# E-WASTE MANAGEMENT SYSTEM: RECOMMENDATIONS AND BUSINESS MODELS

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**Abstract— The act of extensive, reckless and haphazard disposal of e-waste for monetary gains mostly, coupled with governments inefficiency and unorthodox systematic control of it in any society is without a doubt extremely dangerous and harmful to the society`s public health and economy as a whole. The untreated e- waste poses enormous threat to public health and the quality of life of the people in general. It also shatters and renders the environment inexplicably unproductive. In addition, it is the socially and economically weaker sections of the society, who suffer the most in these situations. With the number of the souls purchasing electrical and electronic goods increasing manifolds, many areas are being used as a dumping ground for e-wastes, and weaknesses in governmental waste management processes has made WEEE become a serious dilemma. Previously the environmental and sustainability management of e-waste has received low priority. Lack of financial resources, institutional weaknesses, improper choice of technology and public unawareness towards WEEEM are some of the factors that contributed to the upward slide of seeing E-Waste as a problem. However on the flip side of the coin, the economic benefits of WEEE through recovery and recycle of the materials, which can later be reused and re-sold as secondary materials is a very good source of job creation for individuals and revenue generation for businesses. To address this serious matters and also lay out a framework for the times ahead, various recommendations have been made and three business models have been advocated for the management of E-Waste as a part of the research.**

**Keywords—formal sector, informal sector, environmentally sound techniques, sustainability, business models.**

## INTRODUCTION

In general E-waste can be defined as old, end of life electronic and electrical(EEE) or waste generated from any equipment running on electricity or battery becomes unfit for their originally intended use or have crossed their expiry date. Computers, servers, mainframes, monitors, compact discs (CDs), printers, scanners, copiers, calculators, fax machines, battery cells, cellular phones, transceivers, TVs, iPods, medical apparatus, washing machines, refrigerators, and air conditioners are examples of e-waste (when unfit for use). These electronic equipments get fast replaced with newer models due to the rapid technology advancements and production of newer electronic equipment. This has led to an exponential increase in e-waste generation. People tend to switch over to the newer models and the life of products has also decreased. Electronic waste as such is emerging as a serious public health and environmental issue in India. India is the "fifth largest electronic waste producer in the world"; approximately 2 million tons of e-waste are generated annually and an undisclosed amount of e-waste is imported from other countries around the world. Annually, computer devices contribute about 70% of e-waste, 12% comes from the telecommunication industry, 8% from medical equipment and 7% from electric appliances. The government, public sector companies, and private sector companies generate approximately 75% of total electronic waste, with the contribution of households being merely a 16%. Unfortunately the governments of the past and present have not intervened adequately in the monitoring and controlling the indiscriminate dumping as well as e-waste management. This can be attributed to the fact that the government has relatively low ability and capacity to handle such situation because of the requirements such as education, infrastructure, technical know- how, finance, training, and experience. The import of e-waste to the developing countries is also violation of the ban imposed by Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, as e-waste come under the definition of hazardous waste (Basel Convention, 1992).Following this, India, a party of

the convention, banned the import of hazardous waste including e-waste into the country. But a major source of e-waste in India is illegal imports.Laws to manage e-waste have been in place in India since 2011, mandating that only authorized dismantlers and recyclers collect e waste. E-waste (Management) Rules, 2016 was enacted on October 1, 2017. Over 21 products (Schedule-I) were included under the purview of the rule. The rule also extended its purview to components or consumables or parts or spares of Electrical and Electronic Equipment (EEE), along with their products. The rule has strengthened the Extended Producer Responsibility (EPR), which is the global best practice to ensure the take-back of the end-of-life products. A new arrangement called Producer Responsibility Organization (PRO) has been introduced to strengthen EPR further. The producers have to meet targets, which should be 20 per cent of the waste generated by their sales. This will increase by 10 per cent annually for the next five years. The law also says that the responsibility of producers is not confined to waste collection, but also to ensure that the waste reaches the authorized recycler/dismantler. And despite new rules that have come into place to safely process this hazardous material, close to 80 per cent of e-waste — old laptops and cell phones, cameras and air conditioners, televisions and LED lamps — continues to be broken down, at huge health and environmental cost polluting ground water and soil, by the informal sector.E-waste is growing at a compound annual growth rate (CAGR) of about 30 per cent in the country. ASSOCHAM, one of the apex trade associations of India, estimated that e-waste generation was 1.8 MT per annum in 2016 and would reach 5.2 MT per annum by 2020.

## LITERATURE REVIEW

A number of books, journals and publications have been accessed to help in this study. These books, publications, and articles serve as the theoretical background of the research.

**Matthew J. Realff, et al. (2004)**, in their publication titled "E-waste: an opportunity", understood that designing a waste management system could be a big problem for nations, most especially the developing nations, where the most part of e-wastes end up. These authors pointed out that in order to achieve an efficient e-waste management system that government, individual and business must have a common goal. This goal must reflect sustainable development; hence it requires education, innovation and legislation.

**S Chatterjee and Krishna Kumar (2009),** in their published academic journal titled "Effective electronic waste management and recycling involving formal and non-formal sectors", pointed out the problems facing developing nations with regards to management of e-waste. The authors argued that WEEEM can be a profitable business if managed professionally. In addition, they observed that technology is a vital tool in e-waste management process, as they referred their point to e-waste-to-resources management in developed nations. Moreover, they did not fail to point out that for effective and efficient WEEM practices, the formal and non-formal sectors of the society ought to collaborate.

**Athias Schluep et al (2009),** with a title called "Sustainable innovation and technology transfer: recycling from e-waste to resources", is an interesting publication because the study reflected the market situation and e-waste management condition in 11 countries that cut across the whole globe. It´s a peculiar study as it talks about the market creation concepts, market potential concepts; and stages of e-waste recycling as it relates to both technologically innovative markets and developing nations. Moreover, it went further to state that that the market potential of innovative recycling technologies is defined through the critical volumes, which can justify the transfer and installation of technologies in order to manage e-waste in the most sustainable way. Hence having a market potential doesn'tnecessarily mean that an operation can be run in a self-sufficient way, which means paid by the sales of recycling output fractions or materials. The report went further to stress on how to make the business of e-waste-to-resources sustainable and profitable.

## THE E-WASTE FLOW CHART

Dealing with E-waste is a dominant issue in our endeavour to create a sustainable society Electronics waste is constantly becoming a colossal crisis for civil society, and like all waste management practises, the aim of e-waste management is to drastically reduce, reuse or recycle most of the materials or components that are found in electrical and electronic equipments, with a very little left for landfilling. In recent years however, huge accumulations of e-waste and its primitive recycling

methods; for extraction of precious metals has become a major concern in most developing countries because of the hazardous materials e-waste contains. The Recycling of e-waste through proper technologies, although profitable in developed countries due to the presence of precious metals (including gold, silver etc.) in printed circuit boards (PCB) is also an ill favoured venture to undertake because of its initial investments into recycling technologies. Also, the high recycling cost involved in e-waste recycling makes it an unattractive venture for most entrepreneurs in third world countries. Thus, huge volumes of e-waste are exported to the developing countries like India, China, Brazil etc., where manpower is in-expensive and enforcement of environmental laws are not so stringent Here, crude methods are applied by artisans, with no proper knowledge in hazardous waste management, to dismantle WEE parts, in the hope of finding usable parts, mainly electronic, and scrap metal such as copper

The main motivation for non-formal operators is to extract precious metals (gold, silver) from printed circuit board (PCB) using unscientific and unhygienic methods, which are dangerous for the workers and the environment. (Kumar et al, 2005) On the other side of the coin is the formal sector where professionals use various methods to disassemble electrical and electronic products in an environmentally sustainable manner.

## FLOW CHART; INFORMAL SECTOR

The informal sector, is most prevalent in developing countries.. In the informal sector, the collection and re-cycling of e-wastes is done by the local artisans.. The practice exhibits a highly stratified system, comprising collection, recycling, refurbishment and reuse activities and eventually the disposal of the residuals. The electrical and electronic devices are managed informally in small workshops using basic methods such as manual disassembly and open burning The appliances are stripped of their most valuable and easily extracted components which are processed into directly reusable components or secondary raw materials in a variety of refining and conditioning processes. There are also indications that some selected components like printed wiring board are selected for export probably to Asia for recycling The remaining parts are then landfilled or stored directly.

Also found alongside in this sector is a large number of refurbishing and repair operations for electric and electronic products that are largely imported, drawing close business linkages with importers and retailers of second hand electrical and electronic products.

The mass flow chart, as illustrated in the figure below shows the flow of electrical and electronic products between different actors involved in refurbishing and e-waste recycling chain in a typical informal sector.

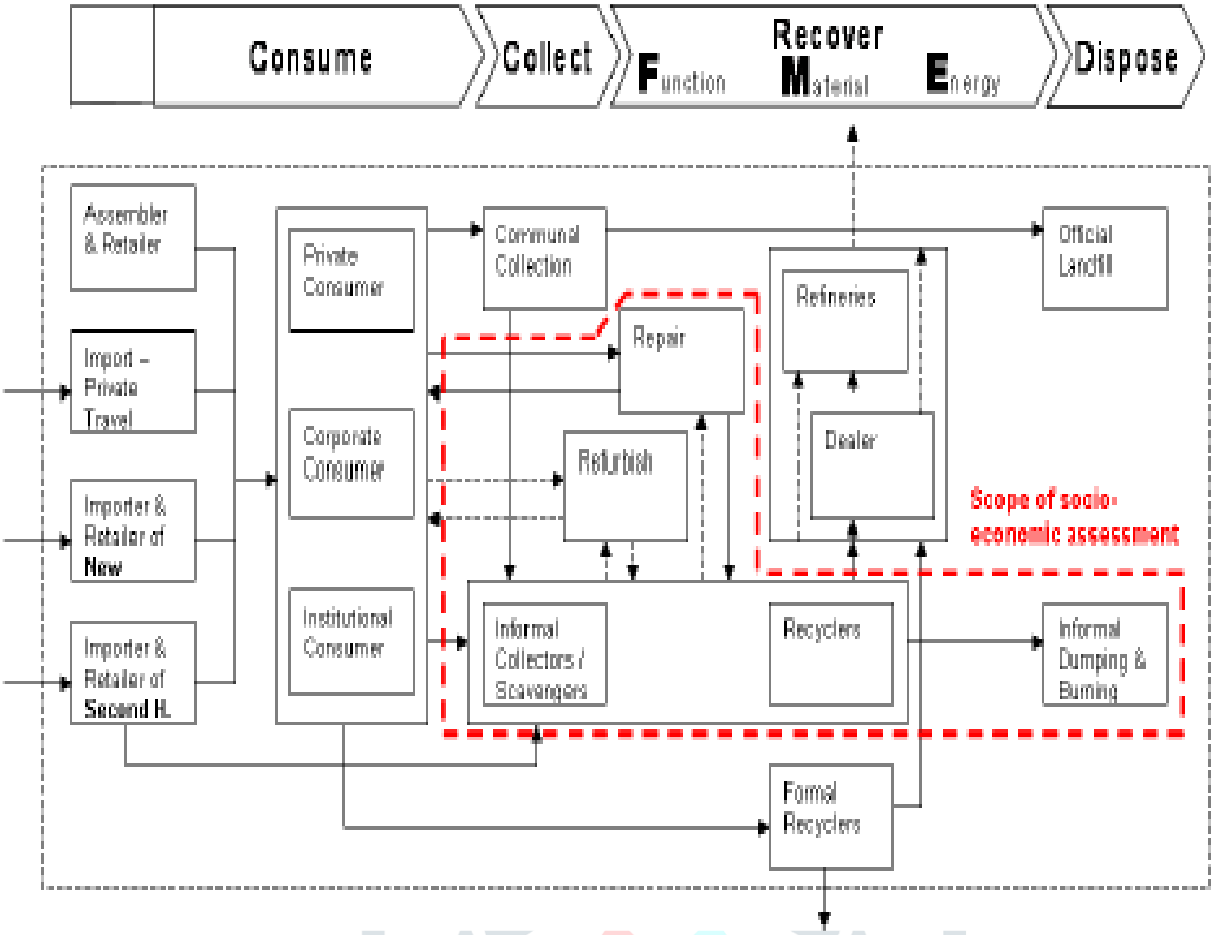


**Figure 1.** Mass flow chart of the refurbishing and e-waste recycling in an informal sector. It also shows a socio-economic loop within the informal sector among its structured stages: collection, refurbishing / repair, recycling (involving dismantling, also burning) and final disposal.

## FLOW CHART; FORMAL SECTOR

Units in formal sector use all types of methods to disassemble and segregate the e-waste materials. These methods are varied from manual or semi-automated or automated techniques. These methods are environmental friendly and take care of the safety of the health of the operators. Disassembly involves the removal of hazardous components such as batteries and other high and low grade including component, part, group of parts or a sub-assembly from a product (partial disassembly) or the separation of a product into all of its component parts

(complete disassembly). The recovery of valuable materials such as printed circuit boards, cables and engineering plastics is simplified by such approach.

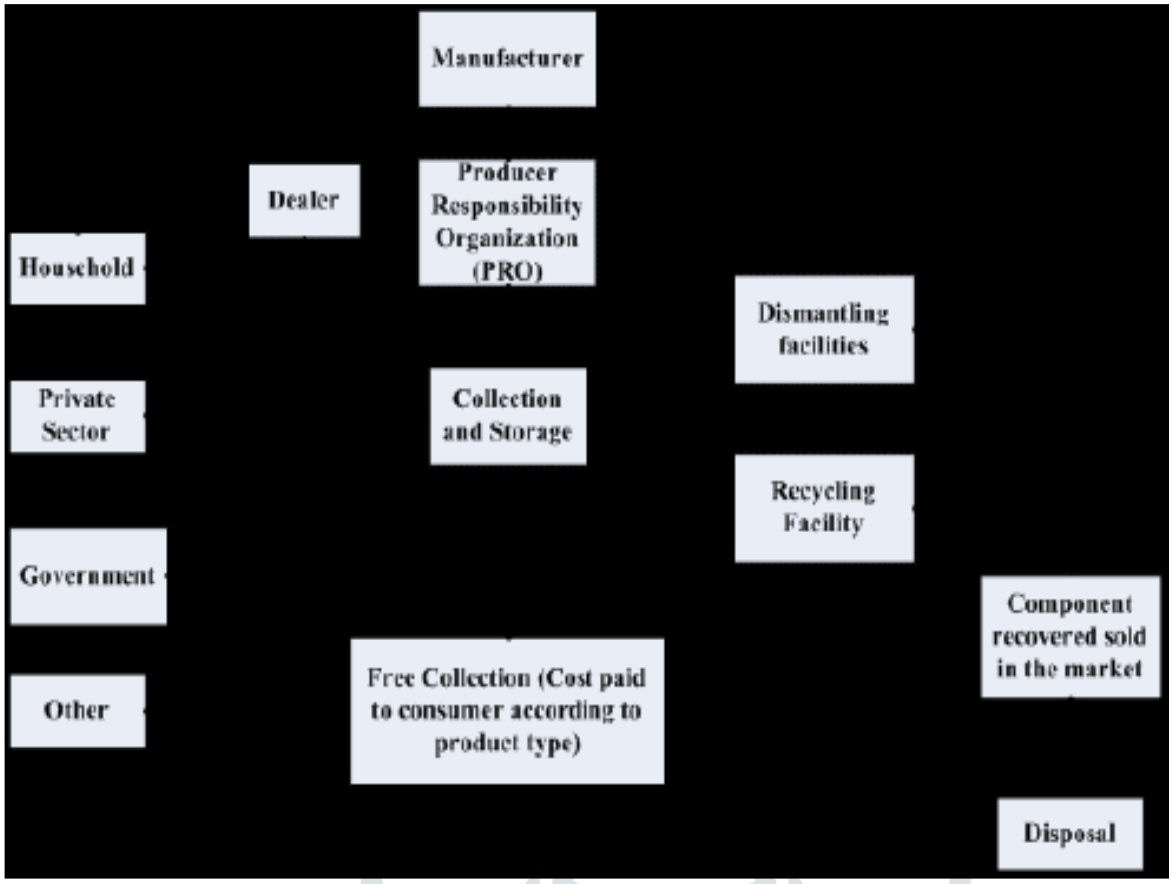


**Figure 2.** Typical e-waste flow chart in a formal sector

## NEED FOR GUIDELINES FOR ENVIRONMENTALLY SOUND MANAGEMENT

The famous saying waste is misplaced wealth holds true in the case of e-waste as well. The recyclability of e-waste and the precious metals which can be extracted from the waste make recycling a fruitful business. But recycling using environmentally sound techniques stands for costly business and thherefore majority of the e-waste is recycled via the informal sector. Informal recycling involves minimal use of technology and is carried out in the poorer parts of big cities. The standard procedure drill involves physically breaking down components often without any protective gear, burning poly vinyl chloride (PVC) wires to retrieve copper, melting of lead and mercury laden parts. The extraction of gold and copper requires acid processing. The plastic parts, which contain brominated flame retardants (BFR) are also broken into small pieces prior to recycle. All these processes release toxic fumes into the atmosphere and polluted water into soil and water bodies leading to contamination. Most of those who work in the recycling sector are the urban poor with low literacy lacking awareness of the hazards of the toxic e-wastes. Children and women are routinely involved in the operations. Most of the work is done by bare hands. Waste components which do not have resale value are openly burnt or disposed off in open dumps (Kurian, 2007).Rapid pace of product obsolescence resulting in short life span of computers and other electronic equipments coupled with exponential increase in consumption of such products will result in the doubling of waste over next five to six years. The toxicity of constituents in e-waste, lack of environmentally sound recycling infrastructure and the large scale current practice of informal recycling highlight the urgent need for guidelines for environmentally sound management of e-waste.

## E-WASTE COMPOSITION AND RECYCLE POTENTIAL

The composition of e-waste and its recyclable potential is different for each appliance. In order to handle this complicated issue, the parts/materials found in e-waste can be broadly classified into six categories as follows:

**1)** Iron and steel, used for casings and frames

**2)** Non-ferrous metals, especially copper used in cables, and aluminum

**3)**Glass used for screens, windows

**4)** Plastic used as casing, in cables and for circuit boards

**5)** Electronic components

**6)** Other materials (rubber, wood, ceramic etc.)

Overview of the composition of the appliances in the three categories mentioned earlier is given in table below

**Table 1** Average Weight and Composition of Selected Appliances (Typical)

| Appliances | Average weight (kg) | Fe % weight | Non Fe-metal % weight | Glass % weight | Plastic % weight | Electronic components % weight | Others % weight |
|---|---|---|---|---|---|---|---|
| Refrigerats and freezers | 50 | 65 | 6 .6 | 1.3 | 13 .1 | 0.2 | 15.0 |
| Personal computer | 30 | 19.6 | 23 | 16 | 22.5 | 17.8 | 0.7 |
| TV sets | 36. | 5.5 | 5.8 | 61.6 | 22.5 | 1.3 | 3.5 |

The recovery potential (typical values) of items of economic value from refrigerator, personal computer and television are given in tables 2,3,4 respectively.

**Table 2** Recoverable Quantity of Materials in a Refrigerator

| Material Type | % (by weight) |
|---|---|
| CFCs | 0.22 |
| Oil | 0.30 |
| Ferrous Metals | 46.31 |
| Non-Ferrous Metals | 5.27 |
| Plastics | 13.64 |
| Compressors | 24 |
| Cables/Plugs | 0.50 |
| Spent Foam | 7.65 |
| Glass | 0.86 |
| Mixed Waste | 1.25 |
| **Total** | **100.00** |

**Table 3** Recoverable Quantity of Materials in a Personal Computer

| Elements | Content (% of total weight) | Content (Kg) | Recycling efficiency (%) | Recoverable weight of element (kg) |
|---|---|---|---|---|
| Plastics | 23 | 6.25 | 20% | 1.251 |
| Lead | 6 | 1.71 | 5% | 0.086 |
| Aluminum | 14 | 3.85 | 80% | 3.084 |
| Germanium | 0.0016 | 0.00 | 0% | 0 |
| Gallium | 0.0013 | 0.00 | 0% | 0 |
| Iron | 20 | 5.57 | 80% | 4.455 |
| Tin | 1 | 0.27 | 70% | 0.192 |
| Copper | 7 | 1.88 | 90% | 1.696 |
| Barium | 0.0315 | 0.01 | 0% | 0 |
| Nickel | 0.8503 | 0.23 | 0% | 0 |
| Zinc | 2 | 0.60 | 60% | 0.360 |
| Tanialum | 0.0157 | 0.0046 | 0% | 0 |
| Indium | 0.0016 | 0.00047 | 60% | 0.00026 |
| Vanadium | 0.0002 | 0.00 | 0% | 0 |
| Beryllium | 0.0157 | 0.0046 | 0% | 0 |
| Gold | 0.0016 | 0.00047 | 99% | 0.00043 |
| Europium | 0.0002 | 0.00 | 0% | 0 |
| Tritium | 0.0157 | 0.00 | 0% | 0 |
| Ruthenium | 0.0016 | 0.00047 | 80% | 0.00035 |
| Cobalt | 0.0157 | 0.0047 | 85% | 0.00363 |
| Palladium | 0.0003 | 0.00 0077 | 95% | 0.000077 |
| Manganese | 0.0315 | 0.01 | 0% | 0 |
| Silver | 0.0189 | 0.0156 | 98% | 0.00504 |
| Antimony | 0.0094 | 0.00 | 0% | 0 |
| Bismuth | 0.0063 | 0.00 | 0% | 0 |
| Chromium | 0.0063 | 0.00 | 0% | 0 |
| Cadmium | 0.0094 | 0.00 | 0% | 0 |
| Selenium | 0.0016 | 0.00047 | 70% | 0.0003 |
| Niobium | 0.0002 | 0.00045 | 0% | 0 |
| Yttrium | 0.0002 | 0.00 | 0% | 0 |

| | | | | |
|---|---|---|---|---|
| Mercury | 0.0022 | 0.00 | 0% | 0 |
| Arsenic | 0.0013 | 0.00 | 0% | 0 |
| Silica | 24.8803 | 6.77 | 0% | 0 |

**Table 4** Recoverable Quantity of Materials in a Television

| Elements | % by weight | Recoverable Weight of element (Kg) |
|---|---|---|
| Aluminium | 1.2 | 0.4344 |
| Copper | 3.4 | 1.2308 |
| Lead | 0.2 | 0.0724 |
| Zinc | 0.3 | 0.1086 |
| Nickel | 0.038 | 0.0138 |
| Iron | 12 | 4.344 |
| Plastic | 26 | 9.412 |
| Glass | 53 | 19.186 |
| Silver | | 0.000724 |
| Gold | | 0.000362 |

## RECOMMENDATIONS

### LEGISLATION

Strict laws and regulations to deal with waste electrical and electronic equipments in order to control aspects of production, recycle, reuse and disposal is need of the hour. Several countries have such laws in place. In our country, draft e-Waste (Management and Handling) Rules have been published by the Ministry of Environment and Forests, Government of India on 14.5.2010. Laws should not be only formed but also implemented in latter and spirit.

### EXTENDED PRODUCER RESPONSIBILITY (EPR)

Conventionally, the legislative approach towards the environmental issuess has been one of 'command and control', mainly addressing 'end-of-pipe' pollution issues. Now, the emphasis is changing towards producer responsibility whereby those who generate goods are then responsible for the environmental impacts throughout the whole of their life cycle, from resource extraction to recycling, reuse and disposal (Nnorom et.al, 2008). Implementation of EPR in the developing countries has become vital in the light of the present high level of trans-boundary movement of e-waste into the developing countries and the absence of core or state-of the-art facilities for sound end-of-life material/energy recovery and disposal of e-waste.

The Organization for Economic Cooperation and Development(OECD) defined EPR as "an environmental policy approach in which a producers' responsibility for a product is extended to the post-consumer stage of a products life cycle including its final disposal"

The main goals of EPR are:

• Prevention and reduction of waste

• product reuse;

• increased use of recycled materials in production;

• reduced natural resource consumption;

• internalization of environmental costs into product prices

• energy recovery when incineration is considered appropriate

Under EPR, the producer is expected to take back all electrical and electronic equipment at the end of their life. It is recommended that the government of Ghana ratify the Basel convention, of which it agreed to in the 1980's. If this happens, it will greatly make producers assume responsible roles for the end of life of their products as per the "extended producer responsibility" (EPR) tenet enshrined in the convention.

**REDUCTION IN USE OF HAZARDOUS SUBSTANCES (ROHS)**

This objectives is reducing the hazardous substances entering the atmosphere while dismantling the e-waste by prescribing threshold limits for use of such substances in e-waste. The government of India should develop an effective e-waste management system to stop the current trend of haphazard e-waste recovering and discarding practices. This has become necessary because of the potential these practices, if unregulated, have on the environment and public health in the long run. The disposal of these hazardous materials, should also be meeting or conforming to known international controls and regulations

**INVESTMENT IN MANPOWER, TRAINING AND INFRASTRUCTURE**

It is important that the government of Ghana should create the needed manpower through training and also employ technical expertise to effeciently manage the associated e-waste linked to the drive towards ICT development in all facets of our developmental process. It is envisaged that the needed investments in manpower and technology will be made to ensure effective e-waste management as the country embraces the digital age. Also, the EPA should be strengthened in its supervisory role of monitoring e-waste management within the city by making sure that actors within the sector adhere to laid down procedure and processes of managing such hazardous wastes. This will ensure culpability and accountability on the part of both managers and actors in the e-waste management business, from creation to disposal.

**TAKING A CUE FROM THE WEST; THE NEED FOR INSTITUTIONAL AND REGULATORY REFORMS**

Last but not the least, the government should take a cue from the European example on their management of e-waste. Directive 2002/96/EC of the European Parliament and Council, 2003 on waste generated by electrical and electronic equipment and amended by Directive 2003/108/EC, and Directive 2002/95/EC of the European Parliament and of the Council, 2003 on the limit to the use of certain hazardous substances in electrical and electronic equipment was adopted by the EU on the 27th January 2003 to ensure the recycling and reuse of electric and electronic products. Subsequently, these directions were successfully enshrined into the national legislation of member states on 13 August 2004.

Additionally, the Directive on Electrical and Electronic Equipment waste obliges EU Member States to gather at minimum 4kg of EE waste from households per year. It also mandates members to create collection systems for electronic equipment by August 2005 (August 2007 for the new Member States). When these systems are established, consumers will be in the position to return outdated products to shops and collection points at no cost for safe disposal. As a matter of fact, producers of electrical and electronic equipments are supposed to bear the cost for such collection systems. Also, the Directive limiting the use of Hazardous Substances bans such hazardous substances like lead and cadmium from electronic equipment from 1 July 2006.

Further, the directive categorises e-waste into different groupings, namely;

* Electrical and Electronic tools

* Medical instruments and devices

* IT and telecommunications equipment

* Toys, leisure and sports equipment

* Consumer equipment

* Automatic dispensers

* Lighting equipment

The grouping of e-waste into such categories is to make it obligatory for producers or manufacturers to recognize improved procedures in design and assembly to ease their dismantling, recovery and recycle after disposal.

## SETTING UP AN INDEX FOR ESTIMATING THE TOXICITY OF AIR, WATER AND SOIL

The process of e-waste causing environmental pollution and the health problems associated with it is a complicated and cumbersome issue. Detailed studies, surveys and investigations about the process of e-waste recycling, transportation of toxic and dangerous components to environment and then to organism have to be undertaken. It is as such suggested that government establish the e-waste evaluation and management centers of excellence, working in cooperation with existing organizations in the area of recycling and waste management. Sampling the toxicity levels of air, soil and water and the related human biological sampling to correlate its impact and reaching to the threshold levels beyond which may cause huge problems to organisms. Calculating periodic Toxicity levels of various places and publishing in news paper, TV, radios and Social media regularly for creating awareness on impending health concerns and preventive actions .

## WORLDWIDE COOPERATION TO COUNTER ENVIRONMENTAL IMPACT

Since e-waste generation, growth and disposal across nations, directly concerns environmental impact, global treatment as cohesive & collaborative efforts among the nations is very vital. International network for e-waste management between developed, under- developed and developing nations is required to share the best suitable methods of e-waste management and disposal for bringing proper focus and knowledge & technology sharing . This would also address problems of illegal export of second hand -e-waste equipment's among various countries.

## CHARGING OF RECYCLING FEES TO THE BUYER

This program can help to shift the recycling burden from the manufacturer to the buyer. When a consumer buys an electronic device like a new laptop, he/she will have to pay a nonrefundable recycling fee of 3% to 5% of the total cost price.

## WASTE MINIMIZATION BY CO PROCESSING

The concept on "Utilization of Hazardous waste" as add on resource or for energy recovery, or processing in line with hazardous waste (movement, handling & trans-boundary movement) Rules,2008. Central Pollution Control Board (CPCB) has been empowered to accord approval for utilization of different categories and type of hazardous waste. Subsequently CPCB has developed guidelines in February-2010 for co processing of hazardous waste in cement kilns. Other substances with high calorific value viz.; tires and plastic wastes, which are otherwise treated as "waste" not in the purview of "hazardous waste" can also be co-processed in the cement industry, thermal power plant, iron and steel industry, through co-processing. At present Gujarat pollution control board has permitted a few cement plants to co- process different compatible hazardous wastes. During the year 2009-2010 approx. 13000 MT of waste has been co-processed in the cement Industries, which is a good initiative to start with even in Kashmir region.

## BUSINESS MODELS

### BUSINESS MODEL 1: CSR ORIENTED E-WASTE MANAGEMENT

A business model is put forward for e-waste management as a part of CSR initiative for socio-economic exhilaration. It is self powered and very sustainable model. The corporations earning revenue more than five hundred crores yearly are required to spend two percent revenue under CSR Bill. In our country main issues are Literacy, poverty and energy. The business model addresses all the 3 problems to large extent. It provides B2B , B2C and B2G model . The various steps of the model are as follows:

a. Government authorized CSR consultants and personnel to monitor and regulate CSR incomes and financing.

b. The corporations and industries generating E-waste will contact CSR consultant [New position- job opportunity] for proper disposal. The companies will provide certificates for working non-working hardware. The Non -working hardware would be then

given to the government authorized recyclers for appropriate disposal .However the working hardware can be utilized to setup various public clouds at district and state level.

c. The CSR consultants can engage the college, universities and IT department of various companies to get the required technical and financial assistance to set first time public cloud.

d. Government should facilitate computer literacy programs in every manner. CSR consultants to affiliate with various colleges, universities and government organisations to launch free education programs and create centers for learning's with NGO's for educating people. This will create huge literacy, empowerment and employability for the people living in slums , under privileged, orphans and families below poverty line.

e. The employees from the companies can also share their knowledge and experience in the training centers as part of corporate social responsibility, which would improve the personal gratification and engagement.

**ADVANTAGES OF THE MODEL:**

i. Centralized model for CSR finance to allow accountability and transparency by thegovernment for regulating and directing investments/expenses to needed ventures.

ii. The model assists in utilizing the thrown away hardware for betterment of society which otherwise would be left out in use or put in landfills or incinerators. Extending the life of these equipments by an additional two (2) to three (3) years is manifolds greater for the environment than recycling it.

iii. Tremendous opportunity for NGO. It provides a huge opportunity with many literacy and employment initiatives to utilize the money being made

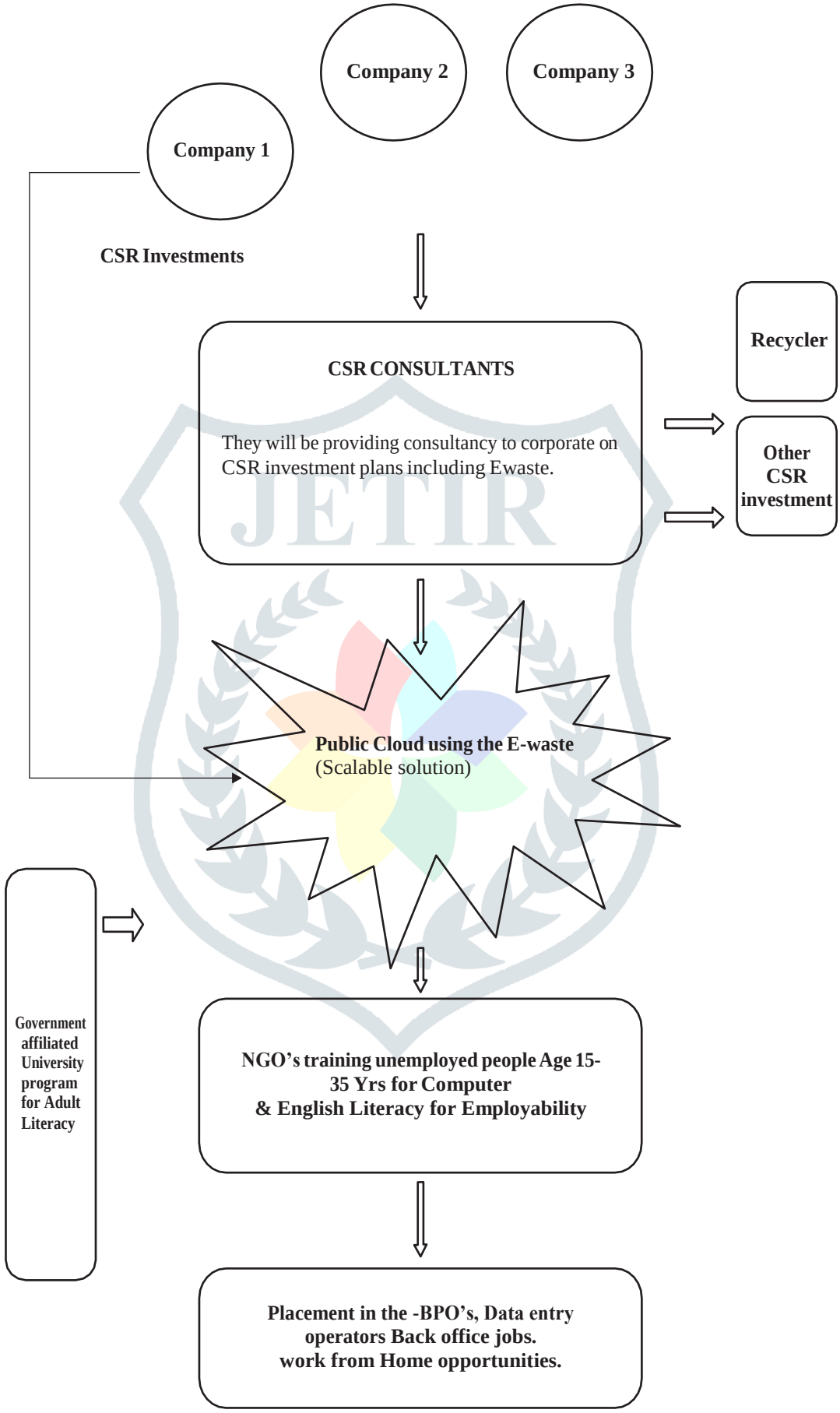


**Figure3: CSR Oriented E-Waste Management**

**BUSINESS MODEL 2: IOT ORIENTED E-WASTE MANAGEMENT**

a. The equipments after being sold to the buyer , the tracking mechanism is enabled and device is registered with customer details.

b. The health check report of the equipments is regularly shared with the manufacturer- customer care and the customer by the device via a message.

c. The equipments faults are reported, and the manufacturer's customer care ties up with the Technical support.

d. On reaching EOL of the equipments, the Alerts are send to the customer care, recycler and customer.

e. Customer care initiates the recycler and customer interaction, where-in the equipments is sold by customer if in non-working conditions.

f. Manufacturer also sends personalized offers on the buy-back of working equipment crossed EOL, with the new model , in exchange offer's with discount.

g. Recycler recycles the non-working device in his premises via appropriate process.

h. Manufacturer updates the information of the equipment in his device tracking system.

i. Yearly reports are revealed by the manufacturer to the government, on the total sales of the equipment, buy back of the equipment and recycled .

j. If customer wants to re-sell the equipment on his own , then he has to register at manufacturer's- customer care with new owners details, rest of the flow remains same however.

**Advantages of the Model**

1. Accountability of the equipment maintenance and recycle remains with manufacturer.
2. Government has an eye on electronics production and recycle quantity for all the manufacturers.
3. E-waste is disposed by a proper Formal method, reducing carbon footprint and impact to the environment.

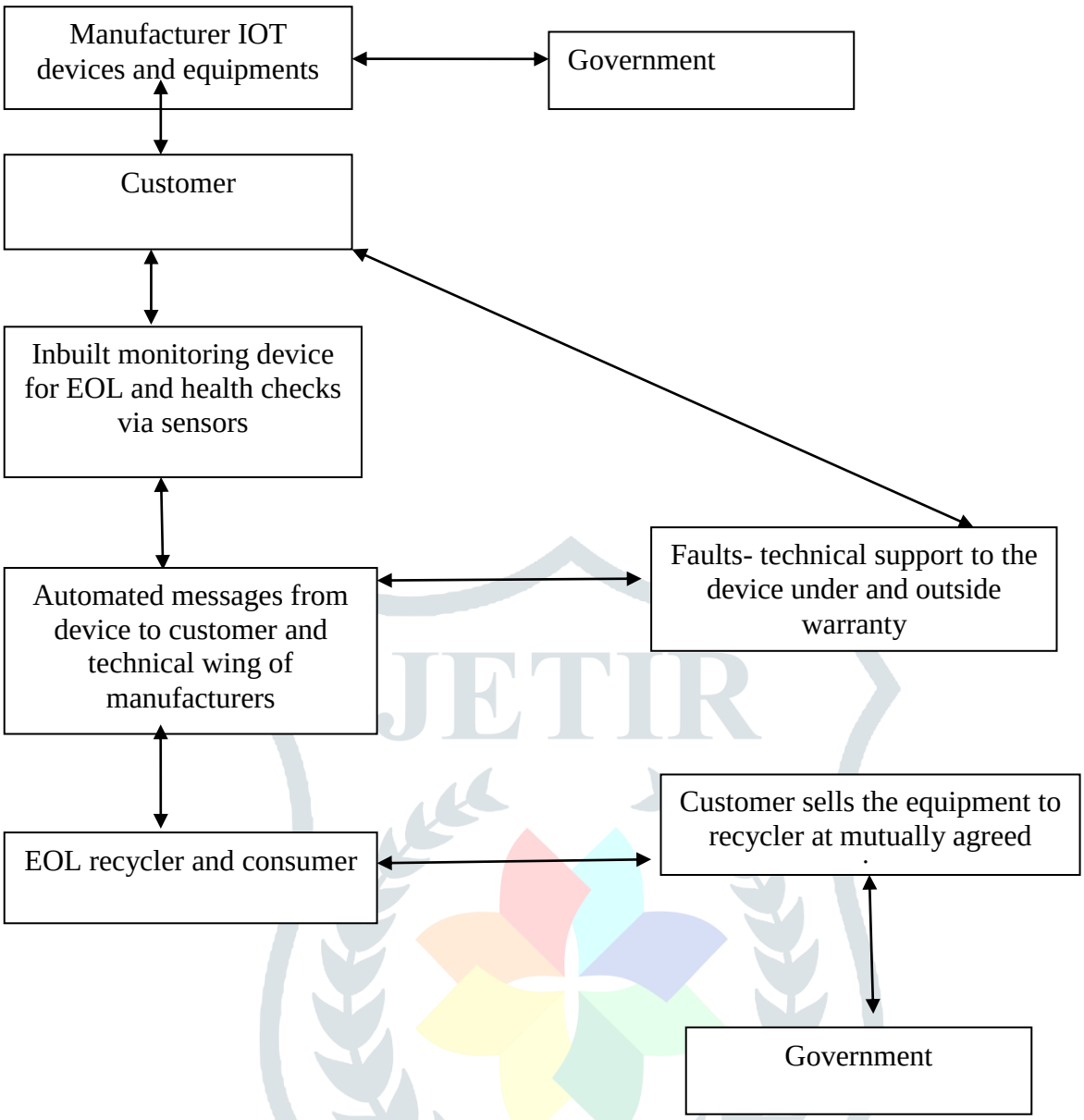


**Figure 4: IOT Oriented E-Waste Management**

**BUSINESS MODEL 3 - SMART CITY BUSINESS MODEL**

A Business Model is put forward for E-waste management by creating a bridge between the end-user/s and Recycler giving a sight to the government on E-waste generation and its consumption. A mobile application or a website can be established to support the model. It is B2B, B2C and B2 G Business model.

a. Individuals will have to Register into the Software system aper their profile Recycler , End User- IT Companies, Government .

b. The IT Companies / Individual users can enter the E-waste devices to be sold with their preferred price also current status as - Working / Non-Working .

c. The other companies can buy the pre-owned Working items at lower cost and can bid for same.

d. The End-user also holds the rights to sell the devices at his preferred quote and customer.

e. The Non-working equipment available in the system can be bought by the registered recycler's .

f. Government will be able to monitor the trasctions easily. It will also be able to calculate E-waste generated from city/state and its end life.

**Advantages of the Model**

I. Disposal from the IT Company can be tracked through the system in any time frame.

ii. It provides a platform for "Open Market "concept where both the supplier and customers are available at one place, allow fast circulation of items and transactions.

iii. E-waste can be resold through the system, which allows extending the EOL of the devices.

iv. Recyclers can reach the IT Companies to directly buy the E-waste system .

v. It provides ONE STOP shop for E-waste disposal.

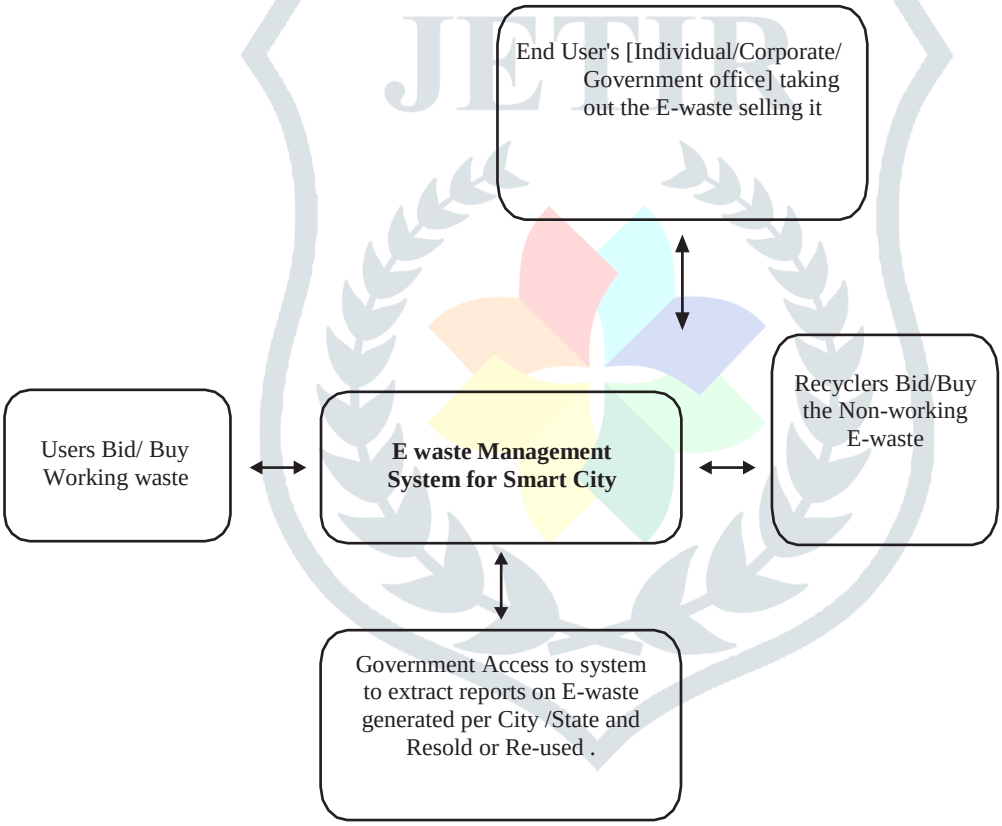


**Figure 5: Smart City Business Model**

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