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Research Article

Evaluation of E-waste Generation through G-PESTLE Analysis in the City of Zamboanga, Philippines: Basis for Management Strategies

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Abstract

Due to a growth in the production of electronic waste (e-waste), the Philippines, particularly Zamboanga City, a top-tier, highly urbanized city on the Zamboanga Peninsula, is coping with an e-waste problem. Understanding the outside forces influencing e-waste management is necessary for creating effective strategies. With the help of a G-PESTLE analysis (geographical, political, economic, social, technical, legal, and environmental) and recommendations for improvement, this study assessed the city's existing e-waste management situation. The study looks at possibilities and problems, then offers management tactics based on the results. The study employed a hybrid methodology. Using the G-PESTLE analysis framework, the external factors affecting the management of e-waste were looked into. This procedure included focus groups, key informant interviews, and literature studies. To direct the analysis process, a framework for the research design was established with particular questions. The findings and discussions highlight the need for specific legislation, educational initiatives, technology advancements, and monetary incentives to solve e-waste concerns successfully. This study aims to provide focused management plans and actions that will enhance Zamboanga City's sustainable lifestyles and decrease the harmful effects of e-waste on the environment. The research applications of this study include informing future e-waste management research and initiatives, assisting stakeholders and policymakers in creating efficient policies and programs, and enhancing e-waste management practices in Zamboanga City. The results offer insightful information and a basis for promoting sustainable development, minimizing environmental impact, and implementing effective e-waste management strategies.

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Introduction

Electronic waste (e-waste), often known as waste electrical and electronic equipment (WEEE), refers to abandoned electrical and electronic equipment and its components. When owners dump these objects without planning to repurpose them, waste is produced. Depending on the area and the situation, the word "e-waste" may change. It includes various products containing circuitry or electrical components with a power source or battery supply, including those used in households and businesses [1].

The WEEE Directive of the European Union recognizes six kinds of e-waste: screens and monitors, lighting, large equipment, compact equipment, and minor information technology (IT) and telecommunication equipment [2]. Figure 1 also includes a category for temperature exchange equipment (cooling and freezing equipment).

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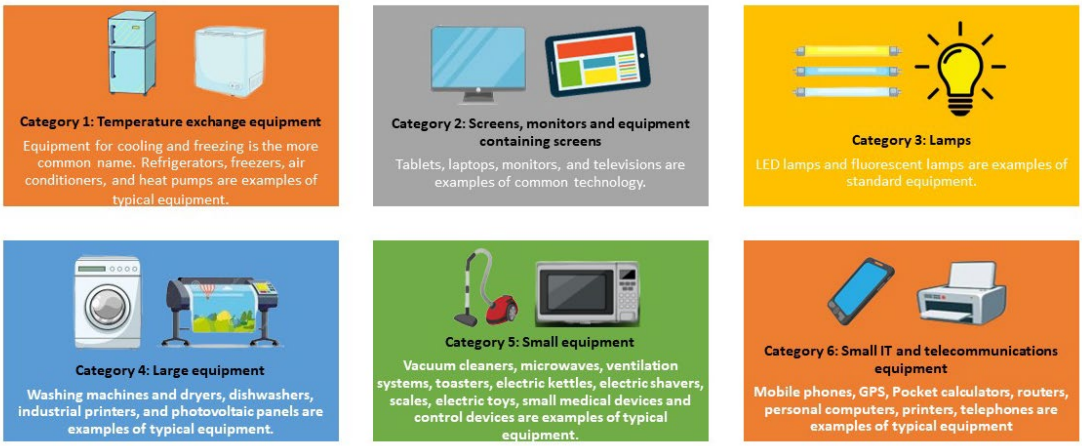

Figure 1 Categories of EEE covered by WEEE Directive.

E-waste production reached a global average of 7.3 kg per person in 2019 (53.6 million tonnes, Mt) [3]. The e-waste production is projected to rise by 2 Mt annually to 74.7 Mt in 2030 [4] and up to 110 Mt in 2050 [5]. Electrical and electronic equipment (EEE) has become obsolete due to economic expansion and technological innovation, making e-waste the fastest-growing waste source globally [3].

According to Table 1, Asia produced the most e-waste globally in 2019. The Americas, Europe, Africa, and Oceania were next in production. Regarding making the most e-waste per capita worldwide, first Europe. The Americas came in second, followed by Oceania, with Asia and Africa having the least, respectively [4].

Table 1 E-waste generated in 2019

Region	E-waste generated (Mt)	E-waste generated (kg per capita)
Asia	24.9	5.6
Americas	13.1	13.3
Europe	12.0	16.2
Africa	2.9	2.5
Oceanic	0.7	16.1

As of May 1, 2020, there were over 7,000 islands that make up the Republic of the Philippines. It had about 109 million [6], of whom 48% resided in cities. The Philippines' economy has shifted from primarily agricultural to services and development. Nearly half of all industrial value is contributed by the semiconductor and other electronic component industries, and electronic items make up the majority of the country's exports and imports [7].

According to 2019 Environmental Management Bureau (EMB) data [8] and the Global Environment Report, each individual annually produces about 3.9 kilograms of electrical and electronic equipment (WEEE), which is a total of 32,664 metric tonnes of e-waste.

Increasing e-waste volumes, a lack of legislation explicitly addressing e-waste, restrictions on the infrastructure for managing e-waste, competition between formal and informal sectors for valuable e-waste components, problems with legal and illicit import and export, and mixing of e-waste with other waste streams like metal scraps are the leading causes of the rising number of unmanaged e-waste flows, according to a summary provided by researchers [3].

If it is not appropriately managed, each sort of e-waste could have a varied impact on the environment, human health, trash amounts, and economic values. Because of this, every category has a unique collection, logistics, and recycling technology and an individual consumer attitude toward the disposal of electrical and electronic equipment.

Remembering that e-waste should be managed appropriately and recycled to lessen environmental contamination and recover valuable resources is essential. Many nations and organizations have implemented rules and programs to address the correct handling and recycling of e-waste.

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, the Toxic Substances and Hazardous and Nuclear Wastes Control Act, the Electronic Waste Management Act, and the Department of Environment and Natural Resources Administrative Order [9] are a few of the laws and regulations that govern e-waste management in the Philippines. To guarantee that importers and producers bear responsibility for the disposal of e-waste, the government also promotes Extended Producer Responsibility (EPR) programs. It's essential to stay current with the most recent recommendations and policies for the country's e-waste management.

In the Zamboanga Peninsula of the Philippines, Zamboanga City is a world-class, densely populated city.

According to the 2020 census, there are 937,234 residents. It is the fifth most populous city in the Philippines and the third largest in land area. It serves as the Zamboanga Peninsula's regional center for business and industry [10]. The WEEE produced by Zamboanga City between 2020 and 2023 was 22.4 tonnes, according to the Department of Environment and Natural Resources - Environmental Management Bureau Regional Office IX - Zamboanga Peninsula [11].

According to DENR-EMB IX employees interviewed during the researcher's focus group discussion (FGD), Zamboanga City has an e-waste problem. The city's various industries were asked to provide their perspectives. Despite the lack of e-waste treatment facilities, the participants in the FGD are aware of the possible problems and inconveniences that could arise from the long-term accumulation of e-waste. Properly storing the created e-waste and exchanging best practices would improve the city's approach to managing e-waste. Participants can register for the debate and participate, enabling them to contribute to developing workable solutions. In conclusion, the FGD is crucial for resolving the issues that e-waste in Zamboanga City is causing and may cause in the future.

To fully comprehend and address the issues relating to the management of e-waste in Zamboanga City, a detailed G-PESTLE (geographical, economic, social, technical, legal, and environmental) analysis is required. It aids in determining the issue's scale, assessing the effectiveness of existing laws and regulations, evaluating the economic ramifications, gauging public perception and attitudes, evaluating technology capabilities, and determining the ecological impact. With this knowledge, interested parties can develop focused plans and initiatives to address the e-waste problem in Zamboanga City, lessening its adverse effects on society and promoting sustainable solutions.

A G-PESTLE analysis is utilized as a complete tool to examine the geographic, political, economic, social, technical, legal, and environmental aspects influencing the production and treatment of e-waste in the Philippine city of Zamboanga. By considering these elements, the study helps understand the geographic characteristics and location, national policies, economic ramifications, social attitudes, technology capabilities, legal obligations, and environmental impact of e-waste. This analysis is the foundation for effective strategies and initiatives to manage e-waste, decrease environmental harm, and promote sustainable behaviors in Zamboanga City.

The proposed ordinance No. 2019-40 aligns with the Philippine Environmental Policy (PD1151). The E-Code, commonly known as the City of Zamboanga's Environment Code, is primarily concerned with maintaining sanitation and managing garbage. It significantly emphasizes preventing waste at the source and promotes resource recovery, recycling, and reuse at the barangay level. The regulation also emphasizes the importance of collecting residual waste efficiently and sending it to a sanitary landfill. Incentives will be given to barangays, companies, and non-profit groups to encourage participation; these incentives may even include a revenue-sharing agreement from trash management costs. There is no mention of e-waste in Article IX Section 4C, which deals with managing poisonous chemicals and hazardous waste under R.A. 6969's implementing rules and regulations. The overarching objective of the E-Code is to establish a comprehensive and durable framework for waste management in Zamboanga City.

Using the G-PESTLE analysis methodology, the study sought to assess the amount of electronic trash produced in the Philippine city of Zamboanga. Analyzing the geographical, political, economic, social, technological, environmental, and legal aspects that affect the development of e-waste is a part of this process. The study also sought to pinpoint issues and chances, then suggest management plans in light of the results. The study aimed to help Zamboanga City establish efficient e-waste disposal procedures.

Methodology

1) G-PESTLE analysis

The PESTLE analysis framework has been modified into the G-PESTLE analysis methodology. Geographical, Political, Economic, Technological, Legal, and Environmental factors are what it stands for. This method evaluates the external factors affecting a situation by considering particular aspects within each category. Political factors examine government stability and policies, whereas geographic factors focus on location and physical characteristics. Technological factors examine developments and innovations, while economic factors evaluate economic indicators. Environmental factors discuss sustainability and ecological trends, while legal aspects consider rules and compliance. E-waste management can make more informed strategic decisions by thoroughly understanding the external environment through analysis of these factors.

The framework supports decision-making and risk management by identifying threats and opportunities. A cost-benefit analysis is used to determine the indicators, and the framework can be used in particular sectors, like e-waste management. G-PESTLE offers a detailed view of the external environment for making strategic decisions in general [12].

The research design framework in Table 2 considers the G-PESTLE analysis aspects, used questions, and technique. The techniques include focus group discussions (FGD), key informant interviews (KII), and literature reviews (LR).

2) Literature review

There are several steps involved in choosing and searching for literature. The first step is to specify the research goal or question and choose the pertinent databases. The topic-related search terms and keywords, such as "e-waste management" or "WEEE management," were created and used in the literature search, and 100 articles were collected. A few articles are chosen for full-text reading after the titles and abstracts of the retrieved articles are reviewed and screened, with 30 articles selected. The quality and applicability of the complete texts are then evaluated. As necessary, the search procedure can be repeated or improved. The entire process is documented, and to address the research question or objective, the selected literature is synthesized and examined with a total of 50 articles. The progressive nature of this process may necessitate multiple rounds to find the most relevant literature.

3) Focus group discussion (FGD)

To gather qualitative information and opinions on the production and management of e-waste in Zamboanga City, a FGD was held with a small group of participants based on the list of industries provided by the DENR - EMB IX. The procedure involved setting the goal, choosing appropriate participants, choosing an experienced moderator, creating a question guide, running the FGD session, analyzing the data collected, and summarizing the results. The G-PESTLE analysis and other research findings were combined with the FGD data to provide a thorough understanding of e-waste and to inform management strategies.

4) Key Informant Interview

Experts on the management of e-waste in Zamboanga City, the Philippines, are interviewed using the qualitative research technique known as the Key Informant Interview (KII). By creating questions based on the G-PESTLE analytical framework (geographical, political, economic, social, technical, legal, and environmental variables), researchers learned about the external elements affecting e-waste management. Key informants provide great depth about e-waste management policies, rules, economic influences, social dynamics, technology breakthroughs, legal frameworks, and environmental impacts. Researchers understood the macro-environmental elements affecting e-waste management in Zamboanga City by carefully evaluating the interview data.

Table 2 Research design framework

Factors	Questions	Method
G – geographical	1. What geographic factors influence e-waste management practices in the city? 2. How do diverse industries and sectors impact e-waste management practices in the city?	LR, KII
P – political	1. What policies apply to the management of e-waste? 2. How does the policy work to reduce the risks to the environment and human health?	KII
E – economical	1. What economic opportunities are associated with adequately managing e-waste in the city? 2. How does e-waste management contribute to the city's overall economy?	FGD, KII
S – social	1. How does the city's e-waste management affect the societal desire for valuable things? 2. What is the impact of the lack of awareness of the risks associated with e-waste and proper disposal?	FGD, KII
T – technological	1. How can the city improve its technological advancement to handle and address the growing e-waste problem? 2. How much does emerging technology impact e-waste management?	FGD, KII
L – legal	1. What are the ordinances, specific laws, or regulations in place for the handling and disposal of e-waste in the city? 2. What are the potential legal implications for non-compliance with these regulations?	LR, KII
E - environmental	1. What are the environmental challenges or risks associated with improper e-waste disposal? 2. How can raising awareness, implementing recycling programs, enforcing regulations, and developing appropriate e-waste management systems contribute to addressing the environmental problems?	FGD, KII

Results and Discussions

1) Geographical

There are 98 barangays split into two congressional districts in the first-class, highly urbanized city of Zamboanga City, Philippines. Veterans Avenue separates the two districts. District 1 consists of 36 barangays on the west coast, whereas District 2 comprises 61 barangays. Thirty urban and 68 rural barangays include 98 barangays [13]. The map in Figure 2 depicts a variety of industries and sectors, each denoted by a star icon and based on DENR-EMB Region IX data for Zamboanga City from 2020 to 2022. Government and military institutions, wholesale of liquid and gaseous fuel products, fishmeal production, fish cold storage and canning, ice production, cargo handling and passenger services for sea vessels, hospitals, radio stations, telecommunications, livestock production, beverage production, financial institutions, real estate activities, fuel refilling stations, manufacturing and exporting of coconut products, oil depots, resorts, and other businesses are among them shown in Table 3 the most generated waste.

The geographical analysis of e-waste management includes pinpointing where e-waste is produced and consumed on the map in Figure 2. Some geographical elements influencing e-waste management practices include the availability and accessibility of e-waste collection and disposal infrastructure, rules and policies governing e-waste management, and cultural attitudes toward e-waste.

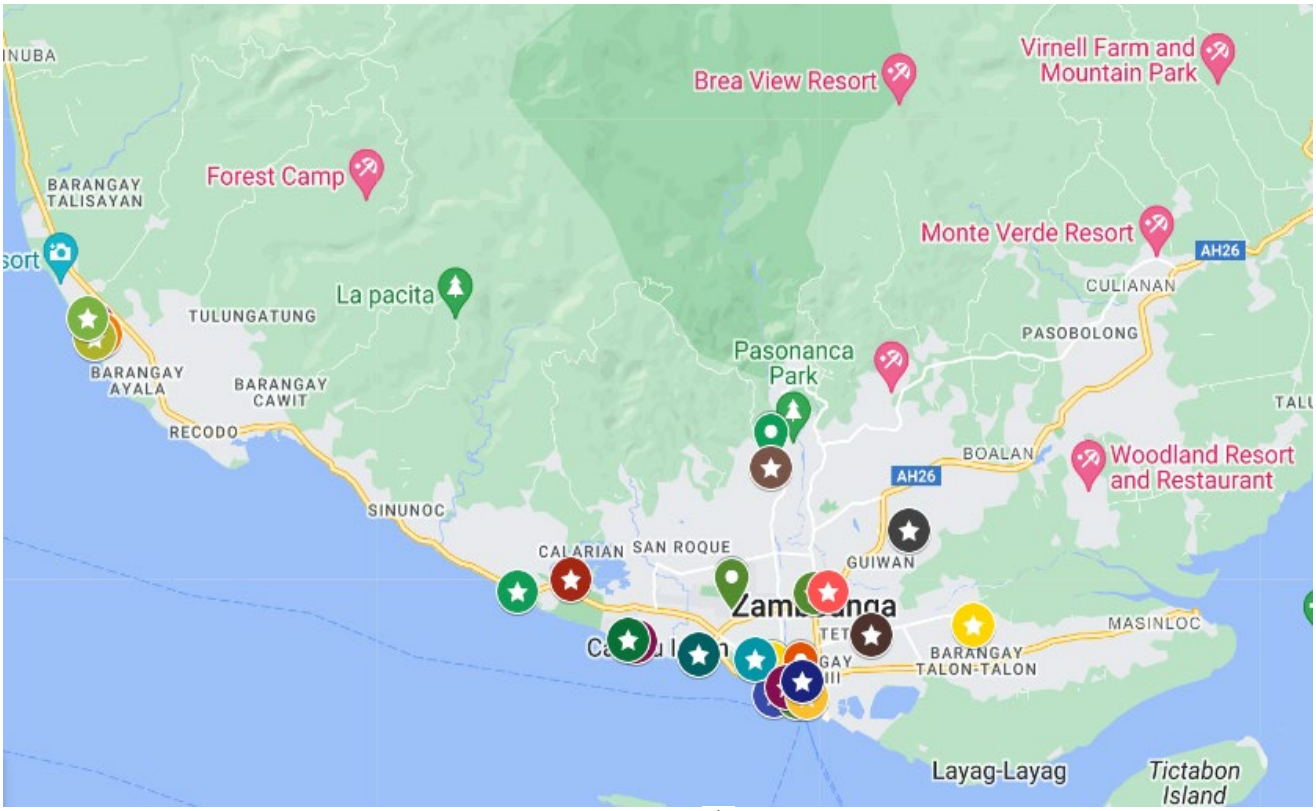

Figure 2 Zamboanga map indicating the industries (☆) with e-waste generated from 2020-2022.

Table 3 Most e-waste generated by the industries

Industry	Most e-waste generated
Government and military institutions	Computers, laptops, servers, networking equipment, communication devices (phones, radios), and electronic surveillance equipment.
Wholesale of liquid and gaseous fuel products, Fuel refilling stations	Systems for dispensing fuel, electronic meters, sensors for monitoring tank fuel levels, and electronic payment systems.
Fishmeal production	Industrial-scale mixers, grinders, dryers, and control systems are used in fishmeal production.
Fish cold storage and canning	Systems for controlling temperature, electronic canning equipment, and refrigeration systems.
Ice production	Ice-making machines, refrigeration units, and control systems are used in ice production.
Cargo handling and passenger services for sea vessels	Cranes, hoists, conveyor systems, dockside equipment, and communication devices are used in cargo handling and passenger services.

Table 3 Most e-waste generated by the industries (*continued*)

Industry	Most e-waste generated
Hospitals	Medical equipment, patient monitoring devices, imaging systems, laboratory equipment, and communication systems are used in hospitals.
Radio stations	Broadcasting equipment, transmitters, receivers, mixing consoles, and communication systems used in radio stations.
Telecommunications	Networking equipment, switches, routers, modems, telecommunication towers, and communication devices used in telecommunications infrastructure.
Livestock production	Automated feeding systems, climate control systems, monitoring devices, and electronic milking machines are used in livestock production.
Beverage production	Industrial-scale production machinery, bottling equipment, labeling machines, and control systems used in beverage production.
Financial institutions	Computers, servers, networking equipment, ATMs, electronic payment systems, and security systems are used in financial institutions.
Real estate activities	We build real estate properties' automation, security, access control, and communication devices.
Manufacturing and exporting of coconut products	Processing machinery, drying equipment, sorting machines, and control systems are used in coconut product manufacturing.
Oil depots	Oil depots use storage tank monitoring, control, and communication devices.
Resorts	Hospitality systems, room automation systems, entertainment systems, and communication devices are used in resorts.

2) Political

The Basel Convention, Senate Bill No. 751, Republic Act No. 6969, DAO 2013-22, DAO 1994-28, Republic Act No. 9003, and the anticipated DAO 20XX-NO are just a few of the legislative frameworks for the management of hazardous waste, solid waste, and e-waste in the Philippines that are included in Table 4. To reduce the dangers associated with inappropriate disposal for the environment and human health, they regulate these wastes' production, processing, storage, handling, and disposal.

The "Toxic Substances and Hazardous and Nuclear Wastes Control Act of 1990" (Republic Act No. 6969) and the "Ecological Solid Waste Management Act" (Republic Act 9003) establish a framework for the ethical treatment and control of e-waste in the Philippines. These regulations ensure that poisonous materials and hazardous wastes are handled and disposed of in a way that reduces environmental and public health hazards. In addition, the Ecological Solid Waste Management Act promotes ethical waste management practices like recycling and proper disposal methods.

Furthermore, it outlines the waste disposal, recycling, and segregation protocols. In response, local governments, including Zamboanga, have proposed ordinance no. 2019-40, the E-Code or the City of Zamboanga Environment Code [14]. This ordinance emphasizes waste management and the maintenance of sanitation standards.

3) Economic

The research and development programs of the US, China, Japan, and the EU must be incorporated into the framework for managing WEEE in the Philippines, with adjustments made for the country's real economic models and conditions. Economic policies like material and product taxes, subsidies, upstream combined taxes and subsidies, advance disposal fee systems, deposit or return systems, and refund systems have all been proposed. In the Philippines, DENR has 95 registered Treatment, Storage, and Disposal (TSD) facilities of hazardous waste code for M506(WEEE); however, unofficial recycling occurs in slums and crowded areas outside major large cities. Eco-labeling aims to change consumer behavior and persuade people to buy "green" products. Eco-labeling is a form of environmental stewardship. Economic systems will protect vulnerable people and environments if law enforcement is effective.

In Zamboanga City, e-waste has a variety of economic effects. On the positive side, it opens up positions in the recycling, renovation, and collection industries. Recovering valuable materials from e-waste can increase revenue and lessen the need to import raw materials. Productivity can be raised by integrating the formal and informal sectors. Businesses that repair and refurbish electronic devices can reduce costs and advance the circular economy. However, improper e-waste management can harm the environment and people's health, requiring expensive cleanup and posing health hazards. It is essential to put effective e-waste management methods, ethical recycling practices, and legislation into place to maximize the positive economic implications and minimize the negative ones.

Table 4 Legal frameworks for the management of e-waste in the Philippines

Legal Framework	Description
Basel Convention	Basel Convention on the Control of Transboundary Movements of Hazardous Waste and their Disposal
Senate S. No. 751	An Act Regulating the Disposal of Electronic Equipment at Solid Waste Management Facilities and Requiring the Establishment of Recovery and Collection Facilities, therefore
RA 6969	Toxic Substances and Hazardous and Nuclear Waste Control of 1990
DA 2013-22	Revised Procedures and Standards for the Management of Hazardous Wastes
DAO 1994-28	Interim Guidelines on the Importation of Recyclable Materials Containing Hazardous Substances
RA 9003	Ecological Solid Waste Management Act of 2000
Pending DAO 20XX-NO	Guidelines on the Environmentally Sound Management of Waste Electrical and Electronic Equipment (WEEE)

4) Social

The Philippines has been Asia's most sensitive nation for the third consecutive year [15] due to its imported second-hand electronics and electrical appliances, often known as "Segunda Mano" in the local language. Due to their sentimental significance, most Filipino consumers store their EOL goods or donate them to their families, friends, or other loved ones. The Harmonized System Code for Import Tariffs organizes the e-waste inventory but does not discriminate between new and used electronics imports. Filipinos greatly desire valuable items such as gadgets due to their culture. A shift in mentality is required to internalize waste separation and recycling as a habit.

In Zamboanga City, social variables impact how e-waste is managed. One is a general need for increased information on the risks associated with e-waste and suitable disposal methods. There is also a hazardously active unregulated recycling sector. The lack of infrastructure makes collecting and recycling e-waste more effortless, leading to improper disposal. The problem has worsened due to the need for more programs to increase capacity and educate people about e-waste management. Additionally important are socioeconomic variables like poverty and a lack of resources. The government, communities, NGOs, and the corporate sector must collaborate to address these difficulties, improve infrastructure, and provide alternative income streams.

5) Technological

As technology develops, many individuals buy non-essential electronic devices, which results in the illicit transfer of WEEE from developed countries to under-developed ones. Japan is a global innovator and leader in implementing an EPR-based system for e-waste. Urban mining is a modern technique for recovering valuable parts. Like many other countries, the Philippines has made significant strides in information technology. Nevertheless, the Philippines must deal with an expanding e-waste problem and more hazardous chemicals from the materials used in their creation as technology develops swiftly worldwide [16].

Additionally, e-waste must be gathered, recycled, and properly handled, all requiring technical assistance. For Zamboanga City, the management of e-waste and technology difficulties should be improved. As technology is used more and more, electronic product creation also increases. Improper e-waste disposal harms the environment and public health because of the dangerous compounds in electronic gadgets. The city needs to increase public awareness of appropriate disposal and recycling procedures. It's also necessary to establish infrastructure like recycling centers and collecting hubs. E-waste management can be more effective through partnerships and cooperation between NGOs, the commercial sector, and the government. To handle e-waste in Zamboanga City, government laws, infrastructural development, and public education are necessary.

6) Legal

By taking source reduction and waste-decreasing measures, the Ecological Solid Waste Management Act of 2000 establishes standards and objectives for lowering the amount of solid waste and preventing its formation. Consumer electronics are not subject to any additional regulations for disposal, although they are classified as special wastes that must be treated separately from typical household and commercial wastes [17]. The e-waste management must be adequately addressed by Philippine law or carried out ineffectively. There is no unique legal system in the Philippines. Still, the responsible agency or particular body can be legally required to submit an annual report to the government on its performance and implementation. In the Philippines, informal recycling facilities flourish, with recycling rates ranging from 20 to 50%. "Final Draft Guidelines on the Environmentally Sound Management (ESM) of Waste Electrical and Electronic Equipment" has been drafted by the Philippines [18].

In Zamboanga City, the handling of e-waste is subject to regulations and penalties. Environmental laws and waste management rules govern the proper processing and disposal of electronic trash. Under Section 41 of DENR Administrative Order (DAO) series 1992 number 29, also known as the "Toxic Substances and Hazardous and Nuclear Wastes Control Act 1990," violations and fines are listed in Table 5 of the Implementing Rules and Regulations of Republic Act 6969.

Planning for the handling of e-waste must take legal considerations into account. Depending on the country or location, different regulations may apply to how to dispose of e-waste. In some cases, there may be no restrictions or insufficient enforcement of the ones that do. The recycling or reusing e-waste items may also be subject to legal limitations.

A legal examination of e-waste management procedures includes an assessment of the laws and regulations governing those operations. The availability of legal frameworks for the reuse and recycling of e-waste materials, the existence and applicability of e-waste management legislation, and their enforcement are a few of the legal variables influencing e-waste management practices.

7) Environmental

The majority of Filipinos require greater ecological understanding and familiarity with environmental laws. According to Alam [16], nearly all respondents were required to be informed of the e-waste disposal procedures that applied to their outdated cell phones, laptops, and personal computers. Although its implementation has yet to be made public, technical suggestions for WEEE environmental management were released by the DENR through the EMB in 2016 [8]. To ensure that they will support the system's expansion and send products for authorized recycling when necessary, consumers must be well-informed on the environmental benefits of recycling. Impromptu E-waste recycling plants have observed significant soil, air, and water pollution incidents.

Electronic waste, or "e-waste," is a significant cause of environmental problems in Zamboanga City, Philippines. When improperly disposed of or recycled, hazardous waste can harm the environment and contaminate soil and water. More infrastructure and knowledge are two more obstacles to efficient e-waste management. International imports of e-waste increase the threats to the environment. Raising awareness, promoting recycling programs, enforcing legislation, and implementing suitable e-waste management systems are vital to address this issue.

The conceptual frameworks for ASEAN E-waste management systems are essential for the Philippine city of Zamboanga. The Table 6 framework's vision is "Towards a Green Loop Recycling in Managing E-Waste in ASEAN,[19]" and they work toward several related objectives. One of the main objectives is to support the Sustainable Development Goals (SDGs). First and foremost, they work to improve the knowledge and management of e-waste, which is essential for the environment, particularly regarding clean water and sanitation (Goal 6) and the population's well-being (Goal 3). These frameworks also support Goal 12, which encourages responsible consumption and production, and Goal 11, which focuses on sustainable cities and communities. Additionally, they support Goal 14 by addressing life below the ocean, negatively impacted by improper e-waste disposal. In addition to emphasizing decent work and economic growth, these frameworks support Goal 8 because efficient e-waste management can lead to job opportunities and a sustainable economy. Zamboanga can inspire other ASEAN nations to proactively manage e-waste by embracing and implementing these frameworks, promoting a healthier and more sustainable future.

Table 5 Violation and fines for Section 41 of DAO 92-29

Administrative violation	Fines in Php
a. Failing to disclose information to the DENR upon registration	Php 10,000.00
b. Submitting documents with inaccurate information	Php 50,000.00
c. Failing to report information as required by law	Php 50,000.00
d. Failing to adhere to a permit's requirements, excluding those listed below, is.	Php 50,000.00 / condition violated
e. Failing to adhere to labeling requirements is.	Php 50,000.00
f. Not attaching signs to the vehicle or conveyance	Php 50,000.00
g. Failing to comply with a subpoena or subpoena duces tecum issued by the Secretary or his properly authorized representative.	Php 50,000.00
h. Failing to provide the required information within the period mandated by these regulations	Php 50,000.00
i. Violations of any provisions of the Governing Rules and Regulations	Php 10,000.00

Table 6 Conceptual frameworks for ASEAN e-waste management systems

<table>
<tr><td colspan="3">Vision: Towards a green loop recycling in managing e-waste in ASEAN</td></tr>
<tr><td colspan="3">GOAL: A better understanding and management of e-waste to inspire ASEAN countries to take leading action in support of the achievement linked to Goal 3 (Good health and well-being), Goal 6 (Clean water and sanitation), Goal 11 (Sustainable Cities and Communities); Goal 12 (Responsible Consumption and Production), Goal 14 (Life Below Water); and Goal 8 (Decent Work and Economic Growth)</td></tr>
<tr><td colspan="3"> 
</td></tr>
<tr><td colspan="2">TRUST
1. Shared Responsibilities
Regulation & Awareness of “shared responsibility” among stakeholders.</td><td>2. Extended Producer’s Responsibility
Producers of electrical and electronic appliances are responsible for ensuring proper e-waste management after the ‘end of life’ of the products.</td></tr>
<tr><td>A. Major factors:
Material Flow
Financial Flow
Information Flow</td><td>B. Strategic enablers:
Financial
Infrastructure
Regulation
Enforcement</td><td>C. Strategic dimension:
Specific dimensions to determine the strategies, policies, and action plans.
i. Source
ii. Collection
iii. Dismantling
iv. Recycling
v. Disposal</td></tr>
</table>

8) Framework (Theory of change)

The goal of the G-PESTLE analysis performed in Zamboanga City, Philippines, was to evaluate the management of electronic waste (or "e-waste") while considering various factors. Geographically, the analysis considered the 98 barangays of the city and their e-waste-producing industries, highlighting the importance of infrastructure and cultural attitudes in handling this waste. Politically, the Basel Convention and Philippine laws were acknowledged as key legal frameworks for regulating hazardous waste and e-waste. Regarding the economy, effective e-waste management was seen as a means of generating income and jobs and reducing the need to import raw materials.

However, poor management may cause environmental damage and necessitate expensive clean-up procedures. In terms of society, the analysis emphasized the need to change perceptions about waste separation and recycling, address information dissemination issues, and consider socioeconomic factors. E-waste has been identified as being caused by technological development and rising electronic device consumption. Although there are legal protections, enforcement needs to be improved. E-waste presents serious environmental risks like contaminated soil and water. The analysis emphasized the value of building infrastructure, spreading awareness, and having efficient management systems. To address e-waste issues and maximize beneficial effects, coordinated efforts from the government, communities, NGOs, and the corporate sector were deemed essential.

The theory of change for managing e-waste in Zamboanga City, Philippines, emphasizes short-term, medium-term, and long-term changes to enhance e-waste management procedures shown in Figure 3. The immediate changes include strengthening the legal framework, raising awareness, and educating people about the risks of e-waste. The plan recommends infrastructure development, partnership and collaboration, and capacity building over the medium term. The long-term changes request to expand producer accountability and advance a circular economy strategy while promoting global cooperation. These adjustments deal with problems like improper disposal, a lack of infrastructure, knowledge, and an unregulated recycling industry. Legislative frameworks, economic effects, social and cultural considerations, technological advancements, and environmental issues are some of the forces driving change. Positive results from successfully applying the theory of change may include improved public health, resource conservation, social awareness, and environmental protection. Reduced pollution, improved resource recovery, more job opportunities, and a move toward responsible consumption and sustainable waste management practices are all desired results. To achieve these results, collaboration between government organizations, business stakeholders, communities, and individuals is necessary.

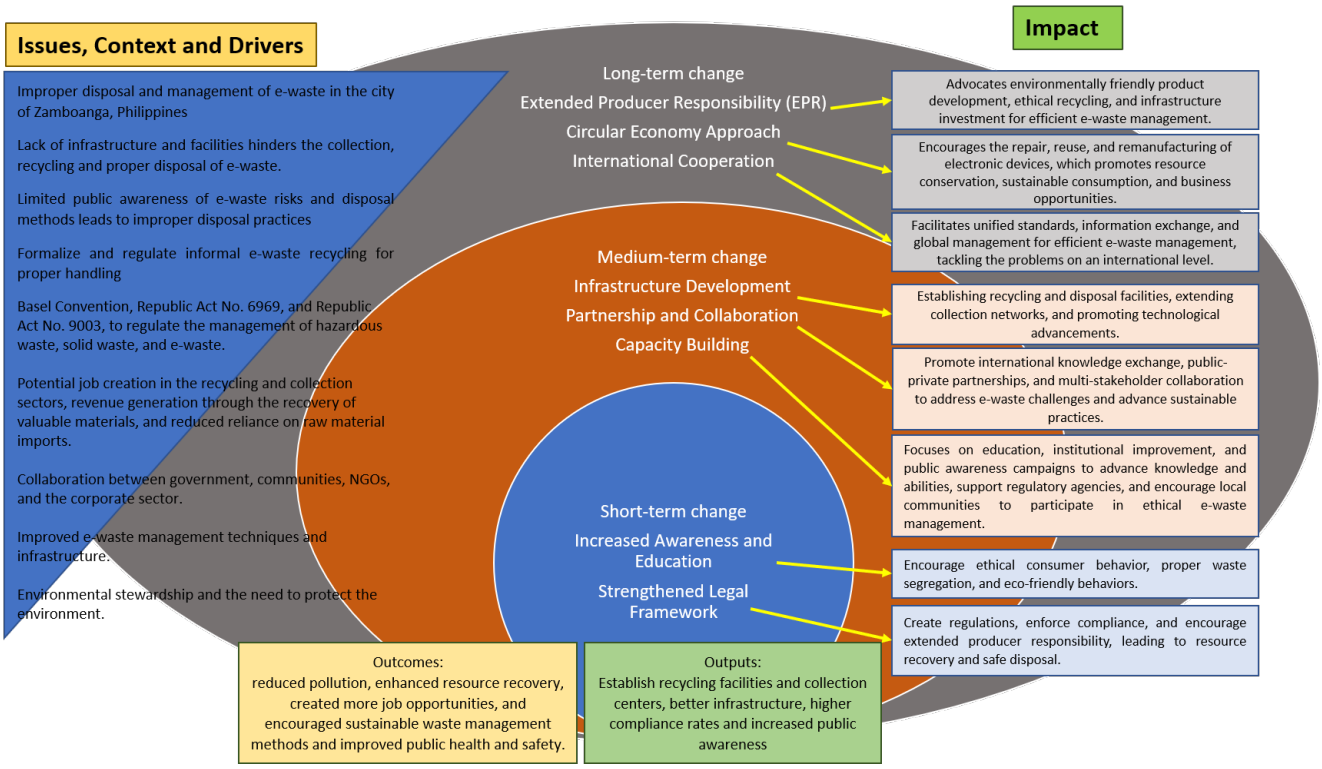

Figure 3 Theory of change for e-waste management in Zamboanga City, Philippines.

Conclusions and recommendations

In the Philippine city of Zamboanga, inappropriate processing and disposal of e-waste have seriously endangered the environment and public health. The absence of suitable infrastructure and knowledge of treating e-waste makes pollution and contamination more accessible. Several laws and regulations in the Philippines now govern the treatment of e-waste. Nevertheless, given that 125,000 tonnes of garbage are expected to be created annually, the problem is just getting worse. The G-PESTLE analysis method was used to assess the geographic, political, economic, social, technical, legal, and environmental aspects affecting the management of e-waste in Zamboanga City.

In conclusion, e-waste management issues in Zamboanga City require the creation of particular norms and regulations. These regulations should outline proper disposal techniques and ensure that those responsible for creating and managing e-waste are held accountable. Promoting safe disposal practices and raising public awareness of the dangers of e-waste is also crucial. Responsible behavior can be enabled through educational initiatives and awareness campaigns, and e-waste-related social attitudes can be changed.

Furthermore, technological advancements have the potential to improve Zamboanga City's e-waste management procedures significantly. E-waste collection, recycling, and disposal can be done more effectively and efficiently by investing in new technologies. Adopting creative solutions can assist the city in managing the rising e-waste issue while minimizing its adverse environmental effects. In addition, effective e-waste management can create business opportunities by recovering, recycling, and reusing resources. Zamboanga City can gain economically while fostering environmental responsibility by investigating these opportunities and developing sustainable practices.

Adopting conceptual frameworks for ASEAN e-waste management systems is consistent with several Sustainable Development Goals (SDGs). It can help Zamboanga City realize objectives for clean water and sanitation, sustainable cities and communities, responsible consumption and production, and other purposes. By implementing these, Zamboanga City can improve its e-waste management processes, safeguard the environment, and create economic benefits. Additionally, the city can encourage other ASEAN countries to take the initiative in e-waste management, fostering a healthier and more sustainable future.

The study's recommendations for bettering e-waste management in the City of Zamboanga include fostering partnerships and collaborations, educating the public about the value of proper disposal, establishing e-waste collection programs, enforcing regulations and penalties, promoting eco-design and product stewardship, investing in recycling infrastructure, encouraging eco-design and product stewardship, and encouraging research and innovation. These steps will enhance e-waste management, reduce pollution, enhance human health, and sustainably manage electronic trash.

In summary, Zamboanga City must establish specific regulations, increase public awareness, support techno-

logical advancements, and look for economic opportunities to address its e-waste issues. By implementing these findings and suggestions into practice, the city can enhance its e-waste management procedures, protect the environment, and generate economic benefits.

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