



# Analysis of Effectiveness in the Utilization and Control of Electronic Waste (E-Waste) in Indonesia

Savitri Amalia\*, Ibrahim Amyas Tarigan, Anita Rizkiyani, Catur Apriono

Department of Electrical Engineering, Faculty of Engineering, Universitas Indonesia

\*Correspondence: savitri.amalia@ui.ac.id

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**ABSTRACT:** In Indonesia, E-waste continues to grow rapidly, along with the increasing use of electronic goods such as telecommunications devices, households, offices, etc. Although it can be recycled, only a small portion can be done, and the recycling process is still under minimal control. Most E-waste is categorized as hazardous and toxic material waste. E-waste has a very high hazard impact if it is not recycled properly and correctly, such as polluting, damaging, and endangering the environment. This article uses forecasting of e-waste growth and canalization e-waste in Indonesia. The first data was obtained from EWasteRJ, a social community engaged in e-waste collection. The second data is obtained from questionnaires distributed to 110 respondents, focusing on knowledge and ways of handling E-waste. Using statistical analysis on both data shows that the amount of E-waste in Indonesia continues to increase every year, and public awareness of the dangers of E-waste is increasing.

**KEYWORDS:** Electronic waste; recycle; hazardous and toxic substances; e-waste management system

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## 1. Introduction

The telecommunication device market in Indonesia is enormous. The launch of smartphones in 2019 hit the highest mark of 9.7 million units in history [1]. The increase in delivery of smartphones is also increasing, as much as 21% in 2020 [2]. This increase is also going linear with the increase of electronic waste produced [3]. The volume of electronic waste has broken the record of the largest electronic waste produced in 2019. The total volume of electronic waste in the world exceeded 53.5 million tons, 9.2 million tons higher in electronic waste reported in 2014, and only 17.4% of the waste that could be recycled. Meanwhile, from February to October 2020, 22.6 tons of electronic waste were produced in Jakarta, Indonesia [4]. Some laws regulate electronic waste management, such as UU No.32 for the year 2009, UU No.18 for the year 2008, and PP No. 101 for the year 2014. However, these regulations have not been well-implemented, thereby impacting the mishandling of the waste. Furthermore, society often violates the regulations. One example is the forced shutdown of two locations in Tegal Adus village, Banten province, by the Directorate General of Law Enforcement of the Ministry of Environment and Forestry due to smelting and burning of electronic waste in open spaces [5].

Indonesia currently generates 1.8 million tonnes of e-waste every year and properly recycles 0.1 million tonnes [6]. According to the journal written by Santoso [7], it is predicted that there will be a 14.91% year-on-year increase in electronic waste volume in Indonesia from 2020 to 2028. One popular way to reduce electronic waste is to recycle. However, the process brings positive impacts such as increasing society's income, forming an economic chain in the informal sector, and reducing the volume of electronic waste dumped into the natural environment. The informal sector only pays attention to certain metal waste and ignores the technicality of the proper recycling process [8]. Formalized paraphrase based on the background of the problem; the study was designed to report data related to e-waste in Indonesia through two resources. One of the sources is EWasteRJ, a social community that specializes in gathering electronic waste [9]. The writer also handed out 110 surveys with the focus question being to find out what society's knowledge of and the handling process of electronic waste is in their daily life. Therefore, the writer could have a clearer map of the situation of electronic waste in Indonesia for forecasting e-waste growth and canalization of e-waste in Indonesia.

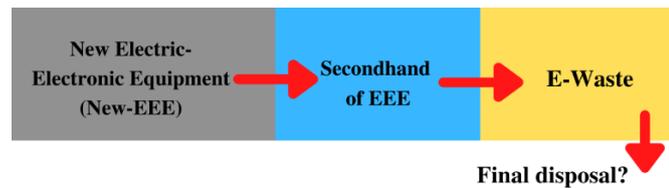
## **2. Definition, Cycle, and Movement of E-Waste**

### *2.1. Definition of e-waste*

Until this day, there is no specific definition of electronic waste [10]. Electronic waste is an electronic and electric object that is not being used, does not function properly, or is unwanted because the object is out of date and needs to be thrown out wholly or partially [11]. Most electronic waste is categorized as toxic, hazardous waste due to the components made from hazardous substances, including lead, mercury, cadmium, etc. Toxic and hazardous substances are defined as "substances, energy, and or other components whose nature and or volume can directly or indirectly pollute, contaminate, damage, and or endanger the environment, including human life, health, and other living creatures" [12]. Some electronic wastes contain valuable substances that can be recycled, such as plastic, glass, iron & steel, precious metals (silver, gold, platinum, copper), and rare earth metals (scandium, yttrium, cerium, neodymium).

### *2.2. E-waste Life Cycle*

In Indonesia, electronic waste does not directly go to landfills and sent over to the recycling center to be reused or modified. The process cycle of electronic waste in Indonesia is shown in Fig. 1. The product's useful life could be longer since the cycle varies and is not only managed by the formal sector [13]. New goods usually come from local manufacturers or legal importers. Generally, the goods go to distributors and retailers from this step, unless the goods come from illegal importers. When the end customers buy the goods, the term "used" or "second-hand" appears. Usually, at this stage, there is no meaningful control and supervision from the authorities. When the goods are completely damaged, the goods were sent to the flea market and the parts that are still in good shape and considered valuables were retailed again.



**Figure 1.** A cycle of E-Waste in Indonesia

### 2.2.1. Informal sector

Figure 2 shows an example of the cycle of electronic waste in Indonesia in the informal sector in the Greater Bandung area [13]. However, the used electronic goods were recollected by informal sector in Indonesia. The good parts were recollected and resold, leaving the damaged parts to be discarded. In this sector, a social community collects electronic waste in several areas in Indonesia called EWasteRJ [14]. They have several drop-off points for people to dispose of electronic waste in several areas of Indonesia. By doing this, they have indirectly helped to separate electronic waste from general waste. Later, the waste was periodically sent to the main warehouse for separation into different categories. Instead of treating electronic waste, this community sends it to formal toxic and hazardous waste officials.

### 2.2.2. Formal sector

Figure 3 depicts the formal sector's electronic waste cycle in Greater Bandung [13]. The cycle of new goods is better classified in this sector because official institutions are involved. If a device is broken, the parts are examined first. If the damaged component can be repaired, it would be replaced. If it can't be repaired, the good components were kept as a backup in case similar items can be repaired with them. This is called "cannibalization" and they collected and delivered the damaged components to the official institution to destruct it safely and legally.

### 2.3. Hazard substances

Because most electronic waste is categorized as toxic and hazardous waste, electronic waste has a negative impact that can cause environmental problems if not handled properly. However, many parties are still not aware of the negative impact of electronic waste. One of the reasons for the lack of awareness is caused by the lack of information about electronic waste [15]. There is not much of a discussion regarding electronic waste in Indonesia, so, naturally, not all levels of society know the negative impacts of electronic waste. The next factor is the lack of understanding of the difference between household waste and electronic waste. It is often found in electronic waste mixed with other waste in the public waste dump. However, the handling of electronic waste is very different due to the hazardous substances in electronic waste that need to go through special treatment not to be harmful to the environment. The last factor is the unavailability of technical provisions. Therefore, many people still dispose of electronic waste in public trash bins where it was mixed with other types of waste.

In India, officials pay special attention to personal data security on items that have become electronic waste [16]. To minimize the collection of personal data from electronic waste, they do several things. The first step is to provide data destruction certification. Secondly, they implement a policy to regulate third parties and shops that do not have an official license. Mobile companies in India should put more effort into channeling cellphone

waste to recycling plants rather than going with a heuristic way in the used market. Another policy is to give permits to officialize second-hand markets. If there is a violation in the implementation of the destruction process, the permit was revoked.

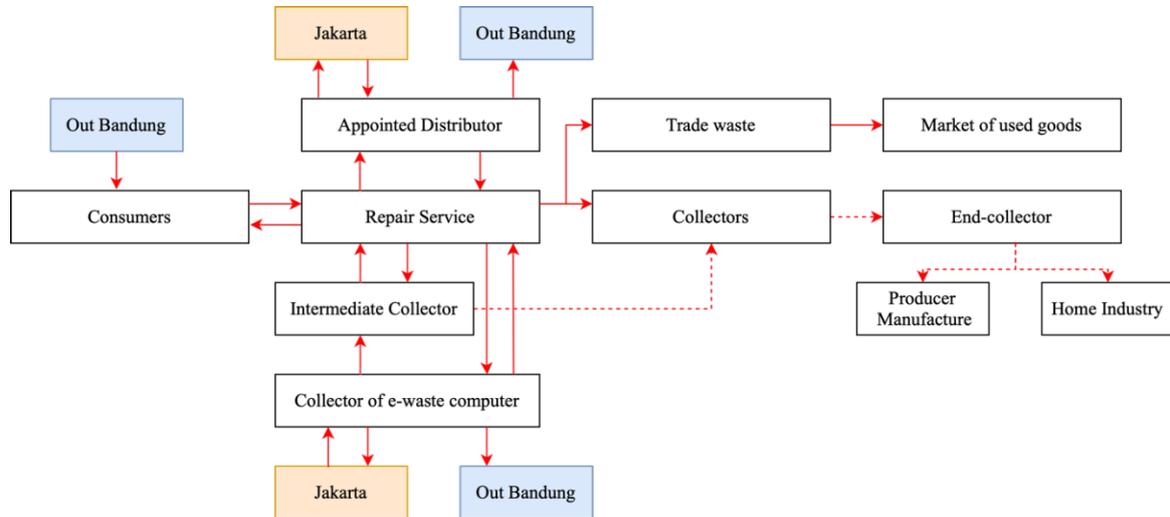


Figure 2. E-Waste Scheme of the informal sector, Bandung area case

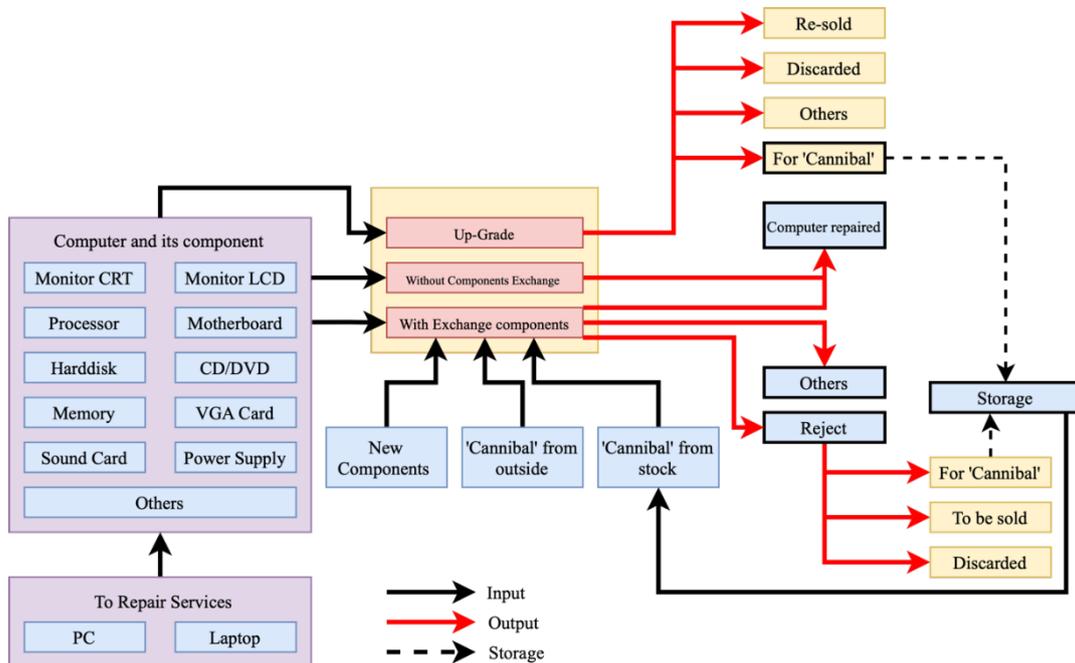


Figure 3. E-Waste Scheme of the formal sector, Bandung area case

### 3. Methodology

#### 3.1. Research data

There are two types of data: the volume of electronic waste in Indonesia and procedures for handling the electronic waste. These data can be obtained through public data on the relevant agency's website, collecting data from independent non-governmental organizations' websites,

and conducting a questionnaire distributed to 110 respondents with the main questions according to Table 1.

### 3.2. Data processing method and research parameters

In this study, there are two types of data processing methods. The first is the electronic waste category. The second is statistical data analysis by checking some parameters as follows:

1. Unit of remediable electronic waste.
2. The procedure for managing electronic waste.
3. Each category's success in countermeasures.
4. Percentage increase in successful electronic waste management in upcoming years.

**Table 1.** Main Questions

No	Question
	<b>Question:</b> Explain how you dispose of electronic waste. Instruction: <b>Allowed to choose multiple choices</b>
	A. Separated and input in the trash bin according to the type of electronics waste
	B. Put in a general garbage bin
	C. Calling e-waste disposal services
	D. Sell the waste to the second-hand market
	E. Repairing the devices
1	<b>Activity#1</b> heat-generating appliances e-waste Answer A B C D E
2	<b>Activity#2</b> E-waste with screen Answer A B C D E
3	<b>Activity#3</b> Light bulb e-waste Answer A B C D E
4	<b>Activity#4</b> Big volume e-waste Answer A B C D E
5	<b>Activity#5</b> Small volume e-waste Answer A B C D E
6	<b>Activity#6</b> Handphone and accessories e-waste Answer A B C D E

## 4. Results and Discussion

### 4.1 Research data on EWasteRJ

To support the study on electronic waste, the writer used data from the social community engaged in collecting electronic waste in Indonesia, EWasteRJ [16]. The used data is from 2018-2020, covering areas from 3 major islands in Indonesia, Java (Covering Banten, DI Yogyakarta, DKI Jakarta, West Java, and East Java), Sumatra (Covering South Sumatra), and Sulawesi. (Covering the area of South Sulawesi).

Below are a few types of electronic waste according to EWasteRJ:

1. IT & Telecommunications Equipment (ICT), e.g., smartphones, chargers, smartphone/notebook charger cords, notebooks, HDMI cords, etc.
2. Household appliances (HA), e.g., iron, drilling machines, water pump machines, etc.
3. Consumer Equipment (CE), e.g., clocks, DVDs, remote controls, etc.
4. Lighting Equipment (LE), e.g., light bulbs, desk lamps, etc.
5. Toy equipment (TS), e.g., toy cars, game consoles, and other accessories, etc.

6. Electrical and electronic tools (EE) include items such as power supplies, PCBs, socket cords, and so on.

Table 2 shows the electronic waste data that EWasteRJ managed to collect in 2018, 2019, and 2020. The 2018 and 2019 have a unit column as the unit of goods collected in each category. However, in 2020, this column changed to show the total weight of the collected goods. This condition is due to data collection forms by the EWasteRJ. In 2020, it was not calculated per unit in each category but the total weight of units in each category. There has been an increase in total weight every year. As shown in Table 3, e-waste increases by more than 70% each year. In 2018 and 2020, there was an increase in total weight of up to 205%. It has been shown that the ICT category has become the largest contributor to electronic waste every year. In 2018, only 45 ICT units were collected, and in 2019, there was a very drastic increase of 211 ICT units collected. The number of units collected in the ICT category in 2020 is unknown. However, the total weight reaches 744.43 kg, almost equivalent to the total weight of all categories of objects in 2019 (772.95 kg).

The significant increase matches with the data on the increasing number of telecommunication equipment in Indonesia. This data proves that the more telecommunication equipment circulates, the greater the electronic waste generated. This condition indicates that there is a possibility that in 2021 or 2022, this number could increase to 1 ton (1000 kg) if referring to the increasing trend of total weight per year. The increasing trend is happening in the ICT category and almost all categories in terms of units and total weight due to the addition of electronic waste drop-off points that EWasteRJ opens every year. The increasingly active socialization regarding electronic waste in various regions indirectly increases public awareness of the impacts and dangers of handling electronic waste more properly.

**Table 2.** EWasteRJ Collected Electronic Waste Data in 2018, 2019, 2020.

Years	2018			2019			2020		
	Variable	Unit	Weight (kg)	Unit	Weight (kg)	Unit	Weight (kg)	Weight (kg)	
ICT	45	55.56	431.5	211	66.98	772.95	744.43	56.8	
HA	5	6.17		17	5.4		138.655	10.52	
CE	22	27.16		38	12.06		224.73	17.05	
LE	3	3.7		13	4.13		34.17	2.59	
TS	3	3.7		36	11.43		19.155	1.45	
EE	3	3.7		0	0		156.975	11.91	
<b>TOTAL</b>	81	100	315	100	1318.115	100			

**Table 3.** EWasteRJ Collected Electronic Waste Data in 2018, 2019, 2020.

Years	2018	2019	2020
Weight (kg)	431.5	772.95	1318.115
Increasing	79%		71%

#### 4.2. Knowledge regarding electronic waste

It is also important to know the level of public awareness of electronic waste. The results of the survey taken from random respondents randomly are shown in Table 4. From the results of the questionnaire shown in Table 1, based on gender, there are still many people who know about electronic waste, both for men and women. Knowledge of electronic waste in males is 42.2%, which is smaller than in females at 57.8%. This indication can be caused by many

factors, such as social environment, age, and other factors. For further analysis, the next assessment aspect is conducted. From the questionnaire results in Table 4 based on gender comparison, both men and women are quite knowledgeable about electronic waste. Based on the correspondence, the difference between men who know electronic waste is higher than men who do not. While for women, the difference is not significant.

It is also necessary to look at respondents' age range when surveying their knowledge about electronic waste shown in Table 4. The age range of 20 years old is superior for being literate for information on electronic waste. Because this age group excels at using technology and has easy access to information, they can easily gain knowledge on electronic waste. It is also seen that the older the respondents, the less awareness of electronic waste becomes. Regarding the education level from Table 4, there is a tendency that the knowledgeable group is competing with an unknowledgeable group. This condition proves that the level of education affects the dissemination of information and understanding of electronic waste. The next parameter is occupation. The work environment can be a medium for disseminating information about electronic waste. Based on Table 4, there are many varieties of two-way interaction for private corporation employees, many of whom already know about electronic waste. Diverse two-way interaction is considered important because, as observed in the university student environment, their conversation is mostly about their major. Therefore, the topic of electronic waste is rarely discussed. Lastly, there is the neighborhood. Due to the basic nature of humans to adapt to their social environment, the behavior of the surrounding community is likely affecting the character and knowledge of electronic waste. In big cities, people are more knowledgeable because they have different character and urgency than people living in smaller regions.

#### *4.3. General waste management*

If referring to scenarios in the processing of electronic waste, four main scenarios can be used to observe people's tendency in handling electronic waste. The details of each scenario are as follows:

- a. Electronic waste was formally systematically collected through formal institutions. The government has regulated or disposed of certain landfills according to their type and effect on the environment. For scenario 1, the option was separated and placed it in a landfill according to the type of electronic waste.
- b. In scenario 2, electronic waste is disposed of and other types of non-electronic waste in a landfill. The option of this scenario is to dispose of the electronic waste in a regular trash can.
- c. The third scenario is to dispose of electronic waste to a non-profit organization, but it operates only on a regional management basis. In this scenario, the option is to call electronic waste disposal services.
- d. The fourth scenario is to dispose of electronic waste without considering the type and how to handle the electronic waste properly. There are three options in this scenario, which are either to resell it to the flea market.
- e. The last scenario is to repair the item.

**Table 4.** Knowledge survey data regarding Electronic Waste.

No	Category	Result	
	<i>Gender</i>	Yes	No
1	Male	30	10
2	Female	41	26
	<i>Age</i>	Yes	No
1	10s	8	3
2	20s	38	24
3	30s	5	0
4	40s	3	1
5	50s	9	5
6	60s	2	0
7	70s	1	0
	<i>Education</i>	Yes	No
1	Junior High School	1	0
2	Senior High School	10	6
3	Vocational High School	5	3
4	Diploma	0	1
5	Bachelor's	45	24
6	Master's	8	2
7	Doctoral	1	0
	<i>Domicile</i>	Yes	No
1	Bandung	14	2
2	Bekasi	5	5
3	Bogor	2	1
4	Boyolali	0	1
5	Cimahi	1	0
6	Depok	6	1
7	Jakarta	18	13
8	Jambi	0	1
9	Kebumen	1	0
10	Kediri	0	1
11	Malang	2	0
12	Mataram	1	0
13	Nganjuk	1	0
14	Palembang	1	1
15	Pamulang	1	0
16	Pasuruan	1	0
17	Purbalingga	1	0
18	Purwakarta	1	0
19	Purwodadi	0	1
20	Purwokerto	0	1
21	Serang	0	1
22	Semarang	2	0
23	Solo	1	0
24	Sukabumi	0	1
25	Surabaya	1	0
26	Tangerang	5	0
27	Tangerang Selatan	3	2
28	Yogyakarta	1	3
	<i>Job</i>	Yes	No
1	Unemployed	3	2
2	Labor	2	0
3	Lecturer	3	0
4	Freelancer	5	1
5	Teacher	2	0
6	Housewife	4	0
7	Private sector employee	25	13
8	Student	13	12
9	retired	2	3
10	Public sector employee	2	1
11	Profesional	1	1
12	Entrepreneur	6	4

Furthermore, the important points are to know the knowledge of each gender in a certain age range regarding electronic waste disposal treatment. Based on the questionnaire, the writer obtained the following data:

- a. Heat-Generating Electronic Waste: from Table 5, The highest response is to scenario 4, specifically to sell the waste to the flea market. In the gender data, women mostly go to flea markets to deal with electronic waste that generates heat because it is more practical as people retrieve the items in their respective houses. They can generate income out of it. The economic value they obtain when discarding this item at flea markets has become an attraction for people in their 20s.
- b. Electronic Waste with Screens: Waste with screens such as computer screens, monitors, and tablets are included as waste that contains components, especially glass that can be useful. As seen from Table 5, there is a significant difference in how respondents dispose of this type of electronic waste. Based on the gender and age range, many respondents chose scenario 4 to resell the waste to the flea market. They could obtain higher value from the various valuable components, which became a special attraction.
- c. Light bulb Electronic Waste: Lamp-type waste is the second most common type of waste generated from households. The possibility to change light bulbs up to twice a year and the usage difference in each household makes people handle the waste differently. From Table 5, many female respondents choose to dispose of this waste immediately since it is not valuable. However, there is a lack of concern about separating the disposal of this type of waste from other non-electronic waste. There is not much difference in the gender and age graph. They show the same behavior in dealing with this type of waste. They combine this type of waste with other household waste because it carries no economic value and is inconvenient to separate.
- d. Large Electronic Waste: People's response to large electronic waste disposal is the same as dealing with electronic waste in Points 1 and 2. Table 5 shows that the respondents have the tendency to resell this waste, but some suggest giving it to others if possible.

**Table 5.** Electronic Waste Handling Data Result.

Treatment	Percentage (%)					
	Activity#1	Activity#2	Activity#3	Activity#4	Activity#5	Activity#6
A	11,9	12	16,5	11	16,5	16,4
B	17,5	5,6	74,8	3,1	19,4	24,6
C	11,9	8	0,9	14,2	7,9	3
D	49,7	54,4	7,8	59,1	41	40,3
E	9,1	20	0	4,2	1,8	1,8

- e. Small Electronic Waste: This type of waste has quite different results than the other types of waste. Although it is still using scenario 4, the other options have much higher rates, as shown in Table 5. This condition was due to the possibility of how to treat the waste. It can be given to others, or people tend to keep them. The components in a small electronic waste can be reused for other devices that need substitutes.
- f. Electronic Waste of Mobile Phones and Accessories (Mobile Phones and Computers): Another option in Table 5 is higher than the other option available. Due to its small part, many people use it for other purposes, so people tend to resell it.

## 5. Conclusion

It can be concluded from the analysis that there was a yearly increase in the amount of electronic waste in Indonesia. With the increasing number of telecommunications equipment in Indonesia, the electronic waste generated was increased. However, the increasing number of items that EWasteRJ has collected shows that Indonesian people are becoming more aware of electronic waste disposal. At least if the amount of electronic waste increases, people able to separate electronic waste from other general waste. From the results of the questionnaire on 110 respondents, many people still rely on Scenario 4, or the alternative scenario where there was no official governing institution. Scenario 4 was widely used in developing countries that reselling their electronic items to flea markets was an option. This condition was considered practical by the respondent because it can be beneficial to both parties. Besides that, they don't have to bother to throw it away because people from the flea market like to search for electronic waste by themselves in our area.

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## Competing Interest

The authors declare no financial or non-financial competing interests.

## References

- [1] Kompas Tekno. Accessed: 1 March 2021, Mengamati Pergeseran Pasar Smartphone Indonesia di 2019, link: <https://tekno.kompas.com/read/2019/09/02/14010097/mengamati-pergeseran-pasar-smartphone-indonesia-di-2019?page=all>.
- [2] Kompas Tekno. Accessed: 1 March 2021, Ini Dia 5 Penguasa Pasar Smartphone di Indonesia Kuartal III-2020, link: <https://tekno.kompas.com/read/2020/11/27/09110097/ini-dia-5-penguasa-pasar-smartphone-di-indonesia-kuartal-iii-2020?page=all>.
- [3] Kompas Tekno. Accessed: 28 February 2021. Limbah Elektronik Dunia Catat Rekor Tertinggi 53.6 Juta Ton, link: <https://tekno.kompas.com/read/2020/07/09/15180087/limbah-elektronik-dunia-catat-rekor-tertinggi-53-6-juta-ton?page=all>.
- [4] Tirto. Accessed: 1 March 2021, Limbah Elektronik di Jakarta Capai 22 Ton, link: <https://tirto.id/limbah-elektronik-di-jakarta-capai-22-ton-f7ch>.
- [5] ValidNewsID. Retrieved: 1 March 2021, Menanti Solusi Konkret Sampah Elektronik, link: <https://www.validnews.id/Menanti-Solusi-Konkret-Sampah-Elektronik-KGD>.
- [6] Kementerian PPN/Bappenas (2021). The Economic, Social, and Environment Benefit of A Circular Economy in Indonesia, Kementerian PPN/Bappenas Indonesia.
- [7] Santoso, T.Y.M.; Zagloel, Ardi, R.; Suzianti, A. (2019). Estimating the Amount of Electronic Waste Generated in Indonesia: Population Balance Model, *IOP Conference Series: Earth and Environmental Science*, 219, 012006. <http://dx.doi.org/10.1088/1755-1315/219/1/012006>.
- [8] Terazono, A.; Yoshida, A. (2009). Environmental Management System of E-waste in Formal/Informal Sector. E-waste Training Workshop for Asia and the Pacific, Vietnam.
- [9] Damanhuri; Sukandar, E (2006). E-waste Disposal and Health and Safety in 5R of E-waste. BCRC-SEA Workshop on E-waste, Siem Reap.

- [10] Pusat Pengkajian Industri Hijau dan Lingkungan Hidup, Badan Pengkajian Kebijakan, Iklim, dan Mutu Industri (2012). Pemetaan Teknologi Pengolahan Limbah Elektronik.
- [11] Wahyono, S. (2012). Kebijakan Pengelolaan Limbah Elektronik Dalam Lingkup Global dan Lokal. Pusat Teknologi Lingkungan, Badan Pengkajian dan Penerapan Teknologi
- [12] Undang Undang Republik Indonesia Nomor 32 tahun 2009 tentang Perlindungan dan Pengelolaan Lingkungan Hidup.
- [13] Damanhuri, E. (2018). Electronic Industrial Waste Management and Waste as Industrial Resources to Support Reducing Releases of PBDEs/UPOPs. Development of E-waste Management and Technology in Indonesia workshop, Ministry of Industry and UNDP, Bali.
- [14] EWasteRJ, E-WasteRJ - Data Pengumpulan Sampah 2018 - 2020, Recycling E-Waste, Available: <https://ewasterj.com>.
- [15] Shagun, K.; Ashwani; Rora, A. (2013). Proposed Solution of e-Waste Management, *International Journal of Future Computer and Communication*, 2, 490-493. <https://doi.org/10.7763/IJFCC.2013.V2.212>.
- [16] Debnath, B.; Das, A.; Das, S.; Das, A. (2020). Studies on Security Threats in Waste Mobile Phone Recycling Supply Chain in India. IEEE Calcutta Conference (CALCON) 2020, pp. 431-434, <https://doi.org/10.1109/CALCON49167.2020.9106531>.



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