

E-WASTE

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**Assessment of Policies and Practices
for E-waste Management:
A Study of Asia**

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A Study of Asia**

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ABSTRACT

Worldwide electronic waste (e-waste) is a prime contributor to environmental degradation and leads to adverse impacts on human health. Asia is the prime victim of e-waste. Asian countries have e-waste policies regarding illegal trade, dumping, recycling techniques, and extended producer responsibility (EPR) to ensure the safe and responsible disposal of e-waste by reducing its impact on the environment. However, countries are struggling to cope with e-waste. The study aims to assess e-waste policies in Asian countries and find best practices for e-waste management. The study also highlights the extent of e-waste generated in Asian countries and how much new electrical and electronic equipment (EEE) are put on the market. Based on analysis and issues related to e-waste policies in Asian countries, the study proposes a general framework for e-waste management. Lastly, a brief context of Pakistan is discussed. Precisely, the study encourages the feasibility and efficacy of e-waste management policies and practices in Asia.

Keywords: E-waste, Legislation, Policies, EEE, Asia, E-waste Management, Policy Issues.

1. INTRODUCTION

Climate change is the biggest problem across the globe. There are several contributing factors in climate change like burning of fossils fuels, industrial waste, transportation, household emissions, landfilling etc. One of the small category of solid, industrial and household waste is electronic waste (e-waste), dramatically impacts human health and environment. The rapid evolution of technology and hi-tech advancement has caused early obsolescence of electrical and electronic equipment (EEE) which has imposed immense effects on human health and environment by generating e-waste. In 2019, globally 53.6 million metric tons (Mt) of e-waste (eliminating solar panels) was produced (Forti et al., 2020). The presence of heavy metals such as mercury, nickel, lead, and cadmium in e-waste bring risk to human health and environment (Duan et al., 2009; Song et al., 2013).

Waste electrical and electronic equipment (WEEE) produced in developed nations are exported to developing nations (Iqbal et al., 2015). Due to the lack of infrastructure and no/limited legislation, a large quantity of e-waste is dumped into developing countries (Frazzoli et al., 2010). The export of e-waste from developed countries to developing countries causes adverse impacts on environment, economic, and social system (Widmer et al., 2005). The result of economic development, industrial revolution, consumer affordability, and technological advancement in 21st century has brought a spike in demand for all types of EEE. Today, approximately every household has several EEE such as a refrigerator, air conditioner, television, microwave oven, etc. Moreover, extensive internet usage has brought enormous utilisation of information and communication technology (ICT) gadgets like laptops, personal computers, tablets, and smartphones (Baldé et al., 2017).

Conversely, the lack of proper e-waste recycling, inappropriate disposal practices, and no/limited e-waste legislative policies add fuel to the fire. The e-waste is illicitly exported (as used item) from Australia, United States of America (USA), Germany, United Kingdom (UK), Canada, Belgium, Netherlands to India, China, Pakistan, Indonesia, Malaysia, Philippines, Ghana, Hong Kong, Nigeria (Sthiannopkao & Wong, 2013; Baldé et al., 2017). Overall, domestic and imported e-waste is handled crudely like burning openly, grill heating, coal-fired, and filtrate using acid baths to extract valuable metals. Subsequently, residuals from extraction process are dumped into land and water, polluting the environment and causing serious health issues (Sthiannopkao & Wong, 2013).

2. LITERATURE GAP

Since, e-waste poses a huge problem for all developing countries in Asia. To best of our knowledge there is no/less studies on the similar topic. Therefore, the study examines country specific e-waste policies in Asia. While shedding light on the extent of e-waste

generated in-line with EEE put on Asian countries. The paper inspects numerous policies of several Asian countries, the study puts forward a general framework and policy recommendation for Asian countries to mitigate the problem of e-waste. Moreover, since the study is from Pakistan it includes a gist of e-waste in Pakistan.

The Study Contributions

Table 1

Major Difference Between Other Studies and Our Study

Areas	Other studies	Our study
Discuss e-waste policies	Covers 7 – 8 Asian countries	Covers 15 Asian countries
Policy issues	Covers 4 – 5 Asian countries	Covers 8 Asian countries
EEE generation in Asia	Covers 10 – 12 Asian countries	Covers 42 Asian countries
EEE put on Asian market	Covers 2 – 4 Asian countries	Covers 42 Asian countries
Framework to mitigate e-waste problem	Not specific to Asia	Specific to Asian countries
Framework implementation	Not specific to Asia	Specific to Asian countries
Policy recommendation	Not specific to Asia	Specific to Asian countries
Pakistan's context	Few studies	Covers with primary research

Objectives of the Study

The objective of the paper is to have a comprehensive overview of e-waste related policies, practices, and policy issues happening in Asian countries where one country can learn from the mistakes of other country. Moreover, the study aims to bring a collective solution for Asian countries to mitigate the problem of e-waste in Asia.

3. METHODOLOGY

A systematic literature review of e-waste policies and practices was conducted with a comprehensive search of existing literature from published journal articles, independent/institutional reports, official websites, and news articles covering the time span of 1990 to 2022. As mentioned by Schwarz et al (2007) well established literature review is essential for quality work. Moreover, in the context of Pakistan, data was used from authors' other papers.

Initially, the most relevant impact factors journals and reports were scrutinised with particular focus on e-waste laws, policies, and practices. Secondly, authentic websites and top news articles were reviewed. Lastly, the scope of the study was delimited to e-waste policies and practices in Asia.

4. E-WASTE AND GLOBAL REGULATIONS

The international treaty Basel Convention prohibits transboundary movement of harmful waste among countries emphasising the transfer of waste from developed countries to developing countries (Choksi, 1989). The total number of parties of Basel Convention are 188 countries while 53 are signatories (Convention, 2021). Moreover, Rotterdam Convention is an international agreement developed to make well-informed decisions by countries related to import and export of harmful chemicals (US Dept of State, 1998). The Stockholm Convention also addresses transboundary movement of dangerous materials among countries (UN Environment Programme, 2001). However, developing countries lack resources, technical expertise, competing priorities, information, and political will to implement the Stockholm Convention.

In 1995, European Union (EU) explicitly announced its first guidelines to control the toxic materials in plastic. The “Packaging Directive” of EU, controls toxic substances like cadmium, chromium, mercury, and lead in plastic (De Santo, 2010). In 2006, under Restriction of Hazardous Substances (RoHS), EU restricts EEE manufacturers to not to exceed the maximum limit of toxic substances like lead, mercury, chromium, polybrominated diphenyl ethers (PBDEs) and polybrominated biphenyls (PBBs) in their production (Directive, 2011). Primarily these regulations aim to safeguard environment and human health.

5. E-WASTE POLICIES IN DEVELOPED AND DEVELOPING COUNTRIES

Developed Countries

E-waste laws in developed countries vary, but many of them have implemented regulations to address the growing issue of electronic waste.

The WEEE Directive (2012/19/EU) was introduced by the European Commission in 2012 to establish consistent regulations for managing electronic waste across EU member countries. This directive serves as a comprehensive law governing the proper collection, recycling, and recovery of resources from e-waste (EU Commission, 2013). The WEEE Directive mandates EU member states to promote the creation and manufacturing of electrical and electronic equipment (EEE) that can be easily disassembled and recycled. In order to ensure environmentally sustainable practices, the directive specifies treatment procedures for certain materials and components found in e-waste, as well as requirements for storage sites. Additionally, the directive adopts the principle of Extended Producer Responsibility (EPR), holding producers accountable for the recycling of their products at the end of their lifecycle (Patil & Ramakrishna, 2020).

Among the countries in the Oceania region, Australia stands as the sole nation to have enacted a dedicated law addressing e-waste management (Patil & Ramakrishna, 2020). The Product Stewardship Act, established in 2011, focuses on the recycling of televisions and computers (Dias et al., 2018). This legislation has served as a blueprint for other countries within the region, inspiring them to implement similar frameworks that hold producers responsible for managing e-waste. New Zealand and several Pacific Island countries have followed Australia’s lead by introducing product stewardship programs. Furthermore, some smaller nations in the Pacific region have engaged in collaboration with the European Union to effectively handle hazardous waste (Baldé et al., 2017).

The United States has implemented several general measures to address domestic e-waste management. These include regulations under the Resource Conservation and Recovery Act (RCRA), specifically targeting the recycling of Cathode Ray Tubes (CRTs). The country has also developed the National Strategy for Electronics Stewardship framework. To further enhance e-waste management, the Environmental Protection Agency (EPA) has launched the Sustainable Materials Management (SMM) Electronics Challenge initiative in collaboration with Original Equipment Manufacturers (OEMs) and retailers. This initiative encourages the collection of used electronics by OEMs and retailers, who then ensure its proper recycling through certified recyclers (Kang & Schoenung, 2005).

Singapore plays a crucial role as a strategic hub, connecting the eastern and western regions due to its strategically positioned harbors. In the 1990s, the Singaporean government implemented strict regulations on the transportation of hazardous waste through its ports in compliance with the Basel Ban (Patil & Ramakrishna, 2020). The National Environment Agency (NEA) has been actively overseeing and regulating waste management practices throughout Singapore. In recent years, the Ministry of the Environment and Water Resources has undertaken efforts to introduce dedicated legislation specifically addressing e-waste management. This legislation incorporates the principle of EPR to ensure effective handling and accountability for e-waste in Singapore (Patil & Ramakrishna, 2020).

Developing Countries

E-waste laws in developing countries vary widely, and not all developing countries have comprehensive regulations in place to address electronic waste management.

The disposal infrastructure for e-waste in Eastern European countries such as Russia, Ukraine, and Moldova are not as advanced as in the European Union (EU). The collection and recycling of e-waste are insufficient, despite various efforts made by the private sector, which does not receive government subsidies. To address this situation, several initiatives have been launched to assist these countries in managing e-waste effectively. These initiatives aim to develop specific legislation tailored to e-waste management and raise awareness among the public. With the exception of Moldova, all countries in Eastern Europe currently have national laws in place that regulate e-waste. In 2017, Russia implemented an EPR program for electrical and electronic scrap. Under this program, manufacturers and importers are obligated to participate in the collection and processing of outdated electronics in accordance with Russian circular economy legislation (Baldé et al., 2017).

South Africa stands out as a developed country in comparison to other regions in Africa, and it addresses various legislations including e-waste, there is currently no specific law in place solely for e-waste management. However, the South African government and organisations such as the South African Waste Electrical and Electronic Enterprise Development Association (SAWEEDA) are actively working towards developing legislation dedicated to e-waste management. Extensive research and planning have been undertaken, and it is anticipated that this forthcoming legislation will encompass regulations for e-waste disposal and processing, as well as incorporate the EPR (Grant, 2019).

Colombia has taken significant steps in the realm of e-waste management by implementing a comprehensive national system for the selective collection and effective management of computer and peripheral waste. This initiative is governed by a resolution that outlines the specific protocols and guidelines for the proper handling and disposal of such e-waste. Furthermore, Colombia has recently introduced a national policy dedicated to the management of WEEE, which was enacted in June 2017. This policy serves as a guiding framework to ensure the responsible and sustainable management of e-waste across the country (Baldé et al., 2017).

In Argentina, the establishment of legal frameworks for e-waste management has primarily occurred at the provincial level, with a particular emphasis on the collection of e-waste. Despite the presentation of three bill projects in the national congress, no comprehensive national law specifically addressing e-waste management has been approved. Consequently, the collection and recycling of e-waste in Argentina currently lacks regulation at the national level. As a result, it is likely that e-waste management is handled by the informal sector or private recycling companies operating within the country (Baldé et al., 2017).

The focus of this paper is primarily on e-waste policies within Asian countries; therefore, it does not encompass all developed and developing countries e-waste policies.

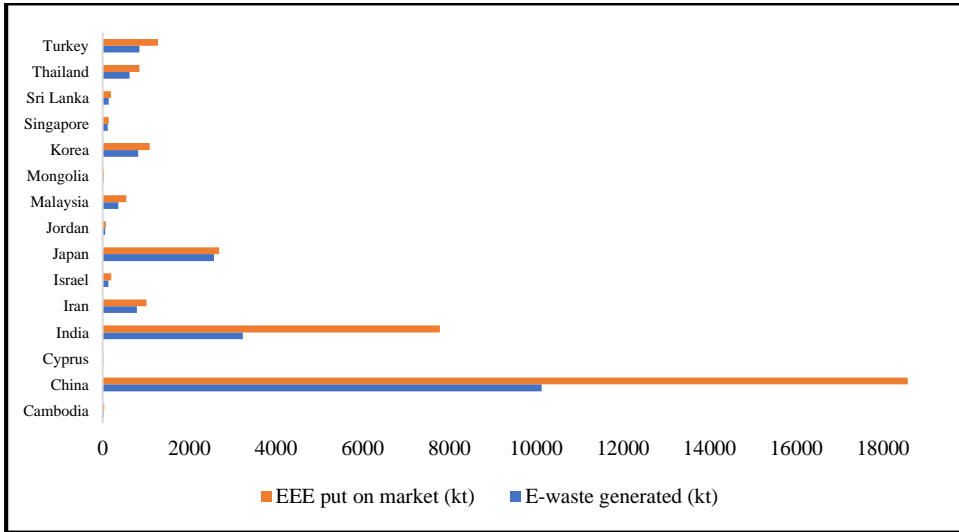
6. E-WASTE POLICIES IN ASIAN COUNTRIES

As compared to other continents Asia is at the top in generating e-waste. In 2019, about 24.9 Mt of e-waste waste generated in Asia (Forti et al., 2020). In Asia, only 15 countries have exclusive e-waste legislation for details (refer to Table A1 in appendix). Countries having e-waste legislation with e-waste generation and EEE put on market are depicted in Figure 1a. Moreover, countries having no e-waste law with e-waste generation and EEE put on market are shown in Figure 1b.

India has Ozone Depleting Substances Rules which aims to control the trade of EEE containing hazardous elements and stating that only authorised dismantlers and recyclers can collect e-waste (Ind, 2000; Patil & Ramakrishna, 2020). Moreover, India has E-Waste Management and Handling Rules that controls the e-waste at every stage of EEE life from manufacturers to recyclers (Bhaskar & Turaga, 2018).

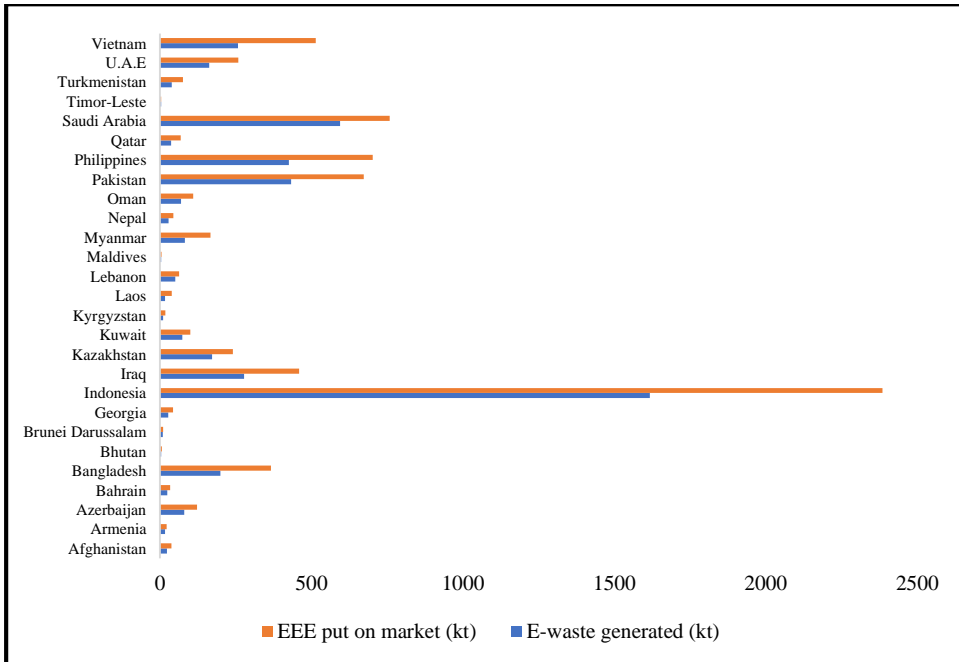
E-waste law in China controls 14 types of electronic wastes including refrigerators, air conditioners, washing machines, kitchen exhausts, electric heaters, electric gas heaters, desktop computers, monitors, mobile phones, televisions, fax machines, printers, copiers, and single-machine telephones (Forti et al., 2020). In China, Technical Policy on Control of WEEE prohibits e-waste import and increase recycling rate and standards of discarded EEE (Chung & Zhang, 2011; Patil & Ramakrishna, 2020). Moreover, The Cleaner Production Law and Circular Economy Promotion Law aims to reduce the usage of harmful substances in EEE manufacturing and focus on averting the pollution caused by dismantling, recycling, and disposal of e-waste (Chung & Zhang, 2011; Patil & Ramakrishna, 2020). Lastly, China has also made Extended Producer Responsibility (EPR) policy for EEE producers to adopt ecofriendly practices for discarding EEE (Chung & Zhang, 2011; Patil & Ramakrishna, 2020).

Fig. 1a. Countries having National e-waste Legislation with e-waste Generation and EEE Put on Market in 2019



Source: Authors using data from (Global E-waste Monitor Statistics Partnership, 2021).

Fig. 1b. Countries having No National e-waste Legislation with e-waste Generation and EEE Put on Market in 2019



Source: Authors using data from (Global E-waste Monitor Statistics Partnership, 2021).

In Japan e-waste is treated in two ways. One it has Law for the Recycling of Specified Kinds of Home Appliances (LRHA), which enforce recycling responsibilities of used home appliances on consumers and manufacturers. Second, Law for the Promotion of

Effective Utilisation of Resources (LPUR), specifically focuses on reducing e-waste and improving recycling standards of used EEE. LPUR and LRHA includes computers, batteries, mobile phones, television, washing machines, air conditions, and refrigerators. The major difference between LPUR and LRHA is that the former encourages manufacturers' voluntary efforts while the latter imposes compulsory obligations on manufacturers (Chung & Rie, 2008; Periathamby & Victor, 2013).

In Singapore, all EEE are treated according to the first schedule of Resource Sustainability Regulation (Regulation, 2019a). Singapore has Environmental Protection and Management Act (EPMA) which aims to regulate the licensed trade of all products containing heavy metals like lead, mercury, and cadmium (Bai & Sutanto, 2002; Patil & Ramakrishna, 2020). Moreover, for e-waste recycling Singapore has National Voluntary Partnership program (NVP) with industrial partners like Toshiba, HP, StarHub, Panasonic (NVP, 2018; Patil & Ramakrishna, 2020).

In South Korea, recovery and recycling of all EEE are covered under the guidelines of Recycling and Recovery Obligations on Electrical and Electronic Products. For electric vehicles Korea has Resource Recycling of WEEE and Vehicles Act (Regulation, 2018a). The policy focus is to increase recycling rate by adopting Extended Producer Responsibility (EPR) and reduce the quantity of e-waste going to landfills and incinerators (Jang & Kim, 2010). Korea has EPR policy for EEE manufacturers to recycle collected e-waste and report to the government with results (Yoon & Jang, 2006; Lee et al., 2007; Chung & Rie, 2008).

In Taiwan, e-waste management is approached through a straightforward legislative framework. The primary law governing waste disposal and recycling procedures is called "The Waste Disposal Act." This law has been subject to periodic amendments and has incorporated e-waste management within its scope in recent years. One notable initiative introduced is the "4-in-1 recycling program," which involves four key stakeholders responsible for maintaining environmental cleanliness: community residents, the recycling industry, local government, and the newly established Recycling Fund. The Recycling Fund is financed by collecting fees from manufacturers and retailers and plays a significant role in supporting e-waste recycling efforts in Taiwan (Patil & Ramakrishna, 2020).

Israel has e-waste laws and policies. Environmental Treatment of WEEE and Batteries Law guides how e-waste should be treated in an environmental friendly manner (Regulation, 2012a). Under WEEE Law, EEE importers and manufacturers are responsible to fulfill their duties for managing e-waste (Regulation, 2013). Prevention of Illegal Dumping of Waste Products is specific law for dumping and disposing of waste products in Netanya city (Israel) (Regulation, 1981).

In Turkey, e-waste is treated according to Control of WEEE Regulations (Regulation, 2012b). For sustainable development Turkey has a Zero Waste Regulation which aims to preserve environment, human health, and natural resources (Regulation, 2019b).

Malaysia's waste management legislation includes an e-waste policy. All EEE products are treated according to Scheduled Waste Management (including e-waste) (Regulation, 2018b). In Jordan all EEE products are collected and treated under WEEE Draft Instruction (Regulation, 2014). In Cyprus, The Waste Law has been in place since 2011. It includes Directive 2002/96, 2006/66, and 2011/65 which are related to e-waste control and management (Regulation, 2011).

Philippines does not have an explicit law for e-waste. However, it has a range of "harmful waste" laws that covers e-waste. The Philippines has developed the "Final Draft Guidelines on the Environmentally Sound Management (ESM) of WEEE", which is

expected to be passed soon (Forti et al., 2020). Cambodia has a particular law on e-waste with the Sub-decree on WEEE. The Sub-decree covers disposal, stockpiling, collection, transportation, recycling, and dumping of e-waste (Forti et al., 2020). Previously Myanmar not explicitly considered e-waste as hazardous problem and had no laws on e-waste. However, recently Myanmar has perceived the significance of e-waste and is currently working on master plan for e-waste management (Forti et al., 2020).

Bhutan's e-waste policy was in force till 2013 (Balde et al., 2015). Bhutan has Waste Prevention and Management Regulation (WPMR) and Waste Prevention and Management Act (WPMA) under which all e-waste management activities are carried out (Zangpo, 2014). Some of the countries Iran, Mongolia, Sri Lanka, Thailand, and Bhutan has e-waste legislation with no/less implementation (Taghipour et al., 2011; Mallawarachchi & Karunasena, 2012; Zangpo, 2014; Ochir & Buyankhishig, 2014; Ganjuurjav et al., 2015; Chareonsong, 2016).

Pakistan has National Environment Policy (NEP) it covers air, water, ozone, climate change, agriculture, and import/export of hazardous chemicals or waste products (NEP, 2005). Recently, on June 28, 2022, Pakistan's federal cabinet approves National Hazardous Waste Management Policy (NHWMP) which includes e-waste trade, generation, dumping and discuss transboundary movement of hazardous wastes. However, it fails to elucidate how e-waste will be managed in the country (NHWMP, 2022). Unfortunately, no policy implications are observed.

E-waste policies are crucial for developing countries as they often receive e-waste exports, leading to environmental and health risks. Rapid urbanisation and industrialisation result in increased e-waste generation, making proper e-waste management policies essential to avoid negative impacts. Valuable materials in e-waste can be recovered and reused, creating job opportunities and promoting economic growth. Sustainable e-waste management can be achieved by promoting the formal e-waste recycling sector, reducing health risks associated with informal recycling, and promoting the sustainable use of natural resources. Therefore, developing countries must implement e-waste policies to manage e-waste sustainably, minimise health risks, and promote economic and environmental sustainability.

7. EXTENDED PRODUCER RESPONSIBILITY IN ASIAN COUNTRIES

According to OECD, (2016), extended producer responsibility (EPR) is a strategic plan to include environmental costs related to the product throughout the product life cycle. EPR gives financial benefits to manufacturers for producing eco-friendly products and holds manufacturers responsible for managing their products till the end of life. In EPR, companies individually, collectively or producer responsibility organisation (PRO) (third party services) manage their product throughout the product life cycle.

In 2012, China Imposed EPR for e-waste management. It was implemented on domestic EEE manufacturers and importers who are taxed by government. The taxes are majorly used for subsidising e-waste recycling and managing information systems (MIS). Moreover, subsidies encourages formal recycling companies to purchase e-waste from private vendors because mostly e-waste is managed by informal companies (Cao et al., 2016).

In 2011, India enforced EPR for e-waste management. For take-back services collection sites were provided by producers. For being authorised dealers, all producers, recyclers, and dismantlers must be registered in state pollution control board (SPCB).

Along with take-back requirements, new rules are added such as collection targets based on sales percentage of electronic items. Moreover, new rules require the manufacturers to establish a deposit-refund system (Turaga & Bhaskar, 2017).

In Japan, according to Home Appliance Recycling Law (HARL) all stakeholders' roles are defined in EPR system. For collection retailers are responsible, for recycling e-waste manufacturers are responsible, and consumers have to pay an additional fee to cover recycling and transportation costs (Ogushi & Kandlikar, 2007).

In South Korea, EPR imposes compulsory take-back schemes either with individual collection or PRO. Violation of the rules may cause a penalty up to 130 percent of standard recycling cost. Moreover, consumers have to pay a certain fee at the time of e-waste disposal (Manomaivibool & Hong, 2014).

8. MAJOR ISSUES OF E-WASTE POLICIES IN ASIAN COUNTRIES

Effective legislation requires proper framework, implementation, and monitoring. Limitations to any of the step may lead to overall mismanagement. E-waste is no more a novel issue but the framework to its legislation is new for countries that's why most of the countries lack complete and strong e-waste legislation or enforcement network. About 66 percent of the world's population is covered with e-waste law (UNE, 2019; WEF, 2019), but there are some serious issues in e-waste laws. For details refer to Table 2.

Table 2

Major Issues in e-waste Legislation in Asian Countries

Country	Issues	Description
China (Wei & Liu, 2012; Wang et al., 2013; Lu et al., 2015)	Legal framework	Mostly the current laws are not designed with a systematic, practical, and inclusive approach. That's why they are not efficient.
	Illegal import	Illicit import of e-waste and secondhand electronics from developed nations.
	No regulation	China has no law to regulate informal e-waste.
	Weak enforcement	Environmental protection law is weak and lack support from private sector.
	E-waste collection	The lack of legal obligation on consumers for e-waste disposal and formal sector strives in e-waste collection as compared to informal sector.
India (Kumar & Chaudhary, 2016; Yadav & Bandyopadhyay, 2015)	Infrastructure and capacity	Due to no/less government support, financial resources, infrastructure, and workforce for e-waste management formal sector suffers a lot.
	Accountability	No accountability on informal processing of e-waste.
	Illegal import	Illicit import of e-waste and secondhand electronics from developed nations.
	Crude processing	Using child labour for crude processing.
	No incentive	No incentive programs from enforcement bodies to encourage proper e-waste disposal.
Japan (Chung & Rie, 2008)	No penalty	The legislation has no fine on e-waste related offences like crude processing and illegal trade of e-waste.
	Infrastructure and capacity	Due to the lack of finances and infrastructure e-waste processing is not performing at its fullest.
	Financial obligation	Putting financial constraints on consumers for e-waste recycling with less obligation on manufacturers to take-back their products has increased the rate of illegal e-waste disposal.
South Korea (Chung & Rie, 2008)	Ethical misconduct	To avoid financial liability retailers collected recycling fee from consumers and were persistent in illicit export of e-waste.
	Implementation	Ecofriendly treatment of harmful material is not compulsory in the producer responsibility system.
Taiwan (Chung & Rie, 2008)	Shifting burden	E-waste is illicitly exported to developing countries of East Asia.
	Legislation	There is no explicit law for e-waste recycling.
Cambodia (Sothun, 2012)	Competition	Formal and informal e-waste collectors operate differently which create a negative competition between them.
	Standards	There are low environmental standards for recycling.
	Legal import	Legal import of second hand EEEs.
Malaysia (Suja et al., 2014; Yong et al., 2019)	Infrastructure	Lack of legal framework, strategic plans and finances.
	Facilities	Less e-waste recovering facilities.
	Inclusion	Household e-waste in not covered in e-waste policy.

9. ANALYSIS OF E-WASTE POLICIES AND ITS IMPLEMENTATION

Despite the existence of Basel Convention, Rotterdam Convention and Stockholm Convention, e-waste is exported from USA, Canada, Australia, UK, Japan, and South Korea to China, India, and Pakistan (Puckett et al., 2002; Terazono et al., 2006; Cobbing, 2008; EU Commission, 2013). Illegal trade of e-waste is the primary concern in e-waste laws. Illegal import/export switch the burden of one country to other, which creates a “ripple effect” and the effect ends on a country with no/less e-waste legislation and enforcement. The prime victim of these illegal trades are Asian developing countries where no e-waste laws exist on implementation side, no e-waste items are listed properly, and major stakeholders of e-waste policies are excluded. Moreover, these countries lack proper infrastructure due to insufficient funds and planning. Furthermore, the recycling rate of e-waste is very low in Asian developing countries, unrefined recycling processes of e-waste negatively impacts human health and environment.

The fragmented environmental law enables China to import e-waste in large quantity from developed countries which make China a home for crude e-waste processing (Lu et al., 2015). Despite having a comprehensive e-waste law, India has e-waste management issues like improper infrastructure, employing under age labour for e-waste recycling, public unawareness and inappropriate e-waste disposal (Yadav & Bandyopadhyay, 2015; Kumar & Chaudhary, 2016).

In comparison with China and India, Japan, South Korea, and Taiwan have formal e-waste recycling and collection schemes (Patil & Ramakrishna, 2020). The policy side issues they face are, Japan has illegal export and dumping of e-waste because financial constrains for recycling are on consumers (Chung & Rie, 2008). In South Korea, it is not mandatory for EEE manufacturers to comply with environmental friendly treatment of harmful materials (Chung & Rie, 2008). Which gives a free hand to South Korean EEE manufacturers to produce maximum EEE, which is why all electronic items are available on cheap rates ultimately leading to more e-waste generation. Taiwan has weak environmental protection law which consider e-waste as general waste under one single law that’s why it encounters issues related to e-waste collection, recycling and environmental standard (Chung & Rie, 2008).

In Cambodia, policy to reduce the poverty, allow the import of secondhand EEE to meet the domestic demand of EEEs. Importing secondhand EEE includes scrap metal mostly not functional and low quality which are used only for a short time (1 – 3 years). Technically, Cambodia imports WEEE. Under Basel Convention Cambodia has gotten several international projects, but still lacks a legal framework, financial support and strategic plan for sustainable e-waste management (Sothun, 2012).

In Malaysia, e-waste management includes law enforcement and e-waste recovering facilities. E-Waste with no residual value is disposed in areas authorised by the Department of Environment (DoE). Moreover, for e-waste separation, disassembly, and treatment 18 full and 128 partial recovery facilities are available with various technologies. On the contrary, there are some issues in recovering facilities, the facilities are not achieving the target of converting e-waste into the source full materials. Moreover, the issue include trade of e-waste derived products (Suja et al., 2014). The industrial e-waste is regulated by the legal entities, whereas managing household e-waste is a challenge because household e-waste is not covered in industrial e-waste policy (Yong et al., 2019).

Pakistan's National Hazardous Waste Management Policy covers few aspects of e-waste. Most of the salient features of e-waste management are not covered like recycling, dismantling, stakeholders responsibilities etc. The policy is not a comprehensive road map to e-waste management. With a great sigh, NEP and NHWMP are merely dummy policies as there is no such implications have been observed and Pakistan is still a dumping hub for developed countries (Imran et al., 2017).

Till now the study shows e-waste policies and practices of EEE manufacturers and Asian countries. However, the underlying problem of controlling e-waste is not mitigated because every year a new threshold is set for e-waste generation which is significantly larger than previous records. One of the fundamental reasons for record breaks is ICT boom which leads to a spike in demand for EEE which encourages EEE manufacturers to increase supply to meet demand. Moreover, fragile e-waste laws and enforcement bodies of Asian countries add fuel to the fire by "willful non-compliance" of illegal trade, recycling standards, and collection sites of e-waste.

10. GENERAL FRAMEWORK FOR E-WASTE MANAGEMENT

There is no generic model with fixed regulations for developed and developing countries. Every country has its own scenario. Whereas, for basic building blocks or having a holistic approach for e-waste legislation and its implementation, a general framework is necessary as e-waste is not a country specific issue. Table 3 shows a general framework for e-waste management.

Table 3

General Framework for e-waste Management

Planning	<ul style="list-style-type: none"> › Develop an exclusive e-waste law/policy › Law should be flexible › Design the policy instruments for e-waste › Involve all the stakeholders › Launch EPR systems › Set specific performance standards
Organising	<ul style="list-style-type: none"> › Define specific institutional responsibilities › Legislative guidelines › Declaration of heavy metal and hazardous substances › Strict enforcement of policies with high penalties if not followed › Capacity building
Leading	<ul style="list-style-type: none"> › Awareness generation to all stakeholders › Implement the framework on a trial basis › Cost and benefit analysis › Implementation of the overall framework
Controlling	<ul style="list-style-type: none"> › Manage overall operations of framework › Comprehensive monitoring with identifying gaps and problems › Assess the performance according to the set standards › Quality control check of air, water, soil, and human health
Review	<ul style="list-style-type: none"> › Based on outcome policy can be adjusted › If the performance standards are too high or low, then they can be adjusted accordingly › The continuous process of review and adjustment will lead to a sustainable e-waste management system

For effective and efficient e-waste management, enforcement bodies should promote sustainable recycling processes. Government can provide a tax benefit to consumers buying refurbished electronic products. Moreover, proper guidelines to restrict EEE manufacturers for using heavy metals in production. EEE manufacturers must be responsible for launching EPR systems in which their products should be taken back to them for recycling. Consumers must agree to return their EEE to collection sites when they want to dispose-off their electronic items. Formal public or private recycling departments should be managed by enforcement bodies with proper legislation on labour safety, performance standards, and environmental protection. With continuous feedback and review, the general framework will be able to mitigate the problem of e-waste.

Key Roles of Major Stakeholders

- (1) *Government*: devise domestic and international laws for e-waste and environment. Ensures all the concerned departments are equipped with proper infrastructure and capacity.
- (2) *Non-Government Organisation*: academia should promote and adopt best practices on individual level while conducting domestic and international research on e-waste management. NGOs may create synergies for sharing internationally acknowledged best practices, meanwhile encouraging small and medium size enterprises (SMEs) to promote e-waste management. Consumers must be responsible for actively participating in dropping their WEEE on collection sites and encourage the use of repairable and recycled electronic products.
- (3) *Private*: EEE manufacturers make sure all of their activities are abide by laws. Dealers/distributor/importers must ensure their procurement is according to the proper channel and registered. Retailers can run awareness campaigns on e-waste management for public and provide drop-off locations to consumers. Collectors/recyclers/dismantlers encourage the EPR system at a regional and national level and strictly abide the environmental laws.

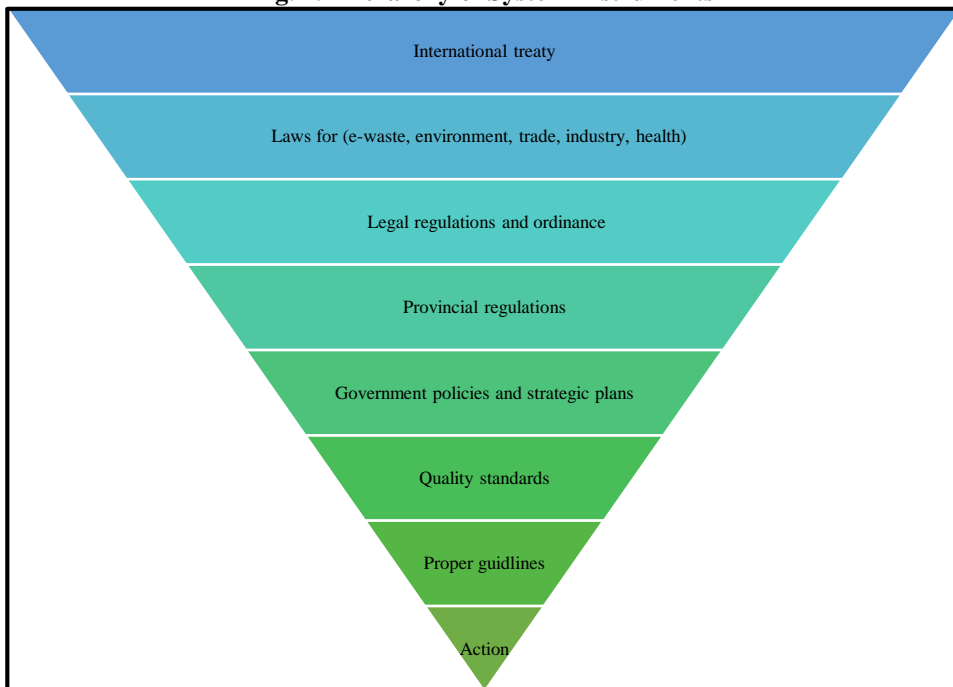
11. DESCRIPTION AND IMPLEMENTATION OF GENERAL FRAMEWORK FOR E-WASTE MANAGEMENT

Planning: an exclusive and holistic e-waste law should be developed with a complete ban on e-waste trade. The law should be flexible so that necessary modifications can be made over time. Design policy instruments for e-waste like infrastructure, governing bodies, financial support, institutional framework, etc. involve all the stakeholders like law enforcement agencies, EEE manufacturers, importers and exporters of e-waste, consumers, customs, authorised recycling companies, non-government organisations (NGOs), etc. Enforce mandatory EPR system to encourage formal recycling and consumers to act responsibly. Set specific performance standards to assure the quality of policy deliverance. For *planning*, a hierarchy of system instruments can be used. See Figure 2.

Organising: all institutions' responsibilities should be clearly defined and communicated with defined penalties if responsibilities are not fulfilled. E-waste law should have proper guidelines for all the stakeholders involved. Moreover, the document

must include all the heavy metals and hazardous substances which cause negative impact on human health and environment. Most importantly develop capacity building like human resource, separate departments, budget allocation, infrastructure, etc.

Fig. 2. Hierarchy of System Instruments



Source: Authors using data from (ITU, 2021).

Leading: prior to implementation, awareness generation is a crucial for e-waste law. Awareness generation is necessary for all the stakeholders especially consumers, recycling companies, and importers and exporters of e-waste. For assessment, the framework can be implemented in one or two cities of a country. Cost and benefits analysis includes both tangible and intangible costs and benefits like financial requirements, quality of health, quality of environment, etc. subsequently, when the model is successful it can be implemented in the rest of the country.

Controlling: Overall model should be implemented and operated according to the pre-defined guidelines. A comprehensive monitoring and controlling mechanism with identifying loopholes and issues in the current model and redesign model accordingly. Assessing the performance standards by quantifying e-waste generated, recycled, imported/exported, EPR system, and any other initiatives used for managing e-waste. Besides monitoring the overall model, there must be department like health that assess the quality of human health, air, water, and soil semiannually or annually.

Review: Based on the outcome, policy/law can be revised or adjusted to operate at its maximum capacity. Practically if performance standards are set too high or too low, they should be adjusted accordingly. A continuous process of taking feedback and reviewing the process will lead to a sustainable e-waste management system.

12. CONTEXT OF PAKISTAN

Pakistan is a country in southern Asia with a population of 220.8 million (World Bank, 2021). It shares a border with Afghanistan, China, India, and Iran. In 2014, Pakistan generated 266 kilotons (Kt) e-waste (Balde et al., 2015), with an increasing rate of 11 percent Pakistan generated 301 Kt in 2016 (Baldé et al., 2017). In 2019, Pakistan generated 433 Kt e-waste which is 2.1 kilogram (Kg) per capita (Forti et al., 2020). Likewise, other developing countries in Asia, Pakistan is also a prime victim of e-waste, with the passage of time situation is becoming worse. Absence of e-waste legislation and accountability, Pakistan has become a destination for e-waste disposal (Imran et al., 2017). Approximately, Pakistan receives 8 percent of global e-waste (Baldé et al., 2016).

Karachi, Lahore and Peshawar (cities in Pakistan) are largest destination for e-waste dismantling and recycling (ANI, 2021). Moreover, Pakistan is under threat of human health due to informal e-waste recycling and crude processing (Forti et al., 2020).

In Pakistan, majority consumers are unaware about e-waste, which is why they demand more EEE ultimately leading to e-waste generation (Zafar & Armughan, 2023). As Pakistan has no exclusive e-waste policy and is not ratified Basel Convention. Therefore, EEE manufacturers, recycling companies, and importers/exporters of e-waste in Pakistan are least bothered about environment and human health risks. Primary data (interviews with e-waste importers and exporters) collected for Armughan and Zafar (2022a), revealed that there are extraction factories in Faisalabad and Gujranwala (cities in Pakistan). In the factories, valuable materials are extracted from wasted EEE by incineration and remained ashes are dumped in lands and rivers. Moreover, the harmful gasses from incineration are released in the air which contaminates the environment and make human lives miserable for the people living in the vicinity.

According to Zafar and Armughan (2023) a study on consumer awareness, disposal behaviour and participation towards e-waste across four provinces (Punjab, Sindh, Balochistan, and Khyber Pakhtunkhwa (KPK)) of Pakistan, with a sample size of 554. About 173 (31 percent) participants were aware about e-waste among 554 (100 percent). Among 554 (100 percent) participants only 75 (13 percent) participants were aware about Basel convention. Only 99 (18 percent) participants were aware about Pakistan's Strategic Trade Policy Framework. Moreover, 120 (21 percent) participants were aware about Pakistan Environmental Protection Act (PEPA). In Pakistan majority of the population has approximately all types of EEE in their homes (refer to Figure A.1 in the appendix). Students and employees in the age group of 18 to 32 with medium or high income demand more EEE. Punjab and Sindh provinces are higher in EEE consumption.

Sentiments of Pakistani Consumers

In the consumer survey of Zafar and Armughan (2023), majority of the participants responded that Pakistan should recycle its e-waste. Majority participants retorted government, manufacturers, and consumers are responsible for e-waste management, which means it is a common responsibility of everyone to contribute to alleviate e-waste. About 194 (35 percent) participants were not pleased with the e-waste management system in Pakistan, 318 (57 percent) were indecisive and 42 (8 percent) were satisfied. Interestingly, 483 (87 percent) respondents were concerned about the environment and

retorted that everyone should contribute to protect environment. Majorly, 424 (76 percent) participants answered “yes” to “e-waste typically contains hazardous material that harms human health and environment.” On a scale of 1 – 5, 5 being the most important and 1 being the least, majority of the participants responded in favour to dispose unwanted EEE in a sustainable manner (refer to Figure A.2 in the appendix).

13. RECOMMENDATIONS

After evaluating the e-waste policies implemented in various Asian countries, several suggestions can be made regarding the management of electronic waste.

- The scope of Basel Convention should be broadened by increasing its signatories to all developed and developing countries. Since e-waste is a global issue, United Nations (UN) can help in bringing all countries under one convention. If in case its cumbersome to have all countries on same page, then continent specific e-waste convention can be developed to hold back transboundary movement of e-waste in Asia.
- Countries having no exclusive e-waste management policy/law must develop a complete e-waste management law with proper guidelines for all the stakeholders. A long with policy design, policy implementation with strict compliance is a need of hour, otherwise devising policy is not an objective to deliver.
- All stakeholders like law enforcement agencies, EEE manufacturers, dealers, and retailers, importers/exporters of e-waste, consumers, customs, authorised recycling companies, non-government organisations (NGOs), etc. must be involved in policy setting with clearly defined roles.
- Strictly ban illegal import and export of e-waste. Developing countries earning from import of secondhand EEE may legally import a certain amount of electronic items which are demanded. Moreover, prohibit open air incineration of e-waste as prohibited in Ghana. However, only authorised recycling and dismantling companies should be allowed to recycle and dismantle e-waste in ecofriendly manner.
- There must be huge penalties on informal e-waste dealers for penetrating formal e-waste dealers for trading more than defined quantity. Moreover, EEE manufacturers must be held responsible for not complying with any e-waste policies/laws.
- One of the major problem is lack of public awareness on e-waste. To increase public awareness there should be extensive e-waste awareness campaigns to aware public about health and environmental risk associated with e-waste. Government and EEE manufacturers can disseminate awareness about e-waste on media (social or print), NGOs can assist by doing research and development to change consumers consumption habits. Changing consumer habits are bit challenging, but with an effective e-waste awareness campaigns and nudging techniques, one can encourage consumers to use their devices until it no longer works and drop their electronic waste on proper drop off locations.

- Asian countries may launch EPR system where EEE manufacturers provide proper e-waste collection sites to take-back their obsolete electronic products and recycle them with sustainable recycling techniques. Enforcement bodies may encourage EEE manufacturers to reuse recycled valuable (gold, copper and silver) materials in their production for other devices.
- Budget allocation and capacity building (infrastructure, human resources and institutional development) plays a significant role in e-waste management. Countries with financial constraints in managing e-waste may collaborate with EEE manufacturers to split financial burden. The collaboration will aid in developing good infrastructure, capacity building, and public awareness.
- Comparatively, Turkey and Singapore can be set as a benchmark for other Asian countries. For policy implementation, initially, policy can be implemented on city/province/state then it can be trickledown to country level. Lastly, rigorous feedback with continuous monitoring and evaluation will lead to a sustainable e-waste management.

14. CONCLUSION

E-waste is a global mess and mostly Asian developing countries are on the verge of destruction. Many Asian countries lack e-waste policies and its implementations which make them a sufferer of e-waste. Therefore, e-waste policies and efficient enforcement bodies are mandatory to control illegal transboundary movement of e-waste, increase recycling standards, and ban incinerations of e-waste. Along with national laws, strengthening international laws will aid the overall e-waste management process. Moreover, managing e-waste is a common responsibility of EEE manufacturers, government agencies, NGOs, consumers, and e-waste dealers. Lastly, for sustainable e-waste management system, a proper framework with effective e-waste policies, strict law enforcement agencies and collaboration among other stakeholders with proper guidelines must be involved in the process. Now it counts on us “We can pay the bill now, or pay dearly in the future.”

Ethical Compliance

The authors declare that they have no conflicts of interest.

APPENDIX

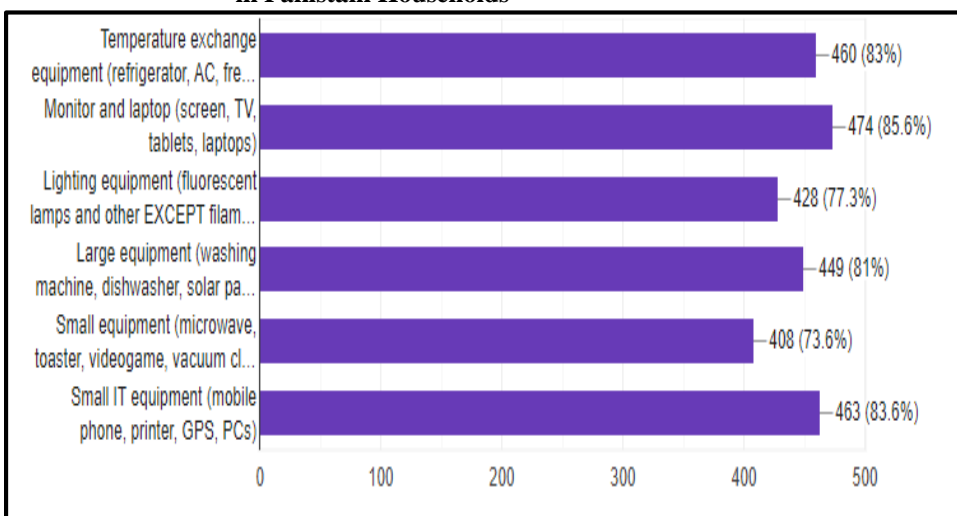
Table A1

Asian Countries Having National e-waste Legislation

Country	Status	Country	Status	Country	Status
Cambodia	Yes	Afghanistan	No	Maldives	No
China	Yes	Armenia	No	Myanmar	No
Cyprus	Yes	Azerbaijan	No	Nepal	No
India	Yes	Bahrain	No	Oman	No
Iran	Yes	Bangladesh	No	Pakistan	No
Israel	Yes	Bhutan	No	Philippines	No
Japan	Yes	Brunei	No	Qatar	No
		Darussalam			
Jordan	Yes	Georgia	No	Saudi Arabia	No
Malaysia	Yes	Indonesia	No	Timor-Leste	No
Mongolia	Yes	Iraq	No	Turkmenistan	No
South Korea	Yes	Kazakhstan	No	United Arab Emirates	No
Singapore	Yes	Kuwait	No	Vietnam	No
Sri Lanka	Yes	Kyrgyzstan	No		
Thailand	Yes	Laos	No		
Turkey	Yes	Lebanon	No		

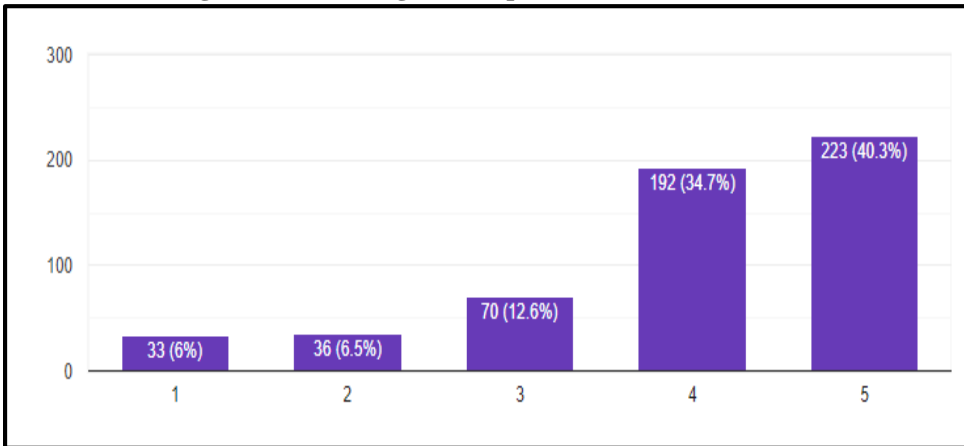
Source: Authors using data from (Global E-waste Monitor Statistics Partnership, 2021)

Fig. A1. Types of Electrical and Electronic Equipment (EEE) in Pakistani Households



Source: Authors using data from (Zafar and Armughan, 2023).

Fig. A2. Participants' Response on Disposing Unwanted Electrical and Electronic Equipment (EEE) in a Sustainable Manner. 1 being least and 5 being most important.



Source: Authors using data from (Zafar and Armughan, 2023).

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