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# An Empirical Investigation into AI-based E-Waste Management Strategies for Sustainable Development WRT India



**Abstract:** - As a member of the Sustainable Development Goals 2030, India aims to achieve environmentally sustainable economic development. However, the biggest challenge is the handling and disposing of the electronic waste. This manuscript is a succinct investigation of the current e-Waste situation in India. While highlighting the ground reality, the manuscript aims to lay out the plausible solutions that can be adopted in India to ensure effective e-waste managing for a sustainable environment.

**Keywords:** E-waste management, Sustainable Development Goals, Electronic Waste, e-Waste, Electronic Garbage

## I. INTRODUCTION

Electronic waste (e-waste) implies waste rising from the end of life of electrical and electronic products (EEE). E-waste is hastily becoming a global alarm[1], [2]. With the rapid technological advancements, the cost of EEE components has reduced and their capability improved manifold[3]. This further amalgamated by the reduced obsolescence age of EEE is leading to increased garnering of e-waste especially in nations with greater per capita income as compared to the ones with lower per capita income[1]. Effective E-waste management has become a grave issue in India, as the country is one of the world's largest producers of electronic waste[4]. Added to this is also the e-waste which is illegally dumped into the nation from other developed nations[5]. The expansion of IT and communication industries in the country has directly increased the usage of electrical and electronic equipment's (EEE) [6]. Thus, proportionally the amount of e-waste in the country is also growing rapidly[7]. India produced a projected 1.7 lakh metric tons of e-waste in 2022[7]. As per records, only 22.7% of the overall e-waste generated in 2019-20 was actually composed, dismantled, recycled or disposed of[8]. This statistic is a grave concern not just from the environmental or human-health perspective but also from the perspective of sustainable development goals (SDG) achievement scenario[9]. In order to ensure a sustainable environment, it is essential to develop effective strategies for managing this rapidly expanding pool of e-waste[10]. The above clearly indicates the grim state of e-waste in India. As a significant member of the SDG2030 as well as the host of G20, it is important that we realize the challenge of e-waste and devise efficient strategies to handle it before it results in wasting us as a nation. We delve into the issue in detail in the sections below:

### A. E-Waste, SDG and India

E-waste can also be best described as the fatal and toxic returns on investment of digitization[11]. Shrinking size, cost and increasing capacity of hardware along with the increased pace of digitization has paved way for short-term replacement of electronic gadgets[12]. This has led to an ever-increasing size of e-waste which due to absence of safe and streamlined disposal and treatment mechanisms is a substantial health and environmental concern[13]. It shall also become a major block in achievement of Goal 3, 6,8, 11,12 and 14 of the 17 sustainable development goals which have also been embodied by India[14]. Scientific methods of e-waste disposal shall help

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in realizing and streamlining sustainable development in a natural, realistic way[15]. Electronic-waste and the SDGs share a strong interconnection[16]–[20]. India like many other neighboring countries faces humongous challenges in disposing and recycling of this e-waste while embarking on the SDG 2030 goals[11], [21]. Table 1 below analyses the inter-relationship between e-waste and the SDG with respect to India.

**TABLE I.** INDIAN INTER-RELATIONSHIP BETWEEN E-WASTE AND SDG 2030

S.No.	SDG	Challenge	Opportunity
1.	3- Good Health and Well-Being	Informal e-waste recycling practices result in exposure to hazardous materials posing serious health concerns to workers and nearby communities.	Formal e-waste management with investment in safer methods and worker training and sensitization can help mitigate the health hazards. Thus, leading to individual well-being.
2.	6- Clean Water and Sanitation	Informal e-waste disposal mechanisms pollute the water. Poor sanitation practices especially for people directly exposed to e-waste may further result in their consumption of harmful ingredients.	Streamlining e-waste disposal and regulating miscreants through strict law enforcement can help in maintaining clean water and thus promoting sanitation of individuals.
3.	8- Decent Work and Economic Growth	Informal e-waste recycling mechanisms are the livelihood source for many. However, this is a major challenge in terms of safety and security.	Formalizing e-waste recycling segment can make decent and sustainable employment opportunities, boosting economic growth while controlling poverty.

4.	11- Sustainable cities and communities	Rapid urbanization has led to higher e-waste concentration in cities.	Investment in centralized/ distributed recycling structures through public/private partnership, awareness campaigns can help make sustainable cities and reduce the environmental impact.
5.	12- Responsible Production and Consumption	Indian middle class increasing consumerism has surged the purchase of electronic devices resulting in e-waste generation	Sustainable production policy and responsible consumption guidelines can help reduce e-waste generation.
6.	13- Climate Action	Informal disposal and recycling contribute to greenhouse gas emissions and climate change.	Sustainable e-waste management can reduce green-house gas emissions and climate change.
7.	17- Partnership for the Goals	Effective e-waste management calls for joint public-private partnership with the government. This can be challenging in India	Strengthening public-private partnership shall help address the e-waste issue as well as achieve the SDGs.
8.	Legislation and Policies in India	India introduced the E-waste management	Enforcement and awareness regarding rules is scarce.

		and handling rules in 2016. These aimed at regulating the generation, collection and recycling of the e-waste align with the SDG12	Regulatory compliance and awareness campaigns are the need of the hour to overcome the e-waste challenge.
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Table I above indicates that e-waste management in India is strongly interlinked to multiple SDGs. Comprehensive regulations, awareness campaigns, collaborative efforts and infrastructural investments are called for to address the e-waste challenge and achieve SDGs.

### B. Global E-Waste Context

E-waste is not just an Indian concern, globally also it is a complex outcome of the rapid proliferation of the electronic goods and devices[13], [22]–[25]. Table II highlights the global problem scope along with its environmental, social impacts and potential solution.

**TABLE II.** GLOBAL E-WASTE IMPACT

S.No.	Issue	Concern
1.	Problem Scope [25]–[27]	
a.	Growing Quantity	E-waste is a rapidly proliferating waste stream globally.
b.	Distribution	High-income countries are the key producers of e-waste. However, a noteworthy portion of this is illegally exported to low- and middle-income nations.
2.	Environmental Impact[28]–[30]	
a.	Toxic Materials	E-waste is constituted of many hazardous materials like lead, mercury, cadmium etc. If not managed properly they leach into the soil, air and water posing significant health and environmental concerns.
b.	Resource Depletion	Improper e-waste disposal results in significant loss of rare earth metals used in EEE. This further leads to resource scarcity and environmental degradation.
c.	Energy Consumption	The manufacturing, use and disposal of electronic devices consumes substantial energy, contributing to green-house gas productions and climate change.
3.	Social and Economic Impact[31]–[36]	

a.	Health Risk	Humans involved and exposed to informal e-waste recycling mechanisms face health risks which may prove fatal if prolonged.
b.	Economic Opportunities	Formal e-waste management can create jobs in the recycling sector.
4.	Regulatory & Policy Compliance[12], [37]–[39]	
a.	Lack of Regulation	Lack of stringent regulations and their implementation leads to inconsistent disposal practices and illegal dumping.
b.	Extended Producer Responsibility (EPR)	EPR can help transfer the problem of disposal and recycling to the manufacturers, forcing them to design sustainable products.

To overcome the e-waste challenges listed in table 2 above, following can be the effective mitigation strategies:

- i. Recycling and Circular Economy- Encourages responsible disposal and formal recycling of EEE, thus recovering valuable material and reducing the environmental impact.
- ii. EPR Programs-Government and industries can implement EPR programs to ensure the manufacturers take life cycle responsibility of their products.
- iii. Consumer Awareness- Consumers need to be enlightened about EEE constituents and their harms thus promoting responsible disposal.
- iv. International Co-operation- international collaboration can help in adoption of best practices and formal recycling methods thus promoting a sustainable ecosystem.

Thus, we may say that global e-waste issues are multifaceted, with far-reaching environmental, social and economic consequences. Addressing these concerns requires a collaborative effort from all the stakeholders involved.

*C. Hazardous Substances Found in E-Waste*

The EEE industry is the largest and most forward-thinking in the world[40]. Various tons of electronics are transported annually across oceans, but once they have outlived their usefulness, they become a complicated waste matter if not stocked and recycled formally[21]. E-waste is complex and made up of over 1000 potentially dangerous heavy metals, acids, poisonous compounds, and non-degradable polymers[41] which may have far-reaching consequences as listed in table III below:

**TABLE III. PROMINENT HAZARDOUS SUBSTANCES IN E-WASTE**

S.No	Hazardous/ Toxic Substance	EEE Source	III Effects
1.	Lead (Pb)	All electronic Products like CRT	Leaching of hazardous content in soil from landfills.
2.	Cadmium (Cd)	Computer Monitors/CRT, Computer Batteries	Contamination of river, well and other water sources after disposal.
3.	Mercury (Hg)	Switches, CFI, Flat Screen	Emission of harmful gases on burning.
4.	Polychlorinated Biphenyls (PCB)	Capacitors, transformers, Brominated Flame	

		Retardant on PCB, Plastic Casing, Cables, PVC Sheathing	Human Health hazard through skin contact, gas inhalation, water intake as well as acid treatment.
5.	Arsenic	Semiconductors, Diodes, Microwaves, LEDs, Solar cells	Long term exposure may result in cancer and skin lesions. It may also result in inhibition of growth and death of plants.
6.	Barium	Electron tubes, filler for plastic and rubber, lubricant additives	Nausea, vomiting, irregular heart beat, muscle weakness, tremors, paralysis and even death in case of prolonged exposure.
7.	Copper (Cu)	Cables, copper ribbons, coils, circuitry, pigments	Excess consumption may lead to liver damage, abdominal pain, cramps, nausea, diarrhoea and vomiting.
8.	Lithium	Mobile phones, photographic equipments, video equipments	Prolonged exposure may result in loss of appetite, nausea, vomiting, diarrhoea and abdominal pain along with coma.
9.	Nickel (Ni)	Alloys, batteries, relays, semi-conductors, pigments	Exposure may lead to skin irritation and harm the lungs, kidney and stomach.
10.	Silver (Ag)	Capacitors, switches, batteries, resistors	Acquaintance to high points may affect breathing, lung and throat irritation and stomach pains.
11.	Zinc (Zn)	Steek brass, alloys, disposable and rechargeable batteries	Overtotoxicity may lead to nausea, vomiting, lethargy, epigastric pain and fatigue.

Table III above is not a complete list of all hazardous substances; however, it details certain common hazardous substances that are part of most of the e-waste generated[42]. The details prove beyond doubt how these substances directly affect the environment be it land, water or air and may finally permeate into humans and result in fatalities.

It may also be noted that, in India most of the e-waste is either dumped, burned, or shipped to recycling facilities[43]. However, over 75% of electronic wastes are not appropriately reused, which includes refurbishing, remanufacturing, and reusing their parts for repair, etc.[44]. Many respiratory and skin disorders are brought on by the smoke and dust particles, which contain carcinogens and other dangerous compounds that cause severe inflammation and sores[3]. Carbon particles from the toners are carcinogens, and they may cause lung and skin cancer if inhaled[45]. The practice of burning circuits to hunt for valuable metals like gold, platinum, and cadmium produces smoke due to the presence of PVC and PCB in the wire coating[42].

#### *D. Objectives of the Study*

The key contributions of this manuscript are as follows:

- i. To conduct an empirical investigation into e-waste classification, the varied issues, current management strategies in India.
- ii. To identify the global e-waste management strategies for the same.
- iii. To lay down an actual e-waste management framework the country can adopt to ensure a sustainable environment with advanced, effective e-waste management.

The main implication of this study is to provide a concise understanding of the e-waste hazards, map the conventional e-waste disposal mechanisms in the country and lay down an effective proposal for the policy makers in the domain of effective e-waste management.

## II. E-WASTE CLASSIFICATION

Before evaluating e-waste management strategies, it is necessary to arrive at common classification ground for e-waste identification and sorting[46]. Hence, a uniform as well as globally acceptable classification system would be desirable, that could classify e-waste products on parameters like: similar function, material composition in terms of hazardous substances and valuable materials, related end attribute etc. This classification has been suggested by United Nations University, (UNU) [47], 2016 report. This report was referred to as UNU-KEYS. Taking this report as the basis the European Union Waste Electrical & Electronic Equipment (WEEE) directive was enforced in EU member states since 2017[47]. The list covered over 900 products which have been classified into 10 primary categories which are further sub-categorized into 54 categories. However, as a recast from 15<sup>th</sup> August, 2018 the list reports only six categories which represent the major e-waste collection streams in actual practice. An overview of these 6 primary categories is listed in table IV below:

TABLE IV. PRIMARY E-WASTE CATEGORY

S.No	EEE Category as per WEEE Directive
1	Temperature Exchange Equipment (Cooling and Freezing)
2	Screen and Monitors
3	Lamps
4	Large Equipment
5	Small Equipment
6	Small IT and telecommunication Equipment with an external dimension of less than 50 cm

Table IV above lists the major WEEE category. It was found that this directive is either directly used (eg: Mauritius) or a smaller scope is applied (eg: China) in different countries across the globe[48]. The EU member states set a collection target based on a percentage of amounts Put on Market (POM or EEE sales) in the three preceding years or as a percentage of e-waste generated[21]. However, this change of target requires an improvement in e-waste statistics related to e-waste collection[49]. After thorough analysis, it is felt that in India despite the availability of regulations and guidelines their awareness among all the stakeholders be it customers, transporters or workers is poor. Hence, the primary need of the hour was to raise awareness among the public about the importance of proper disposal and recycling of any kind of e-waste items.

## III. E-WASTE ISSUES

E-Waste is a globally important apprehension especially in developing countries like India[3]. It comprises of both toxic as well as valuable materials like rare-earth and precious metals. In India, e-waste management can be broadly categorized into two broad categories namely formal as well as informal or unorganized sector[49]. However, it should be noted here that the informal sector is quite disorganized and almost without any specific rules and regulations for e-waste disposal. The informal sector, however, dominates e-waste management in India[49]. This unscientific processing of e-waste resulted in deterioration of environmental as well human-health. Thus, the challenge is to effectively handle this expanding pool of untreated e-waste.

### A. E-Waste issues

We shall now evaluate certain major issues of concern due to the rising e-waste especially wrt India.

Increasing amount of E- Waste

The short life lifetime (less than two years) of many electrical and electronic equipment's is a direct outcome of the rapid pace at which innovation and product manufacturing/marketing are moving[1]. The volume of electronic waste is projected to double during the next five to six years due to the combination of a short product life duration and an exponential increase of 15% annually [50].

#### Toxic components

Toxic materials like aluminum, copper, lead, cadmium, mercury, polychlorinated biphenyls (PCBs), etching chemicals, brominated flame retardants, etc. are commonly found in electronic waste and must be properly disposed off [51]. However, there is a wide variation in recycling procedures between formal and informal sectors, which led to the unchecked discharge of harmful compounds into the environment due to the careless handling of toxic materials [7].

#### Lack of environmentally sound recycling infrastructure

It has been demonstrated that when correct disposal methods are not taken, e-waste ends up in the hands of scrap merchants and is eventually integrated into the supply chain of dismantlers[52]. The current, environmentally unfriendly recycling infrastructure cannot cope with the ever-increasing quantities of e-waste[8]. Most dismantling work is performed in the unregulated informal economy[41]. Due to presence of a wide variety of toxic materials, these contaminants are a grave threat to the ecosystem.

#### Poor Information

There is a complete lack of state-wise e-waste inventories which should be maintained by respective state pollution control boards (SPCBs). Sales data of EEE products which can act as an input to accurate forecasting of e-waste production is also not available. Further, the situation is deteriorated further by e-waste being illegally imported from other developed economies. Hence, regulated systems for effective, transparent, formal collection, transportation and processing of e-waste are the need of the hour.

#### Unsustainable Informal Sector Practices

Despite rise in the number of formal dismantling and recycling facilities the actual e-waste processed in the formal sector is even lower than their capacity[43]. This can be majorly attributed to the lack of awareness and the cost of returning the end-of-life equipment to collection centers. Thus a robust system of collection and processing of e-waste is needed. This would also demand appropriate transformation of the informal units into formal centers as they are the source of livelihood for many marginalized groups.

#### Market Frictions

E-Waste recycling being a relatively novel business opportunity may not attract many private players. Further, lack of information on cost effective recycling technologies could be a major barrier. This calls for a well-defined public policy for effective dissemination and management of e-waste[15].

#### Inadequate regulatory enforcement

Majority of the e-waste processing in India is through the informal sector. Implementation of regulations in this sector is another humongous challenge[53].

### IV. E-WASTE MANAGEMENT IN INDIA

India was the world's fourth-largest producer of electronic garbage in 2018[41]. According to a study done by The Associated Chambers of Commerce and Industry of India (ASSOCHAM) and KPMG in 2018, at an estimated 2.1 million tonnes per year, India is one of the top five countries in terms of e-waste output[54]. Approximately 30–60 million tonnes per year is produced worldwide[43]. Besides this grim situation of e-waste, India is also swiftly progressing towards the attainment of the sustainable development goals SDG2030 [21]. Of the important sustainable development goals namely 3, 6, 8, 11, 12 and 14 an important lacunae is the unavailability of effective and efficient e-waste disposal mechanisms[55]. Thus how efficiently India manages its e-waste in the upcoming years shall decide its attainment of SDG 2030 [15].

### A. Conventional Mechanisms

We now review the conventional e-waste management strategies in India. Table V below lists some significant works that have detailed the same.

TABLE V. CURRENT E-WASTE MANAGEMENT STRATEGIES IN INDIA

Sr. No.	Reference	Description	Critical Opinion
1	[56]	Propagates a legal framework to mandate extended producer responsibility (ERP), and reduction in use of hazardous substances (RoHS) to replace poisonous components with ecologically friendly substitutes.	Legal framework implementation is a long battle in India. Further any specific guidelines for achieving the same have not been proposed.
2	[57]	Most e-waste is dangerous. All stakeholders should thus share responsibility for controlling the environmental impact of these products and save environment.	Any specific guidelines to achieve product stewardship are again missing.
3	[58]	Outlines the course of action for betterment in e-waste management covering the required improvement plans.	Current initiatives are not completely analyzed.
4	[59]	Proposes conceptual models for e-waste strategies and e-waste strategy determinants from the available literature	Actual implementation of the framework to all domains is yet to be seen.
5	[60]	Identifies that major portion of e-waste is dumped in landfills that are a major cause of secondary concerns. It identifies the growing scale of the problem.	Proposes that the only viable solution to the problem of rising e-waste is to reduce the same. However, the proposal does not seem viable.
6	[61]	Health risks and environmental deterioration due to incorrect e-waste disposal is a serious issue in India.	Calls for a more environmentally sound e-waste management with support from all stakeholders.
7	[62]	BRICS nation account for one-quarter of world's land area and almost half of the world's population. However, significant gaps have been identified in waste management in these nations.	Introduces a novel framework for waste electrical and electronic equipment management system that could be implemented in BRICS nations.
8	[63]	Identifies the most intriguing e-waste management issues of India and China.	Calls for a holistic e-waste management strategy to be called for developing countries.
9	[64]	Challenges of e-waste management in India have been delineated.	Needed policy interventions are discussed but their achievement is another challenge.

### V. EFFECTIVE AI ENABLED E-WASTE MANAGEMENT STRATEGIES

Taking que from [63], India should plan a holistic e-waste management framework. This would call for a joint effort from all stakeholders be it manufacturers, traders, customers, government or the recyclers. Only a combined effort at all levels could save the nation from a doomed, environmentally unsustainable future.

Artificial Intelligence (AI) and Machine Learning (ML) based solutions can be useful in planning solutions for the Indian context where tools can be enabled to indicate electronics lifetime exhaustion. For effective e-waste collection and disposal we suggest a basic guideline as below:

**Step 1: DATA COLLECTION & EPR** for Centralized recording of all EEE items manufactured across the country or imported in to the nation-

This is a humongous task as it would imply huge data collection and recording at the individual district level and then a transparent framework for transferring this data to the state and central regulatory authorities. This step would allow the authorities assume and predict the amount of e-waste and dead stock to be handled in the near future. Machine Learning based recording and alarming system should be setup across the country that is available to all manufacturers that can help record production data of all such devices.

**Step 2: REGULATED DISPOSAL** through clear guidelines regarding disposal of e-waste with introduction of attractive schemes like buy back etc. This can also be achieved in diverse nation like India by having ML backed solutions that can track users and lifetime of their products.

Confirmed to be crucial to the expansion of an e-waste management system are both public education and manufacturer participation[48].Hence, public awareness regarding importance of proper e-waste disposal should be raised. Also manufacturers can promote schemes like buy-back or exchange for new to get back the e-waste into the formal supply chain and promote their formal disposal.

**Step 3: FORMALISATION-** Transformation of informal sector of e-waste assembly and disposal to formal collection centers by promotion of private players-

Due lack of knowledge e-waste has never been an attractive business opportunity. However, in recent years due to government support , almost 500 e-waste management firms have come up like [65]–[68]. These firms can play a noteworthy role in converting the informal, conventional, unsustainable e-waste disposal practices to formal, e-waste recycling practices.

**Step 4: RECYCLING-**Start a national inventory spanning all cities and sectors. Define liability of all stakeholders.

Develop a public-private E-waste forum.

Extended producer responsibility (EPR) extends a producer's accountability for a product to its post-consumer stage, including final disposal. All electronic equipment manufacturers must provide end-of-life take-back and management services. The obsolete electronic product should be recycled or re-used in a separate division or a common facility. Collection centers will ensure appropriate collection and transfer to the recycling unit. Only recyclers with authority to handle, process, refurbish, and recycle should be allowed.

“Recycle and Reuse or Stop Use” should be the aim of India with respect to e-waste if we want to keep growing as a sustainable economy and not perish under our own e-waste pile.

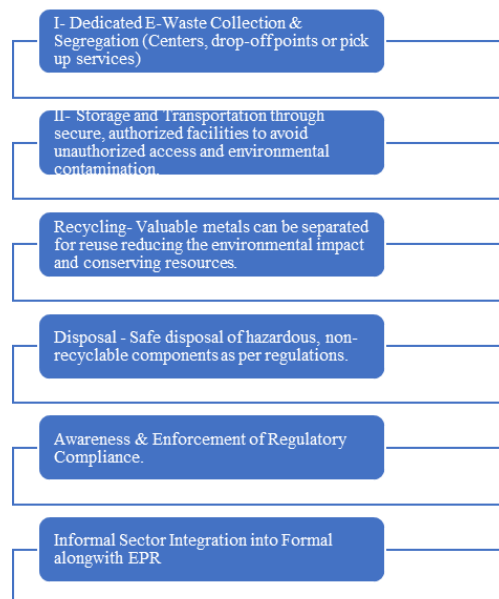


Fig. 1. Proposed E-Waste Management guidelines

## VI. GLOBAL E-WASTE MANAGEMENT SOLUTIONS

It was noted that though each country has its conventional formal as well as informal e-waste management mechanisms[38]. The informal strategies were a potential environmental and health hazard to the workforces and their families. As a result, countries across the globe have identified these underlying risks of e-waste management through conventional means and have adopted certain renewed policies and strategies to process the rapidly generating e-waste in a sustainable manner. Table VI below lists a few such commendable strategies:

TABLE VI. NOTABLE SUSTAINABLE E-WASTE MANAGEMENT SOLUTIONS

Technique	Highlight	Industries Used
Plasma [69]	It creates ionization to eliminate harmful elements & vitrify contaminants in e-waste	Moist paste battery, galvanic sludge, resin, printed circuit board, semi-conductor industries.
Thermal based imaging Technique using Long-Wave infrared (LWIR) range 8-15 $\mu\text{m}$ . [70]	Uses feature vector encompassing of mean intensity, standard deviation & image sharpness extracted from thermograms of individual materials.	E-waste recycling
Mobile Robot [55]	Identification of e-waste and further segregation using transfer learning	Attachment to existing municipality garbage trucks
Microbial Technology [39]	Microbes allow leaching of metal into liquid form and removing hazardous pollutants from different metals.	PCB, 2020 Tokyo Olympics all medals made from recycled waste.
Urban mining [12]	Sustainable, novel trend in dispensation of e-waste	Precious metals extracted can be put back in supply chain reducing the demand and pressure on virgin mining.

Table VI highlights certain global solutions However, it may be noted that in a geographically diverse nation like India an AI-ML enabled solution can only come to rescue of efficient e-waste tracking and management strategy. In our future work, we shall also propose a solution for the same.

## VII. CONCLUSION &amp; FUTURE WORK

The aim of this study was to pronounce and assess the key extents of research on electrical and electronic waste, providing a wider review of the relevant literature to summarize the information accessible and to build common understanding. A few important lacunae were deduced from this. Firstly, many countries across the globe including India, don't have any defined technique to measure e-waste generation. Hence developing countries must implement and frame policies for efficient e-waste management to address environmental concerns arising from improper informal recycling. One of the difficulties for policymakers in developing nations is creating a legal outline for the management of this waste percentage. Education and training programs about the proper disposal of electronic trash should be developed. As such, the purpose of this research was to scrutinize the various national recycling strategies that have been implemented to deal with and manage e-waste. For this study, we opted for a qualitative approach. This study draws on a wide variety of sources, including a conference paper, journal articles, reports, and regulations. We have also suggested basic steps involving AI and ML that government can take towards achieving a sustainable e-waste management policy for the nation as well as the different alternatives which if adopted can also serve as a suitable replacement Current e-waste management strategies in India solutions for e-waste management in a sustainable way. In future, these strategies and their suitability on different e-waste can be evaluated on a case to case basis.

## COMPETING INTEREST DECLARATION

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

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#### AUTHOR CONTRIBUTION

Dr. Parul Arora conceived and created all the figures to support all the text reported in this work.

Dr. Ritika Wason created all the content as well as managed all the citations.

Prof. M. N. Hoda was responsible for all checking the content and guiding for the same

Devansh Arora suggested use of AI-ML for successful management of e-waste in India

#### DATA AVAILABILITY

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

#### RESEARCH INVOLVING HUMAN AND/OR ANIMALS

#### INFORMED CONSENT

No human and/or animal related material was used in this research.

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