Internal and External Factors of Improving Television E-waste Management Through The Supply Chain Infrastructure In Jakarta-Indonesia

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Abstract

Electronic waste (e-waste), also known as Waste Electrical and Electronic Equipment (WEEE), is one of the fastest-growing waste streams worldwide. E-waste has several risks to health, such as the release of toxic and hazardous compounds, water, soil, and air pollution. The risk of e-waste to communities and the environment has increased sharply with a lack of health and safety guidelines and inappropriate recycling techniques. There is a potential from WEEE that could provide employment opportunities for communities and generate economic benefits, such as precious metals, plastics, and glass. Television waste is the largest contributor to electronic waste. The waste here is divided into Cathode-Ray Tube (CRT) and Flat-Panel Display (FPD). Good management also requires good supply chain management. Infrastructure plays an important role in managing electronic waste. Matrix SWOT analysis is used to determine strategies for improving television e-waste management through the supply chain infrastructure in Jakarta. The results were; Periodic outreach to the community, schools, and residents about the benefits and importance of electronic waste management, increasing cooperation with legal and certified waste processing companies, increasing the number of drop boxes in public areas and government agencies, and optimize e-waste collection by socializing and raising awareness.

Keywords

e-waste, television, supply chain, infrastructure, SWOT

1. Introduction

E-waste, also known as Waste Electrical and Electronic Equipment (WEEE), is one of the fastest-growing waste streams in the world (Forti, 2020). Outdated technology has had a strong influence on users to replace their electronic devices. Many manufacturers and suppliers have implemented the concept of supply chain management to improve product development, quality, and delivery goals, and to eliminate waste (Anham, 2019). The European Union's WEEE directive previously had a product-oriented categorization, and in the recent recast, moved to a treatment-oriented categorization, with six main categories: (Honda, 2016):

- Temperature exchange equipment; fridge, freezer, air conditioner, and heater.
- Screens and monitors; television, monitors, laptops, and tablets.
- Lamps; fluorescent lamps, high-intensity discharge lamps, and LED lamps.
- Large equipment; washing machines, clothes dryers, dishwashers, electric stoves, large printers, copiers, and photovoltaic panels.
- Small equipment; vacuum cleaners, microwaves, ventilation equipment, toasters, electric kettles, electric shavers, scales, calculators, radio devices, video cameras, electric and electronic toys, small electrical and electronic devices, small medical equipment, small monitoring, and control instruments.
- Small IT and Telecommunication Equipment; cell phones, Global Positioning System (GPS) devices, pocket calculators, routers, personal computers, printers, and telephones.

A total of 53.6 million metric tons of e-waste was generated worldwide in 2019, up 21 percent in just five years. However, only 17.4 percent of electronic waste in 2019 can be collected and recycled (Forti, 2020). The largest producer of electronic waste is still occupied by China with 10,129,000 tons, followed by the United States with 6,918,000 tons. Meanwhile, Indonesia ranks first in the Southeast Asia region with a total of 1,618,000 tons with an electronic waste per capita of 6.1 kg. (Forti, 2020).

Improper e-waste processing has hurt the environment and society. Hazardous substances such as mercury, lead, chromium, cadmium, arsenic, cobalt, and palladium, which are found in electronic products, have been shown to poison humans. Compared to other countries in Southeast Asia, the handling of e-waste in Indonesia is still poor and unstructured (Anityasari, 2016).

Behind all the threats and dangers of electronic waste, there is the potential for resource recovery from WEEE that can provide employment opportunities for the community and generate economic benefits, such as precious metals, plastics, and glass (Wang et al, 2018). The presence of precious metals such as gold, silver, palladium, and copper makes waste processing attractive (Honda, 2016).

From the six categories of electronic waste, television is a large contributor to electronic waste. Television waste here is divided into Cathode-Ray Tube (CRT) and Flat-Panel Display (FPD) (Wang et al, 2018). Good and appropriate infrastructure plays an important role in processing electronic waste (Tansel, 2020).

1.1 Objectives

This study aims to improve television e-waste management through the supply chain infrastructure in Jakarta-Indonesia. From the results of the analysis of internal and external factors, it can be used as a basis for determining strategies for improving television electronic waste management through the supply chain infrastructure in Jakarta.

2. Literature Review

E-waste is a fast-growing waste stream in the world that is growing at around 3-5% per year. The emergence of electronic waste is also caused by the fast obsolescence of the electronics sector. There is a concern that electronic waste generated in developed countries will end up in developing countries, especially in Asia, resulting in adverse environmental and health impacts. As a result, several countries in Asia are developing policy instruments to ensure proper management of e-waste. This includes the infrastructure for managing the electronic waste supply chain (Pariatamby, 2013).

Electronic waste is not something that should be left behind or thrown away but is a valuable resource, which is why it needs to be encouraged for sustainable management. WEEE can offer economic, social, and environmental benefits; the first benefit can be job creation and profit from business opportunities. The second benefit is reducing or solving health problems. The final benefits are obtained, among others, when the impact is reduced or eliminated so that air and water quality is better and greenhouse gas emissions are reduced (Cruz-Sotelo, 2017). The sustainable management of the electronic waste supply chain depends on the viability of a system which ideally includes the stages of collection, transportation, processing, and disposal (Figure 1).

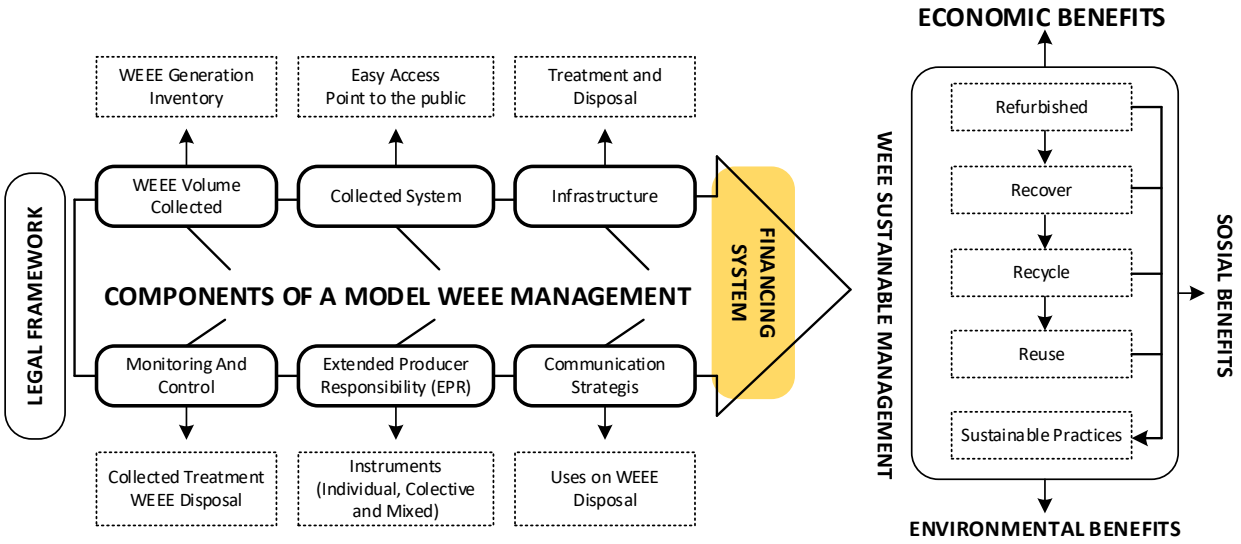

Figure 1. Sustainable supply chain management of electronic waste (Cruz-Sotelo, 2017)

Indonesia, as one of the most populous countries in the world, has significant numbers in terms of the use of electronic products. Reportedly, in 2007 the production of household appliances and IT related equipment in Indonesia had exceeded 3 billion, while the annual consumption of TV was in the first place with 4.3 million followed by 2.1 million refrigerators, and consumption of Air Conditioners (AC) and washing machines reached 900,000 units each. The potential for electronic waste in Indonesia is estimated to be around 40,000 kg per year in 2010 and gradually increasing from year to year (Anityasari, 2016).

Mechanisms to build effective waste management and recycling infrastructure for waste products, similar to supply chain management, are needed for sustainable use (Tansel, 2020). It takes a supply chain management infrastructure for proper electronic waste management (Honda, 2016) and by conditions in Jakarta as the capital of Indonesia.

Based on data regarding the amount of electronic waste obtained from the DKI Jakarta environmental office as attached in Figures 1, 2, and 3. It is seen that there has been an increase in the amount of waste that has been collected through the DKI Jakarta environmental office as the formal manager of electronic waste. However, there is still much potential waste collection that has not been formally managed.

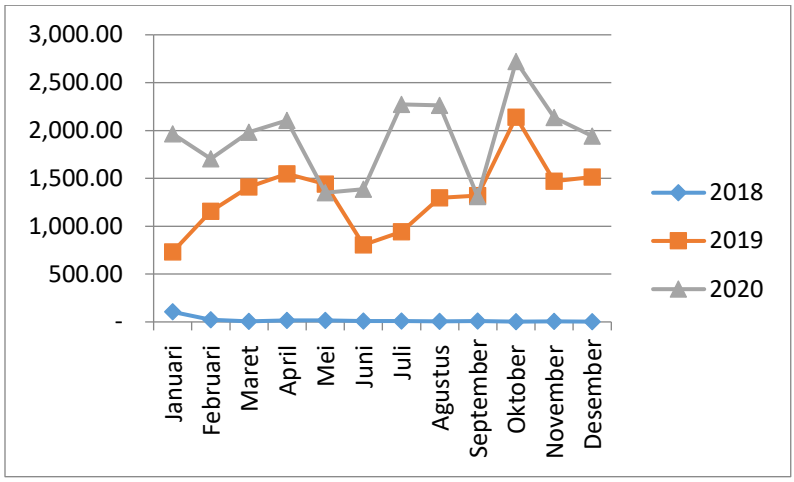

Figure 2. Monthly electronic waste (in kg) collected by the DKI Jakarta environmental office (DLH DKI Jakarta, 2021)

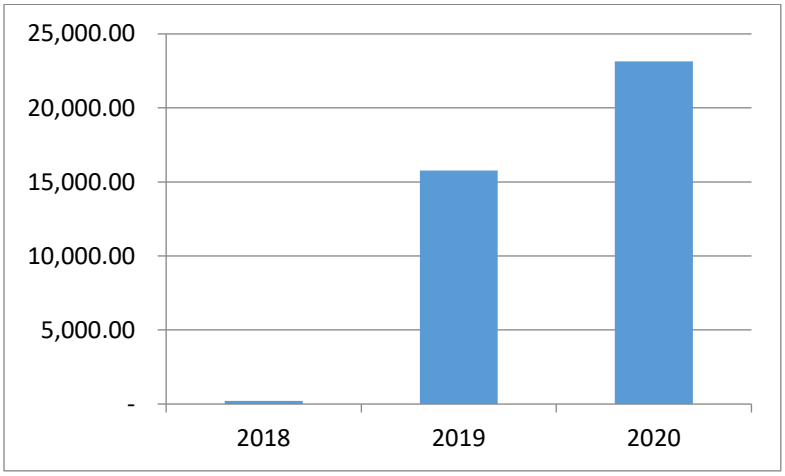

Figure 3. Electronic waste (in kg) collected by the DKI Jakarta environmental office (DLH DKI Jakarta, 2021)

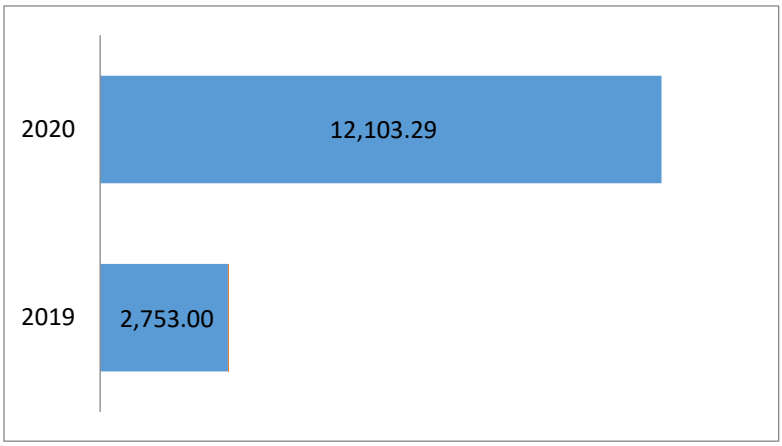

Figure 4. Television e-waste (in kg) collected by the DKI Jakarta environmental office (DLH DKI Jakarta, 2021)

E-waste supply chains will become more effective if the government and waste processing companies can work together in dealing with e-waste. Also, it will be more profitable for the entire electronic waste supply chain if electronic waste processing companies carry out part of the electronic waste collection activities (Ghalehkhondabi, 2020). The supply chain has become the key to the competitiveness of companies, it also has a significant impact on the environment including emissions, pollution, and public health hazards. The industry has begun to implement environmental factors that are integrated into supply chain management (Kamili, 2020).

The analysis of the strengths, weaknesses, opportunities, and threats (SWOT) of the supply chain infrastructure management trend for television electronic waste management was carried out through the SWOT matrix. The SWOT framework is a strategic planning method used to evaluate the Strengths, Weaknesses, Opportunities, and Threats of the management of television e-waste management supply chain infrastructure. SWOT analysis involves identifying internal and external factors that support and do not support the development of a sustainable television e-waste management supply chain infrastructure (Pariatamby, 2013).

3. Research Methodology

This study uses a qualitative method. Data were obtained through literature review and Focus Group Discussions (FGD) with the environmental office of the DKI Jakarta Province and the community. The data obtained discusses strategies to improve television electronic waste management through the supply chain infrastructure in Jakarta. After the data was collected, the data were analyzed using the SWOT analysis method. The data is then processed based on theories related to this research topic.

Data were analyzed by SWOT. According to Mor, (2016) the SWOT approach is used to analyze the opportunities and threats associated with key waste management practices. SWOT is a technique that is useful for identifying various factors that refer to the strengths, weaknesses, opportunities, and threats of a program or other related activities, as can be seen in Table 1. To conduct a SWOT analysis, information on waste management practices in Jakarta was collected through interviews, surveys, and observations. SWOT implementation can assist in developing a concrete strategic action plan to determine a strategy for improving the supply chain infrastructure for e-waste management in Jakarta.

SWOT analysis involves identifying internal and external factors that support and do not support the improvement of sustainable e-waste management (Pariatamby, 2013), where the main features of SWOT are:

- Strengths: the internal elements that benefit or enable the facilitation of strategies to improve television e-waste management through the supply chain infrastructure in Jakarta.
- Weaknesses: elements of internal policies that contribute to or hinder strategies for improving television e-waste management through the supply chain infrastructure in Jakarta.
- Opportunity: an external element that could potentially be utilized to provide benefits for improving television e-waste management through the supply chain infrastructure in Jakarta.
- Threats: external elements that could potentially be exploited to hinder the goal of improving television e-waste management through the supply chain infrastructure in Jakarta.

Table 1. SWOT matrix analysis

EFE \ EFI	STRENGTHS (S)	WEAKNESSES (W)
OPPORTUNITIES (O)	STRATEGY S - O	STRATEGY W - O
THREATS (T)	STRATEGY S - T	STRATEGY W - T

4. Results and Discussion

In 2019, most of the generated e-waste (82.6%) is likely not formally collected and managed in an environmentally friendly manner. These supply chains are usually not consistently or systematically documented. The lack of data on e-waste that is officially collected and recycled implies that most of the e-waste generated in 2019 was managed outside the official collection system (Forti, 2020).

There are limited collection centers provided by several international producers, however, these are limited to voluntary initiatives. The absence of options for proper disposal and recycling coupled with low consumer awareness of proper e-waste treatment has led to very minimal collection via formal collection and channels. As in many other developing countries, the collection and recycling of e-waste take place in the informal sector. Households sell their electronic waste to scavengers through informal transactions, while government agencies continue their waste management to waste management companies (Honda, 2016).

Management of the supply chain infrastructure for electronic waste management in Jakarta consists of internal and external aspects that support it. Internal and external infrastructure factors in this study will be identified based on findings in the field so that they include potential factors.

Table 2. Internal infrastructure factor analysis

Item	Factors	Reference	Strengths/Weaknesses
1	Process information & collection results	Anityasari, 2016	Weakness
2	Availability of adequate waste storage locations in every district and city	Anityasari, 2016 DLH DKI Jakarta	Weakness
3	Regulations related to electronic waste	Cruz-Sotelo, 2017	Weakness
1	Placement of drop boxes in public areas and government equipment	DLH DKI Jakarta	Strengths
2	Availability of personnel and government structures	DLH DKI Jakarta	Strengths
3	Electronic waste pick-up transportation	DLH DKI Jakarta	Strengths
4	The commitment of the DLH DKI Jakarta in handling electronic waste	DLH DKI Jakarta	Strengths

Internal factors that play a role as can be seen in Table 2 are; Management of supply chain infrastructure for electronic waste management in Jakarta, there are several aspects of the supporting criteria, among others; Process information & collection results (Anityasari, 2016), support e-waste management so that it is fast and updated. Availability of adequate waste storage locations in every district and city (Anityasari, 2016) (DLH DKI Jakarta), can support the storage of electronic waste before it is processed by a formal electronic waste management company. Regulations related to electronic waste (Cruz-Sotelo, 2017), it is necessary so that there is good and right on target waste management. Placement of drop boxes in public areas and government equipment (DLH DKI Jakarta), to make it easier for people to collect electronic waste. Availability of personnel and government structures (DLH DKI Jakarta), facilitates services to the public in managing electronic waste. Electronic waste pick-up transportation (DLH DKI Jakarta), is a facility that can make it easier for people to submit waste without the hassle of leaving the house. The commitment of the DLH DKI Jakarta in handling electronic waste (DLH DKI Jakarta), makes all carry out their duties properly.

Table 3. External infrastructure factor analysis

Item	Factors	Reference	Opportunities/Threats
1	The desire to participate	Anityasari, 2016	Opportunities
2	Legal and certified waste processing companies	Honda, 2016	Opportunities
3	Cooperation with educational institutions	DLH DKI Jakarta	Opportunities
4	Cooperation with Household	DLH DKI Jakarta	Opportunities
5	A Legal and certified waste company that is willing to provide economic compensation to the community for certain waste conditions	DLH DKI Jakarta	Opportunities
1	Electronic waste exchange reward	Zhong, 2016	Threats
2	Demographic Conditions	Anityasari, 2016	Threats
3	Informal collectors and unloaders	Honda, 2016	Threats
4	Lack of public awareness of the dangers of electronic waste	Honda, 2016	Threats

External factors that play a role as can be seen in Table 3 are; The desire to participate (Anityasari, 2016), from the community to formally collect electronic waste. Legal and certified waste processing companies (Honda, 2016), make electronic waste management safe. Cooperation with educational institutions (DLH DKI Jakarta), which are widely spread in the province of DKI Jakarta. Cooperation with Household (DLH DKI Jakarta), provides easy service to various settlements. A Legal and certified waste company that is willing to provide economic compensation to the community for certain waste conditions (DLH DKI Jakarta), can provide the community with compensation for the electronic waste that he has provided. Electronic waste exchange reward (Zhong, 2016), relates to community interest informal waste collection. Demographic Conditions (Anityasari, 2016), play a role to collect electronic waste. Informal collectors and unloaders (Honda, 2016), there are still many in the processing of electronic waste. Lack of public awareness of the dangers of electronic waste (Honda, 2016), resulting in less than an optimal collection of electronic waste

From the results of the identification of internal and external factors, a SWOT matrix analysis can be carried out which shows that various strategies can be used to improve television electronic waste management through the supply chain infrastructure in Jakarta.

Table 4. SWOT matrix analysis

	Strengths (S)	**Weakness (W)**
	1. Placement of drop boxes in public areas and government equipment 2. Availability of personnel and government structures 3. Electronic waste pick-up transportation 4. The commitment of the DLH DKI Jakarta in handling electronic wastearatus	1. Process information & collection results 2. Availability of adequate waste storage locations in every district and city 3. Regulations related to electronic waste
Opportunity (O) 1. The desire to participate 2. Legal and certified waste processing companies 3. Cooperation with educational institutions 4. Cooperation with Household 5. A Legal and certified waste company that is willing to provide economic compensation to the community for certain waste conditions	**Strategy S-O** Periodic outreach to the community, schools and residents about the benefits and importance of electronic waste management.	**Strategy W-O** Increase cooperation with legal and certified waste processing companies.
Threats (T) 1. Electronic waste exchange reward 2. Demographic Conditions 3. Informal collectors and unloaders 4. Lack of public awareness of the dangers of electronic waste	**Strategy T-S** Increase the number of drop boxes in public areas and government equipment.	**Strategy S-W** Optimize e-waste collection by socializing and raising awareness

From the results of the factor analysis obtained as can be seen in Table 4, it can be used as a basis for determining the right strategy to support the improvement of sustainable electronic waste management, as follows: Periodic outreach to the community, schools, and residents about the benefits and importance of electronic waste management, increasing cooperation with legal and certified waste processing companies, increasing the number of drop boxes in public areas and government agencies, and optimize e-waste collection by socializing and raising awareness. By implementing this strategy, it is hoped that the improvement of television electronic waste management through the supply chain infrastructure in Jakarta can be realized.

5. Conclusion

Electronic waste has a dangerous impact on human health and the environment. The increasing number of electronic waste, especially television in Jakarta as the capital of the Republic of Indonesia, needs to be supported by electronic waste management. It aims to improve television e-waste management through the supply chain infrastructure in Jakarta. Because besides the dangers that lurk, there are also potential benefits from electronic waste management. From the results of the SWOT analysis, it was found that the analysis involved the identification of internal and external factors that support and do not support the improvement of sustainable electronic waste management. Periodic outreach to the community, schools, and residents about the benefits and importance of electronic waste management, increasing cooperation with legal and certified waste processing companies, increasing the number of drop boxes in public areas and government agencies, and optimize e-waste collection by socializing and raising awareness. By implementing this strategy, it is hoped that the improvement of television electronic waste management through the supply chain infrastructure in Jakarta can be realized.

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Biographies

Jerry Kuswara Piton, S.T. is a graduate of the Department of Industrial Engineering, Universitas Muhammadiyah Jakarta, who received a scholarship from the Saintek Kemenristek/BRIN to continue his studies in the Postgraduate program, majoring in Industrial Engineering at the Universitas Indonesia. He also worked as a government employee at the Agency for the Assessment and Application of Technology (BPPT).

Prof. Dr. Ir. Rahmat Nurcahyo, M.Eng. Sc. is currently active as an academic staff in Industrial Engineering Department, Universitas Indonesia. Started higher education in Mechanical Engineering, Universitas Indonesia, and graduated in 1993. Then, continued the study at the University of New South Wales and obtain his master's degree (M.Eng.Sc.) in 1995. Now, a doctoral degree in the Faculty of Economics, Universitas Indonesia. Mr. Rahmat has taught several courses in Industrial Engineering UI, including Industrial Psychology, Industrial Economy, and Total Quality Management.

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