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# An Indian Insight to Identify the Responsibility of Regulatory Authorities in Managing E-Waste

*Kapil Mohan Garg**

Near to three-decade post Basel Convention (BC), many countries are occupied towards Waste Electrical and Electronic Equipment (WEEE). The agreement on the regulation of Transboundary activities of hazardous wastes and their disposal is the most complete worldwide ecological treaty on perilous and other wastes. There is a noticeable modification in discerning and approach to WEEE (Puja Sawhney *et al.* 2008) but information and intelligence collected in last two decades also shows that e-waste strategies should serve numerous and wider social goals. Progresses in slicing and parting know-hows have led to the understanding that dismantling e-waste may not fetch the anticipated control over the problem. It may also depend on many other factors like role of various stake holder like people dealing with e-waste recycling or consumption, users and generators of waste and regulatory authorities. India is among the top five e-waste producing countries in the world with estimated annual production of 2 million tons (Baldé, C.P., 2017). Unfortunately, the majority of e-waste is recycled in the unregulated informal sector and results in significant risk for toxic exposures to the recyclers (Perkins *et al.,* 2014). Such situations demand prominent intervention of regulatory authorities. Thus, it becomes important to study and identify the role and importance of regulatory authorities, which is the fundamental motive of this study.

***Keywords:*** e-waste, WEEE, Indian e-waste Management, Indian Regulatory authority, e-waste Management.

## Introduction

ELECTRONIC products have made our life easy by saving time and being efficient. Most of our household work is done with help of electronic appliances. Communication systems have been revolutionalized by wireless and mobile phones technology. Entertainment products like television and music system have added enjoyment to our life. Similarly, there are numerous electronic bits and pieces which were once thought to be luxury, have presently become our needs.

From villages to cities, all of them are using electronic products either in one form or the other. There are places in India where people may not have standard access to electricity but they still have battery operated electronic products. Increase in use of these products resulted in augmentation in their production which results in generation of more desecrated products termed as electronic waste or e-waste. Management of electronic waste is a much more formidable challenge in developing countries on account of lack of proper infrastructure, poor legislation and awareness among citizens. Also at stake are the livelihoods of a large number of urban poor involved in processing and recycling of e-waste. India today generates a huge quantity of electronic waste - rough estimate suggest 150,000 tones annually (siliconindia, 2005) - handled across many cities in India, exposing poor workers to environment and occupational health risks (Chatterjee and Kumar, 2009).

The global market for electrical and electronic equipment

* Founder @ 2020classes, @7S Group @ A 7S Tours and Travels, Ghaziabad, India.

continues to expand. Consequently, the waste stream of obsolete electrical and electronic products, commonly called "e-waste", is also vast and growing, and according to the statistical data of the German Federal Environment Agency, about 1.6 million tons of new EEE was brought onto the market and 750,000 tonnes of waste was collected in 2006 (Federal Environment Agency, Electrical and Electronic Equipment Act – ElektroG: Federal Ministry for Environment and Federal Environment Agency, Press Release No. 19/2008, 28 March 2008 (http://www.umweltbundesamt.de/uba-info-presse-e/2008/pdf/pe08-019.pdf) with estimates of 20 times or more per year being generated worldwide. But according to Khaiwal and Suman (2019), Chandigarh generates about 4100/ t of e-waste as compared to 20–25/ mt. globally and this figure is quite alarming and huge as compared to estimation of 2006 above. Many of the products contain numerous hazardous chemicals and materials which poses a threat to the environment and to human health. In some countries and regions, regulations have been introduced with the aim of restricting the use of hazardous substances in these products and the management of e-waste at the products end of life. However, no such regulations exist in many countries where products are manufactured, used and disposed of. Furthermore, even where they apply, regulations do not fully address the management of e-waste or do not control all the hazardous chemicals and materials that are used in newly manufactured electronic products (Ilankoon, 2018). Even in the EU (European Union), where some of the most stringent regulations apply, most of the generated e-waste is unaccounted for e-waste is transported internationally from many countries to destinations where informal recycling and disposal take place, often in small workshops with little or no regulation. As a result, impacts have already been reported in many Asian countries like China. China has also become a major destination for foreign e-waste (C. Hicks *et al.* 2005). The Basel Convention Regional Centre for the Asia Pacific estimates that approximately 33 million tones of illegal e-waste were imported into Asia, with a majority of that finding its way into China; while Tsinghua University estimates that total illegal imports of e-waste to be around 1.5 million tonnes per annum (M. Eugster *et al.* 2007). According to Parajuly *et al.* (2019) it will be a thought-provoking exercise for all the stake holders including regulatory authority to conceptualize future scenarios based on trends and regulatory initiatives.

This study is focused to identify whether organizations are aware about the e-waste or not and how effectively they manage their e-waste in better way. The questionnaire for the survey was designed after considering the objectives of the projects. The data collected have some weakness and strength as the sample size is too small so whatever we conclude is on the basis of the data collected.

## E-waste

"Electronic waste" may be defined as all secondary computers, entertainment device electronics, mobile phones, and other items such as television sets and refrigerators, whether sold, donated, or discarded by their original owners or users. This definition includes used electronics which are destined for reuse, resale, salvage, recycling, or disposal. Others define the re-usables (working and repairable electronics) and secondary scrap (copper, steel, plastic, etc.) to be "commodities", and reserve the term "waste" for residue or material which was represented as working or repairable but which is dumped , disposed or discarded by the buyer rather than recycled, including residue from reuse and recycling operations. Because loads of surplus electronics are frequently commingled (good, recyclable, and non-recyclable), several public policy advocates apply the term "e-waste" broadly to all surplus electronics. The United States Environmental Protection Agency (EPA) includes discarded CRT monitors in its category of "hazardous household waste" (Aspen Publishers, Inc 2006). E-waste comprises of wastes generated from used electronic devices and household appliances which are not fit for their original intended use and are destined for recovery, recycling or disposal. Computers, televisions, VCRs, fax machines are common electronic products. Such electronic products are made up of a variety of components, some of which contain toxic substances that have an adverse impact on human

health and the environment, if not handled and disposed of properly.

## Indian Scenario

There is an estimate that the total obsolete computers originating from government offices, business houses, industries and household is of the order of 2 million nos. Manufactures and assemblers in a single calendar year, estimated to produce around 1200 tons of electronic scrap. (Parthasarathy, 2005). The consumer finds it convenient to buy a new computer rather than upgrade the old one due to the changing configuration, technology, expensive spares and labour and the attractive offers of the manufacturers. Due to the lack of governmental legislations on e-waste, standards for disposal, proper mechanism for handling these toxic hi-tech products, mostly end up in landfills or partly recycled in a unhygienic conditions and partly thrown into waste streams. Computer waste is generated from the individual households; the government, public and private sectors; computer retailers; manufacturers; foreign embassies; secondary markets of old PCs. Of these, the biggest sources of PC scrap are developed countries that export huge computer waste in the form of reusable components.

Electronic waste or e-waste is one of the rapidly growing environmental problems of the world. In India, the electronic waste management assumes greater significance not only due to the generation of our own waste but also dumping of e-waste particularly computer waste from the developed countries. With extensively using computers and electronic equipments and people dumping old electronic goods for new ones, the amount of e-waste generated has been steadily increasing. Unorganized recycling and backyard scrap-trading is close to 100 per cent of total e-waste processing activity. About 25,000 workers are employed at scrap-yards in Delhi alone where more than 10,000 to 20,000 tonnes of e-waste is handled every year. Computers account for 25 per cent of it and in the absence of proper disposal, they find their way to scrap dealers (Bibhu Ranjan Mishra, 2006). India as a developing country needs simpler, low cost technology keeping in view of maximum resource recovery in environmental friendly methodologies.

## Sources of E-waste in India

The main generators of electrical and electronic waste in India are government institutions and the public and private sector consumers. The contribution from individual households, currently relatively small, is also likely to grow alarmingly in future. Manufacturers of components and assemblers are another important source of e-waste generation in the country. However, it is extremely difficult to capture the exact quantity of waste generation by this group. The import of e-waste, which is illegal, is another major source and preliminary estimates do point that the quantity being brought in is very significant. This takes place both in a legal as well as quasi-legal way, since e-waste is either misclassified as 'metal scrap' or imported as second hand or 'end-of-life' goods, which soon become waste.

## Trends of E-waste

The EEE sector provides an example of how product-related legislation and standards that are designed to address national or local environmental concerns in major markets can have significant implications for processes and production methods in other countries. The following important general trends of the EEE sector can be identified:

- Trans-boundary movement of used electrical appliances like refrigerators, personal computers and associated hardware, used electronic equipment and used mobile telephones, is forecast to continue to increase significantly. While offering some economic benefits, massive import of e-wastes coupled with the same wastes being generated locally is placing a heavy health and environmental burden, in particular to developing countries.
- While growing volumes of waste from EEE and associated adverse environmental and health problems can be significant in many countries, policy responses have been diverse. Particularly, the choice between government regulations and controls versus reliance on private-sector initiatives to achieve environmental objectives.

- Environmental policies are increasingly based on the principle of producer responsibility, in particular in dealing with end-of-life environmental impacts.
- The EEE sector illustrates the growing interest of regulators in innovation and product design to develop products that are environmentally-friendly at all stages of their life cycle. This raises questions about:
  - The respective roles of Government and private-sector initiatives;
  - The planning and design cycle of IT hardware industry;
  - The need to take into account differing conditions and needs of developing countries; and
  - Thus the resulting enhanced need for consultation and coordination of key environmental policies.

Trade issues do not figure prominently in national discussions and consultations on policies concerning WEEE, except for concerns about:

(a) The functioning of the EU internal market;

(b) Exports of WEEE to developing countries from developed countries, including used products and donations which may turn into e-waste within next 2-3 months of shipment, leaves developing countries to handle the disposal aspect; and

(c) Voluntary standards on energy efficiency of EEE.

## E-waste Management Methods

There are primarily four methods to manage e-waste. These methods can't give the guarantee of reducing e-waste by 100 per cent but somehow can condense it and save the environment. These four methods are repair, reuse, reduce and recycle. Repair is the most common method and is another way to look at reusing is to repair a broken item. This option can breathe new life into the item and could provide several more years of service (Ikhlayel, 2018). Reuse is another popular method where instead of throwing unwanted items away, they can be put to reuse by donation to someone who needs it. Also there are organizations that repair such items and then sell it for a profit for their cause. You'll probably make a little pocket change and everything that is sold will be reused by someone who will better utilization of it. It can help both that is, saving the environment and reduction of e-waste. Reduce is another where are many ways to reduce the amount of e-waste like reducing the use of disposable products where possible. Items designed to be used again and again are usually much better for the environment. Also, items like electrical cable or battery produces complicated multi-material wastes with different proportions of metals, plastics and glass (Esenduran *et al*., 2019). These can be polluting if they are not adequately treated before final disposal. Material recovery from this equipment is relatively complex but can prove worthwhile when they contain precious and scare metals. Harmful products which can affect the environment should be separated from the waste stream before the final disposal and those products should be disposed off separately so their harmful chemicals do not mix with the atmosphere.

Recycle is considered to be most friendly and economical but before going for recycling of product we must think twice can we use the product means reuse before going for recycling the product because recycling of product require investment (Zeng and Li, 2016). Today the electronic waste recycling business is, in all areas of the developed world, a large and rapidly consolidating business. Electronic waste processing systems have matured in recent years, following increased regulatory, public, and commercial scrutiny, and a commensurate increase in entrepreneurial interest. Part of this evolution has involved greater diversion of electronic waste from energy-intensive downcycling processes (e.g., conventional recycling), where equipment is reverted to a raw material form. The environmental and social benefits of reuse include diminished demand for new products and virgin raw materials (with their own environmental issues). One of the major challenges is recycling the printed circuit boards from the electronic wastes. The circuit boards contain such precious metals as gold, silver, platinum, etc. and such base metals as copper, iron, aluminum, etc. Conventional method employed is mechanical shredding and separation but the recycling efficiency is low.

## Objectives of the Study

- To identify the awareness among the organizations towards the e-waste.
- To ascertain the Role of Government & legal instrument for managing e-waste in India.
- To classify different methods of e-waste management - reuse, repair, reduce and recycle.

## Research Design and Methodology

To meet out the above sited objective a questionnaire based survey was designed to gather information in National Capital Region (NCR) of India. The questionnaire design was influence with the study of Jain and Garg (2011). The said study was covering major parts of Northern India while present study is focused towards NCR to capture spatial effects. Total 200 firms were targeted while 152 received usable. The questionnaire was tested as pilot test study in two parts of NCR namely NOIDA and Greater NOIDA. Rest of the responses was either not received or incomplete.

Nominal and ordinal nature of data and prerequisite to identify the characteristics among various parameters of nonparametric attribute signifying to choose chi-square - a test of goodness of fit establishes whether or not an observed frequency distribution is differ from an estimated frequency distribution.

Best known out of several $\chi 2$ tests is Pearson's chi-square and is used to assess two types of comparison: tests of goodness of fit and tests of independence. Test for fit of a distribution is based on discrete uniform distribution – a simple application is to test the hypothesis that in general population, values occurs with equal probability called theoretical or expected frequencies to test the generalized null hypotheses that the observed distribution follows the expected (there is no preference among observed frequencies).

Test of independence is based on contingency table also known as cross tabulation is often used to record and analyze the dependence between two or more nonparametric variables. In this case, an observation consists of the value of two outcomes and is allocated to one cell of a two dimensional arrays of cell according to the value recorded to test the null hypothesis that the row variable is independent of the column variable.

## Data Analysis

The study is identifying the awareness, need of policy framework, and management of the e-waste with reference to cost, time and environmental impacts. For the term awareness and policy framework, two separate questions have been framed to identify the choice. For the information regarding identification of the methods of Management of e-waste four categories based on 4R principle (Jain and Garg, 2011) namely repair, reduce, reuse, and recycle was given to the respondents to opt best practiced with the consideration of cost, time and environment.

The survey results to assess the awareness of e-waste and need for regulatory framework are given in Table 1. It shows that 80.26 per cent respondents were aware of the term e-waste and 91.45 per cent respondents gave the consent that government should have e-waste management policy. Contrary 8.55 per cent of aware people denied the requirement of policy framework from the government. Table concluded that the high requirement of legal frame work from the government of India in protection of socio-economic responsibilities and impacts.

Table 2 provides the cross tabulation data on awareness and management of e-waste shows that 75 per cent respondents prefer the repair option while only 3.29 per

***TABLE 1***

| Outcomes | | Need for Regulation | | Summary (Awareness) | |
|---|---|---|---|---|---|
| | | No | Yes | Total | % of Total |
| Awareness | No | 4 | 26 | 30 | 19.94 |
| | Yes | 9 | 113 | 122 | 80.26 |
| Summary (Regulation) | Total | 13 | 139 | 152 | 100 |
| | % of Total | 8.55 | 91.45 | 100 | |

***Source:*** Survey.

*TABLE 2*

| Outcomes | | E-waste Management by | | | | Summary (Awareness) | |
|---|---|---|---|---|---|---|---|
| | | Repair | Reduce | Reuse | Recycle | Total | % of Total |
| E-waste Awareness | No | 25 | 4 | 0 | 1 | 30 | 19.74 |
| | Yes | 89 | 20 | 5 | 8 | 122 | 80.26 |
| Summary (Management) | Total | 114 | 24 | 5 | 9 | 152 | 100 |
| | % of Total | 75 | 15.78 | 3.29 | 5.93 | 100 | |

***Source:*** Survey.

*TABLE 3*

| Outcomes | | E-waste Management by | | | | Summary (Type) | |
|---|---|---|---|---|---|---|---|
| | | Repair | Reduce | Reuse | Recycle | Total | % of Total |
| E-waste Regulation | No | 12 | 1 | 0 | 0 | 13 | 8.55 |
| | Yes | 102 | 23 | 5 | 9 | 139 | 91.45 |
| Summary (Management) | Total | 114 | 24 | 5 | 9 | 152 | 100 |
| | % of Total | 75 | 15.78 | 3.29 | 5.93 | 100 | |

***Source:*** Survey.

cent are in favour of reuse. The interesting fact is that 83.33 per cent unaware respondents choose the popular option showing the common attitude of cost reduction. Table further inferred that reduce is the second most preferred option followed by the recycle.

Requirement of regulatory framework and management of e-waste related facts given in Table 3 in the form of cross frequency. Information based on survey shows that 73.38 per cent firms are in favour of the management of e-waste through repair and want that government should have the regulatory framework. While only 6.47 per cent respondents opt the option of recycle and shows the regulatory need. Main finding based on Table 3 is that the regulatory or legal framework is required mainly for the use of e-waste after the repair rather the regulation of recycle procedure and guidelines.

Chi square test of goodness of fit (Table 4) is further supporting the dominant nature of outcomes received. The p-value (asymptotic value of significance) which is zero up to three digits after decimal indicating very high level of significance and infer to rejecting the null hypothesis of similarity of outcomes or in other words opinions are significantly different than others for all three options namely awareness, regulation and management of e-waste.

Test of independence based on chi-square test outcome is given in Table 5 showing the inter-dependency between variable of concern. Test statistics shows that evidence of association of attributes between awareness and regulation are not present since the p-value is greater than the required level of significance, which shows that the opinion given by the various firms related to awareness and regulatory framework are independent. Similarly awareness

*TABLE 4*

| Chi Square | Value | p-value |
|---|---|---|
| Awareness | 55.684 | 0.000 |
| Regulation | 104.447 | 0.000 |
| Management | 207.947 | 0.000 |

***Source:*** Survey.

*TABLE 5*

| Chi Square | Awareness | Regulation | Management |
|---|---|---|---|
| Awareness | - | 1.092 (0.296) | 2.141 (0.544) |
| Regulation | 1.092 (0.296) | - | 2.467 (0.481) |
| Management | 2.141 (0.544) | 2.467 (0.481) | - |

***Source:*** Survey.

and management, and regulation and management also reported the high p-values are again supporting the null hypothesis. Since the survey was designed to acquire the facts from the firms related to e-waste and its management so it was essential to record the unbiased and independent opinions, which was approved by the test based on contingency table.

## Conclusion

Awareness among all stakeholders of society is very critical for any effective change. E-waste, being a very emerging issue involving large number of stakeholders, needs concerted and sustained effort to create proper environment through education and awareness to make the change be progressive and meaningful. The role of state and producers are paramount and critical in this regard. The Regulatory Authorities will be required to take all initiatives and measures to educate the community at large and all other stakeholders make responsible. The producers will also need to play their part in educating the consumers regarding the e-waste management system, product constituents, and handling precautions, etc.

The 4R principle advocated that the repair is the most preferred option for the reduction of e-waste or no waste, while reducing and recycling the waste destined for disposal and the burden on the environment. The strategy for reduction in e-waste generation applies to different levels in the e-waste value chain, which can be achieved by maximization of the use and reuse of electrical and electronic equipment, thereby delaying e-waste generation through repair; encouraging authorized refurbishment of used electrical and electronic equipment to extend the life of the equipment. Obsolete equipment, where ever suitable and usable, may be considered and given as donation to nonprofit/charitable institutions.

The development of supply chain of e-waste, comprising a collection system shall facilitate collection and segregation of e-waste and channelize such waste for the repair to reduce the need for new buying, reuse by the needful or finally recyclers to maximize the economic values and minimize environmental loss.

## Recommendation

Awareness and education: Awareness among all stakeholders is very critical for any change to be effective and meet its desired objective. E-waste, being a very complex issue involving large number of stakeholders, will need concerted and sustained effort in creating the right kind of environment through education and awareness to make the change be progressive and meaningful. The role of state and producers are paramount and critical in this regard.

The Regulatory authorities will be required to take all initiatives and measures to educate the community at large and all other stakeholders of responsibilities and roles of each sector. The producers will also need to play their part in educating the consumers regarding the e-waste management system, product constituents, handling precautions, responsibility of the producers in changed situation. These can be done collectively or individually through proper labelling in the products and other effective tools.

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