Mapping Electronic Waste Flows in Depok, West Java

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Abstract. Electronic waste (e-waste) is a relatively new issue in Indonesia. Policies and regulations regarding electronic waste in Indonesia are still under development and preparation. Also, the physical presence of electronic waste, except used batteries, is not managed yet, especially in the waste management chain. In some regions, especially in Java, the recovery and the handling of electronic waste such as demolition, separation of parts, old product restoration, and metal recovery are carried out by the informal sector. The informal sector handles almost 90% of the total waste produced, mainly from households, offices, commercial areas, recovery materials, and reconditioned products. Nevertheless, e-waste was not commonly found in public landfills, indicative of its valued nature. Previous studies have figured out that e-waste is flowing through several informal processes with rudimentary technology. This study aimed to understand the role of formal and informal actors in the flow and fate of e-waste in Depok, as well as how various actors interacted and differentially benefited from these flows. The results indicated that informal actors were the predominant force in the collection and sorting of e-waste from households. This research suggests that informal actors, who play such an essential role in the current system, should be incorporated into any new regulatory and management schemes, as is currently being developed by the Indonesian government.

1. Introduction
Electronic waste is a relatively new issue in Indonesia. Policies and regulations regarding electronic waste in Indonesia are still under development and preparation. Also, the physical presence of electronic waste, except used batteries, is not managed yet, especially in the waste management chain. In some regions, especially in Java, the recovery and the handling of electronic waste such as demolition, separation of parts, old product restoration, and metal recovery are carried out by the informal sector. The informal sector handles almost 90% of the total waste produced,[¹] mainly from households, offices, commercial areas, recovery materials, and reconditioned products. These recyclers use processes and practices such as open combustion, acid baths, and circuit board heating, which produce emissions and release of toxic elements (including brominated flame retardants) into the environment [²].

This electronic waste handling activity has been running for years in large volume without having adequate personal protective equipment and pollution control devices produced from the recycling process, resulting in cases of environmental pollution due to electronic waste in Indonesia, as well as the Munjul case in East Jakarta. Notes in the memory that in the 2000s, some residents' well water in the Munjul area, East Jakarta, was detected contaminated by heavy metals such as lead, cadmium, and zinc due to electronic waste recycling activities in the Munjul area. The direct impact is the onset of itching in the body and respiratory diseases in the surrounding population [³].
If the handling activity of electronic waste runs as it today without any handling or supervision by the government as a policymaker, of course, this activity will harm the environment and the people living in the area. Also, in parallel NGOs or study groups that have an interest in the electronic waste can provide socialization and introduce what is meant by electronic waste to the public in general, so that public awareness of electronic waste arises.

2. Methodology
A few published studies have examined e-waste flows in Indonesian cities, such as Yogyakarta, Manado, and Serang.[4][5] A previous work attempts to understand the role of formal and informal actors in the flow and fate of e-waste in Yogyakarta, as well as how various actors interacted and differentially benefited from these flows. The results indicated that informal actors were the predominant force in the collection and sorting of e-waste from households but received the lowest profit margins in a complex hierarchy, where money and power were concentrated at higher levels. [4]

A life cycle assessment of mobile phones was conducted in Manado, in which it was discovered that only 1% of the mobile phones sold were recycled correctly [5][6]. A study using Material Flow Analysis (MFA) projected that the accumulation of e-waste generated from Indonesian households in 2025 could reach up to 622,000 tonnes [5]. Previous studies have also looked at the supply chain network of e-waste in Indonesia, recognizing the role of informal sectors in e-waste recycling [6]. [6] highlighted the imbalance of monitoring of e-waste generated from industrial consumers and households, as only the former was often regulated. Nevertheless, it is unclear what are the specific roles played by different informal actors in the e-waste management system, and this study attempted to address that gap.[6]

This study is an extended work from [7] and will focus on electronic waste streams in the city of Depok using qualitative research methodology, field study, and survey to the students of a high school. Qualitative research method itself is a type of research whose findings not obtains through statistical procedures or other forms of calculation. This method seeks to understand and interpret the meaning of an event in human behaviour interactions in certain situations according to the perspective of the researcher himself.

The qualitative research method is a study, where the data collected comes from primary data collection as a result of interviews of stakeholders about waste in general and electronic waste, specifically in Depok City. Besides, the interviews conducted with experts in the field of electronic waste in Indonesia. The following is a list of several electronic waste stakeholders in Depok City who were the respondents in the interview process:
1. Secretary of the Depok City Environment Service
2. Head of sub-field for Environmental Law Arrangement
3. Head of Organic Waste Division, Environmental Agency of Depok City
4. Head of Cipayung Landfill, Environmental Office, Depok City
5. Electronic Waste Collectors in Depok City
6. Prof. Enri Damanhuri (Expert e-waste in Indonesia)
7. Secretary of the DKI Jakarta B3 Waste and Electronics Sector

The data generated from interviews with several speakers is then processed and visualized to be the primary source of information for the results of this study. However, this research still uses secondary data from previous studies that have been conducted in Depok City, as well as from national and international research journals to supplement the research data. Additionally, this study utilized an analysis from field studies and survey to high school students to map e-waste flows.

2.1. General Conditions of Waste in Depok
Depok City is a city in West Java Province with a relatively high level of urbanization, causing Depok City to experience an increase in population reaching 2,033,508. As a result of this increase in population is the increase in waste generation in the city of Depok. At present, Depok City has one TPA that has been operating since 1984, Cipayung Landfill, which is located in Cipayung District.
with an area of 11.2 hectares. Cipayung landfill can accommodate garbage with an average volume of 750 tons/day in 2016. Waste in Depok City comes from several places, as follows: [8].

1. Household waste with a percentage of organic waste is 67.27% of total waste.
2. Waste from commercial areas with a portion of paper type waste is 28.84% of waste.
3. Waste from public facilities such as shelters, stations, terminals, parks, and others which are dominated by types of garbage such as leaves and twigs.
4. Waste from schools which is dominated by plastic waste amounts to 37.10% of the total waste.
5. Waste from 5 markets located in Depok City, with the dominance of organic type of garbage.

In carrying out waste management, the Depok City Government also involves the community through Law No. 18 of 2008 concerning waste management. The Depok City currently has a goal towards a zero-waste city, by making a sorting and management program at the source of waste, both simultaneously and sequentially with waste storage. Waste management starts from the location of waste generation or waste producers. Waste is separated between organic and inorganic waste and placed in different garbage containers. Organic waste will then be processed and processed into compost, while chemical waste will be used for recycling and reuse. Depok City currently has 31 locations that are pilot projects of the implementation of 3R to achieve the goal of being a zero-waste city. The community around the area must follow the scheme/flow of the garbage disposal that has determined with the following scheme in Figure 1 [7]. Then for locations or areas that are not targeted by the Depok City, the community independently or managed by the local sub-district conduct public garbage collection directly with the following scheme in Figure 2 [8] [9].

3. Result and Discussion

This study surveyed e-waste behaviour among high school students in Depok to strengthen the findings from observatory research that had been done previously. The results show that from 78 students, 52% are selling their used electronic goods, 43% are put their e-waste at home and 5% lift their e-waste on household trash.

After seeing the conditions of the waste stream in general in Depok City and the result of the survey in high school student in Depok, the researchers will investigate the situations of the flow of Electronic Waste circulating in Depok City. Through interviews with various actors involved in the flow of electronic waste in Depok City, researchers will try to map the flow with the following scheme in Figure 3.

![Figure 1. Waste Disposal Scheme for the 3R Program in Depok City (adapted from [7])](image1)

![Figure 2. Community Waste Disposal Scheme in Depok City in General (adapted from [7])](image2)
Figure 3. Research Analysis Results for Electronic Waste Flow in Depok City

The picture is a general description of how the flow of electronic waste in Depok City flows today. From the Figure shows that the e-waste flow in Depok City has not yet emptied into an exclusive management place for electronic waste. This condition means that waste management in Depok City is still an ideal form of e-waste flow.

At least several actors have their respective roles in the electronic waste stream in Depok City, as follows [7]:

a. Producers: actors who play a role in producing electronic goods for sale to consumers.
b. Distributors: actors who play a role in distributing electronic goods that have been produced by the manufacturer to the consumers.
c. Consumers: actors who act as users of electronic goods that have been produced by the Manufacturer.
d. The second consumer: an actor who is a user of used electronic goods.
e. Repair Service: an actor who can repair damaged electronic items for reuse, but in some cases, many damaged electronic goods are sold to repair services or not taken back by the Consumer, then the repair service repairs the electronic products and resells them.
f. Scavengers: actors with a role in searching waste that has economic value, such as plastic, cardboard, paper, and electronic goods.
g. Landfill: the estuary of all types of waste circulating in Depok City. The role of the current landfill is to accumulate garbage that carried out from residents without processing.
h. Collectors: a place where people or scavengers can sell used goods that have selling value, such as plastic, cardboard, bottles, and electronic goods. In the case of Depok City, goods or electronic waste rarely comes to collectors.

4. Conclusion of the study
From research or research that has been carried out regarding the flow of waste in Depok City, we have several conclusions from this study as follows:
Most of the high schooler in Depok do not know how to treat electronic waste safely, proof by most of them re-sell their broken or used electronic devices.

Conclude that each stakeholder related to electronic waste has not been yet integrated, so that the flow of garbage in Depok City is not well organized yet

There is no electronic waste found in TPA.
Electronic waste in Depok City has the potential to be buried in a household warehouse so that its presence is not detected.
Electronic waste in Depok City has the potential to be buried and spinned in the Rongsok Mall (mall used goods).
In this study, electronic waste streams in the city of Depok have not been detected thoroughly until the end of each component in electronic goods.

5. Recommendation Scenario for Electronic Waste Collection Center in Depok

Recommendation Scenario for Electronic Waste Collection Center in Depok

- Making a collection center or electronic waste collection center used as a first step or a pilot project for a series of electronic waste management in Depok City.
- Be preceded by making cooperation with third parties as parties that can manage electronic waste. In this phase, of course, Depok City must already have a budget for the management of this electronic waste or can look for other funding schemes such as grants or donors from organizations that have concerns about electronic waste.
- Then proceed with making electronic waste collection programs from the community.
- The researcher has conducted a comparative study with DKI Jakarta Province, located not far from Depok City.

DKI Jakarta Province currently has an electronic waste handling program, as follows:
- Electronic waste collection at the Neighbourhood level, chaired by the head of the DKI implementing unit
- Picking up electronic waste to DKI residents (min. 5 kg)
- Electronic waste box at busway shelter (collected each month)
- Electronic waste box at the train station (managed each month)

The city of Depok could duplicate programs such as DKI Jakarta by doing some improvisation, such as opening electronic waste collection sites in schools and universities located in Depok City. It also aims to educate and increase awareness of students and students on proper and correct management of electronic waste management as shown in Figure 4.

**Figure 4. Recommendation Scheme for E-waste Collection Project in Depok**
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