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Electronic Waste Management In India: A Sustainable Perspective

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ABSTRACT

India is striving hard to become a developed nation. In this journey India has to overcome a lot of obstacles and one such obstacle is growing heaps of e-waste which are a result of increasing consumption of electrical and electronic items. Numerous initiatives have been adopted by government and NGO to deal with e-waste. The concern is that improper disposal of e-waste leads to harmful effects on human health as well as on the environment. Therefore there is a need to manage e-waste sustainably. Through this paper an attempt has been made to propose a solution for managing e-waste in a sustainable manner. One of the major concerns in e-waste management is the immense presence of informal sector which recycles 95 % of the e-waste in India. It has been proposed that formal sector should work in collaboration with informal sector for ensuring management of e-wastesustainably.

1. Introduction

Sustainability has been a key issue in the recent times across the globe. In simple terms sustainability means that the resources are used in the present time in such a manner so that they can be made available to future generations as well. Environmental sustainability and electronic waste management practice go hand in hand. Electronic waste is increasing at an alarming rate and is not just a problem for India but is an issue of international concern. United Nations University has stated in a report 'Global E-waste Monitor 2017' that 44.7 million metric tonnes of e-waste was generated across the world in 2016 which is almost equivalent to 4500 Eiffel towers. Apart from being the second largest hub for mobile phones in the world, India is also the second largest generator of e-waste in 2016 amongst Asian economies. E-waste includes all electrical and electronic items and all related components that have been discarded by the owner without the intent of re-use. Exiting systems of e-waste management are generally not sustainable as collection, sorting, reuse, disassembling, recycling etc are undertaken by informal sources. Informal recyclers do not abide by the rules and regulations and the activities carried out by them are often harmful for humans and environment.

2. Research objectives:

The main objective of this paper is to study the issue of electronic waste management and to propose a sustainable solution for managing e-waste keeping in view numerous opportunities that this segment can offer.

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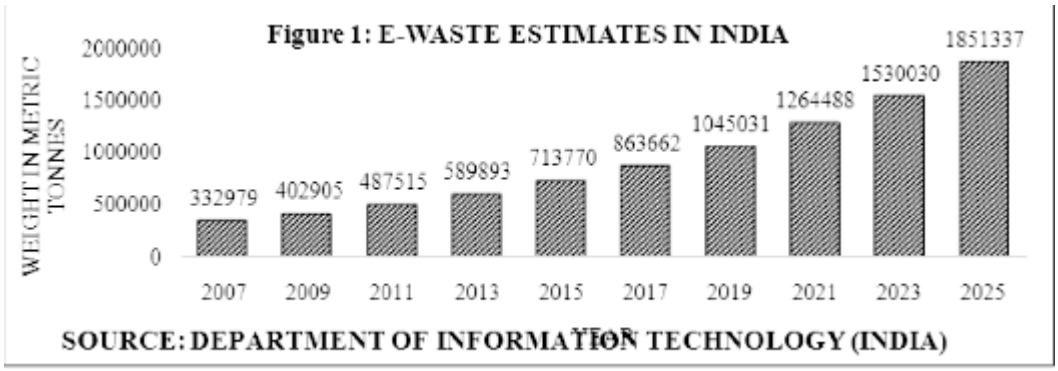
3. Scenario of E-waste Management in India

India has been ranked second in terms of number of mobile phones used but what happens after an individual discards that handset. Unless donated to another user, it becomes E-Waste. Refrigerators, air conditioners, printers, microwaves, calculators, monitors, laptops, mobile phones, hard disks, remote batteries, pen drives etc are all a part of e-waste. India is the second largest generator of e-waste in 2016 amongst Asian economies. China is the largest generator of e-waste and consequently numerous policies have been initiated with regards to management of e-waste. Some reasons for this exponential growth are lack of awareness amongst consumers about proper disposal of e-waste, ineffective implementation of regulations, and growing presence of informal recyclers.

Figure 1 shows the estimated quantity of e-waste growth in India as reported by Ministry of Information Technology, Government of India.



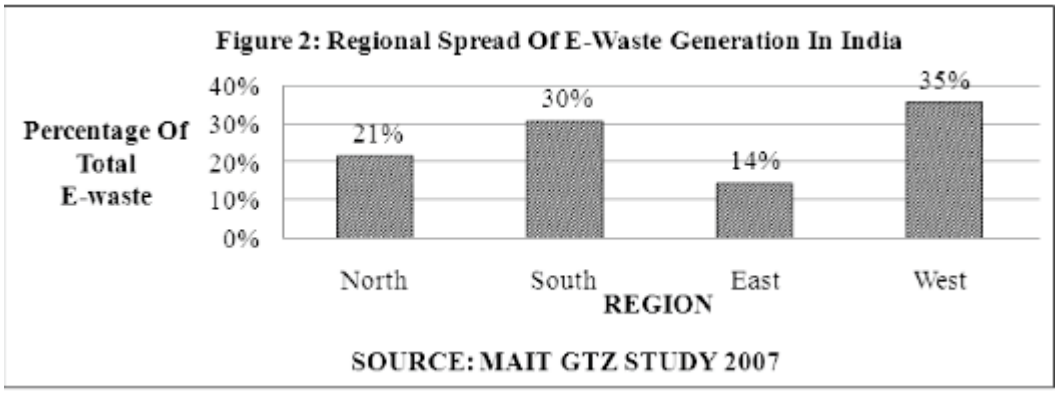


Figure 2 shows the regional spread of E-waste generation in India where it has been highlighted that Western region is responsible for producing maximum percentage of E-waste followed by Southern region. Moreover to understand the status of E-waste in India, it is important to see the quantity of e-waste generated in different states as shown in Table 1.

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Tablel: Quantity of E-Waste Generated In Indian States And Union Territories

Rank	States/UT	E-waste generated (In metric tons)	Percentage Of Total E-Waste
1.	Maharashtra	20270.60	13.87
2.	Tamil Nadu	13486.20	9.23
3.	Andhra Pradesh	12780.30	8.74
4.	Uttar Pradesh	10381.10	7.10
5.	West Bengal	10059.40	6.88
6.	Delhi	9729.20	6.66
7.	Karnataka	9118.70	6.24
8.	Gujarat	8994.30	6.15
9.	Madhya Pradesh	7800.60	5.34
10.	Punjab	6958.50	4.76
11.	Rajasthan	6326.90	4.33
12.	Kerala	6171.80	4.22
13.	Haryana	4506.90	3.08
14.	Bihar	3055.60	2.09
15.	Orissa	2937.80	2.01
16.	Assam	2176.70	1.49
17.	Chhattisgarh	2149.90	1.47
18.	Jharkhand	2021.60	1.38
19.	Uttarakhand	1641.10	1.12
20.	Himachal Pradesh	1595.10	1.09
21.	Jammu and Kashmir	1521.50	1.04
22.	Goa	427.40	0.29
23.	Tripura	378.30	0.26
24.	Chandigarh	359.70	0.25

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25.	Puducherry	284.20	0.19
26.	Manipur	231.70	0.16
27.	Meghalaya	211.60	0.14
28.	Nagaland	145.10	0.10
29.	Arunachal Pradesh	131.70	0.09
30.	Andaman and Nicobar Islands	92.20	0.06
31.	Mizoram	79.30	0.05
32.	Sikkim	78.10	0.05
33.	Daman and Diu	40.80	0.03
34.	Dadra and Nagar Haveli	29.40	0.02
35.	Lakshadweep	7.40	0.01
	TOTAL	**146180.70**	**100**

SOURCE: RAJYA SABHA, 2011

4. Management of E-Waste by informal sector:

E-waste management industry has been occupied majorly by informal recyclers in India. As per a study in 2014, it has been stated that 95 % of electronic waste is recycled by informal sector and only 5 % of it is being dealt by any formal sources. The major issue with informal recyclers dealing with E-waste is that they do not abide by environmental norms. Maximum percentage of workers engaged in informal recycling sites are women and children who are illiterate and are not aware of the hazardous consequences of improper recycling of electronic waste. Informal sector includes certain scrap dealers, waste collectors, *raddiwalas* etc (Ikhlayel, 2018). Major operations of e-waste in informal/ unorganised sector are as follows:

- **Collection**: *The kawariwalas who are small scrap dealers provide door to doore-waste collection facility.*Consumers are encouraged to sell e-waste to such small scrap dealers *in exchange of a nominal amount. The kawariwalas are one of the most efficient informal source of e-waste collection. They are not just limited to household consumers but they also collect e-waste in bulk quantities from large companies, government establishments, universities, offices etc.*
- **Segregation**: E-waste collected from numerous sources is segregated into different categories like metals, plastics, glass components and others depending upon the saleability condition of the material.
- **Disassembly: Disassembling of e-waste is of two types, destructive and non-destructive.**In destructive disassembly method each type of material is segregated for recycling process whereas non-destructive method involves recovery of disassembled parts that can be reused but this method is not very viable as technology is changing at a fast pace and the reuse of these components is not guaranteed. Disassembly of Personal computers recovers cooling fan, hard

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disk drives, metal enclosures, power cable, monitor, scanner, modem, mother board, power supply unit, auxiliary cards and few more cables.

- **Reuse of recovered materials:The small scrap dealers sell all the segregated and dismantled parts of glass, plastic, metals and other components which are found in saleable condition. There are also certain components which are not in reusable condition but can be melted and then can be further casted in a new product. Such components are sold by kawaris to some experts who have knowledge about these processes.**
- **Recycling of Printed Circuit Boards (PCBs):**The populated PCBs, constituting 3 to 5% by weight of total e-waste, have rich value of metals such as copper, silver, gold, palladium, platinum, tantalum and other metals in traces level. The recovery of all the metals requires professional skill, expensive equipments and machineries. The lack of knowledge, affordable logistics and greed for quick money motivates unorganised sector to employ unhygienic and un-scientific methods for recovery of valuable metals. The typical methods employed by unorganised units are focussed to recover gold from the integrated circuits (ICs), gold plated terminals of connectors/PCBs and other components etc. The gold rich components are removed by loosening of the lead solder by surface heating, which causes air pollution (Kumar et al, 2017).

Table 2 shows the list of registered E-waste recyclers and dismantlers in India for the year 2014 and 2016. The number of such recyclers have increased from 138 to 178 in a couple of years. But still considering the growing rate of e-waste, there is need to adopt a more formalised system of managing e-waste.

Table 2 : List Of Registered E-Waste Dismantler/Recycler In India

S.N.	State	Number Of Registered Recyclers (Units)			
		2014	MTA	2016	MTA
1	Andhra Pradesh	2	11800	0	-
2	Chhattisgarh	1	900	2	1650
3	Gujarat	1	20849.12	12	37262.12
4	Haryana	13	47,225	16	49981
5	Karnataka	52	50318.5	57	44620.5
6	Maharashtra	22	32180	32	47810
7	West Bengal	1	600	1	600
8	Uttar Pradesh	11	43,150	22	86,130
9	Uttarakhand	4	28150	3	28, 000
10	Tamil Nadu	14	38,927	14	52427
11	Rajasthan	9	67470	10	68670
12	Madhya Pradesh	2	6585	3	8985
13	Orissa	0	-	1	N/A
14	Punjab	0	-	1	150
15	Telangana	0	-	4	11, 800
	Total	**138**	**349154.6**	**178**	**438085.62**

SOURCE: Central Pollution Control Board
http://www.cpcb.nic.in/Ewaste_Registration_List.pdf

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5. **Effects of informal recycling of Electronic Waste in India:**

Electronic waste is a problem because of the disposal methods adopted by consumers. It is often recycled, reused, refurbished and is also incinerated. Incineration of e-waste is very dangerous. Dangerous toxins are released with open air burning which not only pollute the local environment but also affect the global air currents (Ramachandra and Saira, 2004, Mahato, 2016). Once useful items are extracted out of the total e-waste, then the remaining waste which is non-hazardous can be burnt but burning prior to treatment of hazardous substance is very risky. Table 3 shows the harmful effects of some e-waste pollutants.

Table 3 : Harmful Effects Of Some E- Waste Pollutants

E- Waste Pollutant	Health Effect	Source
Lead[1]	Damage to central nervous system. Affects brain development of children.[1]	Printed circuit boards and monitors, glass panel.
Cadmium[2]	Affects Kidney[3] Causes neural damage.[3]Long term exposure to cadmium can cause Itai-Itai disease.	Sensors, lamps, mobile phones, Relays, switches, flat panel display,batteries.[2]
Beryllium[3]	Causes cancer and skin diseases[3]	Computer motherboards
Mercury[3]	Damage to brain.[3]	Circuits and switches
Plastics including PVC*[3]	Burning of plastic damages immune system, affects regulatory hormones.[3]	Cables and computers[3]
Barium[3]	Damages heart and liver. Can cause muscles weakness.[3]	Front panel of CRTs[3]
Nickel[4]	Causes asthma and lung damage.[4]	Wires

* PVC →Polyvinyl Chloride

Sources: Yang et al (2013)[1] , Verma and Agrawal (2014)[2], Shagun et al (2013)[3], Saritha et al (2015)[4]

6. Opportunities for developing a more sustainable e-waste management system:

6.1. Research opportunities:

Numerous problems are associated with management of electronic waste in India. Some of the problems can actually be viewed as an opportunity. Some important areas under which opportunities can be explored are shown in Figure 3 and are mentioned below:

6.1.1. Data management:

Currently the methods used for tracking the quantity of electronic waste management are very limited. Few estimation models are available forthis purpose which are based on either the sales volume of electronics in a particular year in a specific region. Robinson (2009) has specified a formula to estimate the amount of e-waste being generated.

$E = MN/L$

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Where E = annual e-waste production (kg/year)

M = Mass of electronic item

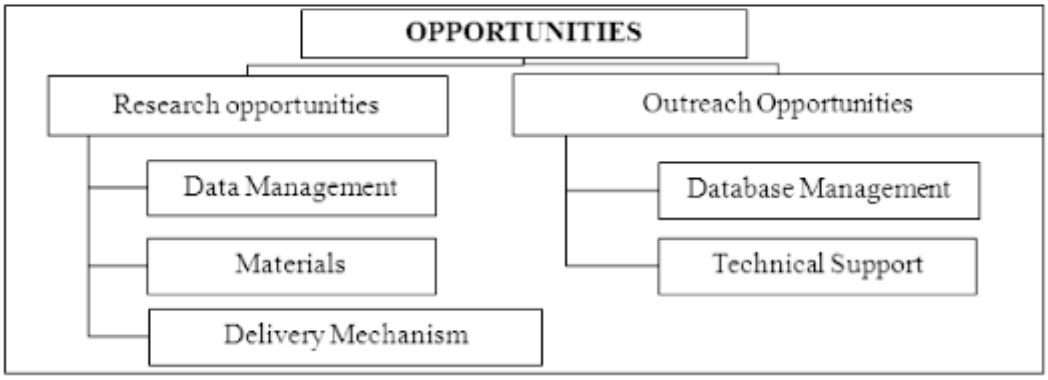
N = Number/quantity in the market

L = Average life cycle (Years)

Gaidajis et al have mentioned another method for e-waste estimation in which it is assumed that with the growing levels of Gross Domestic Product (GDP), more number of electronic goods are purchased eventually leading to increased e-waste production.

In India there is no formal system for recording of quantity of electronic waste generated. United Nations University published Global E-Waste Monitor 2017 in which it has been stated that 1975 kilotonnes of E-Waste was generated in India in 2016. The segment of e-waste management can actually open gates for lot of data scientists.

Figure 3: Opportunities available for managing electronic waste sustainably



1.1.1. Materials:

E-waste contains lot of materials out of which some are valuable and some are hazardous to both the humans as well as the environment. Consequently, there is a need to develop products which are manufactured using more environmentally safe materials and processes. For this method a researcher has quoted a term DOE i.e. Design for Environment which means that the manufacturing of the products should be carried out in an environment friendly manner (Herat and Agamuthu, 2012).

1.1.2. Delivery Mechanisms:

One of the reasons of increasing pile of e-waste is the rapid consumption facilitated by globalisation and increased purchasing power of the consumers. But as a matter of fact, it is not important for consumers to own the electronic product and they are only concerned with the usage of it. So in order to ensure that electronics are used to the maximum capacity till they complete their lifespan, certain services can also be provided by electronic product vendors like lease contracts or service contracts etc. This would help in reduction of quantity of e-waste.

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1.1. Outreach Opportunities

1.1.1. Database Management:

In order to manage e-waste sustainably, it is important to have a complete e-waste outreach program. All information related to electronic products including the materials needed for manufacturing, the extent to which such material meet the environmental standards, the lifespan of electronic products, number of units manufactured and sold etc is to be managed. Hence lot of opportunities are available for database management for maintaining data concerned with all aspects of e-waste.

1.1.2. Technical Support:

Researchers have stated that the best method for managing e-waste is to recycle it. Sophisticated technology is required for carrying out the recycling processes. In addition to it there is need of Technical assistance regarding e-waste collection methods, storage, transportation, feedstock management etc.

2. Proposed sustainable E-waste management policies:

2.1. Collaborative effort of formal and informal recyclers:

In India there is a general tendency that e-waste is disposed off with regular household waste and in some cases it is sold to scrap dealers for a minimal amount who provide door to door collection service. Empirical evidences have also highlighted that one of the main challenges related to e-waste management is lack of awareness amongst consumers about proper methods of disposal of e-waste. Due to infrastructural problems, India does not have a formal collection system for e-waste. Consequently all types of waste materials are discarded together and consumers opt for most convenient option for doing so. On the basis of different research articles available on the subject of behaviour of consumers towards e-waste, it has been identified that informal sources have a very wide approach in collection of waste streams which is more preferred by consumers due to convenience. Henceforth the best way of managing e-waste cannot be exclusively through formal establishments. Rather it is suggested that upto the stage of disassembling of e-waste, informal recyclers should be involved and rest of activities can be carried out more efficiently by formal recyclers.

2.2. Tapping of numerous opportunities related to the field of e-waste management:

Activities related to e-waste management have gradually gained momentum in fast few years. E-waste management has developed as a full-fledged industry and have lot of potential for numerous opportunities that can be tapped by young entrepreneurs. There are several opportunities related to research and outreach aspects like database management, feedstock management, delivery mechanism, technical support etc.

TABLE 4 : Legislations relating to Electronic Waste in India

Laws and Regulations	*With effect from*	*Issuing Authority*
The Environment(Protection) Act	23rd May, 1986	Ministry of Environment and Forests, Govt. of India
Municipal Solid Waste (Management & Handling) Rules 1999	25th September, 2000	
National Green Tribunal Act 2010	18th October, 2010	
E-Waste (Management & Handling) Rules 2011	1st May, 2012	

Source: Ministry of Environment and Forests, Govt. of India

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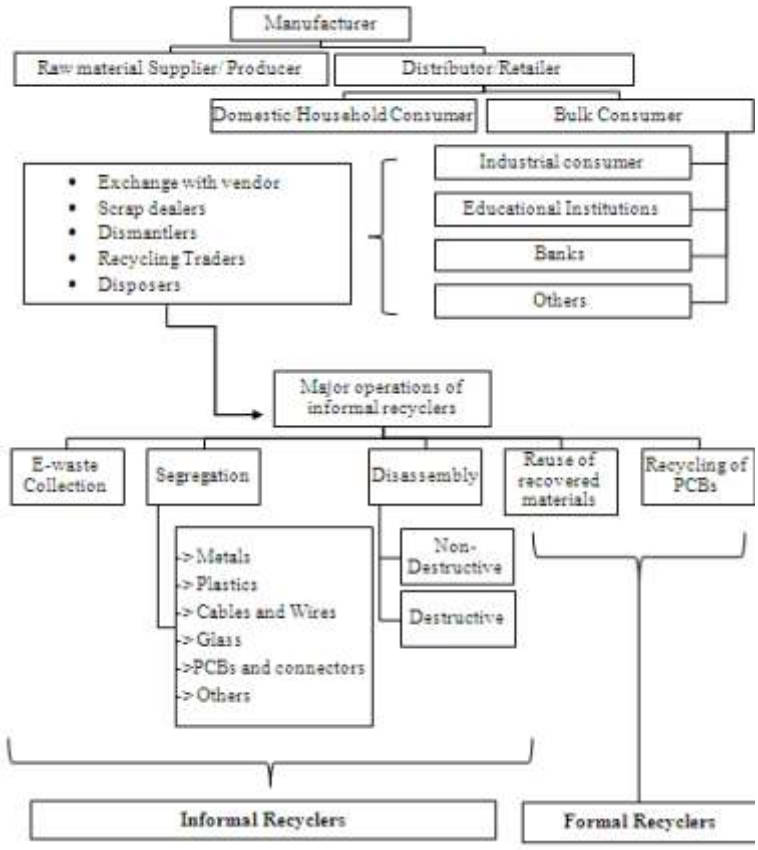
1.1. EPR Approach in India:

Government of India has taken few initiatives towards framing legislations for management of e-waste as shown in Table 4. The first formal E-Waste (Management and Handling) rules, 2011 were introduced to ensure that the recycling and other disposal activities are carried out in a safe manner without causing any damage to human health and environment. Further in 2016, a new draft of rules namely E-waste (Management) Rules, 2016 was proposed in which the concept of EPR gained more momentum. Extended Producer Responsibility is a concept which implies that the responsibility of disposal of electronic item is of the producer of that product, so producers should encourage certain take back initiatives (Yoon and Jang, 2006). For instance, mobile manufacturer Nokia began electronic waste management program in 2008 in four cities namely Delhi, Mumbai, Bengaluru and Ludhiana. Under this program drop boxes were set up in different corners of these cities in which customers were asked to drop used phones, chargers and other mobile accessories (Cao et al, 2016). Another leading mobile company Samsung also introduced Samsung Take-back AndRecycling (STAR) program under which various fixed drop of locations were set up and even pick up service of different used electronics like refrigerators, microwaves, televisions etc was also provided. Despite of efforts adopted by some private organisations, NGOs and certain government initiatives, the problem of electronic waste has reached at an alarming stage and now it is utmost important to deal with it.

Figure 4: Proposed Framework For Sustainable Management Of E-Waste



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7. Conclusion:

In figure 4 a model has been proposed for sustainable management of E-waste. Since informal recyclers have more access to the disposers of e-waste, so few operations like collection, segregation and disassembly should be carried out by them and further the operations like recycling of recovered materials should be taken care by formal sector. E-waste cannot altogether be managed unless citizens of the nation join hands with the government for adopting practices for sound disposal of used electronic products. For this awareness of consumers has to be raised through different workshops, programs, campaigns, seminars etc. Moreover youth of the country can actually see this segment as an upcoming opportunity and can explore it in form of a business venture. The idea of management of E-waste in form of a business proposition is not just to earn profits but the management activities need to be carried out in such a sustainable manner that it is beneficial for both humans and the environment.

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