Strategies for Managing Electronic Waste: A Systematic Review of Literature

Anjani Kothari
Research Assistant,
Indian Institute of Management, Udaipur
anjanikothari9@gmail.com

Dr. Anshika Sharma
Assistant Professor,
Nirma University,
Institute of Technology, Ahmedabad
anshika.sharma@nirmauni.ac.in

Harsha Kumawat
NET-JRF,
Mohanlal Sukhadia University, Udaipur
harsha.kmwt04@gmail.com

Abstract

Over the past two decades, the global market for electrical and electronic equipment (EEE) has experienced enormous expansion, and it is predicted that this growth will continue in the years to come. The fact that these products are winding up in landfills and recycling facilities presents law makers with a new hazard. To identify e-waste (Electronic waste) management strategies, this paper will conduct a systematic review of literature. The study uses the SALSA (Search, Appraisal, Synthesis, and Analysis) and PRISMA(Preferred Reporting Items for Systematic Reviews and Meta-Analyses)framework for the systematic review of literature along with VOS viewer software which helps in creating a map based on text and bibliographic data and NVivo for creating a wordcloud. Under the SALSA framework, SLR (Systematic Literature Review) is carried out in 4 steps. While in PRISMA studies are evaluated at four levels. The research paper concludes that rules and regulations, take-back programs, EPR (Extended Producer Responsibility), reuse, repair, recycle, reducing, green computing, and registered e-waste collectors as the efficient strategies for the management of e-waste, and the same is represented through a model. This paper is used for future research.

Keywords: Waste Management, Strategies, Electronic, Sustainability, Recycling

Figure1: WordCloud

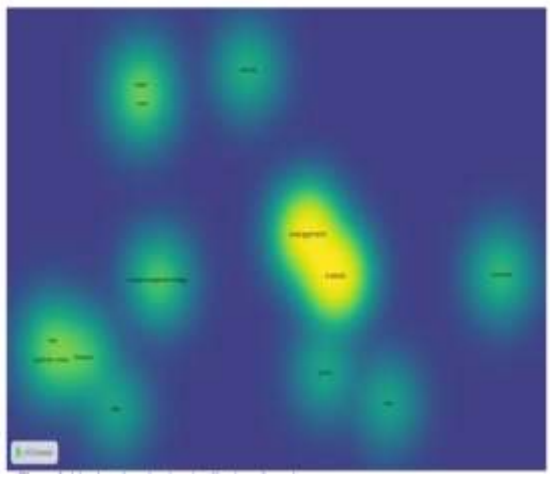
Source: Developed by researchers using NVivo

Introduction

Any malfunctioning or undesired electrical or electronic item that has been thrown by its original user is considered electronic garbage, often known as e-waste. It also includes garbage that was produced when producing and putting together electrical equipment. Since harmful substances like dioxins, polycyclic aromatic hydrocarbons, heavy metals, lead, and mercury can contaminate both the soil and the water, and because people who live close to e-waste disposal sites are more likely to be affected by the release of such harmful substances, it has resulted in the atmosphere degrading (Do et al., 2023; Ullah, 2023). Thus, it is very important to tackle the issue of e-waste through proper management to reduce its harmful impacts.

According to (Finlay and Liechti, 2008)current situation of e-waste could be managed through government regulations such as by positively linking job creation and economic development with e-waste management. As per (Gaidajis, 2010; Yu, 2023), corruption in the crime and recycling industry, lack of proper e-waste initiatives, constant technological advancements, and disrupted recycling models are the major reasons for the increase in the volume of e-waste. Electronic waste can be managed through enhancing industry participation, technological investment, public education, small business development, health and safety, recycling impact assessment, informal collection, and recycling, import of second-hand products, and monitoring (Shi et al., 2023). While as per (Joseph, 2007), it is the responsibility of manufacturers to manageе-waste such as adopting a take-back policy. In the view of (Borthakur, 2023; Kumar et al., 2017; Pandey and Singh, 2023; Chien et al., 2021), safe disposal, eco-labeling, recycling, awareness, tracking, rules, and regulations are the various e-waste or solid waste management approaches adopted in the country.

Figure 2: Map based on density visualization of text data



Source: Developed by researchers using VOS viewer

A total of 7 clusters were formulated based on text data. Only those words were identified by the software which was used most frequently. In the figure above, we can see that all the terms which are in the same cluster are related closely. Even the darkness of the yellow color shows the degree of relatedness between the two terms. The darker the color, the more the terms are used frequently such as management and e-waste are mostly used together, repair and reuse generally come together, etc.

Research Questions

- A research question is formulated and is mentioned below:
- What are the e-waste management strategies' shortcomings and how to overcome them?

Objectives of the Study

- To classify various e-waste management strategies identified by different authors
- To identify strategies practiced for the management of electronic waste in different countries
- To examine the number of E-waste management studies reviewed
- To develop a map based on bibliographic data using a VOS viewer software.

Methodology

Method Overview

This study conducts a thorough literature evaluation on e-waste management strategies. The systematic review of literature is very different from the literature review. Though both use secondary data and summarise existing literature on a specific topic. A systematic review of literature is used to identify, select, appraise, and synthesize high-level secondary data to answer formulated research questions (Andriuškevičius and Štreimikienė, 2022; Mengist et al., 2020). While on the other hand, literature review uses informal or subjective methods to qualitatively summarise topics related to studies. The key principles behind systematic literature reviews are integration, focus, transparency, clarity, equality, coverage, and accessibility. Thus, for carrying out a systematic review of literature; SALSA Framework is used (shown in Table-1).

Table 1:The Framework for the systematic review of literature

	Steps	Outcomes
SALSA Framework	Search	Finding
	Appraisal	Assessing for quality
	Synthesis	Looking for patterns
	Analysis	Making sense of the patterns

Source: Developed by researchers

It supports an exhaustive search process by combining strengths of critical review so that broad or narrow questions can be analysed in the best way. It is not only used to identify each type of review but is also used to distinguish them from each other. In this article, we will evaluate 20 reviews against the already established SALSA framework. This framework for a systematic review of literature applied 4 steps and the details of the same are shown in Table-1 above.

Method Details

It involves 4 basic steps:

Step 1 for SLR: Search

This step of the systematic review of literature is very essential for increasing the transferability, transparency, and replicability. Under this step, search scope, search choice, and search criteria all will be covered.

Search Scope

The researcher investigated Extended Producer Responsibility (EPR), e-waste management solutions, e-waste policies and regulations, recycling, repairing, reusing, reducing, e-waste collectors and efforts to be undertaken by government and manufacturers for the management of electronic waste. The study reviews literature related to e-waste management strategies. This study is an effort to present the literature systematically so that future researchers will be benefitted from acomplete understanding of this area in a single place.

Search Process

Articles, doctoral dissertations, and book chapters are selected from various research databases such as EBSCO, Scopus, Web of Science, and Research Gatebased on keywords and reference work. A wide range of studies is selected from these databases. Some specific journals like the Journal of Environmental Engineering and Management, Sustainability, Journal of Cleaner Production, Economies, Sustainable Development, etc were used for the selection of articles. Relevant keywords such as e-waste, management, strategies, repair, reuse, and recycle were used for the selection of studies(shown in Table-2).

Table 2: Literature Search Details

Research Databases	Scope	Time of search	No. of articles selected.
EBSCO	Keywords, Abstract, Full-Text	January 2021-May 2023	7
Scopus	Keywords, Abstract, Full-Text	January 2021-May 2023	15
Web of Science	Keywords, Abstract, Full-Text	January 2021-May 2023	20
Research Gate	Keywords, Abstract, Full-Text	January 2021-May 2023	20

Source: Developed by researchers

Search Criteria

The selection of studies for a systematic review of literature is based on inclusive exclusive criteria. The major focus is on studies that had predefined keywords present in the abstract or title or both and the studies which were primary or original. While on the other hand, duplicate studies, conference proceedings, editorial letters, and publications before 2006 are excluded (shown in Table-3).

Table 3: Inclusion & Exclusion Criteria of Studies

Criteria	Decision
Studies that have predefined keywords present in their abstract or title or both	Included
Studies that are freely accessible or require access	Included
Articles, Books, Doctoral Dissertations	Included
Studies that are primary or original	Included
Publications before 2006	Excluded
Duplicate studies	Excluded
Conference Proceedings, Editorial Letters	Excluded

Source: Developed by researchers

Step 2for SLR: Appraisal

This is a phase where selected studies are evaluated (Grant and Booth, 2009).Evaluation of studies was done using PRISMA Framework (Beller et al., 2013; Johnson et al., 2020; Stewart et al., 2015; Zarate et al., 2022)in 4 levels:

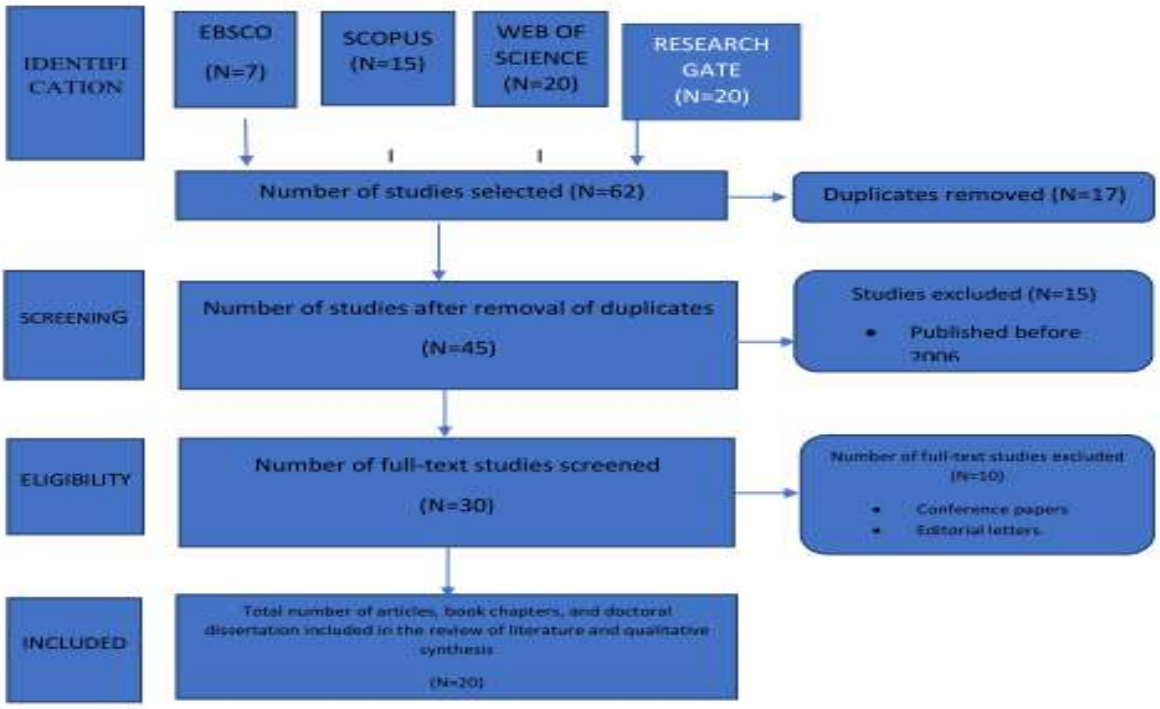
Level 1 (Identification): After searching relevant keywords and reference work through EBSCO, Scopus, Web of Science, and Research Gate, a total number of 62 studies were selected. Out of 62, 7 were selected from EBSCO, 15 were selected from Scopus, 20 were selected from Web of Science, and 20 from Research Gate.After selecting studies, 17 duplicate studies were removed.

Level 2 (Screening): 45 studies were identified after the removal of duplicates; out of which 15 studies were excluded. At this step, those studies were excluded which were published before 2006.

Level 3 (Eligibility): A total of 30 full-text studies were screened and based on eligibility criteria; 10conference papers and editorial letters were eliminated.

Level 4 (Included): Finally, after the first 3 steps of the systematic literature review process, 20 studies from articles, doctoral dissertations, and book chapters were found suitable for the systematic review of literature and qualitative synthesis.

Figure 3: SRL through PRISMA Framework



Source: Developed by researchers

Step 3 for SLR: Synthesis

Under this, extraction and categorization of studies are done (Andriuškevičius and Štreimikienė, 2022; Siksnelyte-Butkiene et al., 2021). Researchers carried out research both at national and international levels for determining practices for waste management of electronic products and on that basis, the review is divided into seven parts:

Figure 4: Classification of e-waste management strategies

Source: Developed by researchers

Studies addressing rules and regulations formulated for proper management of e-waste

Ghatak (2021) studied sustainable municipal waste management in Indian cities. The study reflected efficient solid waste management as one of the main issues Indian cities are now facing because of the high standard of living and increase in population. The study even threw light on rules formulated for proper solid waste management such as The Municipal Solid Wastes Rules, 2000 which were later amended in 2016 and were introduced by the Ministry of Environment and Forests, and Solid Waste Management Rules,2016 which were implemented by Government of India to improve the current situations and the findings demonstrated that these rules had a significant impact on solving the issues associated with waste management such as landfill, pollution, disposal, and dumping.

In the view of (Arya and Kumar, 2020)the Indian government has taken several steps to address the issue of e-waste, including Municipal Solid Waste Management, domestic e-waste collection by the unorganized sector, and the formulation of several rules for managing e-waste, including the E-waste (Management) Rules 2016 and E-waste (Management) Amendment Rules 2018 and the E-waste (Management and Handling) Rules, 2011.The study also emphasized the necessity of managing e-waste and recommended approaches to address this issue, such as technological advancement, application of the 4'Rs, EPR, and ECR, development of value-added products, development of an ideal supply chain, manufacturing premium quality products, ensuring environmental policies implementation, enhancement of skill and proper training and the important players involved in this are government sectors, The Directorate General of Foreign Trade, NITs, IITs, Manufacturer Association of Information Technology, NGOs, and NEILIT. According to the article, the main e-waste components were LCD, fluorescent lamps, PCBs (Printed Circuit Board) and CRT (Cathode-Ray Tube), switches, relays, flat-screen displays, old computers, polyvinyl chloride (PVC) plastics, mobile phones, batteries, lubricant additives, plastics fillers, tubes, microwaves, LEDs, semiconductors, and diodes, all of which could weaken the immune system, cause cancer, upset the stomach, damage brain as well as liver, deplete ozone, contaminate air and water, create medical complications or cause spewing.

Oteng-Ababio and Amankwaa (2014) research was done on Ghana's present e-waste management techniques. The study included information on numerous programs and international legislation developed for managing e-waste as in Japan, the "Consumer Pay model" was adopted, which required retailers to accept returns of the products they were provided with and required consumers to cover the cost of product collection and recycling. While, the Extended Producer Responsibility policy adopted by the European Union held producers accountable for their products, the 'Mixed Model' employed by the USA which involved state regulations, “Regulation on the Administration of the Recovery and Disposal of WEE” propagated by China; under which designated cash was given for e-waste collection and treatment. In the African continent, acts have been designed to manage electronic waste such as Consumer Protection Act and The National Waste Act.

Studies addressing efforts to be undertaken by government and manufacturers for the management of e-waste

Danish et al. (2019) observed that e-waste is a major environmental problem all around the globe and with the innovation in technology, this problem had increased. The study's findings revealed that social responsibility, social identity, conditional value, emotional value, functional value quality, and price all had a substantial beneficial influence on the behavior of sustainable consumers towards the purchase of electronic products.

Singh (2016)analyzed the waste management and public health issues in Indian cities because the chemicals in e-waste are harmful to both the environment and human health and identified solutions to these issues. Toxic substances present in e-waste which had harmful impacts were Lead, Chromium, Plastics, Mercury, Acid, Beryllium, and Cadmium. While on the other hand, strategies such as multi-criteria analysis, law, logistics, material flow analysis, collecting system formulation, life cycle analysis, EPR, and personnel, as well as stringent rules on better

management for a better working environment, were identified.

Studies addressing the management of e-waste through repair

Hernandez et al. (2020) were opinionated on enabling sustainable consumption by restoring the "Right to Repair" to customers. The themes reviewed in the article were the eco-design, circular economy, circular design, repair, sustainable product design, product repair, and sustainable behavior. The article highlighted social learning, making possible, empowering, educating and informing as the possible approaches for promoting repair behavior. While the proposed dimensions of repair are repair level, agent, outcomes, and barriers.

Kianpour et al. (2017) studied the elements that encourage customers to recycle discarded electronic goods through reverse management of the supply chain. The article defined RSCM (Reverse Supply Chain Management) as a process through which the producer agrees to take the parts or products from customers for recycling, reuse, and repair. The study highlighted the factors such as risk perception, self-efficacy, knowledge of ecology, and benefits related to recycling, reuse, and repair as the crucial elements for shaping the customers' attitude towards returning end-of-life electronic products.

King et al. (2006) studied waste reduction tactics of repair, reconditioning, remanufacturing, and recycling. The study characterized mending as a strategy for correcting specific product flaws; as a result, the quality of a repaired product is lower than that of reconditioning, remanufacturing, and reconditioning, which involves rebuilding a product to improve its functioning. While recycling is the process of gathering and processing waste materials and remanufacturing is the practice of manufacturers who purchase discarded goods and remanufacture them into new goods with higher quality. Reducing waste through recycling has been found to require the most corrective effort.

Studies addressing the management of e-waste through recycling

Islam et al. (2021) carried out a case study with college students to learn more about their awareness of e-waste and their usage, disposal, and recycling practices. The study found that customers buy laptops and televisions more frequently than any other electronic device and are well conscious of e-waste and its harmful impacts. Also, it was found that the majority of consumers threw away their electronic devices because they were defective or broken.

Widyarsana et al. (2021) predicted about the generation of e-waste in Bandung City of Indonesia. The study was conducted on 3 electronic products which were mobile phones, laptops, and television as they were the highest generators of e-waste because they were replaced most frequently. Since there were no specific regulations on WEEE (Waste Electric and Electronic Equipment), the results revealed that the waste produced per day in Bandung city from mobile phones, television, and laptops was 0.61 tons, 3.61 tons, and 8.66 tons respectively. The study highlighted high replacement frequency, high purchasing power, increasing diversity of electronic products, and age factor as the major reasons behind the increase in e-waste and recommended proper management of WEEE and recycling could be done to protect the environment.

Thi Thu Nguyen et al. (2019)studied the factors that affected people's behavior when it came to recycling e-waste. The paper emphasized that perceptions of behavioral control, such as cost and inconvenience, as well as attitudes, including awareness of and attitudes towards recycling, prior recycling experiences, and subjective norms, including laws, regulations, and social pressure, were the primary factors. The study's findings showed that rules and regulations; regardless of gender, had the greatest influence on people's behavior when it came to recycling electronic waste.

Kyere (2016) [20] examined the management of e-waste in Ghana along with an analysis of factors affecting its management because the processing of inherently valuable fractions from e-waste has created an avenue for dominating the informal recycling sector which used primitive and crude recycling procedures and thus, polluted water, soil, and atmosphere and posed consequent threats not only to the environment but also to human health. Thus,

to minimize the health and environmental risks from the processing e-waste; an appropriate mix of local and international collaboration, infrastructure, and legislation together with the ability to enforce it can protect critical rare metals on earth.

According to (Tengku-Hamzah and Adeline, 2011) electronic waste should be disposed of sustainably way because of its hazardous nature. Since e-waste is hazardous, the price of recycling it in an environmentally sound treatment plant is high which restricts the consumers from proper management of e-waste. Thus, the article suggests that recycling of e-wastes should be done in less-developed economies as it will not only reduce the cost of recycling because of the cheap availability of labor but will also contribute towards providing employment opportunities to the people of that country as well as help in generating business to many people. Hence, with the decrease in the cost of proper management of e-waste; people will be motivated towards sustainability.

Hagelüken (2006) analyzed that due to Waste Electrical and Electronic Equipment and similar technological innovations have enhanced the durability of electrical products in the entire world. The article states that the metal smelter and refinery process play a crucial role in increasing the efficiency of the recycling process through the reuse and recycling of electronic scrap and concludes that integrated metal smelters and refineries are the best way to recycle electronic products without even compromising with the quality of the products. The study suggests that substitutes such as plastics can be used in place of fuels or coke and laws such as WEEE could be formulated to increase electronic items' durability.

Studies addressing the management of e-waste through reuse

Lepawsky et al. (2017) proposed Best-of-Two-Worlds as a single strategy for dealing with e-waste. The study emphasized that adequate wages, worker safety, and resource use reduction are the practices that EER4 and Bo2W are aiming to achieve and that an array of economic options, such as profit organization, can be used to manage ethical electronic repair, reuse, repurposing, and recycling (EER4) of discarded electronics. According to the study, electronic products should only be recycled after repair, repurposing, and reuse. It has been thoroughly investigated that the activities of R4 can be utilized to improve the implementation and conception of a variety of economic possibilities.

Marques & da Silva (2017) research was done on Portugal's e-waste management. The study emphasized dangerous e-waste components like arsenic, lead, barium, cadmium, beryllium, chromium, mercury, nickel, and selenium that can even cause serious health conditions and suggested that more recollection points, higher reusing of equipment, changes in how equipment is produced, such as using sustainable materials and raising awareness through information and campaigns for minimizing e-waste.

Studies addressing the management of e-waste by reducing

Blake (2018) studied about behaviors of household consumers in New Zealand towards the management of e-waste. The study threw light on households' efforts to reduce e-waste such as zero waste targets, waste management and minimization plans, and behavioral change. The study even suggested solutions for e-waste management such as government and municipalities' management, EPR, reduction in consumption, economic instruments, better designs of electronic products so that it reduces obsolescence factors, and recycling services.

Mary & Meenambal (2016) studied the perspective of bulk consumers on the development of policy and incentivisation of e-waste. The article highlighted environmental conservation, public awareness, safe disposal, and policy framework as the guiding principles of e-waste policy, with the primary focus on four main elements which were legal framework; which took into consideration environmental laws published by the Government of India, capacity building for a safe environment, management of e-waste in an environmentally sound manner and resource mobilization. The findings of the study demonstrated that e-waste generation in India has increased exponentially and to reduce e-waste it is essential to spread awareness among all

the stakeholders of the supply chain and organizations shall also formulate suitable e-waste management policies to tackle this issue.

Studies addressing the management of e-waste through e-waste collectors and green computing

Nowakowski et al. (2020) studied that through the utilization of a novel vehicle and an artificial intelligence algorithm, sustainable e-waste collection was conducted. The first step in sustainable e-waste collection is to register with a waste collection company on their server and send a request for the pickup of e-waste through communication channels like cell phones and mobile apps. After the waste is collected, an artificial intelligence algorithm is used to optimize the routes that the e-waste collection vehicle takes. This is followed by the final step, which involves using a novel vehicle to get the most out of the waste equipment that has been collected.

Panda (2013) explored green computing and e-waste management. According to the article, waste management is the process of disposing of any item that has been dumped in an ecologically beneficial way, and green computing is the effective use of computer resources. The article highlighted television, computers, LCD, air conditioner, plasma panels, mobile phones, and printing-scanning devices as the major elements that contributed in the generation of e-waste because of constant changes in technology. The study's conclusions showed that using green computing lowered power usage and helped reduce pollution. Nevertheless, burning electronic garbage instead of burying or disposing it of was the biggest issue with managing e-waste.

Step 4 for SLR: Analysis

This stage is concerned with evaluating the synthesized data and generating meaningful information from them.

Various e-waste management strategies identified by different authors

Management of e-waste is a global and dangerous problem. Despite that, measures for effective handling of this problem are rarely followed. Since this research is an effort to provide a deep insight into the various e-waste management strategies, the classification of strategies identified by different authors is given in Table-4:

Table 4: Classification of strategies identified by different authors

Authors	Year	Journals, Books, or Universities	Strategies Identified
Shashi Arya Sunil Kumar	2020	*Journal of Cleaner Production*	Technology development Adoption of the four R's EPR ECR Creation of value-added products Creation of optimal supply chain Better quality Rigorous adherence to environmental regulations skill enhancement and proper training
Vicktoria Marie Blake	2018	Massey University	government and municipalities management EPR reduction in consumption economic instruments better designs of electronic products
Muhammad Danish Saqib Ali Muhammad Azeem Ahmad Hasan Zahid	2019	Economies	functional value quality functional value price social value responsibility social value identity conditional value emotional value

Authors	Year	Journals, Books, or Universities	Strategies Identified
Tapas Kumar Ghatak.	2021	*Environmental Management: Issues and Concerns in Developing Countries*	Rules and regulations
Christian Hagelüken	2006	*World of Metallurgy*	substitutes such as plastics can be used in place of fuels or Coke Formulation of laws Recycling
Ricardo J Hernandez Constanza Miranda Julian Goñi	2020	Sustainability	Repairing Empowering Educating Informing
Md TasbirulIslam Pablo Dias Nazmul Huda	2021	*Journal of Cleaner Production*	Recycling Altering disposal behavior
Kamyar Kianpour Ahmad Jusoh Abbas Mardani Dalia Streimikiene Fausto Cavallaro Khalil Md. Nor Edmundas Kazimieras Zavadskas	2017	Sustainability	Shaping the customers' attitude toward return ing the end-of-life electronic products Recycling Repairing Reusing
Andrew M. King Stuart C. Burgess Winnie Ijomah Chris A. McMahon	2006	Sustainable Development	Repair Recondition Remanufacture Recycle Buy-back of used electronics
Vincent Nartey Kyere	2016	Bonn University	local and international collaboration infrastructure legislation
Josh Lepawsky Erin Araujo John-Michael Davis Ramzy Kahhat	2017	Geoforum	Best-of-Two-Worlds Ethical electronic repair, reuse, repurposing, and recycling (EER4)
Célio Gonçalo Marques Vasco Gestosa da Silva	2017	*Journal of Information Systems Engineering & Management*	producing equipment through the use of sustainable material Spreading awareness Reusing or purchasing second-hand electronics
Senophiyah Mary J. Meenambal T.	2016	*Procedia Environmental Sciences*	Reducing e-waste through spreading awareness among all the stakeholders of the supply chain and organizations formulation of e-waste management policies
Piotr Nowakowski Krzysztof Szwarc Urszula Boryczka	2020	*Science of the Total Environment*	E-waste collection by combining a novel vehicle and an artificial intelligence algorithm
Martin Oteng-Ababio Ebenezer Forkuo Amankwaa	2014	*African Review of Economics and Finance*	Rules and Regulations
Ranjita Panda	2013	*International Journal of Environmental Engineering and Management*	Green computing

Authors	Year	Journals, Books, or Universities	Strategies Identified
Kalpana Singh	2016	*International Journal of Scientific Research in Science, Engineering and Technology*	life cycle assessment multi-criteria analysis material flow analysis EPR preparation of the collection system legislation logistics, and manpower strict regulations
Tengku Tengku - Hamzah Adura Adeline	2011	Durham University	Recycling of e-wastes should be carried out in the less - developed economies
Hong Thi Thu Nguyen Rern-Jay Hung Chun-Hung Lee Hang Thi Thu Nguyen	2019	*Sustainability*	Recycling through influencing behavioral intentions
I Made Wahyu Widyarsana Dewi Suryanindah Supramono Nabil Fadel	2021	*Environmental and Climate Technologies*	Recycling

Source: Developed by researchers

From Table 4, it can be evaluated that the most important e-waste strategies as identified by maximum authors are recycling, repairing, reducing, EPR, reusing, rules, and regulations. There are various other strategies identified in the table above, and if people all around the world come together and bring a small behavior change, we all would be able to live a healthy and prosperous life. Apart from individuals, if government, manufacturers, retailers, and organizations pay attention to this global issue, we will be successful in reducing e-waste.

E-waste management strategies practiced in different countries

Various authors in their articles, book chapters, or theses talked about e-waste management strategies currently practiced in their countries. While others just recommended strategies for the proper management of disposed of electronics. Through an extensive review of literature, e-waste management practices of a few countries were revealed. The practices currently adopted in their country are mentioned in Figure 5 below:

Figure 5: E-waste management strategies adopted in different countries

Source: Developed by researchers

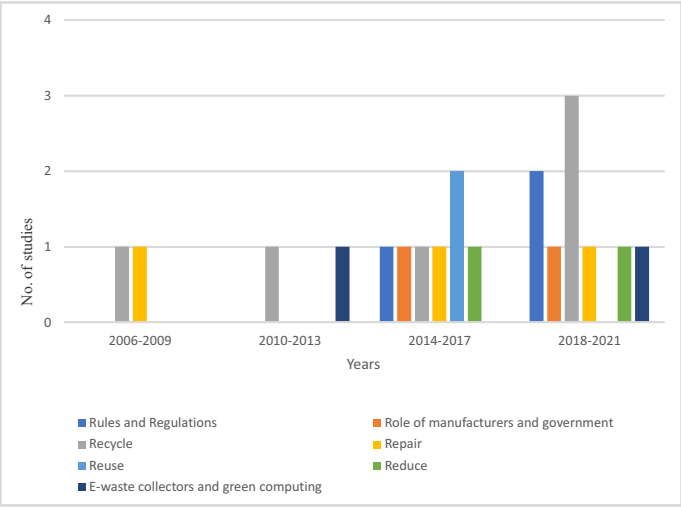
From the data in Figure 5, it can be analysed that India, China, and countries in Africa have shown some seriousness towards disposal of electronic waste in an environmentally friendly manner through the formulation of rules and regulations. While countries like Ghana, Portugal, New Zealand, Japan, the USA, and countries of the European Union are also taking initiatives for the management of e-waste but Indonesia on the other hand, has no specific regulations to date towards the same and this is the major reason behind constant growth of e-waste in the country.

Number of e-waste management strategies reviewed

- Year- wise distribution of studies reviewed

A total of 20 studies (17 articles, 1 book chapter, and 3 doctoral dissertations) were reviewed systematically. Year wise distribution of studies reviewed in each classified review is shown in Figure below:

Figure 6: Year - wise distribution of studies reviewed



Source: Developed by researchers

Through this Figure, it can be said that the major number of studies reviewed were those which addressed the management of e-waste through recycling. Also, the maximum number of studies reviewed were from 2018-2021. The total number of studies between 2006-2009, 2010-2013, 2014-2017, and 2018-2021 were 2,2,7 and 9 respectively. While total articles from e-waste management strategies like rules and regulations, the role of manufacturers and government, repair, recycle, reuse, reduce, e-waste collectors, and green computing are 3,2,3,6,2,2 and 2 respectively. It is evident that the highest number of studies reviewed were on recycling e-waste management strategies. While on the other hand, e-waste management strategies like the role of manufacturers and government, reuse, reduce, e-waste collectors and green computing has the lowest number of studies reviewed in this article.

- Studies reviewed based on continents

While few studies have the same study site, others have different ones. Based on the study sites, where research has been conducted; a number of studies are divided into different continents (shown in Table-5).

Table 5: Number of studies from each continent

Continents	No. of studies	Percentage of studies
Asia	9	45%
Africa	2	10%
Antarctica	0	0%
Australia	2	10%
Europe	3	15%
North America	2	10%
South America	1	5%
More than 1 continent	1	5%
Total	20	100%

Source: Developed by researchers

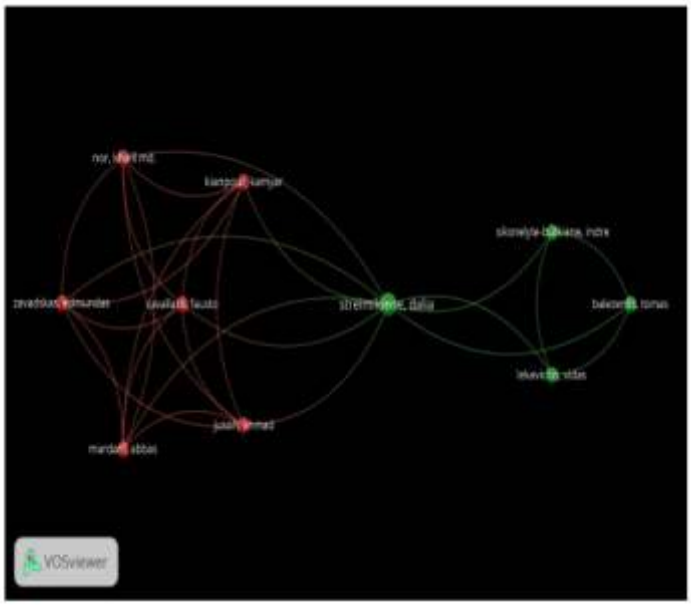
From theTable-5, it is clear that the highest number of studies are done in Asia, and Asia maximum study sites of research are from India among the studies reviewed. While no study has been reviewed, whose study site is in Antarctica. Moreover, there is a study reviewed in this article, whose study site is on more than 1 continent.

Bibliographic analysis using VOS viewer

For doing bibliographic analysis, a software tool VOS

viewer has been used. This tool is used to create a map based on the bibliographic date i.e. to identify the co-authorship and coupling of bibliographic data. The map formulated using the VOS viewer software is shown in the figure below:

Figure7: Bibliographic analysis using VOS viewer



Source: Developed by researchers using VOS viewer

Through our Bibliographic data, we can conclude that there are a total of 52 authors in our bibliography but through this map, we can identify that only 10 items are linked to each other. There are 27 links and they all form only 2 cluster. Moreover, the total link strength is 3.50.

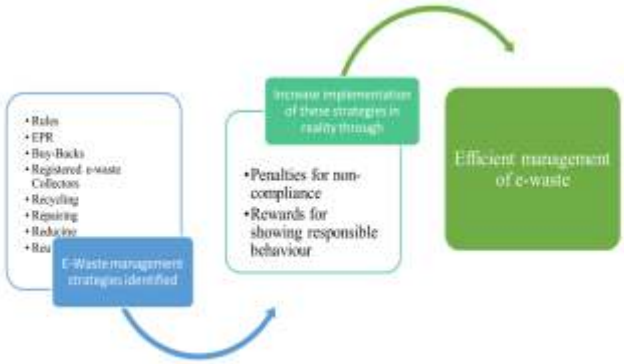
Results

The results through the SALSA framework provided a basic idea about the different types of reviews such as key e-waste management strategies identified as are 4 R's, EPR, rules, and regulations. The findings of the study depict that countries in Asia and Africa are concerned about the waste generated through electronics and have taken measures to reduce such waste. Moreover, the maximum number of studies reviewed were from Asia and were between 2018-2021. Results of the reviewed articles depicted that there were 52 authors and 10 items are linked with each other.

Conclusion

After systematically reviewing literature through SALSA (a simple analytical framework that is used to illustrate processes and inputs of review types), it can be said that though there are numerous strategies for the management of waste generated through electronics, they are hardly practiced. Hence, there is a huge gap between practiced strategies and identified strategies for e-waste. It is very essential to overcome this gap for combating the harmful impacts of e-waste. It is high time that we take up this global issue seriously and leave no stone unturned in reducing e-waste. Thus, for overcoming this gap; strategies, as identified by authors, should be practiced in reality rather than in books. A summary to overcome this gap in India is reflected in the figure below:

Figure 8: Model developed for efficient management of e-waste



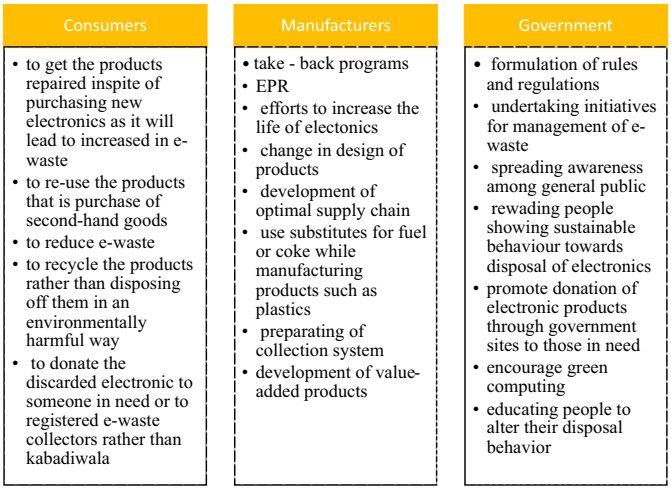
Source: Developed by researchers

Even though rules have been formulated in India on handling e-waste systematically, it is rarely followed. The scope of "E-waste management rules, 2016" is very wide and it clearly defines the responsibilities of manufacturers, producers, consumers, dismantlers, recyclers, collection centers, dealers, and refurbishes. Apart from the responsibilities, the E-waste management rule has even established a procedure for receiving grants for the management of e-waste and much more. It is such a contradictory situation, that despite such rules, e-waste is at constant growth in India. Hence, strict penalties should be imposed on those who unfollow rules, and citizens showing responsible behavior should be rewarded in some form.

Suggestions

To manage waste generated from electronics, it is very essential to define the roles of consumers, manufacturers, and government clearly. If they can discharge their responsibilities, people all around the world would be able to live happy and healthy life by combating the harmful effects of the disposal of electronic waste in an environmentally unfriendly manner. Various roles and responsibilities of consumers, government, and manufacturers are listed in the Figure 9.

Figure 9: Roles and responsibilities of Consumers, manufacturers, and government



Source: Developed by researchers

References

- Andriuškevičius, K., Štreimikienė, D., 2022. Sustainability Framework for Assessment of Mergers and Acquisitions in Energy Sector. Energies, 15(13), 4557. https://doi.org/10.3390/en15134557
- Arya, S., Kumar, S., 2020. E-waste in India at a glance: current trends, regulations, challenges and management strategies. Journal of Cleaner Production, 122707.https://doi.org/10.1016/j.jclepro.2020.122707
- Beller, E. M., Glasziou, P. P., Altman, D. G., Hopewell, S., Bastian, H., Chalmers, I.,Gøtzsche, P.C., Lasserson, T., Tovey, D., PRISMA for Abstracts Group., 2013. PRISMA for abstracts: reporting systematic reviews in journal and conference abstracts. PLoS medicine, 10(4), e1001419.https://doi.org/10.1371/journal.pmed.1001419
- Blake, V. M., 2018. The e-waste management behaviours of household consumers in Whangarei, New Zealand [Doctoral dissertation, Massey University]. Massey University.http://hdl.handle.net/10179/14248
- Borthakur, A., 2023. Design, adoption and implementation of electronic waste policies in India. Environmental Science and Pollution Research, 30(4), 8672-8681.https://doi.org/10.1007/s11356-022-18836-5
- Chien, C. F., Aviso, K., Tseng, M. L., Fujii, M., Lim, M. K., 2021. Solid waste management in emerging economies: Opportunities and challenges for reuse and recycling. Resources, Conservation and Recycling, 172, 105677.https://dx.doi.org/10.1016/j.resconrec.2021.105677
- Danish, M., Ali, S., Ahmad, A. M., Zahid, H., 2019. The Influencing Factors on Choice Behavior Regarding Green Electronic Products: Based on the Green Perceived Value Model. Economies, 1-18. https://doi.org/10.3390/economies7040099
- Do, M. H., Nguyen, G. T., Thach, U. D., Lee, Y., Bui, T. H., 2023. Advances in hydrometallurgical approaches for gold recovery from E-waste: A comprehensive review and perspectives. Minerals Engineering, 191, 107977.https://doi.org/10.1016/j.mineng.2022.107977
- Finlay, A., Liechti, D., 2008. E-waste assessment South Africa.
- Gaidajis, G., Angelakoglou, K., Aktsoglou, D., 2010. E-waste: environmental problems and current management. Journal of Engineering Science and Technology Review, 3(1), 193-199.
- Grant, M. J., Booth, A., 2009. A typology of reviews: an analysis of 14 review types and associated

methodologies. Health information & libraries journal, 26(2), 91-108.https://doi.org/10.1111/j.1471-1842.2009.00848.x

- Ghatak, T. K., 2021. Sustainable Municipal Waste Management in Indian Cities. Environmental Management: Issues and Concerns in Developing Countries, 107-125.https://doi.org/10.1007/978-3-030-62529-0_6
- Hagelüken, C., 2006. Recycling of Electronic Scrap at Umicore's Integrated Metals Smelter and Refinery. World of Metallurgy, 151-161.
- Hernandez, J. R., Miranda, C., Goñi, J., 2020. Empowering Sustainable Consumption by Giving Back to Consumers the 'Right to Repair'. Sustainability, 1-15.https://doi.org/10.3390/su12030850
- Islam, M. T., Dias, P., Huda, N., 2021. Young consumers'e-waste awareness, consumption, disposal, and recycling behavior: A case study of university students in Sydney, Australia. Journal of Cleaner Production, 282, 124490.https://doi.org/10.1016/j.jclepro.2020.124490
- Johnson, K. F., Belcher, T. A. W., Zimmerman, B., Franklin, J., 2020. Interprofessional partnerships involving school counsellors for children with special needs: a broad based systematic review using the PRISMA framework. Support for Learning, 35(1), 43-67. https://doi.org/10.1111/1467-9604.12285
- Joseph, K., 2007. Electronic waste management in India–issues and strategies. In Eleventh international waste management and landfill symposium, Sardinia.
- Kianpour, K., Jusoh, A., Mardani, A., Streimikiene, D., Cavallaro, F., Nor, M. K., Zavadskas, K. E., 2017. Factors Influencing Consumers' Intention to Return the End of Life Electronic Products through Reverse Supply Chain Management for Reuse, Repair and Recycling. Sustainability, 1-23.https://doi.org/10.3390/su9091657
- King, A. M., Burgess, S. C., Ijomah, W., McMahon, C. A., 2006. Reducing waste: repair, recondition, remanufacture or recycle?. Sustainable development, 14(4), 257-267.https://doi.org/10.1002/sd.271
- Kumar, A., Holuszko, M., & Espinosa, D. C. R., 2017. E-waste: An overview on generation, collection, legislation and recycling practices. Resources, Conservation and Recycling, 122, 32-42.https://doi.org/ 10.1016/ j.resconrec.2017.01.018
- Kyere, V. N., 2016. Environmental and health impacts of informal e-waste recycling in agbogbloshie, accra, ghana: recommendations for sustainable management [Doctoral dissertation, Bonn University].Bonndoc.https://nbn-resolving.org/urn:nbn:de:hbz:5n-43250
- Lepawsky, J., Araujo, E., Davis, J. M., Kahhat, R., 2017. Best of two worlds? Towards ethical electronics repair, reuse, repurposing and recycling. Geoforum, 81, 87-99.https://doi.org/10.1016/j.geoforum.2017.02.007
- Marques, C. G., Da Silva, V. G., 2017. E-waste Management in Portugal: Legislation, Practices and Recommendations. Journal of Information Systems Engineering & Management, 2(4), 22.https://doi.org/10.20897/jisem.201722
- Mary, J. S., Meenambal, T., 2016. Inventorisation of e-waste and developing a policy–bulk consumer perspective. Procedia Environmental Sciences, 35, 643-655.https://doi.org/10.1016/j.proenv.2016.07.058
- Mengist, W., Soromessa, T., Legese, G., 2020. Method for conducting systematic literature review and meta-analysis for environmental science research. MethodsX, 7, 100777.https://doi.org/10.1016/j.mex.2019.100777
- Nowakowski, P., Szwarc, K., Boryczka, U., 2020. Combining an artificial intelligence algorithm and a novel vehicle for sustainable e-waste collection. Science of the Total Environment, 730, 138726.https://doi.org/10.1016/j.scitotenv.2020.138726
- Oteng-Ababio, M. M., Amankwaa, E. F., 2014. The e-

waste conundrum: Balancing evidence from the North and on-the-ground developing countries' realities for improved management. African Review of Economics and Finance, 6(1), 181-204.https://doi.org/10.1016/j.habitatint.2014.03.003

- Panda, R., 2013. e-Waste management: a step towards green computing. International Journal of Environmental Engineering and Management, 4(5), 2231-1319.http://www.ripublication.com/ ijeem.htm
- Pandey, P., Singh, R. K., 2023. E-waste Management Practices in India: Challenges and Approaches. Microbial Technology for Sustainable E-waste Management, 63-74.https://doi.org/10.1007/978-3-031-25678-3_3
- Shi, J., Chen, W.,Verter, V., 2023. The joint impact of environmental awareness and system infrastructure on e-waste collection. European Journal of Operational Research. https://doi.org/10.1016/j.ejor.2023.03.011
- Siksnelyte-Butkiene, I., Streimikiene, D., Lekavicius, V., Balezentis, T., 2021. Energy poverty indicators: A systematic literature review and comprehensive analysis of integrity. Sustainable Cities and Society, 67, 102756.https://doi.org/10.1016/j.scs.2021.102756
- Singh, K., 2016. E-waste management and public health: A scenario of Indian cities. International Journal of Scientific Research in Science, Engineering and Technology, 2(3), 887-890.
- Stewart, L. A., Clarke, M., Rovers, M., Riley, R. D., Simmonds, M., Stewart, G., Tierney, J. F., 2015. Preferred reporting items for a systematic review and meta-analysis of individual participant data: the PRISMA-IPD statement. Jama, 313(16), 1657-1665.https://doi.org/10.1001/jama.2015.3656
- Tengku-Hamzah, T., Adeline, A., 2011. Making sense of environmental governance: a study of e-waste in Malaysia [Doctoral dissertation, Durham University]. Durham E-Theses.http://etheses.dur.ac.uk/
- Thi Thu Nguyen, H., Hung, R. J., Lee, C. H., Thi Thu Nguyen, H., 2019. Determinants of residents' E-waste recycling behavioral intention: A case study from Vietnam. Sustainability, 11(1), 164.https://doi.org/10.3390/su11010164
- Ullah, N., 2023. Challenges and Approaches in E-waste Management. Microbial Technology for Sustainable E-waste Management, 101-111.https://doi.org/10.1007/978-3-031-25678-3_6
- Widyarsana, I. M. W., Supramono, D. S., Fadel, N., 2021. Electronic Waste Generation Prediction in Bandung City, Indonesia. Environmental and Climate Technologies, 25(1), 111-120.https://doi.org/10.2478/rtuect-2021-0007
- Yu, Z., Gao, C., Yang, C., Zhang, L., 2023. Insight into quantities, flows, and recycling technology of E-waste in China for resource sustainable society. Journal of Cleaner Production, 393, 136222.https://doi.org/10.1016/j.jclepro.2023.136222
- Zarate, D., Stavropoulos, V., Ball, M., de Sena Collier, G., Jacobson, N. C., 2022. Exploring the digital footprint of depression: a PRISMA systematic literature review of the empirical evidence. BMC psychiatry, 22(1), 421.https://doi.org/10.1186/s12888-022-04013-y