Lifespan of Small Electronic Devices in Indonesia

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***Abstract*— E-waste is one of the main problems in the world, including Indonesia, which has a high level of consumption of electronic products. E-waste in Indonesia is expected to continue to increase along with the economic development in Indonesia and the rapid development of technology in the world, which of course will be like a time bomb if not handled. At present, Indonesia's current condition is more dominated by the informal sector, which is possible to increase the environmental damage from the way they process E-waste. In actual condition, electronic devices that have finished their life are often not directly disposed but stored or fall into the category of storage time. This paper investigates the active use and storage time of mobile phone and laptop based on an online questionnaire survey taken from households in Java Island. The lifespan distribution of two small electronic devices is based on the results of the online questionnaire survey, which were analyzed using Weibull distribution. The lifespan of mobile phones and laptops were estimated to be 4.51 years and 4.79 years, respectively. The results of the research are expected to be an input for the development of strategies to solve the problem of E-waste in Indonesia.**

Keywords*— *E-waste, lifespan, Indonesia, Weibull distribution

I. INTRODUCTION

E-waste becomes one of the major problems in the world. The global amount of E-waste is expected to grow every year, with an annual growth rate of 3 to 4% [1]. The rapid development of technology causes a shift in the consumption of electronic products and make lifespan electronic products shorter, especially on small electronic devices. Lifespan small electronic devices that tend to be shorter will affect the annual amount of E-waste. The problem of E-waste can be a serious problem if not handled properly, especially for developing countries that do not have E-waste management system like Indonesia. In Indonesia, the amount of E-waste is expected to continue to increase due to the high consumption of the inhabitants of Indonesia to electronic products. In addition, the condition of Indonesia is currently dominated by the informal sector, so it is possible for high environmental impact because of how they process E-waste. A good E-waste management system is needed in the formal sector in Indonesia to reduce the impact of E-waste. Lifespan becomes one of the key parameters to calculate the amount of E-waste generated. On actual conditions, electronic products that have end-of-life are not directly discarded, but stored or can be categorized in storage time.

In this study, we investigated the active use and storage time of small electronic devices in Indonesia. The active use is defined as the time of a device between the first time received and the time when the transfer to next owner or disposed. The storage time is defined as the time between the end of active use and the time its final disposal or transfer to the next owner [2, 3].

The paper is organized as follows. Section 2 describes literature review and previous researchers about lifespan distribution. Section 3 describes the method to collect data and to estimate the lifespan of small electronic devices. Section 4 describes the results and discussion about lifespan models. Section 5 discusses some concluding marks.

II. LITERATURE REVIEW

The lifespan of electronic and electrical equipment (EEE) is essential information for the estimation of E-waste generated. There are two approaches for estimation of EEE lifespan [2]. One is the non-parametric approach, which does not assume any statistical distribution to estimate lifespan. The other one is parametric approach, which assumes a statistical distribution function such as Normal distribution, Lognormal distribution, and Weibull distribution. In parametric approach, the observed data approximate to the statistical distribution function.

Methodologies that were used for estimating lifespan generally there are four. Estimation from the number of discarded devices for each lifespan, estimation from the number of devices for each devices age, estimation from the number of devices in use for each devices age at beginning and the end of certain period, and estimation from the total number of devices in use by using mass balance principle [2].

Lifespan distribution of EEE has already been conducted by several researchers. Lifespan distribution assessment by using Weibull distribution has been done in Australia [4], China [5], Czech Republic [6], South Korea [7] and

Vietnam [8]. There is also a lifespan distribution assessment by using Lognormal distribution that has been done in the USA [9].

III. METHOD

Mobile phones and laptops are selected as product targets. In this study, we have used a method estimation from the number of discarded devices for each lifespan. The method used to obtain data is an online questionnaire survey to the

owners of small electronic devices that they have disposed of in the past.

An online questionnaire survey adopted and developed from literature [3, 4, 8] and translated into Bahasa. The questionnaire was the result of iteration based on the language and ease of filling for selection bias and pilot testing, which has been done twice to see the validity of the questionnaire. The questionnaire asks for how many devices they have, the year of each device's bought or received, the year when respondent stopped using the devices, the year when the respondent disposed of the devices and disposal pathway for devices that already disposed of.

For estimation of lifespan, an online questionnaire survey was conducted mainly on Java Island in 2018. Java Island is considered to represent Indonesia as the population of Java island about 145 million people or about 56% of the total population in Indonesia. In addition, Java Island is the center of government and economy in Indonesia. The questionnaires are distributed through online in social media (Facebook, WhatsApp, Twitter, Instagram, etc.), discussion forums, and direct to colleagues.

To calculate sample size, we adopted equation from Cochran [11]. This is due to Indonesia still does not have a good E-waste management system so that the proportion of the population of those who have discarded small electronic devices against the total population cannot be determined.

$$n_0 = \frac{z^2 pq}{e^2} \quad (1)$$

Where n_0 is the sample size, z is the confidence level, p is the proportion of the population, q is $1\text{-}p$, and e is the margin of error.

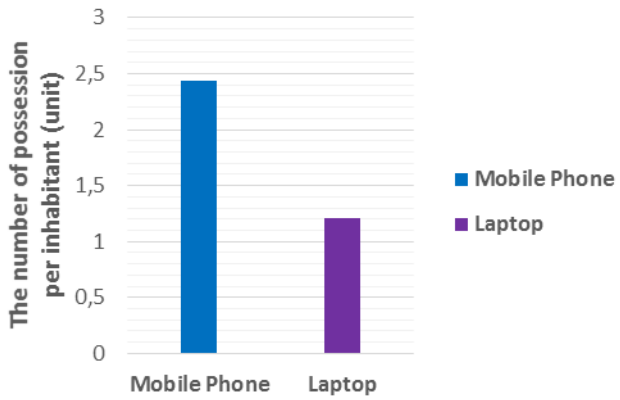
According to (1), we used maximum proportion 0.5 and margin of error 5%. Therefore, the online questionnaire surveys were carried out for the randomly selected 400 respondents for each device.

In this study, we use Weibull distribution to explain the lifespan distribution of selected small electronic devices. We use the Weibull distribution because many researchers use it [4, 5, 6, 7, 8] and it was verified that it is a better approach for lifespan distribution of appliances [7, 10]. Information from respondents obtained on the results of the online questionnaire survey is cumulative for 1-year periods so that midpoint value is taken per year as an average data point of computation [4, 7, 10]. For instance, between year 0 and 1, we take the number 0.5, and between year 1 and 2, we take number 1.5 and so on.

IV. RESULT AND DISCUSSION

The results of the online questionnaire survey on Fig. 1 shows the numbers of possession of mobile phones and laptops in 2017 on Java Island for the population that over 18 years old and have a minimum high school education. The possession ratio of mobile phones is 2 units per inhabitant. And the possession ratio of laptops is 1 unit per inhabitant. This proves that small electronic devices will have a significant effect on Indonesia and can be a time bomb if not appropriately handled because it allows the number of devices that fall into the category of storage time that may at any time be discarded and will be difficult to predict.

When electronic devices are deemed no longer in use, it will be E-waste and proper disposal to be one crucial thing because E-waste contains dangerous material in each item. The more E-waste generated, the more dangerous if not handled, especially in developing countries that do not currently have proper funds, resources or facilities to dispose of it properly. Without proper disposal, chemicals such as lead, arsenic, chromium, and mercury may leach into the environment, causing deterioration in environmental quality and pollution of air, soil and water that would pose a threat to humans and animals. Of course, this will be directly proportional to the high level of consumption in small electronic devices such as in Indonesia when viewed from the number of ownership devices per inhabitant



Possession ratio for small electronic devices (mobile phone and laptop) in 2017 on Java Island, Indonesia.

The estimated parameters of the Weibull distribution (shape parameter and scale parameter) of active use and storage time for mobile phone and laptop is shown in Table 1. The mean time to failure (average lifespan)

calculated after obtaining the estimated parameters according to (2).

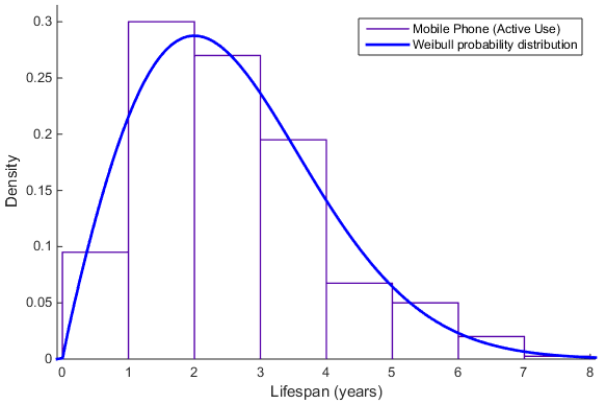
$$MTTF = \eta\Gamma[1+(1/\beta)] \quad (2)$$

Where η is scale parameter, β is shape parameter, and Γ is gamma function.

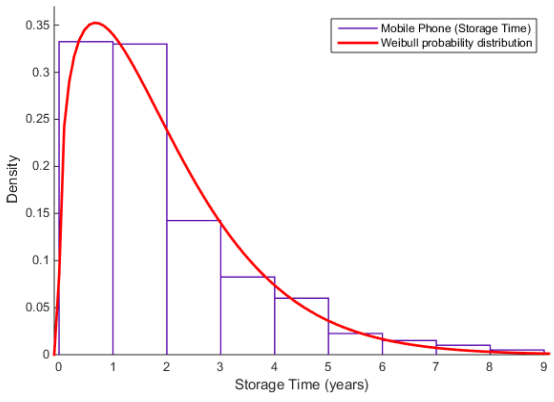
Table 1. ESTIMATED PARAMETER VALUES OF WEIBULL DISTRIBUTION FOR MOBILE PHONES AND LAPTOPS ON JAVA ISLAND

Product	**Profile Lifespan**	**Parameters**		**Average Lifespan (years)**
		Scale (η)	*Shape (β)*	
Mobile Phone	Active Use	2.92	1.93	2.59
	Storage Time	2.09	1.30	1.93
Laptop	Active Use	3.53	2.29	3.13
	Storage Time	1.84	1.51	1.66

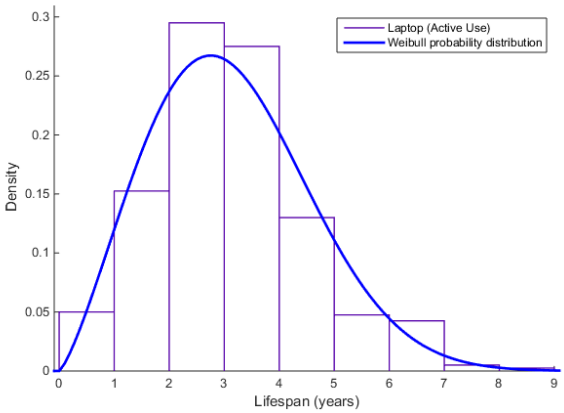
Lifespan distribution based on estimated parameters for active use and storage time on Java Island is shown in Figures 2, 3, 4, and 5.



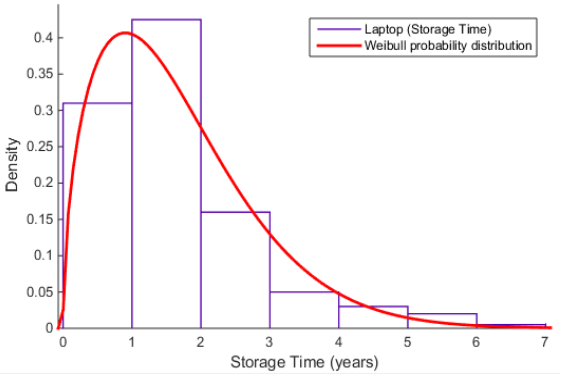
Lifespan distribution (active use) for mobile phone on Java Island.



Storage time distribution for mobile phone on Java Island.



Lifespan distribution for laptop on Java Island.



Storage time distribution for laptop on Java Island.

Average lifespan (mean value) was estimated to be 4.51 years for mobile phones and 4.79 years for laptops. Average active use of mobile phones was estimated 2.59 years, average storage time was estimated 1.93 years. And the average active use of laptops was estimated 3.13 years, average storage time was estimated 1.66 years. There is a significant gap between active use and storage time Due to this fact, about 75% time extended based on storage time in mobile phones and about 53% time extended based on storage time in laptops. From this condition, a tremendous amount of material will escape from recycling if formal sector already implemented and dominated in Indonesia.

The material as much as it will allow into urban mining potential and will provide substantial benefits both regarding economic, social and environmental. And conversely, the condition can be worse if not handled properly. It will have enormous environmental damage if poorly treated because it will contaminate soil, water, and air.

In order to establish a good E-waste management system in the formal sector, it is necessary to know the current condition about disposal pathway in Indonesia. The disposal pathway can be the basis from which the E-waste supply for recycling is obtained. Based on the results of our surveys, most of the population in Indonesia

still sell small electronic devices (mobile phones and laptops) to the second-hand market. The survey results are shown in Table 2.

Table 2. DISPOSAL PATHWAYS FOR MOBILE PHONES AND LAPTOPS ON JAVA ISLAND BASED ON ONLINE QUESTIONNAIRE SURVEYS.

Disposal Pathways	**Product**	
	Mobile Phone	*Laptop*
Landfill	17%	4%
Scavengers	17%	10%
Second-hand market	51%	56%
Donated	14%	29%
Recycling	1%	1%

More than half of respondents who have disposed of small electronic devices said they throw away mobile phones and laptops by selling back to the used market and donating them. This means stocks of obsolete or electronic waste products will be maintained longer in the next owner even if small electronic devices are still in good condition or not. This disposal pattern allows a longer lifespan because reuse continues until the third and subsequent owners.

From this fact, it can be seen that the majority of Indonesian population still considers those small electronic devices that have end-of-life are still valuable items or not yet become waste. That behavior is allowing the amount of E-waste generated to be biased because of the longer lifespan and not knowing where the destination of final disposal of small electronic devices and can be e-waste is disposed to the informal sector in the final disposal. Surely this will be a major problem when there is no preventive action from the formal sector and government because the recycling process undertaken by the informal sectors may have a much higher impact based on how they are processing and the number of residuals generated.

One of the preventive actions that can be applied to develop E-waste management system is Extended Producer Responsibility (EPR) and take-back system for small electronic devices. At present, a discussion on waste management system based on EPR desired E-waste management has just begun in Indonesia. This is something that is very important and needed by all parties, both for producers, consumers, and recyclers [12]. Table 2 shows the implementation of a take-back system can be done by providing incentives to people who will discard their small electronic devices. And the government needs to make a network of the informal sector to provide supply to the formal sector so that the supply can be stable and the system can be sustainable.

V. CONCLUSION

In this study, the lifespan distribution for mobile phones and laptops on Java Island is estimated using Weibull distribution. Lifespan is one of the key parameters for calculating E-waste generated. Lifespan is very important because a stable and predictable supply of raw materials (E-waste) is required to make a sustainable operation of recycling facilities. The average lifespan of mobile phones on Java Island was found to be 4.51 years. Average active use of mobile phones was estimated 2.59 years, average storage time was estimated 1.93 years. The average lifespan of laptops was found to be 4.79 years with the average active use of laptops was estimated 3.13 years, average storage time was estimated 1.66 years. Inhabitants in Indonesia are strongly inclined to buy new models of small electronic devices, especially mobile phones. The results of the survey show the possession ratio for mobile phones and laptops are 2 per inhabitant and 1 per inhabitant, respectively. This fact shows that Indonesia has great potential for urban mining as one of the goals in the development of E-waste management system. Most Indonesians still consider small electronic devices that have end-of-life as valuable items that still sell back to the second-hand market. To overcome this, a good take-back system is needed so that the supply for recycling can be stable and predictable. For a more accurate prediction, it is possible to research about the behavior of households in Indonesia in disposing of electronic devices and feasibility study on the take back system and fund management to be applied in Indonesia.

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