trend of the Fourth Industrial Revolution, characterised by a combination of technologies has obscured and bridged the physical, digital, and biological spheres' gap. The trend is even noticed in some remote areas of developing nations (Osibanjo & Nnorom 2007). ICT growth rate has been attributed to the rapid product innovation and replacement (Cook & Das 2011) as there are new designs released with improvements to the equipment's capacity and also decreasing their lifetime (Planned Obsolescence) (Satyoro, et al. 2018). For instance, technological advancement has led to the migration from analogue to digital technologies, from Cathode Ray Tubes (CRT) to Liquid Crystal Display (LCD) and Light Emitting Diodes (LED) flat screens. (Satyoro et al. 2018). Consequently, this results in an increase in the volume of waste from these products when they reach their end-of-life or become obsolete. This waste is termed electronic waste (e-waste) and refers to unwanted, non-working or obsolete electronic products that have essentially reached the end of their useful life. E- waste generation rates are increasing globally and The United Nations Environment Programme (UNEP) (UNEP (United Nations Environment Programme) 2013) for example forecasts a 500 % increase in obsolete computers by 2020, both in China and in South Africa compared to the 2007 levels.

Globally e-waste is exported from developed nations and imported into developing for diverse purposes and has attracted global attention because part of e-waste is transferred across borders for recycling purposes or charaded as end-of-life used goods or donations (Yu, et al. 2017) (Tansel 2017). This is despite the prohibition of export according to the Basel Convention, a treaty that aimed at reducing transboundary movements of hazardous waste from developed to developing nations (Song, et al. 2017) and the Bamako Convention, a treaty of African nations prohibiting the import into Africa of any hazardous waste.

Some organisations dispose electronic equipment into the environment using well-organised and well-managed best practice waste disposal while other organisations dispose electronic equipment haphazardly. Improper disposal

improper disposal of e-waste can have a negative impact on the environment as well as human health. E-waste comprises material that is valuable as well as toxic (Garlapati 2016). Therefore, the scope of this study was to explore the management of e-waste in South Africa and how the principle of Extended Producer Responsibility (EPR) is applied. The fundamental goal of this study was to examine the management of e-waste by manufacturers through assessing the applicability of the Extended Producer Responsibility (EPR) approach. In view of this, the producers' involvement towards management of e waste through the EPR approach was explored.

2. What is Extended Producer Responsibility

Lifset *et al* defined Extended Producer Responsibility (EPR) as an environmental strategy whereby a product manufacturer is responsible for its entire life cycle (Lifset, et al. 2013) and the physical/financial product's responsibility is extended to the post-consumer stage (Herdiana, et al. 2014) (Brears 2018). The main aim would be to ensure development and promotion of environmentally friendly products as well as being responsible for products waste management at end of life (Kunz, et al. 2018). Moreover, EPR influences product reuse and packaging, dematerialisation and elimination of toxics in product development (Manomaivibool, et al. 2000). The concept's initial main intention as defined by the Organisation of Economic Development and Cooperation (OECD) (Organisation of Economic Cooporation and Development (OECD) 2014; Widmer, et al. 2005; OECD (Organisation of Economic Cooperation and Development),, 2001) was to divert waste from the landfill as well as incentivise producers to design reusable and recyclable products and that are less hazardous at end-of-life for safe disposal (Lifset 1993; Lindquist & Lifset 2003). Sachs (Sachs, 2006) highlights that EPR is a policy approach that apportions long-term product environmental stewardship to producers as they internalise costs and transform the traditional "cradle-to-grave" (Linear) production and distribution patterns into a "cradle-to-cradle" (Circular) system. (Sachs, 2006) termed the above "Planning the funeral at birth".

In EPR both the producers and the users generate wastes, and the principle encompasses both the upstream (raw material extraction or production elements) and downstream (processing of materials into a finished product and its retail) stages of the product life cycle. Figure. 1 shows the downstream and upstream stages of a product lifecycle.

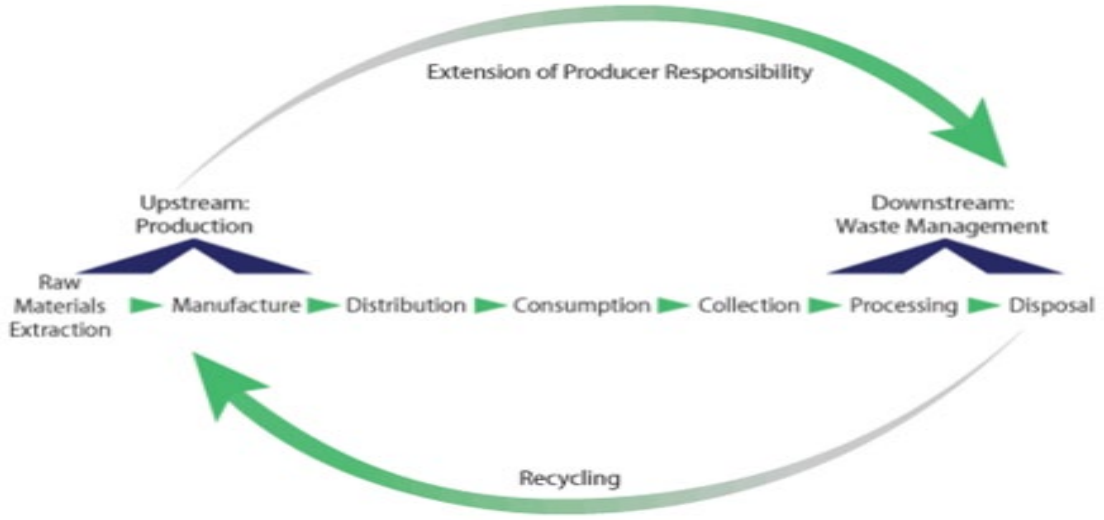

Figure 1. Downstream and upstream stages of a product life cycle (Adapted and edited from (Gupt & Sahay 2015))

The diagram illustrates how producers extended responsibility stimulates prevention of waste through eco-design and recyclability of products. As Lindquist (2000) (Lindquist 2000) suggests, the eventual aim of EPR is the protection of the environment as the product is designed to be environmentally friendly throughout its life-cycle. He identified four core objectives of EPR namely:

- Source reduction of waste as producer's design and manufacture, of products with minimum toxic content and material volume as well as a longer useful life leading to;
- Waste prevention. This is regarded as the highest priority according to the waste hierarchy.

- Compatible product design that is environmentally friendly. This entails reduction in energy use, developing products that are easily recyclable with minimal environmental thus minimising their carbon footprint. The main goal is to extend product life beyond just production and ensuring products that can be safely disposed of at the end of its product life.
- Using the closed-loop approach to promote sustainable development. This is an approach whereby materials are consistently reused rather than discharged as waste.

2.1 Responsibilities in Extended Producer Responsibility

Thomas Lindquist (Lindquist, 2000) identified five basic types of producer responsibility as depicted by figure 2 below:

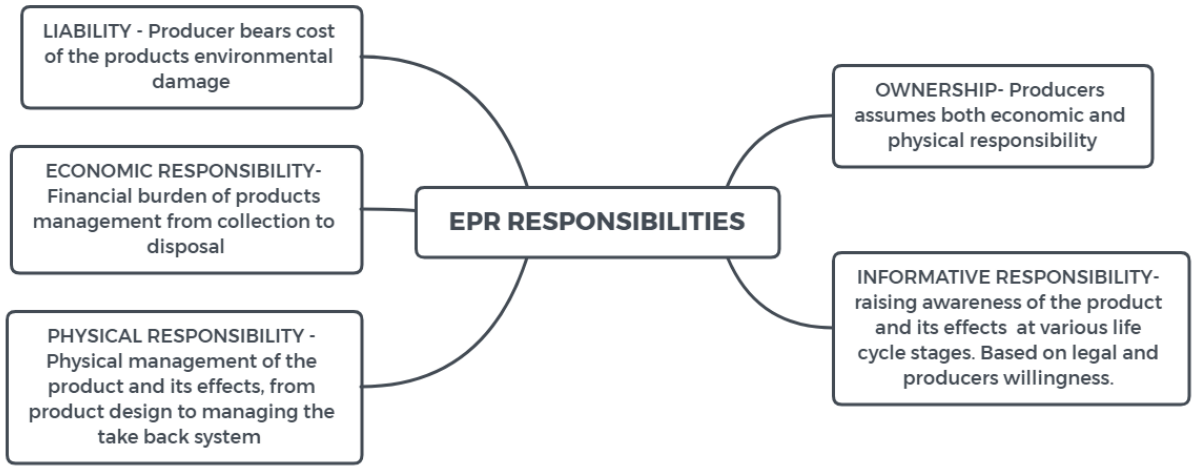

Figure 2. Responsibilities in EPR (Lindquist, 2000)

The strength of an EPR programme is determined by these responsibilities and is depended upon the manufacturer's involvement (Manomaivibool, et al. 2000). Such arrangement would provide an effective incentive to the producers in minimizing the costs of their products that will enhance the process of recycling or treatment. According to Lifset & Lindquist (Lifset & Lindquist 2008) EPR can also use as a tool in curbing issues related to generation of waste and pollution as well as promoting cleaner production. Furthermore, it extends the producer's responsibility on the product to the post-consumer stage which turns out to be flexible for both producers and policy makers in fulfilling their responsibilities. As highlighted by Gupt & Sahay (Gupt & Sahay 2015) the producer's responsibility may be fulfilled by adopting a mechanism or a combination of different policy instruments. These can either be voluntary or mandatory or both. Table 1 shows the examples of the policy instruments used for implementation of EPR.

Table 1. Policy instruments used for implementation of extended producer responsibility (Gupt & Sahay, 2015)

Types of policy	**Mechanism**	**Responsibility**
Administrative Instruments	Collection and/or take-back (mandatory or voluntary) Reuse and recycling targets Setting emission limits Recovery obligation Product standards technical standards	Producers Distributors Consumers Authorities
Economic Instruments	Material/product taxes Subsidies	Producers Distributors

	Advance disposal fee systems Deposit-refund systems Upstream combined tax/subsidies	
Informative Instruments	Environmental reports/labelling Information provision to recyclers Consultation with authorities about collection network	Producers Distributors Consumers

According to Gupt & Sahay (Gupt & Sahay 2015) Nahman (Nahman 2010)and Walls (Walls 2011) highlighted the administrative mandated take-back and economic instruments as the most popular. Producers and /or retailers are mandated to take back end-of-life products and set specific recycling targets. To meet these requirements organisations form 'Producer Responsibility Organisation (PRO) whereby industry collectively work towards fulfilling their EPR obligations [11]. Where there is no specific legislation on EPR, producers can also embrace the voluntary take back scheme whereby the EPR program is purely voluntary and no penalties are imposed on industry for not meeting recycling targets. In addition to the mandating take-back and setting of recycling targets (Gupt & Sahay 2015) producers can practice the Mandatory take-back and targets with a tradable recycling scheme whereby they can trade recycling credits amongst each other to meet the required targets. Economic instruments encompass a variety of policy tools from advanced recycling fees to deposit refund systems. Table 2 outlines the economic instruments in waste management

Table 2. Economic instruments in waste management

Instruments tool	
Advanced Recycling Fee (ARF)	A compulsory tax is imposed on product sales to cover recycling costs. The fees are calculated per unit and charged at the point of sale either separately or upstream on producers and fused into the retail price
Recycling Subsidy	The revenue generated from the ARF is used to subsidise the recycling process. This can be implemented in various ways for instance funding recycling activities or in managing the waste including meeting the infrastructure cost
Deposit Refund System (DRS)	Involves imposing a tax (deposit) on product consumption and a rebate (refund) paid out when the consumer returns the product recycling or disposal that is environmentally friendly. This promotes reduction and reuse of material inputs ensuring recycling and recovery material flow.
Material Taxes	Special taxes administered for the use of harmful and unrecyclable material encouraging producer to use less harmful materials.
Upstream Tax/Subsidy	Producers pay tax to subsidise waste treatment (Organisation of Economic Cooperation and Development (OECD), 2014)

Most policies are promulgated with the use of economic instruments as governments argue that economic instruments do not replace but complement and strengthen regulatory ('command-and-control') and informational strategies. As such, they become an important component of the policy mix and not 'stand-alone' policy instruments. Figure. 3 shows how economic instruments are usually enshrined in waste management policies as in the South African National Pricing Strategy for Waste Management (Department of Environmental Affairs (DEA) 2016). The South African legislation has incorporated the Material Taxes instrument with the promulgation of the Extended Producer Responsibility (EPR) regulations, created under section 18 (1) of the National Environmental Waste Management Act. The regulations require, organisations to register with their sector's relevant "Producer Responsibility Organisation" with the intent to pay the prescribed regulatory fees based on forecasted import or manufacturing volumes.

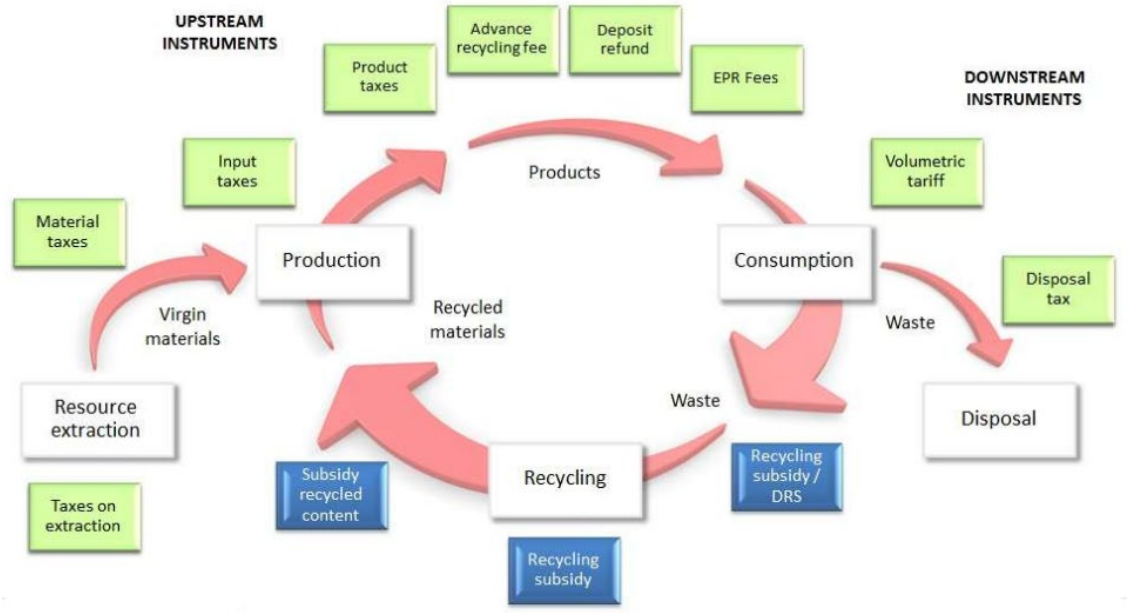

Figure 3. Economic Instruments in Waste Management (Department of Environmental Affairs (DEA) 2016)

From the above, it can be noted that the rationale behind EPR is for producers to design products that are environmentally friendly and less harmful to the environment at every stage of its life cycle. When an organisation places a product on the market, they should extend responsibility for the end-of-life treatment. Consumers are also encouraged to contribute to the management of their obsolete equipment through as they are incentivised through rebates.

Problem Statement & Methodology

Various studies have indicated that electronic products can contain toxic heavy metals that can contaminate the environment. These include cadmium, lead, copper, and chromium (Onwughara, et al. 2010); (Michael & Sugumar 2013) (Song & Li 2014); (Olubanjo et al. 2015; Bharti, et al. 2019). The presence of a myriad of toxic materials can pollute the environment and impact on human health. The South African National Waste Management Strategy (DEA, 2012) also identified e-waste as a waste that could pose great challenges in the waste sector. There is thus a need for an integrated approach towards e-waste management. Moreover, considering that management of e-waste is a crosscutting matter with global significance, it requires an integrated approach where all stakeholders are involved from production right through to final disposal. One such way is to incorporate the principle of Extended Producer Responsibility (EPR) in policy and legislation (Osibanjo & Nnorom 2007); (Awasthi & Li 2017) Internationally, there have been studies to assess the EPR approach associated with e-waste management practices (e.g. (Onwughara, et al. 2010); (Michael & Sugumar 2013). In South Africa however, management of e-waste with reference to the applicability of the EPR principle has not been explored. Therefore, the study aimed at exploring on the role and application of EPR in the e-waste sector. Considering this, a case study on EPR was carried out on selected computer producers in the Gauteng Province.

Methodology

A questionnaire was designed for the producers who were drawn from the Information Technology Association – Producer Environment Group (ITA-PEG) a division of the Information Technology Association - South Africa (ITA-SA). The questions were a mixture of both closed and open-ended questions spread across five sections namely:

- production/distribution/supply of Electrical and Electronic Equipment (EEE);
- environmental impact of reuse/recycling/disposal of used EEE;
- recycling of EEE;
- environmental legislation, compliance and awareness; and

• challenges in effective e-waste management.

The closed questions were designed to guide the respondents on the survey and make it easier to answer the questions so as to establish the respondents' level of knowledge and degree of involvement with the topic. In order to gain in-depth information on the status of e-waste management in South Africa, interviews were also carried out. The interviewees were drawn from the Information Technology Association – Producer Environment Group (ITA-PEG), The Africa Institute for the Environmentally Sound Management of Hazardous and Other Wastes commonly known as the Africa Institute and the Department of Environmental Affairs (DEA)

5. Results and Findings

Results showed that producers were involved in their products end-of-life management despite the challenges of weak legislation as there is no specific legislation for e- waste (Baldé, et al., 2018) before the promulgation of the EPR regulations on e-waste in 2021 inadequate recycling infrastructure, poorly developed institutional framework for e-waste management and lack of public awareness. The producers agreed that e-waste had to be tackled in a holistic manner. Although this may increase production costs in the initial stages, the benefit of the environment far outweighs the negative impacts of not engaging in proper e-waste management. They indicated that mandatory EPR is the most popular mechanism to address the e-waste problem as evidenced by the cases in the developed nations. Most environmental experts suggested the use of the EPR principle to manage e-waste (Song & Li, 2014) (Olubanjo, et al., 2015) (Hischier, et al., 2005) (Niza, et al., 2014) (Khetriwal, et al., 2005) (Awasthi & Li, 2017). In view of a global experience, EPR has been identified to be the most popular environmental policy in the management of e-waste.

5.1 Responsibilities in EPR Schemes

The producers indicated they have voluntary EPR schemes as an approach to sustainable management of e-waste. Fig. 3 highlights the responses given by the producers

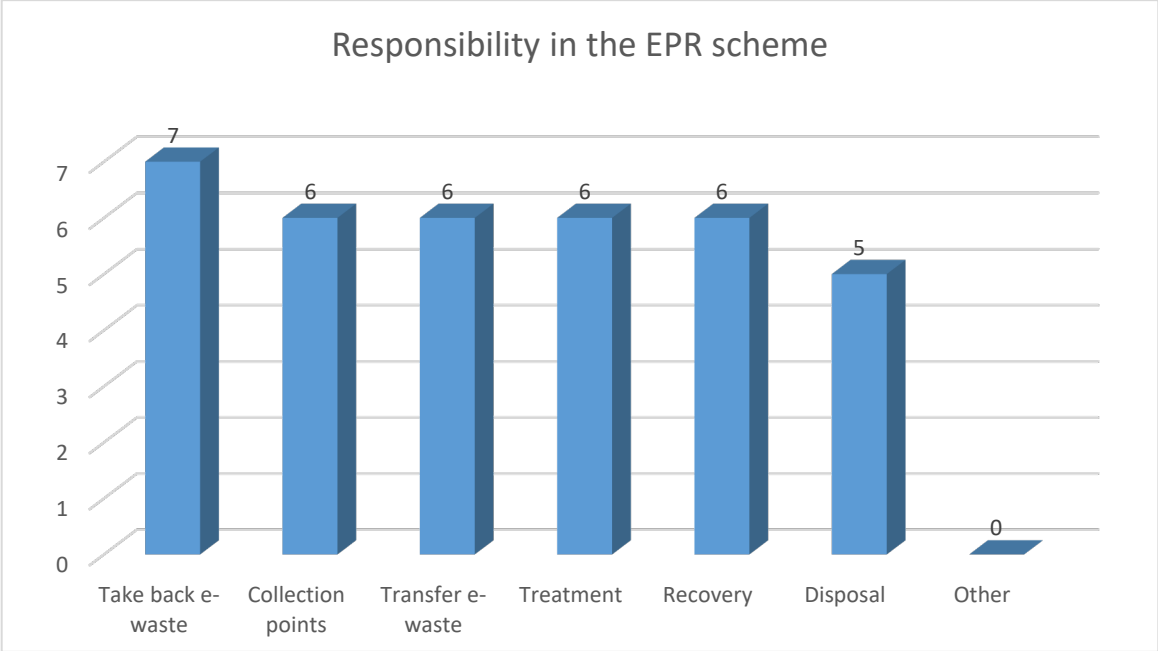

Figure 4. Responsibility in the EPR scheme

The results show that all the respondents surveyed take responsibility in the EPR scheme and the responsibilities in the form of take back e-waste, they indicated that they collect through collection points, transfer, treat, recover and dispose of e-waste. The most popular form of EPR is the take back of e-waste while the less popular is disposal. However, some of the respondents were reluctant to disclose the units they take-back, collect, reuse or recycle citing company policy in terms of information disclosure. The respondents that do not conduct any take-back indicated they

would introduce take-back schemes in their operations after addressing the problems they are facing in introducing the scheme. They cited inadequate resources and infrastructure to conduct the scheme as major obstacles.
There was one respondent who indicated that management of collection points, transfer of the e-waste from the collection points and other responsibilities are contracted to third parties. For instance, transfer of e-waste may be contracted to a waste transport company in the event that the producer does not have the mode of transport to transfer. This implies that there is synergy with the various stakeholders. This illustrates a voluntary initiative by the industry and lays a foundation in the national implementation of EPR in e-waste management

Motivation for Conducting Voluntary e-waste Management Practices

Considering there is inadequate enforcement of a specific e-waste management legislation, the respondents were asked what their motivation for conducting voluntary e-waste management practices was. The common responses were legislation from other countries where the company operates, the need for environmental protection as well as the economic benefits realised from management of e-waste that is, job creation (Baldé, et al., 2018). Fig. 4 shows the responses given.

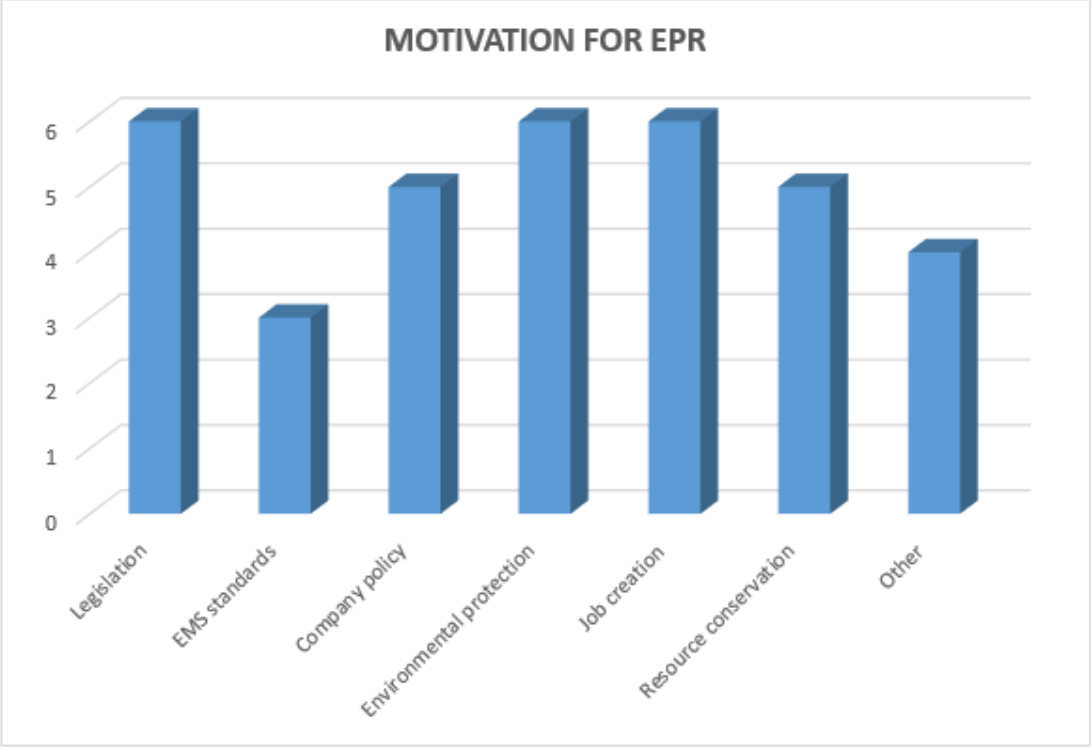

Figure 5. Motivation for voluntary EPR schemes

The majority of the respondents highlighted are motivated by the need to protect the environment and conserve natural resources. They also highlighted the benefits of conducting the voluntary EPR schemes. The responses ranged from the reduction of environmental impacts that are associated with toxic materials from discarded EEE to the fact that it is a responsible environmental approach for their business in terms of sustainable practice. The respondents also highlighted that engaging in voluntary EPR schemes exhibits duty of care in terms of environmental stewardship. Overally it was noted that the producers have initiated a voluntary EPR scheme as summarized in Table 3.

Table 3. Summary of Key Questionnaire Responses On EPR

E-waste management issue	Response
Responsibility in the EPR scheme	Take-back e-waste as a part of the global commitment to safe management of e-waste Management of e-waste collection points Implement the EPR regulations as required by legislation
Motivation for EPR	Comply with legislation as part of the global company requirement Protect the environment Conserve natural resources Global sustainability and strategy and goals
Benefits of EPR	Demonstrate responsibility of a global citizen thus reducing environmental impacts from EEE Green branding Sustainable practice Environmental stewardship thus enhancing good corporate image
Challenges in implementing EPR	Inadequate infrastructure Inadequate e- waste management legislation enforcement and awareness by the consumers Customer education /awareness in terms of responsible end-of-life EEE management is inadequate Discrepancy in terms of perceived value of end-of-life equipment versus proper treatment cost
Organisational compliance and awareness to legislation	Complies with relevant waste legislation However, the policies and legislation are ineffective because it does not make provision for different waste streams Waste management legislation is loosely enforced rendering them ineffective. More so the lack of awareness on e-waste legislation hinders organisational success to implement e-waste programmes in the country
Prioritisation of e-waste at organisational level	Highly prioritised, employees' awareness is raised through environmental training, internal communication services offerings
Challenges in e-waste management	Loose enforcement of e-waste legislation Public awareness Lack of local material fraction markets for beneficiation Low value material.

Practical Managerial Implications and Recommendations

Based on the results of the study, recommendations are thus made for stakeholders concerned to manage e- waste sustainably for the protection of the environment. The following recommendations are thus suggested.

6.1 Review current management system

In view of the results, discussion and conclusions that identified gaps in the prevailing management system, there is need to conduct studies to determine the recent status of e-waste in the country as the information is inadequate as also identified by (Baldé, et al., 2018). This will assist in developing a national inventory of different types of e-waste in the country to be included in the South African Waste Information System (SAWIS). This could be the foundation of the implementation of a successful e-waste management strategy (Awasthi & Li, 2017). Producers had been implanting e-waste management systems voluntarily and it is envisaged that a mandatory e-waste management system as incorporated in the EPR regulations that considers all stakeholders contributions can go a long way in addressing the problem.

6.2 Holistic management of e-waste

For any e-waste management programme to be successful there is a need for all stakeholders to participate in the formulation of all policies, strategies and management systems (Awasthi & Li, 2017). For instance, the incorporation of South African Revenue Service and customs officials from the point of entry right up to the officials that deals with disposal of e-waste. This can also assist in preventing illegal shifting agents mislabelling e-waste for import into the country (Song, et al., 2017) . There is also a need to link with DEFF for waste management fees collection from the ICT sector and transferred to the waste management regulator.

6.3 Adoption and implementation of Extended Producer Responsibility

Having EPR regulations ensures producers take full responsibility for the lifecycle of their products, past end of life phase. It is envisaged that these regulations will, if properly enforced will prevent end of life electrical and electronic products – most of them potentially harmful to the environment are disposed of in landfills. The regulations are also meant to ensure products are recovered and recycled as much as possible, rather than adding to the growing e-waste problem. Moreso, there is need for mandatory labelling of second-hand products, donations and refurbished products as a means of tracking the producer.

6.4 Recommendations to the manufacturers

There is a need for the producers to accommodate all relevant stakeholders. This could be done by creating intensive awareness programmes to ensure consumers are aware of the impacts of improper disposal of obsolete EEE. The producer may introduce incentives as a way of luring the consumers to bring back obsolete EEE and review the programme and determine its effectiveness. Stakeholder involvement and level of convenience is a very crucial aspect in e-waste management hence end users should be aware of the existence of the management scheme by the producers. It is also recommended that collection points for the obsolete EEE should be accessible to both the consumers and the producers.

Conclusions and future research

E waste management is an imminent issue as specific legislation has just been promulgated hence enforcement challenges may be an issue. With the increase in the use of ICT equipment, e-waste generation rates is bound to increase at a rate faster than recycling and recovery. There is therefore a need for effective measures to be implemented so as to address the issue and prevent the risk posed by e-waste and the threat to the environment and human health. In the inadequate enforcement of specific legislation, some stakeholders have come on board to address the situation. Most of the strategies applied are on a voluntary basis. These include eWASA a non-profit organisation which works with stakeholders that include manufactures, informal traders, EEE distributors handlers to manage e-waste effectively. The organisation, in collaboration with the industry, developed guidelines to ensure safe and sustainable recycling processes of e-waste. However, there are some stakeholders, especially the informal recyclers, who are still involved in unsustainable e-waste processes. The producers agreed that e-waste had to be tackled in a holistic manner. Although this may increase production costs in the initial stages, the benefit of the environment far outweighs the negative impacts of not engaging in proper e-waste management.

Though this study looked into specific group of stakeholders, it is imperative that management of e-waste should not be restricted to only the end-of-life but also consider the cradle-to-cradle approach in the quest for a Circular Economy in line with the Sustainable Development Goal number 12. Overall, there is need for the improvement of the waste management infrastructure and perceptions towards recycling through involving all stakeholders concerned to raise awareness on e- waste legislation as well as the harmful effects of e-waste. The government should also consider supporting the industry driven e-waste management approach. Thus, it can be concluded that EPR is the possible mechanism of managing e-waste and that all stakeholders should work in an integrated manner so as to ensure the challenges faced in managing e-waste are addressed.

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