



## CASE STUDY

# Environmental awareness factor of used cell phones

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### ABSTRACT

**BACKGROUND AND OBJECTIVES:** Electronic equipment production is one of the major industrial sectors in Indonesia, as it also contributes to Indonesia's export commodities, which increase because of rapid technological developments. Cell phones, which have considerable potential to become electronic waste, recorded the enormous escalation in electronic production. This research aimed to increase community involvement and the collection of used cell phones from households in e-waste management in Indonesia. A survey was conducted to explore a household's environmental awareness and willingness to recycle based on sociodemographics, environmental hazard awareness, and used cell phone usage in Jabodetabek, Indonesia.

**METHODS:** In this research, a peer questionnaire was used and organized into five sections: The first section contained the sociodemographic details of the respondents. The second section comprised multiple concerns that relate to recycling and environmental awareness. The third section contained the family cell phone information. The fourth section determined the cell phone consumer behavior. The fifth section consisted of willingness to recycle. Statistical correlations between variables were assessed, and the chi-square independence test was used to evaluate the statistical correlations.

**FINDINGS:** Mostly the households will replace their used cell phone if there is damage (66.84%) and keep the used cell phone at home (59.5%), thus becoming an obstacle in applying the appropriate recycling system and a circular economy. The average cell phone ownership in Jabodetabek is 1.28 units, and the average cell phone life span of people in Jabodetabek is 2.6 years. The Environmental Hazard Awareness variable has significant differences with occupation and income level (p-value = 0.028 and 0.046), Used Cellphone Usage variable has significant differences with the income level variable (p-value = 0.024). The others, a statistically significant difference between sociodemographic variable and Willingness to Recycle was observed; p-value = 0.003 for age and p-value = 0.034 for occupation.

**CONCLUSION:** This paper showed that Environmental Hazard Awareness and Willingness to Recycle have an important role in increasing the collection of used cell phones from households. This study assessed community-based factors located in urban areas. The factors could encourage their participation in collection activities, obtain information on the preferred collection channels of residents, and provide a perspective for managing cell phones through an analysis of the improvements and influences of Indonesia's current e-waste recycling program. Therefore, to develop a new strategy, the findings of this study can provide insights into the e-waste problem and citizen's awareness of e-waste management.

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## INTRODUCTION

Electrical and electronic equipment waste (e-waste) is one of the fastest-growing waste sources globally, as fast as technological development and electronic product replacement (Baldé et al., 2017). Moreover, e-waste is one of the materials that contain the most harmful substances in domestic waste (Król et al., 2016). Hsu et al. (2019) reported that the global e-waste in 2016 amounted to 44.7 million tons, expected to reach 50 million tons in 2021 and 100 million t in 2030 (Tiwary et al., 2017). Members of society now need to discuss e-waste with precise planning to avoid environmental damage (Babayemi et al., 2017). Indonesia is an archipelago country that is located on the Asian continent. Indonesia is the fifth country with the largest population, reaching 270 million people, with an annual population growth of 1.25% or approximately 3.37 million people/year (Statistics Indonesia, 2021). The total population in large cities, such as Jakarta, Bogor, Tangerang, Depok, Bekasi, Bandung, Semarang, Surabaya, Medan, and Palembang, reaches 50.7% of the total population of Indonesia. About 58% of this population is concentrated in Java Island. The electrical and electronics market is currently dominated by smartphones, computers, and some electrical and electronic equipment at low import prices (Honda et al., 2016). Used cell phones are one type of e-waste that deserves special attention, as it has a growth rate of more than 40% each year (Xu et al., 2016). Consequently, more than 40 million end-of-life cell phone units are predicted to be produced by Indonesia in 2028 (Santoso et al., 2019). Thus, this case study focused on cell phones. The number of cell phone products in Indonesia increases every year, with 46.9 million units circulating in Indonesia in 2003, 333.9 million units in 2015, and 435 million units in 2017 (ITU-D, 2020). The rapid technological development has also caused an increase in the number of cell phone products in Indonesia, thus increasing e-waste originating from cell phones (Andarani and Goto, 2014). Concerning economic conditions affecting e-waste collection, Li (2017) indicated that cell phones are the most dominant type of e-waste with many precious metals and nonmetals. Therefore, Zeng et al. (2018) stated that conventional mining is less cost-effective than urban mining. The Life Cycle Cost assessment was conducted to investigate the cost of recycling waste cell phones

and the contained precious metal by considering the material flow from waste cell phone collection to waste material disposal after mineral extraction (He et al., 2019). Liu et al. (2020) reported that the hydrometallurgical process for cell phone e-waste was environmentally and economically viable. The process had a 29 % return on investment (ROI), indicating that it could ensure a self-sustaining business. Ghodrat et al. (2016) described the process used to model the economic feasibility of e-waste using copper smelter and determined that the minimum capacity to be still economically feasible is 30,000 t/year. However, the main strategy that creates economic benefits is the optimization of the production of precious metals from cell phones. Babayemi et al. (2017) suggested that three years is the average usage time of cell phones in Nigeria. Mishima et al. (2016) estimated that the use time of cell phones is three years from the increase in the annual production of cell phones in Japan. According to Yin et al. (2014), customers replaced their cell phones for less than three years for various reasons. The level of toxicity in Asian, African, and European nations is used to reference that the end of life of cell phones is faster in some countries nowadays, which is in one or two years (Sarath et al., 2015). Based on numerous previous research findings, most customers replace their used cell phone in just 1–3 years, shorter than the cell phone's life span because of improved features, newer versions, and lower prices. Many used cell phones that users in their households keep because of the small shape and small space occupied is another problem in the collection process, thus becoming a barrier to the implementation of the recycling system (Wilson et al., 2017; Ylä-Mella et al., 2015). Echegaray and Hansstein (2017) suggested that socioeconomic and demographic factors greatly influence the success of the recycling process carried out in Brazil. Additionally, consumer awareness is critical to any successful e-waste control efforts (Awasthi and Li, 2018). Martinho et al. (2017) stated that gender, mainly male, employment level, and families, affected the desire to recycle for cell phone customers in Portugal. Song et al. (2012) studied that educational level can play a significant role in willingness to pay on cell phone consumers in Macau. The most frequently cited barrier to residents returning cell phones was a lack of formal collection channels (Tan et al., 2018). Liang and Sharp (2016)

referred to age and gender as the deciding factors that influence recycling programs. Yin *et al.* (2014) determined that family and educational background had the most significant effect on customer disposal actions. The selling of e-wastes by households to smugglers is one of the main obstacles to e-waste collection (Wang *et al.*, 2017). At the same time, Liang and Sharp (2017) indicated strong associations between higher financial and literacy levels of users of e-waste and their experiences on e-waste and its environmental implications in several Asian countries. Previous studies showed that various factors, including demographic factors (such as age, gender, and educational level) and environmental awareness, likely influence consumers' decisions on different disposal options. The most significant factor in achieving a successful collection rate of e-waste tends to be customer interest. Several studies have examined e-waste management in Indonesian cities. Panambunan-Ferse and Breiter (2013) described the state of e-waste management in Manado City, Indonesia, where e-waste will be disposed of in the landfill due to the government's lack of rules and monitoring systems, which has resulted in a lack of public awareness of e-waste. Informal actors were the most dominant influence throughout the collecting and sorting of e-waste from households in Indonesia. It is necessary to include the informal sector in the regulations made by the government (Rochman *et al.*, 2017). Maheswari *et al.* (2017) suggested the Quatro helix model where producers, government, takeback operators, and the community work together to implement reverse logistics for e-waste properly. Pandebesie *et al.* (2019) studied the behavior of the residents of Surabaya, Indonesia, when dealing with e-waste. They found that willingness to pay may also be a source of e-waste management financing. Although certain cities in Indonesia have performed studies on e-waste management, there is still limited research on the environmental awareness and willingness to recycle e-waste streams. This research aimed to increase community involvement and the collection of used cell phones from households in e-waste management in Indonesia. The research finds out the characteristics of the JABODETABEK households and finds the main factors influencing community involvement in e-waste management in Indonesia. We intend to identify the reasons of residents are unwilling to turn

their cell phones off the shelf. Also, the factors that could encourage their participation in collection activities and provide a perspective for managing cell phones through an analysis of the improvements and influences of Indonesia's current e-waste recycling program. Furthermore, the findings of this research will assist the government in improving e-waste management strategies. The novelty was the relationship model between the sociodemographic of the Jabodetabek community with environmental awareness and willingness to recycle to improve e-waste management in Indonesia. In order to achieve this objective, an experimental online questionnaire survey was undertaken to examine residents' actions and preferences regarding cell phone disposal in Jabodetabek, Indonesia, in 2020. The streams of cell phones used in this region have also been monitored.

#### MATERIALS AND METHODS

This study conducted a household questionnaire utilizing questionnaires to gather information on people's environmental awareness and willingness to recycle e-waste. The questionnaire contained 31 questions, including yes or no questions, single or multiple answer questions, and statements graded on a five-point Likert scale. The questionnaire refers to previous research on consumer behavior toward electronic equipment, and a peer questionnaire was used and organized into five sections: The first section contained the sociodemographic details of the respondents, including gender, age, education, jobs, income, and area (Islam *et al.*, 2016; Song *et al.*, 2012). The second section comprised multiple concerns related to recycling, knowledge, and environmental awareness (Afroz *et al.*, 2013; Islam *et al.*, 2016). The third section contained the family cell phone information (Martinho *et al.*, 2017). The fourth section determined the cell phone consumer behavior (Yin *et al.*, 2014). The fifth section consisted of willingness to recycle (Tan *et al.*, 2018; Yin *et al.*, 2014). Significant differences hypotheses between Environmental Hazard Awareness (EHA), Used Cell phone Usage (UCU), Willingness to Recycle (WTR) within household sociodemographic variables were developed. In order to support the validation and clarification of our findings while also supplementing current theory on e-waste management in the research region. During the survey, information on

### Used cell phones

the sociodemographic characteristics of residents, cell phone usage, and replacement behavior was also collected. Statistical correlations between variables were assessed, and the nonparametric statistical method of the chi-square ( $\chi^2$ ) test for independence was used to evaluate the statistical correlations between variables.

Microsoft Excel was used to evaluate the questionnaires, and Minitab17 was used to do statistical analysis.

### Survey design and data collection

This research used chain referral sampling for the survey (Johnson, 2014). Emails were sent to the family members, acquaintances, and colleagues of the authors. Sixty people, who were, in turn, asked to invite as many people as possible. The emails included a link to the online questionnaire developed using Google Forms. When sending the questionnaire link to acquaintances and colleagues, the authors ask for their help in redistributing it. The respondent's requirement is family-based; only one family member can fill out the questionnaire in that family. Another requirement is that the questionnaire was distributed in different regions and

age ranges so that the respondents obtained will be more diverse. Chain referral sampling (also known as snowball sampling) provides functional advantages for exploratory research, such as the easy selection of participants, high response rate, and relatively low cost (Baltar and Brunet, 2012; Johnson, 2014). Panambunan-Ferse and Breiter (2013) studied an overview of e-waste management in Indonesia using snowball sampling. In comparison, exploring the latest smartphone and tablet consumer consumption and recycling behavior by Martinho *et al.* (2017) and an examination of household e-waste management strategies by Tiep *et al.* (2015). Based on the input from users, the questionnaire was refined. We applied the chi-square ( $\chi^2$ ) test whether there were any significant variations in the respondents' sociodemographic factors with the other awareness factors. We provided a short description of the idea of e-waste and that of a formal concept of a collection system to prevent possible confusion. The survey was available from October 22<sup>nd</sup>, 2020, to November 14<sup>th</sup>, 2020, and 394 responses were received. As a result, 389 questionnaires were appropriate to households living in nine urban districts and cities shown in Fig. 1. The reason why Jabodetabek was chosen as a survey

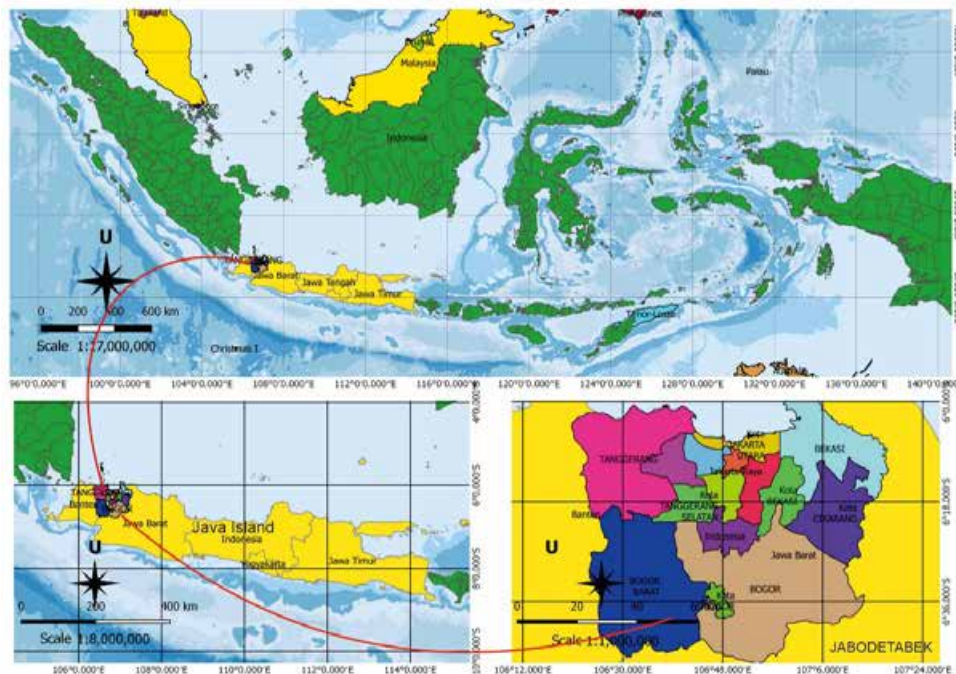


Fig. 1: Geographic location of the study area in Indonesia, Java Island and Jabodetabek

location is due to the fact that the total population in large cities, such as Jakarta, Bogor, Tangerang, Depok, Bekasi, Bandung, Semarang, Surabaya, Medan, and Palembang, reaches 50.7% of the total population of Indonesia. About 58% of this population is concentrated in Java Island; the electrical and electronics market is currently dominated by smartphones, computers, and some electrical and electronic equipment at low import prices (Honda *et al.*, 2016).

*Analytical framework*

Jabodetabek has grown into a more extensive and more integrated megacity from the boundaries of different city regions. This area comprises Jakarta as the business district and its satellite cities, namely Bogor, Depok, Tangerang, and Bekasi. Jabodetabek has become Indonesia’s largest megacity with an important role in social, political, and economic aspects. Jabodetabek has a land area of approximately 7,000 km<sup>2</sup>. In 2010, Jabodetabek’s population was more than 26.7 million and contributed 25.52% to Indonesia’s GDP (Rustiadi *et al.*, 2015). According to the calculated number of households in Jabodetabek (i.e., approximately 460,000), the sample size is set as 384 (CRS, 2016; Islam *et al.*, 2016). The total

number of valid respondents that we have in this research is 389 samples. Thus, the number of sample respondents has exceeded the sample size set based on the previously presented calculations. The behavioral patterns of residents regarding the disposal of their out-of-use cell phones and their attitudes toward cell phone collection activities were considered. Their perceptions of selling their waste cell phones and their priorities were examined in the settings and modes of the collection infrastructure.

**RESULTS AND DISCUSSION**

*Residents’ sociodemographic Characteristics*

According to the respondents’ sociodemographic characteristics, the mean age was 34.90, and 42.93% of the respondents were male. The majority of the respondents held a bachelor’s degree (i.e., 46.53%). The average individual earnings were Rp 6.4 million/month. The top three areas of concern and involvement that respondents were most interested in were study principles, government employees, and businesses or services. These topics were the top priorities of 25.71%, 20.31%, and 18.51% of respondents, respectively. The sociodemographic build of the resident is shown in Table 1.

The other survey results showed that most

Table 1: Sociodemographic build of the resident

Characteristics	N (number)	%
Sex		
Male	167	42.93
Female	222	57.07
Age		
18 - 24	118	30.33
25 - 29	54	13.88
30 - 39	64	16.46
> 40	153	39.33
Occupation		
Business & Services	72	18.51
Government Employee	79	20.31
Corporate employee	138	35.48
Student	100	25.71
Education Level		
High School and associate degree	143	36.76
Bachelor Degree	181	46.53
Master and above	65	16.71
Monthly Income (Rp)		
2 - 3.5 million	116	29.82
3.5 - 5 million	35	9.0
5 - 7 million	50	12.85
7 - 10 million	57	14.65
>10 million	131	33.68

respondents had one cell phone (i.e., 72.24%), whereas 23.65% had two cell phones, 2.31% had three cell phones, and 1.8% had more than three cell phones. Thus, the total number of cell phones owned by a Jabodetabek respondent was more than 1.28 units. This number is slightly lower than the average number of cell phone owners in Indonesia, which is 1.4 units with 371.4 million cellphone users out of a total population of 262 million (Kemp, 2017).

*Life span and reasons for cell phone replacement*

The average life span of cell phone use in our study is 2.6 years (Fig. 2). Based on the respondents' data, most people in Jabodetabek (i.e., 48.59%) still use their cell phones for more than three years. Among the respondents, 30.33% continued to use

the same cell phones for three years, and 14.4% of the respondents changed their cell phones when they reached 1.5–2 years old. The average life span of cell phones in the study conducted by Polák and Drápalová (2012) was 4.35 years. Two years later, Yin et al. (2014) determined that the average life span of a cell phone was shortened to 2.9 years. During its development, the cell phone was initially an electronic product with a slow turnaround; it became an electronic product with a fast turnaround because of the rapid growth of functions, technologies, and sales strategies that pushed new products to the market every year. The average cell phone usage time was 2.61 years in the study conducted by Bai et al. (2018), and the average use of cell phones was 1.9 years in the study conducted by Tan et al.

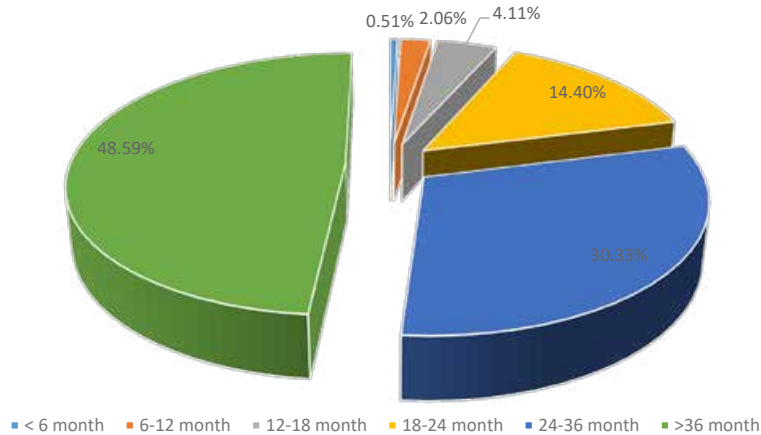


Fig. 2: Households' cell phone replacement frequency

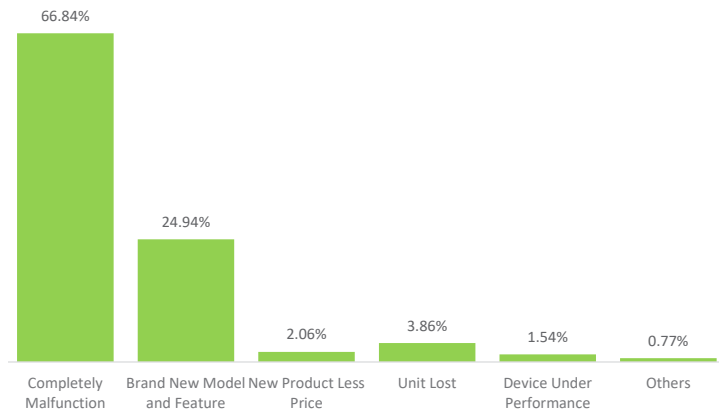


Fig. 3: Households' cell phone reason for replacement

(2018). These studies further proved that cell phones have developed into electronic products with a fast turnaround. Differences between the results depended on the level of income of the respondents in the survey. The users' reasons for replacing cell phones showed that users would replace cell phones if the cell phones are damaged (66.84%) or if their models and features are out of date (24.94%) (Fig. 3). Ylä-Mella *et al.* (2015) showed that 72% of the respondents would replace their cell phones if it is no longer working fine, and 32% of the respondents were driven to change their cell phones by the innovative features of the newer products. Through

this research, the finding is quite similar.

*Resident's used cell phones treatment methods*

Based on the survey results, Fig. 4 shows that most respondents (i.e., 59.9%) keep unused cell phones at home compared their behavior toward other large household appliances, such as televisions, computers, and refrigerators. Only approximately 17% of the respondents keep large household appliances at home after they no longer use them (Islam *et al.*, 2016). The high-level storage of unused cell phones is due to their small size and small space occupied at home. Moreover, a large amount of personal

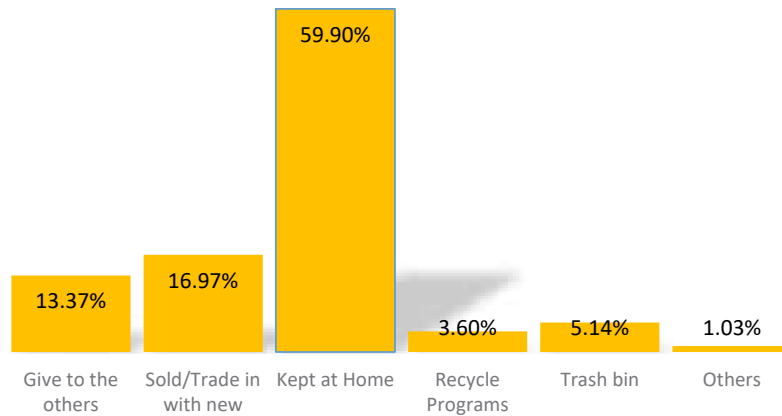


Fig. 4: Household behavior toward used cell phones

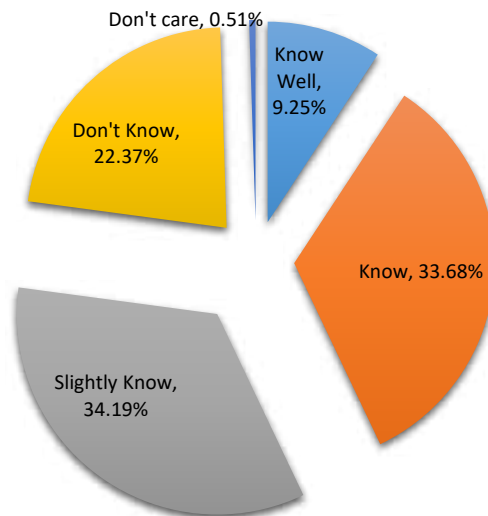


Fig. 5: Household knowledge of used cell phone hazards

### Used cell phones

information is stored in cell phones, making residents more careful in disposing of used cell phones. There were also significant differences in each country or city to hold used cell phones in the other studies. The research conducted by [Ylä-Mella et al. \(2015\)](#) in Oulu, Finland, showed that 85% of cell phone users keep their used cell phones at home. Meanwhile, the research conducted by [Martinho et al. \(2017\)](#) in Portugal showed that 36% of the respondents choose to keep their used cell phones. Similarly, the research conducted by [Yin et al. \(2014\)](#) and [Bai et al. \(2018\)](#) in China showed that the proportion of respondents that store used cell phones at home is 47% and 79%, respectively. These differences were the various income levels of the population in the cities studies were conducted. However, keeping used cell phones at home to a certain extent will prevent re-use and recycling activities. Because for the operation of an economical processing facility, the minimum number of used cell phones collected is required ([Tan et al., 2018](#)). Therefore, changing people's attitudes toward the choice of disposing of used cell phones is a fundamental requirement to solve environmental problems related to used cell phones.

#### Resident's knowledge about e-waste

The results obtained in the survey of household awareness of environmental hazards associated with used cell phones and respondents' attitudes toward the collection process are shown in [Fig. 5](#). The results showed that approximately 77.12% of the respondents knew that used cell phones could harm

the environment, 9.25% were aware of the specific effects of the hazards, and the remaining 22.88% did not know or did not even care. Regarding households' attitudes toward used cell phone collection activities, approximately 52.7% of the respondents were willing to give their used cell phones and support the collection activities. Compared to other studies, Kuala Lumpur, Malaysia, appears to have a tiny proportion of e-waste awareness than Indonesia. Only 59 % of households know that e-waste is harmful to the environment ([Afroz et al., 2013](#)). Another study of residences in Surabaya, Indonesia, found that just 35% of the population is aware that electronic waste is classified as a hazardous substance ([Pandebesie et al., 2019](#)). Contrast findings in Bangladesh, just 9% of citizens worry about e-waste, and 68% of community members are ignorant of the issue ([Islam et al., 2016](#)). The studies show that public understanding of e-waste has a wide range of features, including substantial variances between areas in Indonesia. These might be due to community education and e-waste management strategy in each region. The other variables, such as education level and employment, which differ throughout regions, can also affect differences in knowledge between areas. It is critical to establish the development and enforcement of laws to be aware of the proper handling of e-waste.

#### Relationship between variables

This study used the chi-square ( $\chi^2$ ) test to analyze and determine whether there are significant

Table 2: Chi-square independence test results

Variable A	Variable B	$\chi^2$	$p - value$	Result
Gender	EHA	0.009	0.926	Independent
	UCU	0.457	0.796	Independent
	WTR	2.44	0.785	Independent
Age	EHA	7.119	0.068	Independent
	UCU	1.412	0.703	Independent
	WTR	24.855	0.003	Dependent
Occupation	EHA	9.102	0.028	Dependent
	UCU	2.976	0.395	Independent
	WTR	22.297	0.034	Dependent
Educational Level	EHA	2.512	0.285	Independent
	UCU	1.143	0.565	Independent
	WTR	13.207	0.105	Independent
Income Level	EHA	9.708	0.046	Dependent
	UCU	7.452	0.024	Dependent
	WTR	16.129	0.185	Independent



differences. The variables tested were EHA, UCU, WTR variables, and sociodemographic variables of the respondents, i.e., gender, age, educational level, occupation, and income. Pearson's ( $\chi^2$ ) test is usually appropriate as long as no more than 20% of events are required to have frequencies less than 5; some categories of variables have been merged to enhance the findings (Sheskin, 2011). Table 2 shows all the results of the  $\chi^2$  calculation that examines the differences between sociodemographic and environmental awareness variables. Significant differences were observed between occupation and income categories toward the EHA variable (p-value = 0.028 and 0.046). Work in businesses and services shows more EHA and a higher income (>IDR 10 million), paying more attention to environmental issues when buying new electronic products (p-value = 0.046). Islam et al. (2021) reported that age, family size, and income level influence people's awareness of e-waste, where respondents with an income level

above US\$156,000/year have a deep concern for e-waste. In contrast, Martinho et al. (2017) founded that age above 35 years and occupation have significant differences with awareness behavior, where students and employees have high environmental awareness compared to others. Furthermore, Tan et al. (2018) showed that educational level and occupation area had significant differences with public awareness in China. The other significant differences between the UCU variable and the variable income level on the manner of cell phone acquisition (p-value = 0.024). The differences between sociodemographic and WTR also show significant differences between age and occupation on the number of damaged cell phones but kept (p-value = 0.003 and 0.034). The minimum number of cell phones that are damaged but kept is as much as two units for each family, whereas the minimum number of cell phones that are usable and kept is 4–5 units for each head of the family. These findings are consistent with Pandebesie et al.

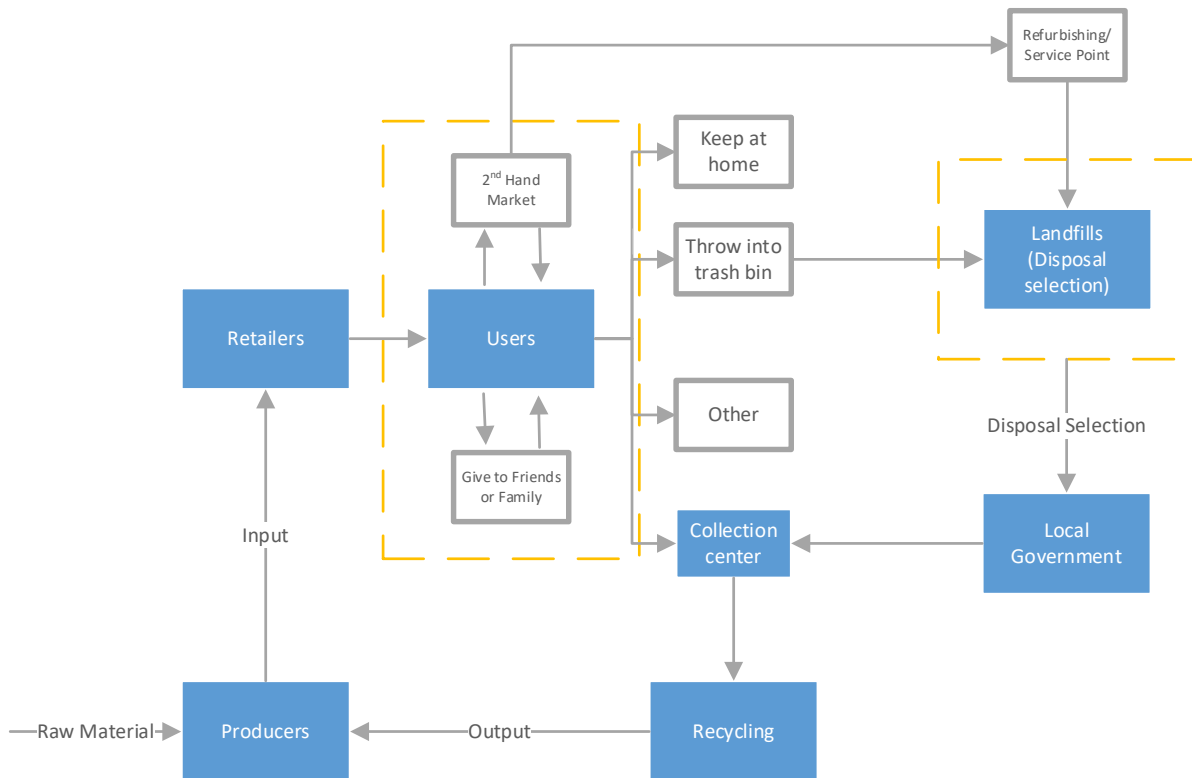


Fig. 6: Used cellphone flow in Jabodetabek

(2019), who found that age and education level had a strong indirect influence on respondent's willingness to manage their waste. Dwivedy and Mittal (2013) demonstrated different results in which the variable income level impacts people's willingness in Indian variables. According to Miner et al. (2020), there are no significant differences in participants' desire to cooperate in e-waste management according to their sociodemographic backgrounds.

#### *E-Waste management in Indonesia*

Indonesia currently has no specific regulations governing the management of electronic waste. Law no. 8 of 2008 concerning waste management and Law no. 32 of 2009 concerning environmental protection and management is currently used as the legal basis for regulations used in electronic waste management. Technical regulations in implementing the Law are regulated in Government Regulations No. 101 of 2014 concerning hazardous and toxic waste management. It explains the use of this waste, including recycling, recovery, re-use, which are important links. Government Regulations No. 81 of 2012 concerning household waste management in which electronic waste is included in its classification. The hazardous and toxic waste regulation originated from Indonesia's participation in the Basel convention on hazardous waste as regulated in Presidential Decree No. 61 of 1993 concerning the ratification of the Basel Convention on the control of transboundary movements of hazardous wastes and their disposal, which Presidential Regulation further amended No. 47 of 2005. Hazardous and toxic waste, according to Government Regulations No. 101 of 2014 section 1, is the remainder of a business and activity containing substances, energy, and other components which, due to their nature, concentration, and amount, either directly or indirectly, can pollute and damage the environment life, and endanger the environment, health, and the survival of humans and other living creatures. Section 53, written in Government Regulations No. 101 of 2014, requires hazardous and toxic waste for people who produce hazardous and toxic waste. If it cannot be done alone, it can be given to hazardous and toxic waste users. Section 54 states that hazardous and toxic waste is used as raw material, energy substitution, and raw material substitution, whose utilization is under the development of

science and technology. Indonesia's current regulations are still in the early stages (Andarani and Goto., 2014). It is undeniable that it will be a challenge for the government to manage e-waste. There are still valuable metals that have economic value in e-waste (Tesfaye et al., 2017). Urban Mining can be one of the strategies that can be applied to overcome the problems in handling e-waste in Indonesia. It can also increase competitiveness in the e-waste management industry's sustainability because there is a large potential for added value (Arora et al., 2017). Reducing the amount of e-waste is one of the options that Indonesia can do. Extended Producer responsibility (EPR) is a potential option where producers must be responsible for the e-waste produced from their products (Afroz et al., 2013). Indonesia needs to reformulate regulations covering the informal sector in e-waste management because the informal sector is an essential part of Indonesia's e-waste management success (Rochman et al., 2017). According to Song et al. (2012), households in developed nations must pay for e-waste collection, and their behaviors and attitudes are critical to the successful collection of home e-wastes. Wang et al. (2017) formulated financing assistance for e-waste management, proper advice and standards for domestic e-waste collection systems, and tax advantage encourage formal collecting companies as essential roles in excellent e-waste management that should be considered.

#### *The flow of e-waste*

No regulations for monitoring e-waste from households, either at the national or regional level, have been established. The Ministry of Environment in Jakarta is the principal agency responsible for waste management in Indonesia. In several cases, diverted e-waste, which was illegally imported using several methods, such as being declared as raw, reprocessed/re-used, or donated materials, was discovered by the government (Panambunan-Ferse and Breiter, 2013). As a result, the central government has adopted the extended producer responsibility method since 2008. However, the regulations are still being formulated at the time of this research. In an interview with the Head of the DKI Jakarta Provincial Environmental Service, e-waste management and regulations were confirmed to be nonexistent in the Jakarta region.

Moreover, the initiative from the local government simply sorts electronic equipment from the local people and disposes it into landfills. Afterward, the sorted wastes are taken to the collection points in each subdistrict or district, then send to the DKI Jakarta Provincial Environmental Service warehouse. E-waste management in Jakarta is illustrated in Fig 6. The DKI Jakarta Provincial Environmental Service has an e-waste dropbox program at car-free day areas or other public places so that people can dispose of their e-waste into e-waste drop boxes. Another program currently being implemented is a service to pick up e-waste from people's residences with a minimum requirement of 5 kg of e-waste. Residents living in Jakarta can use this service for free. E-waste is stored in the DKI Jakarta Provincial Environmental Service warehouse, which the e-waste recycling industry will then utilize. However, consumers are not enthusiastic about this program. Thus, this program does not run as it is desired initially.

## **CONCLUSION**

This study aims to increase the role of the Jabodetabek community and the collection of used cell phones to participate in the success of e-waste management in Indonesia. Sociodemographic characteristics of the people in Jabodetabek, Indonesia were taken for 389 samples of respondents dominated by women (55%), age range > 40 years (39.33%), corporate employees (35.48%), Bachelor Degree educational level (46.53%) with monthly income above IDR 10 million/month (33.68%). This research also identifies reasons residents are unwilling to recycle their cell phones. The households were asked how long it took consumers to replace their cell phones, the reasons for replacing their old cell phones, and how to treat their used cell phones. Based on research, the average cell phone ownership in Jabodetabek is 1.28 units, and the average cell phone life span of people in Jabodetabek is 2.6 years. Mostly the households will replace their used cell phone if there is damage (66.84%) and keep the used cell phone at home (59.5%), thus becoming an obstacle in applying the appropriate recycling system and a circular economy. The significant differences between environmental awareness (i.e., EHA, UCU, and WTR variables) and sociodemographics of households were observed. The EHA variable has significant differences with

occupation and income level (p-value = 0.028 and 0.046), UCU variable has significant differences with the income level variable (p-value = 0.024). The others, a statistically significant difference between sociodemographic variable (age, occupation) and WTR was observed; p-value = 0.003 for age and p-value = 0.034 for occupation. This paper showed that EHA and WTR have an important role in increasing the collection of used cell phones from households. Therefore, to develop a new strategy, the findings of this study can provide insights into the e-waste problem and citizen's awareness of e-waste management. The relationship model between sociodemographic and EHA and WTR as the knowledge contribution helped determine the right characteristics in e-waste management in Indonesia in the future. We believe that these findings will help strengthen decision-making steps to assist formal and informal e-waste recycling activities in Jabodetabek. Either to ensure the success of used cell phone collection activities, the EHA and WTR of the community need to be considered. This study is limited to cell phones in Indonesia's e-waste so that the characteristics of users are limited. The huge potential of e-waste and other types of e-waste such as television, air conditioning, and washing machines also have different user characteristics. The future research for e-waste management with the user characteristics in other countries needs to be compared would be beneficial. It will be interesting if research on e-waste management is carried out with various types of e-waste and various user characteristics because e-waste disposal and consumers' behavior and awareness are dynamically different. Furthermore, a replication of this study in other countries could be beneficial in determining whether cultural differences influence consumers' attitudes toward small electronic equipment repair and resale.

## **AUTHOR CONTRIBUTIONS**

N. Wibowo carried out the literature review, study research, data analysis and interpretation, manuscript text preparation, and manuscript editing. R. Nurcahyo supervised the research, assisted in obtaining the study funding and have granted final approval to the published version. D.S. Gabriel have been evaluated and collaborated in the comprehensive revision of it for important defining substance.

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## CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

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## ABBREVIATIONS

%	Percent
DKI	Special Area of the Capital
E- waste	Electronic waste
EHA	Environmental hazard awareness
Fig	Figure
GDP	Gross domestic product

IDR	Indonesian rupiah
i.e	That is
Jabodetabek	Jakarta, Bogor, Depok, Tangerang, Bekasi Cities
Kg	Kilograms
Km <sup>2</sup>	Square kilometers
t	tonnes
t/year	Ton/year
p-value	Probability value
ROI	Return on investment
UCU	Used cell phones usage
WTR	Willingness to recycle
X <sup>2</sup>	Chi-square test

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