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COMPARATIVE STUDY ON E-WASTE MANAGEMENT AND THE ROLE OF THE BASEL CONVENTION IN MALAYSIA, SINGAPORE, AND INDONESIA: A WAY FORWARD

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Abstract

Electrical and electronic equipment waste (E-waste/WEEE) is a current global concern because of the increasing volume and improper treatment of e-waste. Generally, e-waste can be defined as discarded components of electrical and electronic equipment that have no reuse value. The improper disposal of e-waste can bring about catastrophic effects to mankind and the environment. The Basel Convention in 1992 categorizes e-waste as hazardous waste due to the presence of toxic materials. Currently, the production of e-waste is expanding at a considerable rate and is expected to reach 52.2 million tons globally by 2021. Singapore, Malaysia, and Indonesia are three neighboring countries that are facing the issue of e-waste management. The shortage of appropriate recovery and recycling facilities for formal e-waste treatment in the aforementioned three counties may lead to informal e-waste treatment or unsafe landfill, which cause harmful and hazardous effects to human lives and nature. This review provides a comprehensive overview of e-waste management from the perspective of Singapore, Malaysia, and Indonesia. Inadequate governmental policies, lack of e-waste laws, lack of public awareness, and lack of management strategies have caused various social and environmental issues. This work concludes with recommendations for the three countries to restrict the free flow of e-waste by establishing robust e-waste laws and improving the e-waste management system.

Keywords*: E-waste management; the Basel Convention; recycle; reuse; recovery; hazardous impact; legal mechanism; public awareness*

Abstrak

Limbah peralatan listrik dan elektronik (E-waste / WEEE) menjadi perhatian global saat ini karena meningkatnya volume dan pengolahan limbah elektronik yang tidak tepat. Secara umum, e-waste dapat didefinisikan sebagai komponen yang dibuang dari peralatan listrik dan elektronik yang tidak memiliki nilai pakai ulang. Pembuangan limbah elektronik yang tidak benar dapat menyebabkan efek bencana bagi umat manusia dan lingkungan. Konvensi Basel, 1992 mengkategorikan e-limbah sebagai limbah berbahaya karena adanya bahan beracun. Saat ini, produksi limbah elektronik meningkat pada tingkat yang signifikan dan diperkirakan akan menyentuh 52,2 juta ton secara global pada tahun 2021. Singapura, Malaysia dan Indonesia adalah tiga negara tetangga dan juga menghadapi masalah pengelolaan limbah elektronik. Kekurangan fasilitas pemulihan dan daur ulang yang tepat untuk pengolahan formal limbah elektronik di tiga kabupaten tersebut dapat menyebabkan pengolahan informal atau tempat pembuangan akhir yang tidak aman yang menyebabkan efek berbahaya dan berbahaya bagi kehidupan manusia dan alam. Makalah tinjauan ini memberikan ikhtisar komprehensif pengelolaan limbah elektronik dari perspektif Singapura, Malaysia, dan Indonesia. Kebijakan pemerintah yang tidak memadai, kurangnya undang-undang e-waste, kurangnya kesadaran publik dan kurangnya strategi manajemen telah menyebabkan berbagai masalah sosial dan lingkungan. Makalah ini diakhiri dengan rekomendasi untuk tiga negara untuk membatasi aliran bebas limbah elektronik dengan memberlakukan undang-undang limbah elektronik yang kuat dan memajukan sistem pengelolaan limbah elektronik.

Kata Kunci*: manajemen limbah elektronik; Konvensi Basel; daur ulang; penggunaan kembali; pemulihan; mekanisme hukum; kesadaran masyarakat*

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I. INTRODUCTION

The uncontrolled generation and innovation of electrical and electronic equipment has multiplied the volume of waste electrical and electronic equipment (WEEE), which is also known as electronic waste or e-waste.[1] According to the report by the Global E-waste Statistics Partnership 2017[2], the annual amount of e-waste generated worldwide is alarming, with 44.7–50 million metric tons (Mt) per year or an equivalent of 6.1 kg per inhabitant (kg/inch). This amount is equal to 4,500 Eiffel Towers each year. The amount of e-waste is expected to increase to 52.2 Mt by 2021 or 6.8 kg per inhabitant.[3] The lifespan of electronic products has become shorter due to the enormous increase in the demand for the latest and most efficient technology. As a result, outdated electrical pieces of equipment are becoming obsolete and are being discarded in large amounts worldwide every year.[4] Interestingly, only 20% of e-waste generated is collected and recycled.[5] Of the 44.7 Mt, approximately 1.7 Mt is thrown into residual waste in developed countries and is likely to be incinerated or landfilled. Globally, only 8.9 Mt of e-waste is collected and recycled, accounting for only 20% of all e-waste generated.[6] The low collection rate compared with the total amount of e-waste generated is partly explained by the fact that only 41 countries have official e-waste statistics. The destiny of a considerable amount of e-waste (34.1 Mt) is unknown.

Consequently, the recovery of e-waste is tough and challenging.[7] E-waste contains various materials and toxins, such as lead, arsenic, cadmium, mercury, and flame retardants. E-waste that ends up in an improper landfill may contaminate natural resources, including land, water, and air. While dismantling e-waste without taking any safety measures, workers in poorly managed facilities may suffer frequently from a range of illnesses.[8] Researchers have attempted to identify the effects of the informal treatment and disposal of e-waste on health and have reported conceivable outcomes associated with e-waste exposure; such effects include changes in thyroid function and cellular expression and function, adverse neonatal outcomes, changes in temperament and behavior, decreased lung function, increase in spontaneous abortions, stillbirths, premature births and reduced birth weights.[9] Furthermore,

[1] Pablo Dias, Andréa Moura Bernardes, and Nazmul Huda, "Waste Electrical and Electronic Equipment (WEEE) Management: An Analysis On the Australian E-Waste Recycling Scheme," *Journal of Cleaner Production* 197 (2018): 750-764.

[2] Zoeteman, Bastiaan CJ, Harold R. Krikke, and Jan Venselaar, "Handling WEEE Waste Flows: On The Effectiveness of Producer Responsibility in A Globalizing World," *The International Journal of Advanced Manufacturing Technology* 47, no. 5-8 (2010): 415-436.

[3] Cornelis P. Baldé, Vanessa Forti, Vanessa Gray, Ruediger Kuehr, and Paul Stegmann, *The Global E-Waste Monitor 2017: Quantities, Flows and Resources*, United Nations University, International Telecommunication Union, and International Solid Waste Association, 2017.

[4] Ming Hung Wong, S. C. Wu, W. Jf Deng, X. Z. Yu, Q. Luo, A. O. W. Leung, C. S. C. Wong, W. J. Luksemburg, and A. S. Wong, "Export Of Toxic Chemicals–A Review of The Case of Uncontrolled Electronic-Waste Recycling," *Environmental Pollution* 149*, No. 2* (2007): 131-140.

[5] Vanessa Forti, Kees Baldé, and Ruediger Kuehr, *E-waste Statistics: Guidelines on Classifications, Reporting and Indicators*, 2nd Ed.(Germany: ViE – SCYCLE, 2018).

[6] Baldé, *et. al. The Global E-Waste Monitor*

[7] G. P. Nayaka, K. V. Pai, G. Santhosh, and J. Manjanna,"Recovery of Cobalt as Cobalt Oxalate from Spent Lithium Ion Batteries by Using Glycine As Leaching Agent," *Journal of Environmental Chemical Engineering 4, No. 2* (2016): 2378-2383.

[8] Anna Kučírková, "*E-Waste: A Big Problem Needing Bigger Solutions*", <https://goodelectronics.org/e-waste-a-big-problem-needing-bigger-solutions/> , accessed on 29 October 2018.

[9] Grant, Kristen, Fiona C. Goldizen, Peter D. Sly, Marie-Noel Brune, Maria Neira, Martin van den Berg,

evidence of DNA damage has been found among populations in recycling areas and laborers in recycling facilities. Similarly, sicknesses in boys aged 8–9 has been reported to be caused by recycling facilities and had a lower forced vital capacity.[10] In addition to the sicknesses above, urinary metabolites and skin diseases have also been reported.[11] In countries where no national e-waste legislation is in place, e-waste is commonly treated as general waste and is either landfilled or recycled along with other metal or plastic waste. The likelihood that pollutants are not taken care of properly, managed by the informal sector, or recycled without adequately protecting the workers from waste-emitted toxins is high.[12]

Informal recycling includes the dismantling of discarded e-waste to recover valuable elements with or without low-level technology to minimize exposure.[13] By contrast, formal electronic waste recycling facilities are well equipped and thus can protect workers from the adverse health effects of hazardous substances. However, such centers are expensive to build and are rare in less developed or developing countries. Therefore, developing countries use informal recycling centers for e-waste recycling and thus may cause a severe threat to humans and the environment.[14]

The increasing volume of e-waste in Malaysia, Singapore, and Indonesia is challenging, especially because these three countries do not have specific e-waste laws. The e-waste issue is worse in Indonesia and Malaysia because only 25% of the total volume of generated e-waste is being recycled, and the rest is treated through informal recycling or disposal methods.[15] Given the ongoing concerns on e-waste management, further research is necessary to understand the negative implications of inadequate e-waste management. On this basis, the current study aims to elaborate on the importance, definition, and classification of e-waste. Moreover, this review aims to analyze the compliance of Malaysia, Singapore, and Indonesia with the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (the Basel Convention), specifically toward e-waste management. The main objective is to identify challenges and problems in e-waste management in the aforementioned three countries and propose action plans.

II. DEFINITION AND CLASSIFICATION OF E-WASTE

Before further discussion, the definition of e-waste must be established. The United Nations Environment Program defines e-waste as follows:

> *"Discarded computers, office electronic equipment, entertainment device electronics, mobile phones, television sets and refrigerators. This definition includes used*

and Rosana E. Norman, "Health Consequences of Exposure to E-Waste: A Systematic Review," *The Lancet Global Health 1, No. 6* (2013): e350-e361.

[10] *Ibid*.

[11] Shao-you Lu, Yan-xi Li, Tao Zhang, Dan Cai, Ju-jun Ruan, Ming-zhi Huang, Lei Wang, Jian-qing Zhang, and Rong-liang Qiu, "Effect of E-Waste Recycling on Urinary Metabolites of Organophosphate Flame Retardants and Plasticizers and Their Association with Oxidative Stress," *Environmental Science & Technology* 51, no. 4 (2017): 2427-2437.

[12] Baldé, *et. al. The Global E-Waste Monitor*

[13] Renee Cho, "What Can We Do About The Growing E-Waste Problem?" *State the planet*. August 27, 2018, https://blogs.ei.columbia.edu/2018/08/27/growing-e-waste-problem/, accessed on 27 August 2018.

[14] Ilyas, Sadia, Jae-chun Lee, and Ru-an Chi, "Bioleaching of Metals from Electronic Scrap and Its Potential for Commercial Exploitation," *Hydrometallurgy 131* (2013): 138-143.

[15] Balqis Lim, "Reducing The Impact of E-Waste," https://www.nst.com.my/lifestyle/bots/2019/09/525027/reducing-impact-e-waste, accessed on 27 September 2019.

electronics which are destined for reuse, resale, salvage, recycling, or disposal."[16]

Meanwhile, OECD defines e-waste as "any appliance using an electric power supply that has reached its end-of-life."[17] Similarly, the United States Congressional Research Service states that "e-waste refers to obsolete, broken, or irreparable electronic devices."[18] A globally accepted definition of e-waste has been published by Solving the E-Waste Problem (StEP)[19] in a White Paper, as follows:

"E-waste is a term used to cover all items of electrical and electronic equipment (EEE) and its parts that have been discarded by its owner as waste without the intent of reuse."[20]

The Basel Convention categorizes e-waste as hazardous waste caused by the presence of toxic and contaminated materials.[21] The Basel Convention also defines waste as "substances or objects, which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law."[22] Paragraph 4 of Article 2 defines disposal as "any operation specified in Annex IV" of the Convention.[23] The Basel Convention lists e-waste in Annex VIII as A1180 (hazardous waste: e-waste containing components, such as accumulators and mercury switches containing or contaminated with cadmium, mercury, lead, or polychlorinated biphenyl) and Annex IX as B1110 (non-hazardous waste: electronic assemblies consisting only of metals or alloys, printed circuit boards, without the characteristics of Annex VIII or EEE for direct use and not for recycling or final disposal) of the Basel Convention.[24]

With the definition of e-waste established, how e-waste is classified must be understood. The most inclusive definition, which covers a wide range of classification, is that of the European Union's Directive 2012/19/EU, which divides e-waste into ten major categories:[25] large household appliances, small household appliances, IT and telecommunication equipment, consumer equipment, lighting equipment, electrical

[16] United Nations Environment Programme (UNEP), Policy Brief on E-waste, What, Why and How. <http://www.unep.org/ietc/Portals/136/Other%20documents/PolicyBriefs/13052013_E-Waste%20Policy%20brief.pdf>

[17] OECD, *Extended Producer Responsibility: A Guidance Manual for Governments*, Paris: OECD, 2001.

[18] Environmental Protection Agency (EPA) (2013) Office of Inspector General, Report: Improved Information Could Better Enable EPA to Manage Electronic Waste and Enforce Regulations. <https://www.epa.gov/office-inspector-general/report-improved-information-could-better-enable-epa-manage-electronic-waste>

[19] StEP Initiative, "*Solving the E-Waste Problem*" White Paper: One Global Definition of E-waste. Bonn, Germany. StEP (2014), 3576. StEP Initiative is a membership organization that is part of United Nations University which envisions to be agents and stewards of change, uniquely leading global thinking, knowledge, awareness and innovation in the management and development of environmentally, economically and ethically-sound e-waste resource recovery, re-use and prevention, https://step-initiative.org/.

[20] *Ibid*.

[21] Annex VIII, The Basel Convention, <http://www.basel.int/Implementation/Ewaste/Overview/tabid/4063/Default.aspx>.

[22] The Basel Convention, Article 2.

[23] Text of the Basel Convention, <http://www.basel.int/TheConvention/Overview/TextoftheConvention/tabid/1275/Default.aspx>.

[24] Waste Classification and Control Procedures, Annex VIII & Annex IX of the Basel Convention. The technical guidelines on transboundary movements of electrical and electronic waste and used electrical and electronic equipment, in particular regarding the distinction between waste and non-waste under the Basel Convention, <http://www.basel.int/Implementation/TechnicalMatters/DevelopmentofTechnicalGuidelines/Ewaste/tabid/2377/Default.aspx>.

[25] Directive 2012/19/EU of the European Parliament and of the Council.; Jagran Josh. 2015, "*Types of e-waste"*, <https://www.jagranjosh.com/general-knowledge/types-of-e-waste-1440681505-1>, accessed on 27 August 2015.

and electronic tools, toys, leisure and sports equipment, medical devices, monitoring and control instruments, and automatic dispensers.

III. E-WASTE SCENARIO IN MALAYSIA

Malaysia is one of the fast-developing countries in Southeast Asia, with a population of approximately 32.63 million in the third quarter of 2019.[26] The Global E-Waste Monitor 2017 report by the United Nations University stated that Malaysia has generated 8.8 kg of e-waste per person in 2016, totaling to 280,000 ton.[27] An e-waste inventory project in Malaysia stated that the volume of e-waste is expected to increase to 1.1 million Mt in 2020 at a rate of 14% every year.[28] All e-waste segments have been classified as e-waste by the Department of Environment (DOE). Table 3 shows the list of items that are considered e-waste in Malaysia.

Table 1. Electrical and Electronics Equipment Considered as E-Waste in Malaysia[29]

No.	Waste Description
1	Used television, Used cathode ray tube
2	Used air-conditioner unit, Used electric cable
3	Used computer, Used mobile phone
4	Used refrigerator, Used motherboard
5	Used washing machine, Used hard disk drive
6	Used video recorder, Used printed circuit board
7	Used telephone, Used lead frame
8	Used photocopy machine, Used patterned wafer
9	Use facsimile machine, Used ink cartridges
10	Used microwave oven, Used or rejected or waste of integrated circuit
11	Used radio, Used audio amplifier
12	Used printers, Used electrical and electronic equipment/product
13	imported from other countries

Currently, Malaysia does not have a specific law or regulation on e-waste. According to the DOE, some of the challenges faced on the development of a proper system for household e-waste management in Malaysia include recyclers being interested in only valuable materials. Moreover, collection and transportation are difficult because of scattered household e-waste. Recycling and recovery processes are also costly because it requires huge investment on machinery, equipment, and environmental protection measures; to some extent. this requirement makes the recycling and recovery processes not feasible economically.

[26] Demographic Statistics Third Quarter 2019, Malaysia, Department of Statistics Malaysia, *Population & Demography.*<https://www.dosm.gov.my/v1/index.php?r=column/ctwoByCat&parent_id=115&menu_id=L0pheU43NWJwRWVSZklWdzQ4TlhUUT09>.

[27] Sim Leoi, "DOE Gets Tough on E-Waste." *The Star Online*, <https://www.thestar.com.my/news/nation/2019/05/30/doe-gets-tough-on-ewaste>, accessed on 30 May 2019.

[28] Perunding Good Earth, *The E-waste Inventory Project in Malaysia*, Japan: *Department of Environment, Malaysia & EX-Corporation,* 2009.

[29] Forti, *et. al.*, *E-waste Statistics*

A. E-waste Recovery and Collection Practices in Malaysia

E-waste accumulation is usually a profitable practice in developing and less-developed countries. EEE contains a considerable volume of materials that can be recycled using accessible and advanced tools and technology.[30] E-waste can be recycled formally through the following mechanisms, which are yet to be developed; social associations, manufacturers, and retailers. In Malaysia, these frameworks have yet to develop like those in developed countries.[31] Constant public awareness programs have made social association activities productive in Europe; similar programs have been initiated in Malaysia. For the first time, the DOE and Japan International Cooperation Agency endeavored to set up an e-waste collection system for household waste in Penang.[32] At the point of this initiation, the experience with the model was expected to be utilized to make a countrywide drive in the next couple of years. However, up to the present, no such drive has been implemented. Furthermore, no single clear framework has been established to monitor and examine material attributes and to identify remanufacturing potentials and financial advantages; moreover, a method for streamlining investigations on e-waste is not yet available.[33]

B. Formal and Informal Management Sectors of E-Waste in Malaysia

E-waste recycling in Malaysia is managed by formal and informal industries. The precise area comprises licensed recycling firms that either completely or incompletely recover e-waste.[34] Generally, recycling firms operate as per DOE rules and guidelines. The informal e-waste recycling sector frequently uses traditional or informal methods in the recovery process.[35] In addition, their primary objective is to recover only solid materials. A substantial portion of the simple reusing exercises completed at backyard offices adopts the crudest processes.[36] A major portion of e-waste ends up in informal processing facilities due to its money-making players, loopholes in guidelines, and business firms involved.[37] It is a test for policymakers and authorities to control informal e-waste recycling practices, which may cause a threat to mankind and the environment because of inappropriate and unsafe techniques.[38] According to the DOE, all states of Malaysia have a total of 121 e-waste collection centers, as listed in Table 2.

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[30] Fatihah Suja, Rakmi Abdul Rahman, Arij Yusof, and Mohd Shahbudin Masdar, "E-waste Management Scenarios in Malaysia." *Journal of Waste Management* (2014).

[31] Md. Alam, and Chamhuri Siwar, "Waste Recycling in Malaysia: Transition From Developing to Developed Country." *Jereme, IA, Alam, MM, and Siwar, C* (2015): 1-14.

[32] Final Report Asia Region, "*Data Collection Survey on E-waste Management in Malaysia and Surrounding Countries.*" Japan International Cooperation Agency (JICA), Japan: EX Research Institute Ltd, 2014.

[33] Lim, "Reducing The Impact of E-Waste"

[34] Eric Williams, "International Activities on E-Waste and Guidelines for Future Work," *Proceedings of the Third Workshop on Material Cycles and Waste Management in Asia, National Institute of Environmental Sciences: Tsukuba, Japan*, 2005.

[35] *Ibid*.

[36] Xinwen Chi, Martin Streicher-Porte, Mark YL Wang, and Markus A. Reuter, "Informal Electronic Waste Recycling: A Sector Review With Special Focus on China," *Waste Management 31*, *No. 4* (2011): 731-742.

[37] Michikazu Kojima, "Transboundary Movements of Recyclable Resources in Southeast Asia," *International Trade of Recyclable Resources in Asia* (2005).

[38] Vi Kie Soo, Charles Featherston, and Matthew Doolan. "E-waste Assessment in Malaysia," In *Reengineering Manufacturing for Sustainability* (Singapore: Springer, 2013), p. 389-395.

Table 2 Number of Collection Centers for Household E-waste in the States of Malaysia[39]

No	State Name	Number of Collection Points
1	Perlis	3
2	Kedah	4
3	Penang	14
4	Perak	11
5	Selangor	30
6	Kuala Lumpur	12
7	Melaka	6
8	Johor	15
9	Pahang	4
10	Negeri Sembilan	6
11	Terengganu	3
12	Kelantan	5
13	Sarawak	5
14	Sabah	3

DOE also provides a list of recovery facilities for e-waste, and according to this list, approximately 35 companies are dealing with e-waste recovery.[40] Majority of these recovery facilities are owned by private businesses. In view of this, e-waste Alam Alliance Malaysia was launched by the DOE on 11 December 2013[41] to manage household e-waste more effectively; develop a system of collection, segregation, and transportation across Malaysia; enhance public awareness; increase awareness of EEE producers/sellers/distributors about the importance of being responsible for the management of e-waste from households; encourage EEE manufacturers/vendors/distributors to implement e-waste from households voluntarily; and promote mutual cooperation among all stakeholders in e-waste management.

C. Legal Mechanism for E-Waste Management in Malaysia

Like many other countries in the world, the right to a healthy environment is not included in the Federal Constitution of Malaysia, 1957. Nevertheless, in 1996, in the landmark judgement of *Tan Tek Seng v Suruhanjaya Perkhidmatan Pendidikan & Another*,[42] the Court of Appeal observed that the right to live in a reasonably healthy and pollution free environment is implicit in the right to life, guaranteed through Article 5 of the Federal Constitution. In 1974, immediately after the global move on environment protection started, the Environment Quality Act, 1974 (Act 127) was enacted to prevent, abate and control environmental pollution to score

[39] DOE. "Collection Points by State." <//www.doe.gov.my/hhew/collection-points/>.
[40] DOE. "Recovery Facilities." <http://www.doe.gov.my/hhew/recovery-facility/>.
[41] DOE. "E-Waste Alam Alliance." 2013, <http://www.doe.gov.my/hhew/e-waste-alam-alliance/>.
[42] *Tak Tek Seng v. Suruhanjaya Perkhidmatan Pendidikan & Anor* [1996] 2 CLJ 771.

the commitment of the policymakers towards making a better and environmentally healthy world for the common benefits of the future generations.

In Malaysia, the Environmental Quality (Scheduled Wastes) Regulations 2005, which replaced the revoked Environmental Quality (Scheduled Wastes) Regulations 1989, has classified e-waste as a scheduled waste under the code SW110[43]; whereas specified e-waste, such as waste from lead-acid batteries, batteries containing heavy metals, and fluorescent lamps, are coded as SW102, SW103, and SW109, respectively. Given this classification, the treatment of e-waste is regulated and must be conducted at a licensed onsite treatment facility. E-waste disposal is required to be treated at the prescribed integrated premises, such as Kualiti Alam Sdn. Bhd. Malaysia is one of the parties to the Basel Convention; thus, the export or import of e-waste is strictly prohibited, as stipulated in Article 4, Paragraphs 1(a) and 1(b) of the Basel Convention:

(a) Parties (refer to the country) exercising their right to prohibit the import of hazardous waste or other waste for disposal shall inform the other Parties of their decision pursuant to Article 13 (Transmission of Information);

(b) Parties shall prohibit or shall not permit the export of hazardous waste and other wastes to the Parties that have prohibited the import of such waste when notified pursuant to subparagraph (a) above.

The Basel Convention defines hazardous waste in Article 1, Paragraph 1(a) as waste that belongs to any category contained in Annex I (types of wastes to be controlled) unless they do not possess any of the characteristics provided in Annex III (list of hazardous characteristics). Wastes listed in Annex VIII are also characterized as hazardous in accordance with Paragraph 1(a) of Article 1.

The draft of a new e-waste regulation, that is, the *Environmental Quality (Household Scheduled Waste) Regulation*, is currently being reviewed by Attorney General's Chambers of Malaysia (AGC Malaysia). The following are the key points to be followed in new regulation:

- It starts with the action by the household e-waste generators, which comprise individuals/households, companies/corporations, institutions, and commercial industries.
- These stakeholders are prohibited from adopting actions, such as improper dismantling, illegal dumping, and open burning, which may cause environmental pollution that causes health hazards.
- Under the proposed guideline, authorized retailers will be appointed, and they can be authorized collectors, collection centers, NGOs, or charity organizations.
- These retailers will be imposed with the responsibility to collect (includes take-back services), store, and transport e-waste to authorized household e-waste recovery facilities where e-waste will be treated in accordance with the methods to ensure standards of compliance with a proper reporting system and environmental and human protection.

These steps are part and parcel of the proper Household E-Waste Management System of the upcoming regulation.

IV. E-WASTE SCENARIO IN INDONESIA

Indonesia has no specific law or regulation for e-waste management. Compared with other Southeast Asian countries, such as Malaysia and Singapore, Indonesia

[43] Forti, *et. al.*, *E-waste Statistics*

remains to be moderately falling behind in terms of e-waste management. Furthermore, Indonesia has no precise information on the quantity of electronic merchandise and has no other specialized arrangements on the time of reprocessed products. This defect demonstrates an informal framework that ingests majority of the e-waste in Indonesia, in particular, the finding of a stream of used electronic materials and electronic waste.

The e-waste generated in Indonesia is expected to increase due to the rapid growth of the Indonesian economy and the fast development in technology. According to Sylfannie et al.,[44] the average annual growth rate of e-waste in Indonesia is 14.91%. The total amount of e-waste generated in Indonesia is estimated to reach ±49,627,917 units (±487,416 tons) by 2028.

Law no. 32 of 2009 concerning ecological security and the executives; Presidential Decree no. 101 of 2014 concerning dangerous waste administration. In any case, these guidelines just administer general and do not determine the definition, criteria, or stream of e-waste administration.[45]

The import of e-waste still happens albeit prohibited in Law No.32 of 2009, Article 69, Section 1 and Law No.18 of 2008, Article 39, Paragraph 2.[46] As an archipelago, Indonesia has numerous ports in the external islands, with a goal for e-waste or utilized electronic gadgets from abroad to enter the national market by using the restrictions standard administration offices on the importation of prohibited merchandise. At this point, the measure of e-waste in Indonesia is important despite the fact that information cannot be verified by authorities with respect to the illicit import of e-waste.

A. Hazardous Impact of E-waste in Indonesia

While the effect of contamination because of informal and inadequate handling of e-waste that is not eco-friendly. This malpractice happened in a few districts in Indonesia, for instance, environmental contamination that happened in Pesarean Village, Adiwerna District, and Tegal Regency.[47] This town has a few metal businesses that smelter aluminum, lead, copper, zinc, and utilized batteries. The after-effects of the staying metal industry exercises have caused a heap of metal waste, for example, lead ingots delivered and become crude materials for modern batteries, hardware, metal plating, paint, and glass. In 2011, the consequences of a provincial example test conducted by the Central Java Provincial Government on 50 townspeople provided information that more than 46 individuals had been debased with lead; of the 46 individuals, 12 were at risk on account of exposure to various hazardous stuff.[48]

A limited population bears an unfair proportion of the negative effects of

[44] Sylfannie Santoso, T. Yuri M. Zagloel, Romadhani Ardi, and Amalia Suzianti, "Estimating The Amount of Electronic Waste Generated in Indonesia: Population Balance Model," *IOP Conference Series: Earth and Environmental Science*, *Vol. 219, No. 1*, IOP Publishing, 2019, p. 012006.

[45] Li, Jinhui, Xianlai Zeng, Mengjun Chen, Oladele A. Ogunseitan, and Ab Stevels. ""Control-Alt-Delete": Rebooting Solutions For the E-Waste Problem." *Environmental Science & Technology 49, No. 12* (2015): 7095-7108.

[46] Gundeep Kaur, "Corporate Governance and Corporate Illegality The Effects of Board Structure on Securities Market Violations." (2017).

[47] C. Richard Paddock, "The Toxic Toll of Indonesia's Battery Recyclers." National Geographic,< https://www.nationalgeographic.com/news/2016/05/indonesia-s-toxic-toll/>, accessed on 31 May 2016.

[48] Wilyani, I. T., J. K. Nugraha, M. A. Aryadi, and Nida Mariam, "E-Waste: An Underrated Hazardous Waste in Indonesia," *Journal of Environmental Engineering & Waste Management* 3*, No. 2* (2018).

objectionable e-waste practices. Most e-waste recyclers, either in the formal or informal sectors, are unsafe and less taught than the specific masses typical. E-waste reuse provides income to people who have a couple of other money-related openings. Children and women, especially those living in urban domains, address a far-reaching fragment of e-waste recyclers.[49] Considering the gaps in data, particularly in the informal section, the total number of children displayed to word related prosperity and risks from e-waste is difficult to assess. In any case, the International Labor Organization has identified that e-waste experts are routinely kids.[50] Children are seen as flawless e-waste workers because they have nearly nothing but gifted hands that help them easily dismantle discarded EEE.

The maltreatment of children inside the e-waste recycling industry is especially alarming given the physiological credits that add to a child's weakness. The risks of direct contact to dangerous substances, such as polychlorinated biphenyls and dioxins, are higher for children than for adults. Adolescents are still growing; thus, their confirmation of water, sustenance, and air in a degree to their stature and weight is inside and out higher appeared differently in relation to the affirmation of adults.[51] Children consistently contribute more vitality outside where unsafe exposures are inside closer closeness. From a lead position, youthful youngsters usually show hand-to-mouth direct and creep on the ground, which regularly prompts the quick ingestion of potentially dangerous substances. Children have a juvenile peril insight that can incite dangerous exposures from e-waste.[52] Furthermore, children have a progressively expanded future in the midst of which they would live with the obstruction that injuries or prologue to perilous substances can instigate.

The instant and delayed harmful effects of exposure to hazardous e-waste entities are not totally observed. Nevertheless, a question remains on the connection between e-waste introduction and progressively raised measures of engineered mixes and metals in human-construed characteristic models. Overpowering metals and halogenated blends appear to affect potential prosperity risks.[53] Similarly, weakened lungs have been found in young fellows developed 8 to 9 years living in an e-waste reusing town anyway not in young fellows living in a control town. Immense negative associations between compelled basic point of confinement, a proportion of lung limit and blood chromium obsessions have been represented.[54] Lead is also a developed neurotoxicant that can incite academic impedance and damage to the blood and conceptive structures. Brominated fire retardants have a long half-life and apparently cripple learning and memory work; change thyroid, estrogen, and hormone systems; cause social issues; and induce neurotoxicity. Cadmium tends to bioaccumulate and can be considerably deadly, especially to the kidneys and bones.

[49] Xinwen Chi, Martin Streicher-Porte, Mark YL Wang, and Markus A. Reuter, "Informal electronic waste recycling: a sector review with special focus on China," *Waste Management 31, No. 4* (2011): 731-742.

[50] Lundgren, Karin. *The Global Impact of E-Waste: Addressing The Challenge*. International Labour Organization, 2012.

[51] Duffert, C., M. N. Brune, and K. Prout. "Background Document on Exposures to E-Waste." *Geneva, Switzerland: World Health Organization* (2009).

[52] Chatham-Stephens, Kevin, Jack Caravanos, Bret Ericson, Jennifer Sunga-Amparo, Budi Susilorini, Promila Sharma, Philip J. Landrigan, and Richard Fuller, "Burden of Disease From Toxic Waste Sites in India, Indonesia, and The Philippines in 2010," *Environmental Health Perspectives 121, No. 7* (2013): 791-796.

[53] C. Duffert, M. N. Brune, and K. Prout, "Background Document on Exposures to E-Waste," *Geneva, Switzerland: World Health Organization* (2009).

[54] Kristen Grant, Fiona C. Goldizen, Peter D. Sly, Marie-Noel Brune, Maria Neira, Martin van den Berg, and Rosana E. Norman, "Health Consequences of Exposure to E-Waste: A Systematic Review." *The Lancet Global Health 1, No. 6* (2013): e350-e361.

Mercury is considered to hurt the psyche and central tactile framework, particularly during early progression.[55]

The amount of hazardous stuff that individuals could be obtain from e-waste is difficult to gauge. The classifications of these materials are variable and high, especially inside specific e-waste districts. Although the centralizations of these substances are low, the engineered mixtures remain deadly to individuals and persistent in nature. The heterogeneous thought of dangerous exposures contributes to the difficulties in the research on the effects of e-waste exposure. Notwithstanding whether consistently presentation is low, a total introduction is mostly high and to an incredible degree hard to measure.[56] annihilating e-waste can moreover explicitly brief harm. Certain individuals, for instance, kids, are increasingly defenseless given the affectability of their making systems. The arranging of introduction in like manner may exhibit the ordinary range of certain consequent caring effects of exposure.[57] Much investigation is required on waste presentation and potential threatening prosperity impacts. Strong affirmation that associations occupation presentation of dangerous e-waste substances to prosperity impacts is inadequate. Research on e-waste hazards can be confined by poor access to uncontrolled settings, obliged resources, and political and moral concerns. Monitoring and surveillance, especially of easygoing e-waste reusing exercises, is pitiful. Not only are hazardous examinations of e-waste introduction essential, yet furthermore explore that will empower easygoing neighborhood, common, and overall e-waste recycling plan is required.

B. Legal Mechanism for Waste Management in Indonesia

The Constitution of Indonesia comprises the right to a healthy environment. The State is liable to protect 'right to live' of citizens by protecting and providing a clean and healthy environment. The Article 28H paragraph (1) of the Constitution of Indonesia states:

> *"Every person shall have the right to live in physical and spiritual prosperity, to have a home and to enjoy a good and healthy environment and shall have the right to obtain medical care".*[58]

Although Indonesia has no specific laws about e-waste, e-waste is managed under the following laws;

- Law No. 32 of 2009 on Environmental Management
- Act No. 18/2018 for Municipal Solid Waste Management
- Governmental Regulation No. 101/2014 on Hazardous Waste Management
- Minister Trade's Decree No. 31/2016 on the Regulations of the Importation of Non-Hazardous Wastes

The Appendix of the Governmental Regulation Number 101/2014 on Hazardous Waste Management stipulates the codes for both the assembly of electronic components and electronic equipment in Table 3.

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[55] *Ibid*.

[56] Duffert, et. al., "Background Document"

[57] Harm-Jan Westra, Marjolein J. Peters, Tõnu Esko, Hanieh Yaghootkar, Claudia Schurmann, Johannes Kettunen, Mark W. Christiansen et al. "Systematic identification of trans eQTLs as putative drivers of known disease associations," *Nature Genetics 45, No. 10* (2013): 1238.

[58] Article 28H (1), The Constitution of Indonesia.

Table 3. Codes and Description of E-waste in Indonesia[59]

Waste Code	Waste Description
D219	Electronic Components or Electronic Equipment
A111d	Used refrigerant from electronic equipment
A328-4	Caustic strapping (photoresist)
A328-5	Sludge assembly production
B328-1	Cathode Ray Tube (CRT)
B328-2	Coated glass
B328-3	Residue solder and flux
B328-4	The printed circuit board (PCB)
B328-5	Metal cable waste and insulant
B328-6	Sludge from IPAL

Other segments of waste outside the classification of B3 waste can be natural or inorganic. Recently, foreign nations, particularly the European Union, have laid several appeals (e.g., RoHS, WEEE guidelines, and others) to advance the ecostructure of electrical items and embrace Extended Producer Responsibility (EPR) for the accumulation and reuse of WEEE. However, such proposals remain difficult to apply in developing nations.

In Indonesia, the draft outline of the Regulation of the Minister of State on Electronic Waste Management is orchestrated in terms of definition, extent of electronic waste source, electronic waste sort, EPR[60], electronic waste administration through perilous waste administration component, participation between makers of electronic products and perilous waste handlers, and the remuneration and supervision thereof.

C. E-Waste Management in Indonesia

The biggest concern is lead found in the CRTs of TVs. Lead is utilized in CRTs to shield consumers from conceivably destructive contact to x-rays; in addition, it is bound in a glass framework as lead oxide and is steady and stable. As per Musson et al.[61] who utilized the US Environmental Protection Agency's toxicity characteristic leaching procedure for lead leachability), 21 of 30 shading CRTs surpassed the 5 mg/l lead administrative point of confinement. Additionally, mercury might be contained in fluorescent lights that provide backdrop illumination in LCDs.[62] Similarly, refrigerators contain hurtful synthetic compounds, e.g., chlorofluorocarbon, which winds up waste in the reusing process. In Japan, since April 2004, the retrieval of

[59] Appendix, Governmental Regulation Number 101/2014 on Hazardous Waste Management.

[60] Aretha Aprilia, Tetsuo Tezuka, and Gert Spaargaren, "Inorganic and Hazardous Solid Waste Management: Current Status And Challenges for Indonesia," *Procedia Environmental Sciences 17 (*2013): 640-647.

[61] Stephen E. Musson, Yong-Chul Jang, Timothy G. Townsend, and Il-Hyun Chung, "Characterization of Lead Leachability from Cathode Ray Tubes Using the Toxicity Characteristic Leaching Procedure," *Environmental Science & Technology 34, No. 20* (2000): 4376-4381.

[62] I. T. Wilyani, J. K. Nugraha, M. A. Aryadi, and Nida Mariam, "E-Waste: An Underrated Hazardous Waste in Indonesia," *Journal of Environmental Engineering & Waste Management 3, No. 2* (2018).

CFCs from protection is required[63] in washing machines, especially contain saltwater (utilized as a fluid balancer incompletely programmed clothes washers) and engines, and the circuit sheets cannot be dismantled in light of the fact that they are covered with gum for waterproofing.[64]

An e-waste recycling management system has not been formally set up in Indonesia. However, in Batam Island and East Java Provinces, modern industrial pockets have set up informal recycling units.[65] As previously stated, the backyard informal recycling of PCs and cell phones is a normal practice in Indonesia. People from the casual segment mostly recover valuable materials from e-waste, e.g., gold is obtained from the IC attachment or IC chipset. Utilizing exposed hands and without taking any precautionary measurements, they consume IC and blend with some different synthetic substances (e.g., HNO3 and selenium) to recover gold. This procedure creates wastewater containing overwhelming metals that surpass edge estimations of Indonesian wastewater guidelines (e.g., Cu, Cr, Co, Pb, Ni, Sn, and Zn).[66] Given the diverse attributes of weight and perilous substances, a classification of end-of-life electronic and electrical items would be beneficial. This classification demands further investigation to explore the composition of specific e-waste in Indonesia.

According to Putra et al.,[67] waste reduction and proper handling can play an important role in e-waste management because e-waste reduction can adopt 3R program optimization. Furthermore, both measures must be consistent to achieve 100% service target by 2025, reaching 30% (± 21 million tons/year) through reduction activities and 70% (± 50 million tons/year) through handling activities. There was positive response from public for waste bank being noticed such as the number of the waste bank in Yogyakarta City 433 units can manage waste up to 899,801,8 kg/month, Sleman Regency 34 waste bank units (78.966,4 kg/month) and Bantul Regency 24 waste bank units (49.873,5 kg/month)[68] However, further public awareness is needed.

Jakarta has started e-waste collection services in cooperation with PT Prasadha Pamunah Limbah Industri, the issue is the collection and for that sanitation agency of Jakarta will assist the company. This move is a good initiative, and the government shall take necessary measures to develop improved integrated treatment facilities to treat e-waste.[69] A new formal employment framework should consider the informal sector; in this manner, the policy must aim to improve the business and the working conditions and proficiency of the informal or casual sectors. Indonesia shall enact a specific e-waste regulation that covers e-waste from household and industry resources.

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[63] Shinsuke Murakami, Atsushi Terazono, Naoya Abe, Yuichi Moriguchi, and Hideki Miyakawa, "Material Flows of End-of-Life Home Appliances in Japan," *Journal of Material Cycles and Waste Management 8, No. 1* (2006): 46-55.

[64] T. Matsuto, C. H. Jung, and N. Tanaka, "Material and Heavy Metal Balance in A Recycling Facility for Home Electrical Appliances," *Waste Management 24, No. 5* (2004): 425-436.

[65] Pertiwi Andarani and Naohiro Goto, "Potential E-Waste Generated From Households in Indonesia Using Material Flow Analysis," *Journal of Material Cycles and Waste Management 16, No. 2* (2014): 306-320.

[66] *Ibid*.

[67] Hijrah Purnama Putra, Enri Damanhuri, and Emenda Sembiring, "Integration of Formal and Informal Sector (Waste Bank) in Waste Management System in Yogyakarta, Indonesia," In *MATEC Web of Conferences Vol. 154*, EDP Sciences, 2018, p. 02007.

[68] *Ibid.*

[69] Corry Elyda, "Jakarta Starts E-Waste Collection Service in Cooperation With PT." < https://www.thejakartapost.com/news/2016/02/12/jakarta-starts-e-waste-collection-service-cooperation-with-pt.html>, accessed on 12 February 2016,.

V. E-WASTE SCENARIO IN SINGAPORE

In 1996, Singapore ratified the Basel Convention[70] on the control and management of import, export, and travel of unsafe wastes, which include e-waste. Despite the fact that its transboundary development is limited, e-waste has produced PCs, printers, batteries, and electronic things because e-waste in Singapore is not managed as hazardous industrial waste. At present, no formal administrative structure manages the disposal of e-waste in Singapore. Allegedly, Singapore has a functioning second-hand showcase and compelling reusing activities, thus causing insignificant e-waste winding up in its transfer offices and facilities. Important electronic scrap produced by units of industrial ventures is typically sold to neighborhood e-waste reuses where valuable metals, such as gold and platinum, are recovered.[71]

The National Environment Agency (NEA) demonstrates that the measure of e-waste produced is not worrisome. According to the NEA, approximately 60,000 tons of e-waste is produced yearly in Singapore, of which approximately 50% is regular family unit IT items and home machines, whereas the rest are ICT appliances produced from the business and mechanical sectors.[72]

In the absence of a formal and regular arrangement of e-waste recovery and reusing, substantial information on the reusing rates of e-waste is not accessible. The extensive second-hand area and informal or casual reusing segment are expected to handle majority of the postcustomer e-waste in Singapore.

A. E-waste Recycling Programs in Singapore

Current e-waste recycling endeavors are volunteer activities initiated by privately owned businesses with the help of the administrative agencies. The recycling culture is emerging in Singapore, and many private business entities are voluntarily initiating recycling programs. In Table 3, all recycling programs, which have been actively serving with the support of the NEA, are listed.

[70] Basel Convention, Status of Ratification. <http://www.basel.int/Countries/StatusofRatifications/PartiesSignatories/tabid/4499/Default.aspx >.

[71] Kian Peng Teo, "Electronics and the Environment-Singapore Perspective," (2005): 1-189.

[72] Jeremy N. Rauch and Paul Romer, "The Singapore Way: Planning for a Sustainable Future," (2015).

Table 4. E-waste Recycling Programs in Singapore[73]

No	Recycling Programs
1	Early Disposal Scheme for Non-UL2272 Personal Mobility Devices (PMD)
2	StarHub's RENEW (REcycling Nation's Electronic Waste) Program
3	Singtel x SingPost E-Waste Recycling Program
4	Punggol Eco-Drive
5	M1 E-waste Drop-Off Point Program
6	E-waste Recycling @ North East
7	Shell-Metalo E-waste Recycling Program
8	City Square Mall E-waste Recycling Program
9	Project Homecoming - Ink & Toner Cartridge Recycling Program
10	Dell Recycling Program
11	IKEA's Light Bulb Recycling Program
12	Three cubes Voluntary Lamp Recycling Program
13	Dell Recycling Program
14	HP Planet Partners Program
15	Toshiba-Metech Recycling Program

StarHub has partnered with DHL Express Singapore and TES (Singapore) to place over 400 green e-waste recycling bins around Singapore. E-waste is picked up by DHL and sent to TES (Singapore) for recycling.[74] Similarly, Singtel and SingPost launched an e-waste recycling program known as "ReCYCLE" with the support of NEA.[75] This program provides the means for people to recycle their mobile and internet-related electronic waste, such as mobile phones and chargers, laptops and tablets, modems and routers, and other related accessories, such as lithium batteries and cables. These unwanted devices can be dropped off into the ReCYCLE bins at selected Singtel shops and Singtel exclusive retailer outlets and post offices. The devices can also be sent via Singapore post in a ReCYCLE envelope free of charge because postage is waived. This program reduces waste as it ensures that the valuable metals and components the devices contain are recovered. Otherwise, e-waste that is thrown away, including all the precious metals that it contains, will be incinerated and landfilled at the Semakau Landfill.[76] REcycling Nation's Electronic Waste (RENEW) is another collaborative effort among DHL, StarHub, and TES-AMM to dispose of e-waste, including phones, computers, computer accessories, DVD players, MP3 players, VCRs, remotes, cables, plugs, electronic toys, and lithium-ion batteries. A total of 325 green RENEW bins

[73] NEA, "Where to Recycle E-Waste" <https://www.nea.gov.sg/our-services/waste-management/3r-programmes-and-resources/e-waste-management/where-to-recycle-e-waste#programmes>.

[74] StarHub, "DHL, StarHub and TES-AMM Join Forces To Champion Electronic Waste Recycling in Singapore." StarHub, https://www.starhub.com/about-us/newsroom/2014/september/dhl--starhub-and-tes-amm-join-forces-to-champion-electronic-wast.html, accessed on 16 September 2014.

[75] Singtel and SingPost, "ReCYCLE" <https://recycle.sg/>.

[76] *Ibid*.

have been placed at 274 locations in Singapore. Similar to RENEW, there is M1 Drop-off Point Program where people can drop their e-waste off at any of the seven M1 e-waste bins.[77]

Dell, HP, Samsung, Toshiba and others are offering 'Tackback Services' for consumers which is a positive initiative to minimize the e-waste.[78] Consumers are required to fill up an online form courier will pick it for free. Similarly, Li Tong Recycle offers online Tackback facility for Apple products. Notwithstanding the presence of all recycling programs the outcome is not satisfactory because according to the NEA, the amount of e-waste collected through these programs is only a fraction of the total generated.[79] Currently, there is no national collection system for larger household appliances and it may increase informal e-waste treatment which is unsafe and a threat to the health of human beings and the environment.

B. Legal Mechanism for Waste Management in Singapore

There is no direct provision about the environmental protection in the Constitution of Singapore 1965, but Article 9(1) of the Constitution indirectly protects the life of citizens which is directly linked with the healthy and safe environment. As it states: "no person shall be deprived of his life or personal liberty save under law".[80]

Previously, the Singaporean authorities were dealing e-waste under the following laws: Hazardous Waste (Control of Export, Import and Transit) Act 1997, Environmental Protection and Management Act (revised edition) 2002, Hazardous Waste (Control of Export, Import and Transit) Regulations 2015 and the Environmental Protection and Management (Hazardous Substances) Regulations.

Recently, the Resource Sustainability Act 2019 (RSA) is being enacted and implemented in Singapore to deal e-waste by enhancing the EPR approach where producers bear the responsibility for the collection and treatment of their products when they reach end-of-life.[81] The main objective of this Act is to implement a framework where persons who profit from the supply of products bear the cost of collecting and treating these products when they become waste. Further, to encourage producers of packaging to reduce, reuse or recycle packaging and to regulate persons operating producer responsibility schemes, and to promote resource sustainability.[82]

Following are some key features of RSA 2019:

(a) Firstly, the RSA makes compulsory the registration of the producer of regulated products under the NEA and prohibited unauthorized supply of regulated products if the producer is not registered under NEA.[83]

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[77] Innovation, Sustainable, "Recycling from E-waste to Resources." (2009).

[78] Dell, "Free Consumer Takeback Services,"<https://www.dell.com/learn/sg/en/sgcorp1/corp-comm/recycling-consumer-apj-sg>.

[79] Siau En, "Singapore Looking at Laws for Producers to Take Back E-Waste from Customers Today," <https://www.todayonline.com/singapore/singapore-looking-laws-producers-take-back-e-waste-customers, accessed on 19 January 2018.

[80] Article 9(1), the Constitution of Singapore.

[81] NEA, "Extended Producer Responsibility System for E-waste Management System." *NEA*, https://www.nea.gov.sg/our-services/waste-management/3r-programmes-and-resources/e-waste-management/extended-producer-responsibility-(epr)-system-for-e-waste-management-system. accessed June 7, 2020.

[82] Section 3, Resource Sustainability Act 2019.

[83] Section 8 & 9, the Resource Sustainability Act 2019.

(b) Secondly, the collection and disposal of unwanted regulated non-consumer products is the responsibility of producers and retailers without charging any fee and also waste collector, recycler and disposal required to have a license from the DG under the NEA.[84]

(c) Thirdly, this regulation prohibits collection of e-waste by public or without approval or license from a competent authority and in case of violation it also imposes fine not exceeding $5,000.[85]

(d) Fourthly, it is the producer's liability to submit 3R plan to the NEA to reduce, re-use or recycle packaging in Singapore. The plan must carry all the relevant information and in case of violation, there is fine, imprisonment or both.[86] 3R plan will help to minimize the waste generation and will enhance the culture of recycling and reuse.

(e) Last but not the least, the producer responsibility scheme also implemented under this regulation. Further, it is reported that the producer responsibility scheme is required license from a competent authority under the NEA.[87] The NEA may issue a license with certain terms and conditions such as fees payable by members of producers responsibility scheme, the waste collection operations of the licensee, to ensure comprehensive and regular collection, removal and transport of waste, minimum specified waste collection amounts and to conduct programs or events to educate the public on waste management and resource sustainability.[88]

The implementation of the RAS 2019 is a significant development in Singapore to address the e-waste issue formally. The producers and retailers of regulated products are liable for collection and disposal of unwanted regulated non-consumer products is also a beginning towards formal e-waste management.

It can be expected that the enforcement of the RAS will be able to develop an efficient and formal framework for e-waste management in Singapore. Recovery facilities or collection centers could be assigned available or outside choices.[89] Singapore is taking the cue from countries, such as Sweden by taking on the EPR approach.[90] In Sweden, approximately half of all e-waste obtains a second life as materials for new products and materials.[91]

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[84] Section 13,14 & 17, the Resource Sustainability Act 2019.

[85] Section 16, the Resource Sustainability Act 2019.

[86] Section 21 & 22, the Resource Sustainability Act 2019.

[87] Section 29, the Resource Sustainability Act 2019.

[88] Section 30, the Resource Sustainability Act 2019.

[89] Majeti, N.V. Prasad, and Meththika Vithanage (eds), "*Electronic Waste Management and Treatment Technology.*" Butterworth-Heinemann (1st Ed.), 2019.

[90] NEA, *"Extended Producer Responsibility (EPR) System for E-waste Management System." NEA*, <https://www.nea.gov.sg/our-services/waste-management/3r-programmes-and-resources/e-waste-management/extended-producer-responsibility-(epr)-system-for-e-waste-management-system, accessed on 18 January 2020.

[91] Samantha Boh, "Regulations will be introduced to ensure e-waste is recycled: Masagos." *The Straits Times*, <https://www.straitstimes.com/singapore/environment/regulations-will-be-introduced-to-ensure-e-waste-gets-recycled-masagos, accessed on 17 January 2020.

VI. COMPARATIVE DISCUSSION

Singapore, Malaysia, and Indonesia are three Southeast Asian countries that maintain a strategic partnership to expedite their economic growth together.[92] Singapore, which has a small land area, has attained the status of a developed and high-income country, whereas Malaysia and Indonesia are still struggling. To become a developed country, a country should have a proper e-waste treatment and management system. On the basis of the previous sections, an outline that can provide analogies can be drawn to understand that Singapore is leading the other two countries in terms of e-waste management. Some notable initiatives to promote the culture of recycling have been taken by NEA in Singapore. Malaysia is also following Singapore and focusing on recycling, whereas Indonesia faces challenges in the recycling and recovery or collection of e-waste. Indonesia is a big country and thus requires a systematic approach to overcome the issue of e-waste.

Informal e-waste treatment or recovery is observed in all three countries; however, a formal e-waste mechanism is lacking. Recently, Singapore has implemented the Resource Sustainability Act 2019 for formal and efficient e-waste management whereas Malaysia and Indonesia do not have e-waste law but governments are committed to enacting new laws. In Malaysia, the draft of new e-waste law, namely, the 'Environmental Quality (Household Scheduled Waste) Regulation' is in AG office for approval. Similarly, the Ministry of Environment and Forestry of Indonesia also plans to enact e-waste management law soon. Last but not the least, the Constitution of Indonesia comprises provision about the clean and healthy environment whereas such provision is missing in the Constitutions of Malaysia and Singapore.

VII. CONCLUSION

E-waste management and a proper recycling mechanism are important issues to be addressed. E-waste needs to be skillfully handled and reused as raw materials rather than be stripped down.[93] Recycling alone will not be enough to address the rapidly growing volumes of e-waste worldwide. E-waste requires multiple solutions. There is a need to enhance designing better products, the right to repair, manufacturer or retailer take-back programs, cash for trash, the EPR programs and develop environmentally sound recycling infrastructure. E-waste is disassembled via informal and unsafe methods due to the lack of recycling and recovery facilities, thus resulting in hazardous effects on human health and the environment. Recycling facilities must be developed for a formal treatment of e-waste in developing countries, such as Malaysia, Indonesia, and Singapore.[94] Currently, these three countries do not have a specific e-waste law, and e-waste is managed under other existing general laws. Enacting e-waste laws in the aforementioned countries are necessary to start with, satisfactory hazard limits for unsafe, auxiliary e-waste substances ought not to be diverse for the countries in the discussion. In any case, the satisfactory limits ought to be distinctive for youngsters and grown-ups, given the physical disparities

[92] Terence P. Stewart, and Margaret LH Png, "The Growth of Triangle of Singapore, Malaysia and Indonesia," *Ga. J. Int'l & Comp. L.* 23 (1993): 1.

[93] Jinhui Li, Lili Liu, Nana Zhao, Keli Yu, and Lixia Zheng, "Regional or Global WEEE Recycling: Where to Go?" *Waste Management 33, No. 4* (2013): 923-934.

[94] Emily A. Yu, Matthew Akormedi, Emmanuel Asampong, Christian G. Meyer, and Julius N. Fobil, "Informal Processing of Electronic Waste at Agbogbloshie, Ghana: Workers' Knowledge About Associated Health Hazards and Alternative Livelihoods," *Global Health Promotion 24, No. 4* (2017): 90-98.

and articulated vulnerabilities of children.[95] The outright wiping out of dangerous and harmful segments in EEE is not sensible and is difficult to achieve. Despite the need for research, instructive and public awareness programs on the potential dangers of e-waste reuse must be organized and hence actualized. These projects are crucial for developing countries. The careless response on the part of the political authority and financial constraints have slowed down the process of necessary arrangements to contain the transboundary mobility of e-waste. A strategic worldwide methodology must be established to stem the free streaming of e-waste across national frontiers. Endeavors must be materialized toward the proper execution of the 3R strategy in EEE production and manufacturing in Malaysia, Indonesia, and Singapore. Public awareness among citizens can play a vital role, and citizens may participate in e-waste management programs efficiently. In addition, Singapore can assist its two neighboring countries by offering e-waste management technologies, adopting policies, and importing e-waste for treatment under some conditions. Mutual cooperation and coordination among these three countries can help them achieve rapid economic growth and ensure a healthy and clean environment.

[95] M. Van den Berg, "State of The Art on Risks of E-Waste and Children's Health," Discussion Paper for WHO Working Meeting On E-Waste And Children's Health, 2013.

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