E-waste Management in Communities: Gaps in the Law and a Review of Existing Policies, Thailand

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Article

E-Waste Management in Communities: Gaps in the Law and a Review of Existing Policies, Thailand

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Abstract: This article aims to investigate gaps in the law and policies on e-waste management in communities of Thailand and suggests a guideline for improving, developing, and designing legal measures and state policies for more effective enforcement of the law on e-waste management in communities. The findings reveal that the currently applicable law of Thailand lacks effective approaches and rules for e-waste management. Also, there is not any implementation of key environmental principles for e-waste management in communities, such as the Polluter Pays Principle (PPP) that requires manufacturing companies to take part in being responsible for disposal expenses or the Public Participation principle that requires users, manufacturers, distributors, and government agencies to take parts in disposing e-waste. As a result, problems of e-waste in communities of Thailand have been continuously increasing. According to such problems, the authors suggest that legal measures on e-waste management in communities should be specifically designed by implementing key environmental principles as a basis in determining formats and guidelines of e-waste management, especially participation of all sectors that can help in solving and reducing e-waste in communities that is harmful to health, sanitation, and environment.

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1. Introduction

Electronic waste (e-waste) is an environmental issue that is spreading rapidly. For developed countries, they usually have a management approach by exporting their e-waste to developing countries. One of the countries that imports such e-waste is Thailand. According to the Pollution Control Department of Thailand, the country currently has increasing volume of e-waste, or called waste electrical and electronic equipment, every year. The situation tends to be more severe with a forecast that in 2028 the worldwide volume of e-waste would be 40 million tons per year and the rate would be higher by 4 percent per year. Such forecast also indicates that developing countries would dispose waste computers rather than developed countries and by 2030 the amount of waste computers in developing countries would be doubled over that in developed countries. In addition, in accordance with the data from Kasikorn Research Center, during 2013 – 2016 Thailand had municipal e-waste in average amount of 380,605 tons per year, increasing approximately 2.2 percent per year. This amount of e-waste holds a high proportion of 64.8 percent of the total amount of hazardous waste generated from communities. This is in line with the data from the Pollution Control Department stating that in 2016 Thailand had household hazardous waste 606,139 tons, increasing 2.54 percent from 2015, which consist of waste electrical and electronic equipment in amount of 393,070 tons (65 percent). Based on a study regarding life cycle forms of electronic equipment in Thailand, it can be divided into 2 forms: (1) importing materials to manufacture as electrical and electronic products to be sold by exporting and for domestic consumption; and (2) importing used electrical and electronic equipment from overseas for domestic consumption. When ending of life, the equipment from both forms of life cycle will be disassembled as parts and sent to either domestic or international recycling plants for being transformed to materials for production. Non-usable parts will be further managed. Also, it is found that some parts of the waste equipment that have not been

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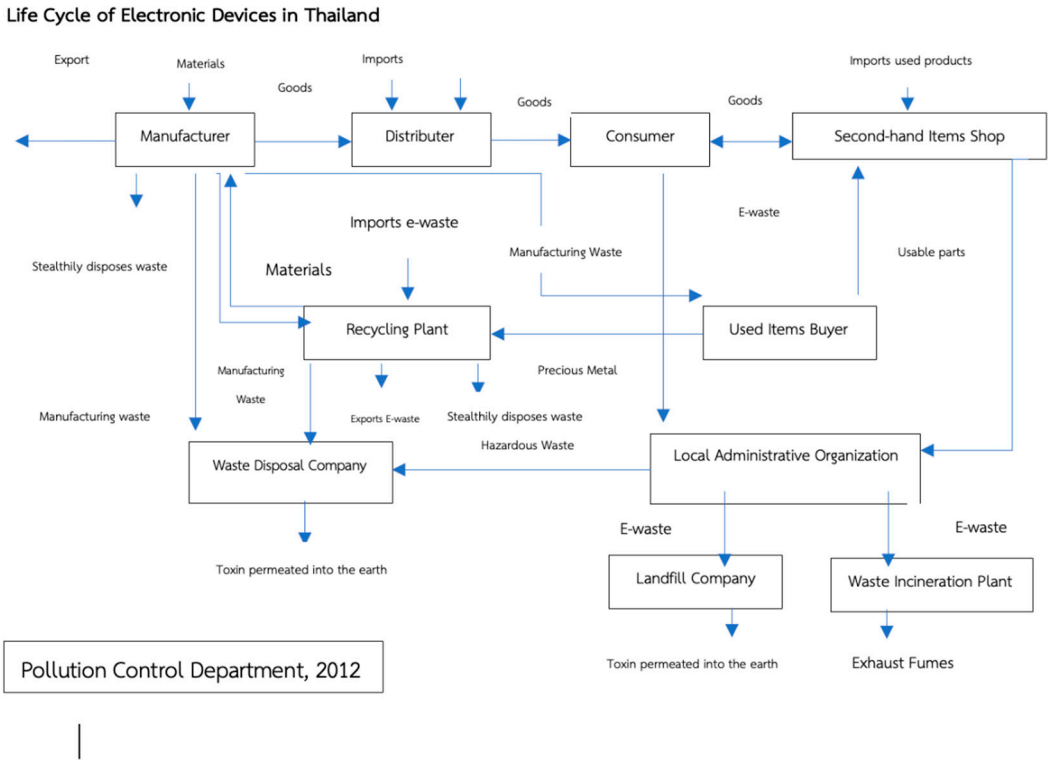
disposed properly will be threw away in association with solid waste from communities which will be collected by local administrative organizations for disposal.

Nowadays, e-waste management is not carried out systematically and in the right manner. Also, there is not any specific law on management for waste electrical and electronic equipment as well as waste of other products. Currently, e-waste is managed by means of incineration and landfill. They are considered the root causes of hazardous substances generated from the waste electrical and electronic equipment, which can be directly harmful to health and environment [4], As black smoke generated from incineration goes up and depletes atmosphere layers, landfill can cause these substances to be permeated into the earth and destroy soil horizons and underground water. These are harmful to health and ecosystem and can cause global warming as well [24],



Many countries are giving precedence to and becoming aware of the forementioned impacts. For instances, European Union promulgated the Waste Electrical and Electronic Equipment (WEEE) regulations and the Restrictions on Hazardous Substances (RoHS) regulations. Member countries are required to issue a law to be in line with the WEEE regulations by providing a collection system for waste electrical and electronic equipment to be handled with the most advanced technology available and designing products to facilitate parts disassembling for recycling and reusing with expenses of manufacturers and importers. Regarding the RoHS regulations, member countries are required to issue a law to restrict uses of 6 types of hazardous substances including lead (Pb), mercury (Hg) cadmium (Cd), chromium hexavalent (Cr6+), polybrominated biphenyls (PBB), and polybrominated diphenyl ethers (PBDE) in electrical and electronic equipment products put on the market after 1 July 2006 [1].

Now, Thailand is still facing with a problem of increasing amount of e-waste every year due to its lack of comprehensive management system for waste electrical and electronic equipment. For instances, there are very few systems for collecting or recalling waste products from manufacturers and distributors. This becomes a burden of local administrative organizations which most of them do not have standard facilities and proper management systems for collecting, sorting, transporting, recycling, and disposing. Furthermore, most people still lack of understanding that waste products are hazardous waste and must be managed in the right way. They also lack of awareness in sorting certain waste products out from general waste and sell them to used item buyers or shops [3], Importantly, Thailand does not have any direct law on management of waste electrical and electronic

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equipment. It only has laws on hazardous waste management and a law on industrial business operations and environment. Such rules of laws do not obviously support waste products management. According to the statistic carried out by the Pollution Control Department, there were 11.98 million of waste mobile phones in 2016 and 13.42 million in 2018. Such figures indicate that there are a very huge number of mobile phones that must be managed properly in order not to impact health and environment in the future [20].

2. Materials and Methods

For methodology of this study, documentary research was applied to investigate and collect basic information on economic, social, and legal aspects. Documents were divided into 2 parts. Part 1: the concepts on waste electrical and electronic equipment management, state policies, rules of Thai laws on waste electrical and electronic equipment management, and Part 2: information of relevant researches on waste electrical and electronic equipment and practical guidelines relating to e-waste.

3. Results

3.1. Contextual *b*ackdrop

E-waste or waste from electrical and electronic equipment means electronic equipment that is unwanted, out of date, or ended of life [21].

3.1.1. Rapid advancement of technologies

In this age of technological advancement, communication systems and electronic equipment have been advanced very rapidly. The development of electrical and electronic equipment industries has driven this equipment to be essential items for every household. Technological advancement and stronger market competitiveness has made the prices of these products to be lower as every level of people can access and own them. This directly affects consumer behaviors. That is, consumers change and buy a new electrical and electronic equipment more frequently, resulting in higher volume of electronic waste every year [12].

3.1.2. Decreased average lifespan

A rapid growth of the electrical and electronic equipment industry has made consumers demand for new products more actively. Especially for computers and mobile phones, most people tend to change their devices before their old ones become deteriorated. Change of consumers' behaviors is a key factor that makes the average lifespan of electronic equipment decreased. This leads to a rapid increase in volume of e-waste [29], It is forecasted that worldwide e-waste would be approximately 40 million tons per year and would be increasing at the rate of 4 percent per year.

Average lifespan of electric and electronic equipment tends to decrease every year. For example, average lifespan of computers decreases from 6 years to 2 years, and average lifespan of mobile phones is less than 2 years and tends to continuously decrease [10], Worldwide e-waste is forecasted to be up to 74 million metric tons by 2030 due to the decreased lifespan of electric and electronic equipment.

3.1.3. Imports of e-waste from overseas

According to the study on life cycle forms of electronic equipment in Thailand [28], it was found that there are 2 parts: 1. importing materials to manufacture as electrical and electronic products to be sold by exporting and for domestic consumption; and 2. importing used electrical and electronic equipment from overseas for domestic consumption. When ending of life, the equipment from both forms of life cycle will be disassembled as parts and sent to either domestic or international recycling plants for being transformed to materials for production while non-usable parts will be further managed. Broken products but not yet expire their lifespans will be fixed for being reused.

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E-waste has currently become a cross-border pollution issue as it has been exported from developed countries to developing countries by giving a reason that such export is for reusing or recycling purpose.

3.1.4. Inadequate capability in waste management

Current inapplicable management of waste electrical and electronic equipment impacts heath, sanitation, and environment. For instances, incineration of electric wires to extract coppers for sale can generate vapors of plastic and some metals that are causes of cancer. Incineration of circuit boards to melt leads and coppers can generate lead vapors spreading to the air and accumulated in soil and water. Use of acids to extract precious metals from circuit boards without waste water treatment procedure can result in contamination of waste water to soil and water sources. Dismantling/disassembling refrigerators and air conditioners without recovery machines can make refrigerant release to atmosphere and deplete ozone layers [17], Therefore, contamination of pollution from e-waste recycling begins from the journey of e-waste producers to e-waste recipients and finally puts the risks on health and sanitation of people and environment.

3.1.5. Lack of standard waste management

Now, Thailand still lacks of comprehensive management system for waste electrical and electronic equipment from collecting, sorting or disassembling, transporting, recycling, to disposing. For instances, there are very few systems for collecting or recalling waste products from manufacturers and distributors. This becomes a burden of local administrative organizations which most of them currently do not have standard facilities and right management systems [15], E-waste is thrown away in association with general waste and sold to buyers or used item shops. The pattern of current waste management is to dispatch e-waste to sorting communities for villagers to sort and dissemble parts and take metals out for sale. Remaining scraps are handled either with a wrong manner of incineration and landfill or by stealthily disposing in any place. Also, some waste products such as electric lamps and dry cells are not accepted by recycling markets, or people have to pay money to recycling plant for disposal of such products. This makes almost all of this group of products be disposed in association with general waste, causing risks of leakage and contamination of hazardous substances in the waste products to environment, ecosystems, and food chain, which can generate problems to environment, communities, and health [26].

3.2. Policy framework for e-waste management in Thailand

3.2.1. Historical evolution

Thailand's collection of waste from industrial sector, healthcare facilities, and communities through government agencies generally focuses on resolving problems at the downstream. It is a collection and disposal/treatment without details that support waste management at the upstream, such as reducing, sorting, and recycling. Also, there is not an assignment of duties and responsibilities to all sectors in society in respect of waste management. In addition, there is not any specific law on community hazardous waste management, especially hazardous waste from used products including e-waste [14]. From the past to present, collection and disposal of hazardous waste, including general solid waste from communities, are duties of "local administrative organizations. However, local administrative organizations do not have policies to properly manage hazardous waste from communities. Therefore, most hazardous waste from communities is thrown away and disposed together with general solid waste in solid waste disposal facilities of the local administrative organizations, which are not designed to prevent contamination of hazardous substances to environment. This may impact on humans' health and environment. Furthermore, there is not any policy or law stipulating fee for community hazardous waste management which expenses are higher than general waste. As a result, local administrative organizations have to bear expenses on the

 doi:10.20944/preprints202303.0195.v1

management of hazardous waste from communities such as department stores, education establishments, hotel, etc.

3.2.2. Intents and key principles of policy framework

Community e-waste management is currently a big issue that tends to be more severe due to an increase of population and growth of technologies. Although the government sector has been trying to encourage people to dispose rubbish by the right type and provides laws to control this issue, the amount of e-waste in communities is found to be continually increasing. In respect of state policies, Thailand has set out principles for waste electric and electronic equipment management as follows.

- The Twelfth National Economic and Social Development Plan (2017-2021)

This National Economic and Social Development Plan was created by virtue of the National Economic and Social Development Council Code, B.E. 2562 (2019) assigning duties and authorities to the National Economic and Social Development Council to conduct the Draft of National Economic and Social Development Plan to be concordant and integrated with the National Strategy and other development plans.

This National Economic and Social Development Plan sets out goals on natural capital and environmental quality. It supports environmental-friendly growth, generates security of food, energy, and water, and increases the volume or proportion of solid waste that is managed sanitarily. However, e-waste management is not explicitly set out. People or communities do not know where and how to dispose or get rid of their e-waste, so they take e-waste out together with other types of solid waste in communities, resulting in difficulties in managing e-waste properly.

As mentioned above, the Twelfth National Economic and Social Development Plan emphasizes sustainable development and human-centered development. If there is a human development for environmental preservation, pollutions generated by human would be decreased. For instance, taking out e-waste properly can help reduce waste in communities that may impact environment due to contamination of its hazardous substances to soils, canals or rivers. This National Economic and Social Development Plan advocates researches and encourages use of advanced technologies for manufacturing products that are environmental-friendly and response to the market demands. People are more likely to pay attention to environment as there are more production of environmental-friendly products and production of electronic products with biodegradable materials and hazardous substances are less used. However, this National Economic and Social Development Plan does not specifically mention e-waste management in communities nor set out goals in reducing e-waste in communities, making amount of e-waste increases every year and tends to continually be higher.

- Draft of the Thirteenth National Economic and Social Development Plan (2017-2022)

Thailand is in the period of conducting the draft of the new National Economic and Social Plan. In such draft, there is an information on use of natural resources beyond the capacity of ecosystems among restrictions on management, resulting in deterioration of natural resources. Environmental issues are more severe due to the expansion of economic activities that still rely on use of middle-class materials and goods. Also, efficiency on use of resources is still low. Demands for natural resources increase over the support capacity of ecosystems, resulting in deterioration of natural resources. Furthermore, waste and pollution issues are more severe. Hazardous waste from communities and industrial sectors in 2019 is 2.041 million tons and tends to increase, especially waste electric and electronic equipment that is not managed properly and comprehensively.

However, plans on driving preservation of natural and environmental interests for fertility and sustainable utilization focus on supporting industrial development and creating growth on basis of environmental-friendly quality of life, including promotion of investment in environmental-friendly infrastructures, development and use of innovations and technologies for reducing pollution and environmental impacts.

- Policy and Plan for the Enhancement and Conservation of National Environmental Quality, B.E. 2560 – 2579 (2017 – 2036)

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Policies and plans for the enhancement and conservation of national environmental quality are purposed to be policy frameworks and directions for integrated management of natural resources and environment of the country for 20 years ahead and to be used by relevant agencies of all sectors as frameworks in conducting master plans and medium-term operation plans (5 years) and driving the management of natural resources and environment of the country to be in an appropriate, proactive, and effective way. Important policies are: 1. policy on management of natural resource base steadily for balance, fairness, and sustainability; 2. policy on creating environmental-friendly growth for prosperity and sustainability; 3. policy on uplifting the natural resources and environment management measures; and 4. policy on building partnership in natural resources and environment management.

According to the above policies, private sector is promoted to make products, especially electronic products, that are friendly to environment and manufacturing companies are encouraged to get their electronic products returned for recycling and reusing. This does not only help reducing production cost, but also help lowering the amount of e-waste in communities.

- Environmental Quality Management Plan

In addition to the above policies, there is the environmental quality management plan formulated by virtue of the Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992), Section 35. The Minister shall, with the approval of the National Environmental Board, formulate an action plan called "Environmental Quality Management Plan" for implementation of the national policy and plan for enhancement and conservation of environmental quality determined by virtue of section 13 (1) which details are as follows.

Natural resources and environment management consists of 10 key principles as follows.

1. Sustainable Development is principle that focuses on developing the country with balance in terms of economy, society, and environment. Economic growth must be developed with quality and competitiveness by considering the capacity of natural resources and environment that are necessary to be conserved and maintained for long lasting utilization. All kinds of resources must be used economically, with maximum efficiency, and by not influencing social needs in present and future. In terms of e-waste management under the principle of sustainable development, production of environmental-friendly electronic products would be a good way for resolving the community e-waste issue.

2. Ecosystem Approach is principle that emphasizes systematic relations for balanced existence of ecosystems to promote sustainable utilization of natural resources and environment. This principle can be applied in community e-waste management by not taking e-waste out to rivers and canals or letting it contaminate with environment since hazardous substances in e-waste would contaminate in consumable water sources, impact aquatic animals, and ruin ecosystems.

3. Precautionary Principle is proactive principle emphasizing precautionary prevention for impacts on natural resources and environment, especially in vulnerable and risky areas to prevent potential damages, and consideration of activities that might cause risks and dangers to humans' health. In respect of e-waste management, manufacturers are required to produce electronic products that are environmentally friendly and have minimum effects on environment when being disposed.

4. Polluters Pay Principle (PPP) is principle that applies economical tools in natural resources and environment management. Polluters or those who cause damages to environment must be responsible for expenses in preventing potential damages on humans' health or environment. In this regard, if manufacturing companies do not accept returns of their electronic products, they are necessary to manufacture recyclable electronic products so that they are able to take returns of their electronic products for recycling and reusing and do not need to pay disposal expenses.

5. Beneficiaries Pay Principle (BPP) is principle that motivates beneficiaries to pay renumeration for both upstream and downstream ecosystem service providers. It also creates fairness for losers to mitigate social conflicts due to taking advantages in utilization of natural resources and promotes mutual responsibilities among relevant sectors. Applying the Beneficiaries Pay Principle in e-waste management in communities, product users are required to take part in being responsible for e-waste disposal expenses. As product users, they may pay e-waste disposal expenses to a local

 doi:10.20944/preprints202303.0195.v1

government agency in communities. In case of companies, they may pay to a federal government agency to be spent as a budget for e-waste management.

6. Public – Private Partnership (PPP) is principle that establishes a shared responsibility to encourage private sectors to make investment and take part in environmental management. This is also the way of implementing public administration projects and generating cooperations between the government and other sectors in terms of natural resources and environment management. The government issues a law that requires manufacturers of electronic products to pay e-waste management expenses. Also, the government needs to encourage the manufacturers to take returns of their products to reduce their burden of disposal cost payment, provides financial supports for those who manufacture products that are environmentally friendly, or grants research funds and environmental-friendly production technologies to help reduce community e-waste issue from the upstream.

7. Good Governance consists of 6 sub-principles: Rule of Law, Ethics, Transparency, Participation, Accountability, and Cost-effectiveness. In applying the Good Governance principle, the government assures electronic product manufacturing companies that are certified for good governance to be entitled with commercial rights both domestically and internationally, resulting in good image and investment attraction to the companies. In addition, the companies have to express their responsibilities by making electronic products that do not impact environment in communities. Regarding the Participation sub-principle, people in communities are encouraged to return their e-waste, which can help reduce waste in communities, make benefits to communities, and build positive image for the companies in terms of good governance.

8. Extended Producer Responsibility (EPR) is principle that enlarges the scope of manufacturers' responsibilities to cover each phase of product life cycle from taking returns, recycling, and disposal of e-waste. Applying this principle enables manufacturers to improve their productions and promotes better environmental quality. This principle also encourages manufacturers to improve and develop their product designs and production systems to be friendly with environment and to make products lifespan longer for reducing e-waste in communities.

9. Resource Decoupling / Resource Efficiency is principle that focuses on reducing resource consumption rate per economic activity. It helps reduce volume of resources in respect of materials, energy, water, and other resources that are necessary in running economic activities to be in a normal manner, resulting in increased productivity and efficiency of use of resources and decreased volume of pollutions. If the government supports researches on technologies that help reduce hazardous substances, when electronic products are taken out as e-waste, this would help reduce contamination of hazardous substances contained in e-waste of communities.

10. Human Rights is principle that regards fundamental rights and freedom of humans, equality, fairness, and non-discrimination, no matter how economically and socially different and unequal economically people are. Human rights concerning natural resources and environmental management include rights of participating in conservation and protection of natural resources as well as enhancing and maintaining the environmental quality, rights of living in good quality environment, and rights of being able to take benefits from natural resources and biodiversity. The Human Rights principle can be applied in community e-waste management by the government requiring both electronic products manufacturers and products users to participate in environmental conservation and protection.

However, there is not any details in respect of e-waste management in this environmental quality management plan; it only provides principles set out broadly. If the principles are adopted and applied for e-waste management in communities, it will be very useful for communities.

- Strategy for the Integrated Management of Waste Electric and Electronic Equipment, B.E. 2557 – 2564 (2014-2021)

This strategy aims at preventing environmental problems at the root cause, reducing amount of waste in every stage, encouraging reuses of resources. It promotes systematic and centralized waste management to mitigate occurrence of pollutions. It also sets out more roles and responsibilities for manufacturers to comprehensively manage their products and waste products. It encourages

 doi:10.20944/preprints202303.0195.v1

participation of all sectors in managing, conserving, and maintaining the environment. Environment must be managed systematically by providing a proper treatment and restoration. Resources must be used wisely without impacting communities and environment.

According to the mentioned goals of the strategy, there should be a law that requires manufacturers, as a source creator of e-waste, to be jointly responsible for costs and expenses in the treatment, disposal, and recycling to motivate them to manufacture products that are environmentally friendly for cutting down such expenses. Also, manufacturers should be required to take part in natural resources management with communities for sustainable conservation, restoration, and utilization by reducing uses of materials that contain hazardous substances, quitting uses of certain types of hazardous substance, or replacing the existing substances with less hazardous ones. However, although this strategy mentions prevention, reduction and elimination of pollutions, remedial actions for affected people, and environmental quality management in communities and other environments, there is not any content that explicitly specifies e-waste management in communities, making the e-waste problem continuously increase and has not been resolved well as it should be.

3.3. Laws and Legislations on the E-waste Management

Thailand has not yet had specific and direct laws on waste electric and electronic equipment. There are only laws legislating hazardous waste management and industrial business operations and laws on environment. Over the past up until now, there have been laws that are relevant and can be applied in management, control, and prevention of waste electrical and electronic equipment, such as the Constitution of the Kingdom of Thailand, B.E. 2560 (2017), the Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992), the Factory Act, B.E. 2535 (1992), the Industrial Estate Authority of Thailand Act, B.E. 2522 (1979), etc.

Laws enforceable by government agencies that are relevant to and in charge of operation in driving law enforcement and setting out guidelines for the management of waste electrical and electronic equipment in Thailand are as follows.

- Constitution of the Kingdom of Thailand, B.E. 2560 (2017)

It is the supreme law of the country and very important to the people. The constitution indicates that a person and a community shall have rights to manage, maintain, and utilize natural resources, environment, and biodiversity in a balanced and sustainable manner, in accordance with the procedures as provided by law and that a person and a community shall have rights to receive information, explanation, and reasons from a state agency, or of other people permitted by the State, prior to the implementation of any activities that impact a person or a community, and the State shall take precautions to minimize the impact on people, community, environment, and biodiversity and shall undertake to remedy the grievance or damage for the affected people or community in a fair manner without delay.

In addition, the constitution is stated that for any undertaking by the State or which the State will permit any person to carry out, if such undertaking may severely affect the natural resources, environmental quality, health, sanitation, quality of life, or any other essential interests of the people or communities or environment, the State shall undertake to study and assess the impact on environmental quality and health of the people or communities and shall arrange a public hearing of relevant stakeholders, people, and communities in advance in order to take them into consideration for the implementation or granting of permissions as stipulated by the law.

Considering the constitution on the whole, there is nothing mentioned about e-waste management at all; there are only fundamental rights that people deserve. Therefore, Thailand does not have any law to specifically control the use of electronic products, resulting in the problem of continuous increase of e-waste in communities.

- Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992)

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This Act is legislated by virtue of the Constitution of the Kingdom of Thailand. It prescribes standards accepted by all sectors in maintaining the conservation of natural resources and environmental quality together with balanced development of the country.

The Act provides a definition of "waste": solid waste, filth, wastewater, waste air, polluting substances, or any other hazardous material which is discharged or originated a source of pollution, including residues, sediments, or the remainders of such matters, either in solid, liquid, or gaseous state. It also defines "hazardous material" as explosive material, inflammable material, oxidizing material, peroxiding material, toxic material, pathogenic material, radioactive material, material that causes genetic change, corrosive material, irritating material, or other materials, whether chemical or not, which may cause danger to humans, animals, plants, property, or environment.

However, this Act does not state the definition of e-waste. Broken or unused electronic products have been taken out to roadsides, rivers, canals, or in association with general waste. Hazardous substances containing in the electronic products can be leaked out and contaminated into soil and underground water, affecting the environment and people in communities.

- *Public Health Act, B.E. 2535 (1992)*

It provides a definition of "waste": waste paper, waste cloth, waste food, waste goods, waste material, plastic bag, food container, ash, animal dung or carcass, as well as any other things swept away from road, marketplace, animal farm, or other places. It also stipulates that disposing of sewage or waste within the area of any local government shall be the authority of such local government. In case of having a reasonable cause, the local government may assign to any person the task under Paragraph One on its behalf under its control, or may give a permission to any person to execute disposing of sewage or waste. Local government shall have the authority to issue local regulations as follows:

1. prohibiting the discharging, dumping, discarding, or causing to exist in any public place or way, except in the place provided by the local government;

2. prescribing that there shall be receptables for sewage or waste available in public places or ways and in private places;

3. prescribing methods of collecting, hauling, and disposing of sewage or waste for the owner or occupant of any building or place to practice hygienically according to the condition and nature of use of such building or place;

4. prescribing rate of fees for services provided by the local government in the collecting, hauling, or disposing of sewage or waste not exceed the rate prescribed in the Ministerial Regulation;

5. prescribing criteria, procedures, and conditions on collecting, hauling, and disposing of sewage or waste to be complied by the person obtaining the license, and prescribing a rate of maximum fee charges collectable by the person obtaining the license;

6. prescribing any other requirements necessary for hygienic practices

Nevertheless, there is neither a definition of e-waste, approaches for community e-waste management, nor e-waste recycling provided in this Act. It assigns local government to perform collecting, disposing, and treatment of e-waste for communities. If there is a grant of authorities in collecting, disposing and treatment of e-waste in communities, it would make e-waste in communities decrease. It should have a good management which manufacturers, people in communities, and local government agencies take parts in collecting e-waste to the designated points, disposing it in the right manner, and retuning electronic products to the manufacturers for recycling. This Act does not cover community e-waste; therefore, local government agencies do not have authorities in performing e-waste management.

- *Maintenance of the Cleanliness and Orderliness of the Country Act, B.E. 2535 (1992)*

It defines "waste" as waste paper, food scrap, goods scrap, plastic bag, food container, ash, animal dung or carcass, as well as any other things swept away from road, marketplace, animal farm, or other places without providing any definition for e-waste. As a result, there has not had any enforcement on communities where e-waste is discharged in association with general solid waste.

 doi:10.20944/preprints202303.0195.v1

This causes the problem of contamination of hazardous substances from the e-waste to other waste, negatively affecting the waste sorting operators' health and environment in communities as well.

- *Hazardous Substance Act, B.E. 2535 (1992)*

This is a law that controls the operation of businesses relevant to hazardous substances. According to the definition provided in the Act, "hazardous substance" means the following substances: 1. explosives; 2. inflammable substances; 3. oxidizing agents and peroxide substances; 4. toxic substances; 5. disease causing substances; 6. radioactive substances; 7. mutagenic substances; 8. corrosive substances; 9. irritative substances; 10. other substances whether chemicals or otherwise, which may be harmful to people, animals, plants, property or environment. Importing, exporting, or possessing such hazardous substances must be notified to the competent official and shall be complied with the criteria and procedures prescribed for importing. Also, for safety reasons, some kinds of hazardous substances are prohibited for production, importation, exportation, or possession.

Obviously, there is not a classification for e-waste into any group of hazardous substances. This Act does not prescribe about asking for permission prior to importing e-waste to the country, making it a gap where many recycling plants are able to freely import e-waste for disassembling some sellable parts. Unsellable parts have been left in community areas, causing the problem of a higher amount of e-waste in communities. This problem is originated from the plants, but the effects are on the health of people and environment in the communities.

- *Industrial Products Standard Act, B.E. 2511 (1968)*

This Act regulates importation of industrial products and prevents importation of bad quality products to the country, promoting a protection to people, industrial businesses, and economy of the country. It is prescribed that for safety reasons, or to prevent damages that may be caused to the people, industrial businesses, or economy of the country, products of any kind shall be required to be complied with the standards.

Although this Act mentions production standards, it focuses on safety of product users, such as the case of uses of electronic products that do not meet the standards and causes damages to property or life. However, it does not prescribe requirements for uses of environmentally friendly materials, correct disposing approaches, nor how the electronic products impact environment.

- *Notification of the Ministry of Industry on the List of Hazardous Substances, B.E.2556 (2013)*

It is prescribed that manufacturer, importer, exporter, or possessor of hazardous substances is required to undertake notifying its operation for the hazardous substances type 2 or submitting an application for permission for the hazardous substances type 3. If there is any hazardous substance that must be registered, it is required to implement the registration by setting up a list. Used electric and electronic equipment (such as refrigerator, television, radio, video player, cassette tape player, air conditioner, washing machines, clothes dryer, electric rice cooker, electric kettle, microwave, electric oven, telephone, fax machine, etc., which contains electric equipment or electronic parts that can be reused, modified, repaired, remodeled, transformed, maintained, sorted for reusing after such procedures or for demolishing) are categorized as the hazardous substance type 3.

Any manufacturing, importation, exportation, or possession of hazardous substances is required to obtain a license. This is a measure for controlling plants importing e-waste to the county as they need to be granted with a prior permission and notify details of the e-waste and hazardous substance to the Ministry of Industry prior to importing or possessing. In addition, disposal of e-waste must be carried out properly according to the law; plants cannot dispose their e-waste by themselves nor stealthily dispose it in communities, making e-waste from communities decrease.

- *Notification of the Ministry of Public Health on Businesses Hazardous to Health, B.E. 2558 (2015)*

Businesses of manufacturing and repairing electric and electronic equipment or electric appliances are defined as businesses that are hazardous to health and required to ask for a permission from a local government for operations.

- *Notification of the Minister of Commerce on Prescription of Electronic Waste as Prohibited Goods for Importing to the Kingdom, B.E. 2563 (2020)*

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This is the law on control of e-waste imported into Thailand. The definition of "e-waste" is provided as parts of electric and electronic equipment or scraps thereof (excluding those from electric generator), including capacitors and other batteries, switches containing mercury as components for operation, glass scraps from cathode-ray tubes and other activated glasses, capacitors containing PCB or contaminated with cadmium, mercury, lead, polychlorinated biphenyl which are considered waste chemical substances. This law can help reduce e-waste containing hazardous substances, that is imported from overseas into Thailand for disposing and causes the problem of e-waste in communities.

- *Ministerial Regulation on the Management of Toxic and Hazardous Waste from Community, B.E. 2563 (2020)*

The term "toxic or hazardous waste from community" is defined as toxic or hazardous waste generated from activities in communities, including objects or those contaminated with substances that have a property of toxic substance, inflammable substance, oxidized substance, peroxiding substance, irritative substance, corrosive substance, reactive substance, explosive substance, mutagenic substance, any other substances or things that may, or is likely to, cause danger to a person, animal, plant, property or environment, but excluding general solid waste, infectious waste, radioactive waste, and hazardous waste according to the laws on factories. It prescribes local government agencies to make available a place for discharging, hauling, and disposing toxic or hazardous waste from communities in a public place or way or to designate methods for managing toxic or hazardous waste from communities in compliance with this Ministerial Regulation or in accordance with the rule prescribed by the Minister that nobody is allowed to discharge, haul, generate, or discharge toxic or hazardous community waste in public places or ways, except for discharging, hauling, or disposing at a place or by means as stipulated by the local government. Also, it prescribes that generators of toxic or hazardous waste from communities are required to sort the electric and electronic equipment, which is toxic or hazardous waste from communities, out of general waste and infectious waste by categories.

To designate means for disposing toxic or hazardous waste in communities, it must rely on an elaborate investigation for appropriateness and possibility before creating a system of disposing toxic or hazardous waste in communities. Also, measures for controlling the disposing of toxic or hazardous waste in communities must be provided to prevent impacts on the people's health and the environment.

According to these laws, it is obvious that current laws regarding environmental management and waste management are not inclusive to an establishment of mechanism for controlling and preventing an occurrence of e-waste in communities, including product design and manufacturing, designation of duties for relevant people, such as manufacturers, importers, and distributors, to be jointly responsible for the products throughout the life cycle of the products. Furthermore, they are unable to supervise, control, and administer the local administrative agencies to execute the management properly according to academic principles under their authorities. Finally, there is no specific law for e-waste management. It is necessary for Thailand to improve the existing laws and/or develop a new law to be up-to-date and consistent with the current changes of economic, social, political, and environmental situations and enforceable effectively.

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4. Challenges and Future Perspectives

A very concerning issue regarding e-waste, apart from the rapid increase in amount, is that hazardous substances and heavy metals contained in parts of electronic waste are not handled properly and cause impacts on health, sanitation, and environment. According to our investigation, there are more than 20 kinds hazardous substance and heavy metal used in the production of electronic equipment parts, and the content of some hazardous substances and heavy metals contained in e-waste worldwide is at least 20 million tons per year **[23],** It was found that the heavy metals most contained in e-waste are copper (820,000 tons per year), nickel (206,000 tons per year), chromium (198,000 tons per year), zinc (102,000 tons per year), and lead (58,000 tons per year). The main source of lead is cathode ray tubes (CRT) of televisions and old-modelled computers. Consumers are more likely to use a new model of televisions and computers with LCD screens. As a result, the televisions and computer screens with CRT have been increasingly disposed and sold to used item buyers and become e-waste that put a great impact on environment today **[16].**

For these reasons, the management for natural resources and environment in communities of Thailand must be relied on cooperation of all sectors in driving sustainable development for communities in terms of economic, socio-cultural, and environmental aspects altogether. Also, waste in communities must be well managed, especially for e-waste that contains hazardous substances. If there is not a proper and correct management system, impacts will definitely be on natural resources, including soil, water, and living things in the ecosystem of communities. The Precautionary Principle, the Polluter Pays Principle, the Beneficiaries Pay Principle, the Public – Private Partnership, the Good Governance, and the Extended Producer Responsibility must be applied for the e-waste management in communities by regulating as a law for both central government and local administrative organization in order to establish the same and united standard for all communities and bring about appropriate practices in accordance with each community's conditions. Requiring manufacturers to take part in being responsible for the costs and expenses of e-waste treatment and disposal enables them to use environmentally friendly materials more increasingly, decreasing the impacts on environment and promoting an effective use of the resources. Furthermore, requiring people in communities to sort and return their electronic products to the distributors or the manufacturing companies makes identifying and collecting the unused products for recycling easier.

Local administrative organizations of Thailand, which are considered the important agencies in implementing the measures on waste management including sorting out hazardous waste in communities from the source, collecting, transporting, and disposing, are necessary to facilitate the people and communities by providing places for disposing e-waste and promoting knowledge and understanding to people on waste sortation, correct disposing methods, and procedures for reducing e-waste in communities. With these, impacts on environment will be decreased as well. In addition, the central government should promote knowledge and code of practice on waste management for a proper, correct, and effective e-waste management with no impacts on environment.

5. Conclusions

The e-waste problem in communities is an important issue that Thailand cannot overlook. All relevant sectors must cooperate in solving such problem by establishing correct knowledge and understanding for the people, raising awareness to all sectors on the impacts of e-waste on environment, and building conscious of cooperation in solving the e-waste problem that is going to be more severe and eventually threatening humans and the world. The government should precipitate into laws, procedures, and regulations on the effective collection and disposal of electronic waste, build confidence for entrepreneurs about a certain amount of e-waste to be allowed for bringing into factories, as well as actively supporting the recycling businesses for development of good and effective recycling systems and procedures. These can help reduce impacts harmful to health and environment due to the toxins from electric and electronic parts sustainably.

Supplementary Materials: The following supporting information can be downloaded at: www.mdpi.com/xxx/s1, Figure S1: Life Cycle of Electronic Devices in Thailand.

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