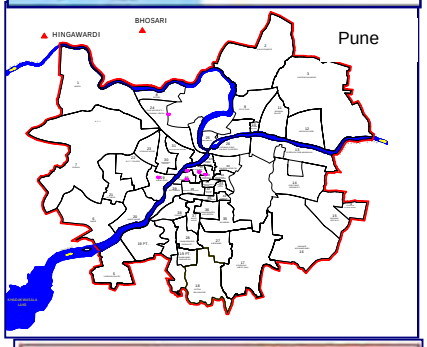
Report on
Assessment of Electronic Wastes
in Mumbai-Pune Area



Maharashtra Pollution Control Board
Kalpataru Point, Sion (E), Mumbai 400 022
http ://mpcb.mah.nic.in

March, 2007

Report on
Assessment of Electronic Wastes in Mumbai-Pune Area

Report Prepared by
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New Delhi – 110017,

Maharashtra Pollution Control Board
Kalpataru Point, Sion (E), Mumbai 400 022
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March, 2007

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Dr. D. B. Boralkar
Member Secretary

महाराष्ट्र प्रदूषण नियंत्रण मंडळ
MAHARASHTRA POLLUTION CONTROL BOARD

FOREWORD

Electronic waste or e-waste is collective terminology for the entire stream of electronic wastes such as used TVs, refrigerators, computers, mobile phones etc. Waste from electrical and electronic equipment (WEEE), if not properly recycled, and disposed, can be detrimental to the environment. Increasing obsolesce rates of electronic products added to the import of junk electronics from abroad, creates complex scenario for solid waste management. Mumbai-Pune industrial belt generate large volumes of e-waste.

Objectives of the project included study of existing recycling system for e-waste, assessment of risk caused by recycling, estimation of quantity of WEEE, evaluation of capabilities of existing stake holders and infrastructure for reuse, recycle and disposal of e-waste. It is estimated that 25,000 MT of e-waste is generated in the study area. It is feasible to set up a common facility for collection, recycling and disposal of e-waste in environmentally sound manner.

The project work was awarded to M/s. IRG Systems South Asia Pvt. Ltd., New Delhi. The United Nations Environment Program office at Paris provided partial technical and financial assistance. The study was supervised by the Expert Committee appointed by the Board (Annexure-I). The support of UNEP and members of the Expert Committee in successful implementation of the project is highly appreciated.

DBBoralkar

(D.B. Boralkar)
Member Secretary
March 30, 2007

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Annexure-I 849

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No. MPCB/MS/B- 579 Date: 23/6/2006

OFFICE ORDER NO. E 129 Dated 23/6/2006.

Sub: Formation of Expert Group on E-Waste management

Preamble: Maharashtra Pollution Control Board (MPCB) has constituted an Expert Group to guide the proposed rapid e-Waste Assessment Study in Maharashtra vide the above order dated 04.10.2005 and to monitor the progress of the study from time to time and help formulate the draft legislation for the e-Waste Management.

Order: MPCB is now pleased to reconstitute the said Expert Group on the e-Waste Management in Maharashtra consisting of the following Expert Members.

1)	Dr. D.B. Boralkar, Member Secretary, MPCB	-	Chairman
2)	Mr. Vinnie Mehta, President, MAIT, N. Delhi	-	Member
3)	Shri Kishor Wankhede, Toxic Links, Mumbai	-	Member
4)	Shri B.K.Soni, M.D., Infotrek Syscom Ltd.	-	Member
5)	Shri Markandeya, Chief Engg. (SW), MCGM, Mumbai	-	Member
6)	Dr. Rakesh Kumar, Dy. Director, NEERI, Mumbai	-	Member
7)	Dr. Ajay Deshpande, R.O. I/c. PCI-II, MPCB	-	Convener

The Terms of Reference (TOR) of this Expert Group remain same and are as follows:

1) Finalize the protocols for the study and to assess the cost component of the study.
2) Study the legislative requirement within a local State Govt. needed for setting up of the facility for recycling and collection system in WEEE.
3) Monitor the progress of the e-waste assessment study
4) Examine the issues related to development of recycling facility for e-waste in Maharashtra
5) Develop for Private Partner Project (PPP) proposal with the help of appropriate institutions
6) Committee shall meet as frequently as may be required to accomplish the above tasks
7) TA/DA and honorarium as per rules shall be paid to the private members of the expert group.

....2/-

This order is issued in supersession of the Office Order No. E-133 dated 04.10.2005.

(D.B. Boralkar)
Member Secretary

Copy submitted to :
1) Chairperson, MPCB, Mumbai.
2) Member Secretary, Central Pollution Control Board, Parivesh Bhavan, East Arjun Nagar, New Delhi-110032- It is requested to nominate your representative for above committee.

Copy to:
1) Dr. S.B. Katoley, Advisor, MPCB, Mumbai.
2) Regional Officers, MPCB, Mumbai & Pune
3) Regional Officer (HQ), MPCB, Mumbai.

Copy to:
WPAE/PSO/ SLO (J)/SLO (D)/ R.O(P&P)/R.O.(C)/Ex.Engg.(H.Q)/CAO/AO/P.S. to M.S., MPCB, Mumbai.

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CHAPTER 1: INTRODUCTION

1.1 Preamble

Electronics industry is the world's largest and fastest growing manufacturing industry. Rapid growth, combined with rapid product obsolescence and discarded electronics is now the fastest growing waste stream in the industrialized world. The growing quantity of waste from electronic industry, known as e-waste is beginning to reach disastrous proportions. Industrialized countries all over the world are beginning to address e-waste as it is inundating solid waste disposal facilities, which are inadequately designed to handle such type of wastes. The problems associated with e-waste in India started surfacing after the first phase of economic liberalisation, after 1990. That year witnessed a shift from in economic policy in turn triggering off an increase in the consumption pattern. This period also witnessed a shift in the pattern of governance. It ushered in an era of infrastructure reform and e-governance. This shift is marked by the application of information technology in a big way in all areas. These developments, along with indigenous technological advancement, have lead to an addition of wide gamut of e-waste churned out from Indian households, commercial establishments, industries and public sectors, into the waste stream. Solid waste management, which is already a mammoth task in India, has become more complicated by the invasion of e-waste, particularly computer waste to India, from different parts of the world.

E-waste contains significant quantities of hazardous waste, including lead, mercury and cadmium. Improper recycling and disposal operations found in different cities of India often involve the open burning of plastic waste, exposure to toxic solders, river dumping of acids, and widespread general dumping. As a result, pollutants are dumped into the land, air and water. As per country level Waste Electrical and Electronic Equipment (WEEE) assessment study, Mumbai and Pune falls under the top ten cities that are generating maximum quantities and Mumbai alone generates maximum among all the cities of India. Total WEEE waste generation in Maharashtra is 20270.6 tons, out of this Navi Mumbai contributes 646.48 tons, Greater Mumbai 11017.06 tons, Pune 2584.21 tons and Pimpri-Chinchwad 1032.37 tons.

The subject of electronic equipment disposal and recycling has captured attention at all levels of government, and has become the subject of serious discussion and debate between government organizations and the private sector manufacturers of computers and consumer electronic equipment. Government organizations (MPCB) would like to foster opportunities to recycle and re-use surplus electronic equipment on as wide a scale as possible. Equipment manufacturers, with intense competition and low profit margins, are also unwilling to absorb the cost of recycling, and are fearful of piecemeal or prescriptive legislation, at the national or state level, which could force them to bear the cost and potentially the logistical and administrative burden of recycling their products.

1.2 E-Waste Categories

There is no accepted definition of e-waste in India. Broadly, e-waste has been defined as a waste from relatively expensive and essentially durable products used for data processing, telecommunications or entertainment in private households and businesses. The range of these products is given below:

o *Computers*	o *Televisions*	o *Telephones*
o *Printers*	o *Radios*	o *Microwave ovens*
o *Fax machines*	o *VCRs*	o *DVDs*
o *CD players*		

1.3 Identification of Problem

Electronic equipment is one of the largest known sources of heavy metals and organic pollutants in the wastewater stream. Some electronic products – usually those with cathode ray tubes (CRTs), printed circuit boards (PCBs), batteries and mercury switches – contain hazardous or toxic materials such as lead, mercury, cadmium, chromium and flame-retardants. The glass screens or CRTs in computer monitors and televisions can contain as much as 27% lead. Electronic products containing these hazardous materials may pose an environmental risk if they are not properly managed at their end-of-life.

E-waste has two primary characteristics:

- ***E-waste is hazardous -*** *E-waste contains over 1,000 different substances, many of which are toxic, and creates serious pollution upon disposal.*
- ***E-waste is generated at alarming rates due to obsolescence -*** *Due to the extreme rates of obsolescence; E-waste produces much higher volumes of waste in comparison to other consumer goods. The increasingly rapid evolution of technology combined with rapid product obsolescence has effectively rendered everything disposable.*

1.3.1 Hazards in E-Waste

E-waste contains a number of toxic substances such as lead and cadmium in circuit boards; lead oxide and cadmium in monitor cathode ray tubes (CRTs); mercury in switches and flat screen monitors; cadmium in computer batteries; polychlorinated biphenyls (PCBs) in older capacitors and transformers; and brominated flame retardants on printed circuit boards, plastic casings, cables and polyvinyl chloride (PVC) cable insulation that release highly toxic dioxins and furans when burned to retrieve copper from the wires.

Due to the hazards involved, disposing and recycling E-waste has serious legal and environmental implications. When this waste is land filled or incinerated, it poses significant contamination problems. Landfills leach toxins into groundwater and incinerators emit toxic air pollutants including dioxins. Likewise, the recycling of computers has serious occupational and environmental implications, particularly when the recycling industry is often marginally profitable at best and often cannot afford to take the necessary precautions to protect the environment and worker health. The toxic effects of these heavy metals are given below.

Antimony (Sb) - Antimony is a metal with a variety of industrial uses, including as a flame retardant (as antimony trioxide) and as a trace component of metal solders. In some forms, antimony shows many chemical similarities to arsenic, including in its toxicity. Exposure to high levels in the workplace, as dusts or fumes, can lead to severe skin problems and other health effects. Antimony trioxide is recognized as a possible human carcinogen.

Cadmium (Cd) - Cadmium occurs in electronics both as cadmium metal, in some switches and solder joints, and as cadmium compounds in rechargeable batteries, UV stabilizers in older PVC cables and “phosphor” coatings in older cathode ray tubes. Like lead, cadmium can accumulate in the body over time, with long-term exposure causing damage to the kidneys and bone structure. Cadmium and its compounds are known human carcinogens, primarily through inhalation of contaminated fumes and dusts.

Lead (Pb) - Lead is found in glass components of CRTs, as well as in electronics components (printed wiring boards and their components) of both CRTs and LCDs. It is widely used in electronic goods, as a major component of solders (as an alloy with tin) in printed circuit boards and as lead oxide in the glass of cathode ray tubes (televisions and monitors), as well as in lead-acid batteries. Its compounds have also been used as stabilizers in some PVC cables and other products. Lead is highly toxic to humans, as well as to animals and plants. It can build up in the body through repeated exposure and have irreversible effects on the nervous system, particularly the developing nervous system in children.

Lead is a significant material in current CRTs, accounting for up to 8% of the overall composition of the CRT by weight (Menad, 1999), with a 17" monitor containing as much as 1.12 kg of lead (Monchamp et. al., 2001). Lead is used in several parts of the CRT monitor, including the funnel and neck glass, the sealing frit, as solder on printed wiring boards (PWBs) within the monitor, and sometimes in the front panel glass of the CRT. Lead is not as prevalent in LCDs, only being found on PWBs. Lead, in the form of lead oxide, lines the inner surface of both the neck and funnel glass of the CRT, or may in some cases be contained within the glass itself. The lead oxide layer acts as a shield, protecting users from x-ray emissions given off by the electron gun. The lead oxide layer can comprise as much as 28% by weight of the funnel (Lee et al., 2000) and 32% of the neck (Menad, 1999).

Nonylphenol (NP) - Nonylphenol is a chemical most widely known as a breakdown product of nonylphenol ethoxylate (NPE) detergents, though it has reportedly also been used as an antioxidant in some plastics. It is a strong endocrine disruptor, capable of causing intersex (individuals with both male and female characteristics) in fish. Nonylphenol can also build up through the food chain and may be capable of causing damage to DNA and even sperm function in humans.

Brominated flame retardants (BFRs) - BFR is used in the plastic housings of electronic equipment and in circuit boards to prevent flammability. More than 50% of BFR usage in the electronics industry consists of tetrabromobisphenol _ A (TBBPA), 10% is polybrominated diphenyl ethers (PBDEs) and less than 1% is polybrominated biphenyls (PBB). Some BFRs have been targeted for phase out by the European Parliament between the years of 2003 and 2006.

Polybrominated diphenyl ethers (PBDEs) - PBDE is one of several classes of brominated flame retardants used to prevent the spread of fire in a wide variety of materials, including casings and components of many electronic goods. They are environmentally persistent chemicals, some of which are highly bio-accumulative and capable of interfering with normal brain development in animals. Several PBDEs are suspected endocrine disruptors, demonstrating an ability to interfere with hormones involved in growth and sexual development. Effects on the immune system have also been reported.

PCBs (polychlorinated biphenyls) - PCB is widely used in insulating fluids for electrical transformers and capacitors, as well as flame-retardant plasticisers in PVC and other polymer applications. They are highly persistent and bioaccumulative chemicals, rapidly becoming widespread through the environment and building up several thousand-fold in body tissues of wildlife. PCBs exhibit a wide range of toxic effects including suppression of the immune system, liver damage, cancer promotion, damage to the nervous system, behavioural changes and damage to both male and female reproductive systems.

Triphenyl phosphate (TPP) - TPP is one of several organo-phosphorus flame-retardants used in electronic equipment, for example in the casings of computer monitors. TPP is acutely toxic to aquatic life and a strong inhibitor of a key enzyme system in human blood. It is also known to cause contact dermatitis in some individuals and is a possible endocrine disruptor.

Cadmium - Cadmium compounds are toxic with a possible risk of irreversible effects on human health, and accumulate in the human body, particularly the kidneys. Cadmium occurs in certain components such as SMD chip resistors, infra-red detectors, and semiconductor chips. Cadmium is also a plastic stabilizer and some older cathode ray tubes contain cadmium.

Mercury - Another top priority toxic material is mercury. The fluorescent tubes that provide the source of light in the LCD contain mercury. Very small amounts of mercury are also found in the LCD backlights. Mercury can cause damage to various organs including the brain and kidneys, as well as the fetus. Most importantly, the developing fetus is highly susceptible through maternal exposure to mercury. When inorganic mercury spreads out in the water, it is transformed to methylated mercury in the bottom sediments. Methylated mercury easily accumulates in living organisms and concentrates through the food chain, particularly via fish. It is estimated that 22 % of the yearly world consumption of mercury is used in electrical and electronic equipment. It is used in thermostats, sensors, relays, switches (e.g. on printed circuit boards and in measuring equipment), medical equipment, lamps, mobile phones and in batteries. Mercury, used in flat panel displays, will likely increase as their use replaces cathode ray tubes.

Hexavalent Chromium/Chromium VI - Chromium VI is still used as corrosion protection of untreated and galvanized steel plates and as a decorative or hardener for steel housings. It easily passes through cell membranes and is then absorbed— producing various toxic effects in contaminated cells. Chromium VI can cause damage to DNA and is extremely toxic in the environment.

Plastics including PVC - Plastics make up 13.8 pounds of an average computer. The largest volume of plastics (26%) used in electronics has been poly-vinyl-chloride (PVC). PVC is mainly found in cabling and computer housings, although many computer moldings are now made with the somewhat more benign ABS plastics. PVC is used for its fire-retardant properties. As with many other chlorine-containing compounds, dioxin can be formed when PVC is burned within a certain temperature range.

Barium - Barium is a soft silvery-white metal that is used in computers in the front panel of a CRT, to protect users from radiation. Studies have shown that short-term exposure to barium has caused brain swelling, muscle weakness, damage to the heart, liver, and spleen. There is still a lack of data on the effects of chronic barium exposures to humans. Animal studies, however, reveal increased blood pressure and changes in the heart from ingesting barium over a long period of time.

Beryllium - Beryllium is a steel-grey metal that is extremely lightweight, hard, a good conductor of electricity, heat, and is non-magnetic. These properties make beryllium suitable for many industrial uses, including, electronic applications such as computers. In computers, beryllium is commonly found on mother-boards and "finger clips" as a copper beryllium alloy used to strengthen the tensile strength of connectors and tiny plugs while maintaining electrical conductivity.

Beryllium has recently been classified as a human carcinogen as exposure to it can cause lung cancer. The primary health concern is inhalation of beryllium dust, fume or mist. Workers who are constantly exposed to beryllium, even in small amounts, and who

become sensitized to it can develop what is known as Chronic Beryllium Disease (beryllicosis), a disease that primarily affects the lungs. Exposure to beryllium also causes a form of skin disease that is characterized by poor wound healing and wart-like bumps. Studies have shown that people can still develop beryllium disease even many years following the last exposure.

Toners - One of the ubiquitous computer peripheral scraps and post consumer E-waste is the plastic printer cartridge containing black and color toners. The main ingredient of the black toner is a pigment commonly called, carbon black - the general term used to describe the commercial powder form of carbon. Inhalation is the primary exposure pathway, and acute exposure may lead to respiratory tract irritation. The International Agency for Research on Cancer has classified carbon black as a class 2B carcinogen, possibly carcinogenic to humans. Little information exists on the hazards of colored toners. Some reports indicate that such toners (cyan, yellow and magenta) contain heavy metals.

Phosphor and additives - Phosphor is an inorganic chemical compound that is applied as a coat on the interior of the CRT faceplate. Phosphor affects the display resolution and luminance of the images that is seen in the monitor. The hazards of phosphor in CRTs are not well known or reported, but the U.S. Navy has not minced words about the hazards involved in some of their guidelines: "NEVER touch a CRT's phosphor coating: it is extremely toxic. If you break a CRT, clean up the glass fragments very carefully. If you touch the phosphor seek medical attention *immediately*." The phosphor coating contains heavy metals, such as cadmium, and other rare earth metals, e.g. zinc, vanadium, etc. as additives. These metals and their compounds are very toxic. This is a serious hazard posed for those who dismantle CRTs by hand. The hazardous substances, their occurrence and their impacts are summarized in the **Table 1.1**.

1.4 E-waste Scenario in India

The Electronics industry has emerged as the fastest growing segment of Indian industry both in terms of production and exports. The share of software services in electronics and IT sector has gone up from 38.7 per cent in 1998-99 to 61.8 percent in 2003-04. However, there has been some welcome acceleration in the hardware sector with a sharp deceleration in the rate of decline of hardware's share in electronics and IT industry. Output of computers in value terms, for example, increased by 36.0, 19.7 and 57.6 per cent in 2000-01, 2002-03, and 2003-04, respectively. Within this segment, the IT industry is prime mover with an annual growth rate of 42.4% between 1995 and 2000. By the end of 2004, India had an installed base of 5 million personal computers (PCs). As per IT industry's estimates, about 1.65 million PC units were sold for the fiscal year 2001-2002. The Indian PC industry is growing at a 45% compounded annual growth rate and touched an installed base of 10 million units in 2003-2004, a survey made by leading Indian computer magazine Data quest (www.findarticles.com).

The Indian IT industry has a prominent global presence today largely due to the software sector. Promotion of the software industry and protection of the hardware industry from external competition has resulted in this skewed growth. More recently however, policy changes have led to a tremendous influx of leading multinational companies into India to set up manufacturing facilities, R&D centres and offshore software development facilities. The domestic market is getting revitalized due to buoyant economic growth and changing consumption patterns.

This growth has significant economic and social impacts. The increase of electronic products, consumption rates and higher obsolescence rate leads to higher generation of electronic waste (e-waste). The increasing obsolescence rates of electronic products

added to the huge import of junk electronics from abroad create complex scenario for solid waste management in India.

Table 1.1: The hazardous substances, their occurrence and their impacts

Substance	Occurrence in e-waste	Environmental and Health relevance
Halogenated compounds:		
PCB (polychlorinated biphenyls)	condensrs, transformers	Cause cancer, effects on the immune system, reproductive system, nervous system, endocrine system and other health effects. persistent and bioaccumulatable
• TBBA (tetrabromo-bisphenol-A) • PBB (polybrominated biphenyls) • PBDE (polybrominated diphenyl ethers)	fire retardants for plastics (thermoplastic components, cable insulation) TBBA is presently the most widely used flame retardant in printed wiring boards and covers for components	can cause long-term period injuries to health acutely poisonous when burned
Chlorofluorocarbon (CFC)	cooling unit, insulation foam	Combustion of halogenated substances may cause toxic emissions.
PVC (polyvinyl chloride)	cable insulation	High temperature processing of cables may release chlorine, which is converted to dioxins and furans.
Heavy metals and other metals:		
Arsenic	small quantities in the form of gallium arsenide within light emitting diodes	acutely poisonous and on a long-term perspective injurious to health
Barium	getters in CRT	may develop explosive gases (hydrogen) if wetted
Beryllium	power supply boxes which contain silicon controlled rectifiers, beamline components	harmful if inhaled
Cadmium	rechargeable NiCd-batteries, fluorescent layer (CRTscreens), printer inks and toners, photocopying -machines (photo drums)	acutely poisonous and injurious to health on a long-term perspective
Chromium VI	data tapes, floppy-disks	acutely poisonous and injurious to health on a long-term perspective causes allergic reactions
Gallium arsenide	light-emitting diode (LED)	injurious to health
Lead	CRT screens, batteries, printed wiring boards	causes damage to the nervous system, circulatory system, kidneys causes learning disabilities in children
Lithium	Li-batteries	may develop explosive gases (hydrogen) if wetted
Mercury	is found in the fluorescent lamps that provide backlighting in LCDs, in some alkaline batteries and mercury wetted switches	acutely poisonous and injurious to health on a long-term perspective
Nickel	rechargeable NiCd-batteries or NiMH-batteries, electron gun in CRT	may cause allergic reactions
Rare earth elements (Yttrium, Europium)	fluorescent layer (CRT-screen)	irritates skin and eyes
Selenium	older photocopying-machines (photo drums)	exposure to high levels may cause adverse health effects
Zinc sulphide	is used on the interior of a CRT screen, mixed with rare earth metals	toxic when inhaled
Others:		
Toxic organic substances	condensers, liquid crystal display	
Toner Dust	toner cartridges for laser printers / copiers	Health risk when dust is inhaled risk of explosion
Radioactive substances Americium	medical equipment, fire detectors, active sensing element in smoke detectors	May cause cancer when inhaled

1.5 Evolution of the IT industry

The global perception of the IT industry in India has typically been "software." Interestingly, a review of the industry statistics show that in 1990-91, hardware accounted for nearly 50% of total IT revenues while software's share was 22%. The scenario changed by 1994-95, with hardware share falling to 38% and software's share rising to 41%. This shift in the IT industry began with liberalization, and the opening up of Indian markets together with which there was a change in India's import policies vis-à-vis hardware leading to substitution of domestically produced hardware by imports. Since the early 1990s, the software industry has been growing at a compound annual growth rate of over 46% (supply chain management, 1999).

The Indian software industry has grown from a mere US$ 150 million in 1991-92 to a staggering US$ 5.7 billion (including over US$4 billion worth of software exports) in 1999-2000. No other Indian industry has performed so well against the global competition. The annual growth rate of India's software exports has been consistently over 50% since 1991. As per the projections made by the National Association of Software and Services Companies (NASSCOM) for 2000-2001, India's software exports would be around US$ 6.3 billion, in addition to US$ 2.5 billion in domestic sale. The Indian cities of IT sectors are shown in **Figure 1.1**.

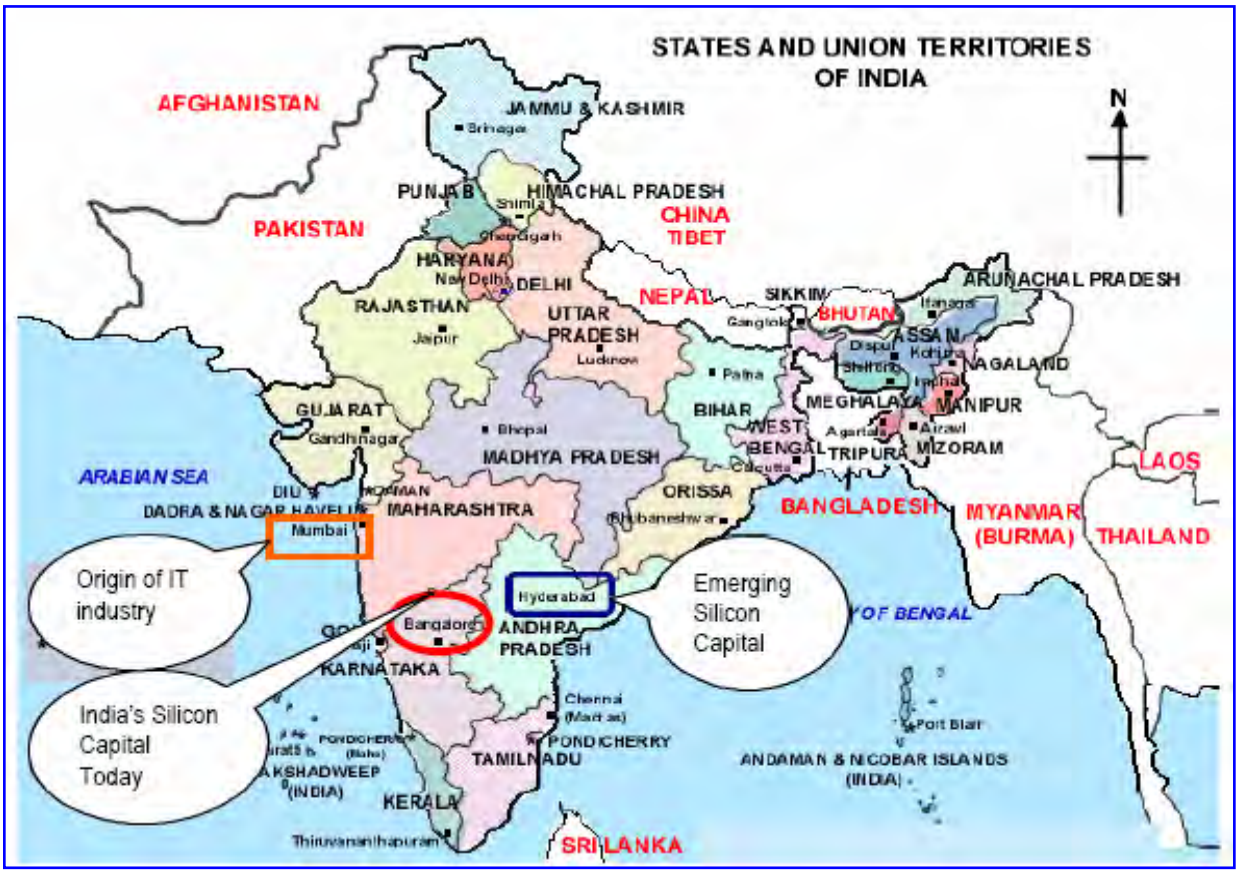


Figure 1.1: Map of India showing Mumbai (where the IT industry began), Bangalore (which is the IT centre today) and Hyderabad (a strong contender for the premier position in the Indian IT industry).

1.6 End-of-life Waste

Electronic waste, or e-waste as it is popularly called, is a collective terminology for the entire stream of electronic wastes such as used TVs, refrigerators, computers, mobile phones, etc. Computer waste is the most significant of all e-waste due to the gigantic amounts as well as the rate at which it is generated. E-waste is of particular concern to India. At the consumer end of the supply chain is the issue of disposal of waste or used product. This entails disposal of packaging, computers, peripherals and consumables. In India computers and peripherals are recycled / reused much more than they are in developed countries. In the US, the computer systems are replaced on an average every three years. In the case of developing countries like India till the last 1-2 years affordability of computers was limited to only a socio-economically advantaged section of the population. Therefore, resale and reuse of computers was (and continues to be) high as does dependency on assembled machines. No reliable figures are available as yet to quantify the computers generating as waste. Increasingly as computers are becoming more affordable (even the branded machines), and there is greater access to technology, the turnover of machines could definitely be higher. Apart from the consumer end, another source of more obsolete computers in the market is from the large software industry where use of cutting edge technology, greater computing speed and efficiency necessarily increase the rate of obsolescence. The end-of-life options for computers in India are presented schematically in **Figure 1.2**.

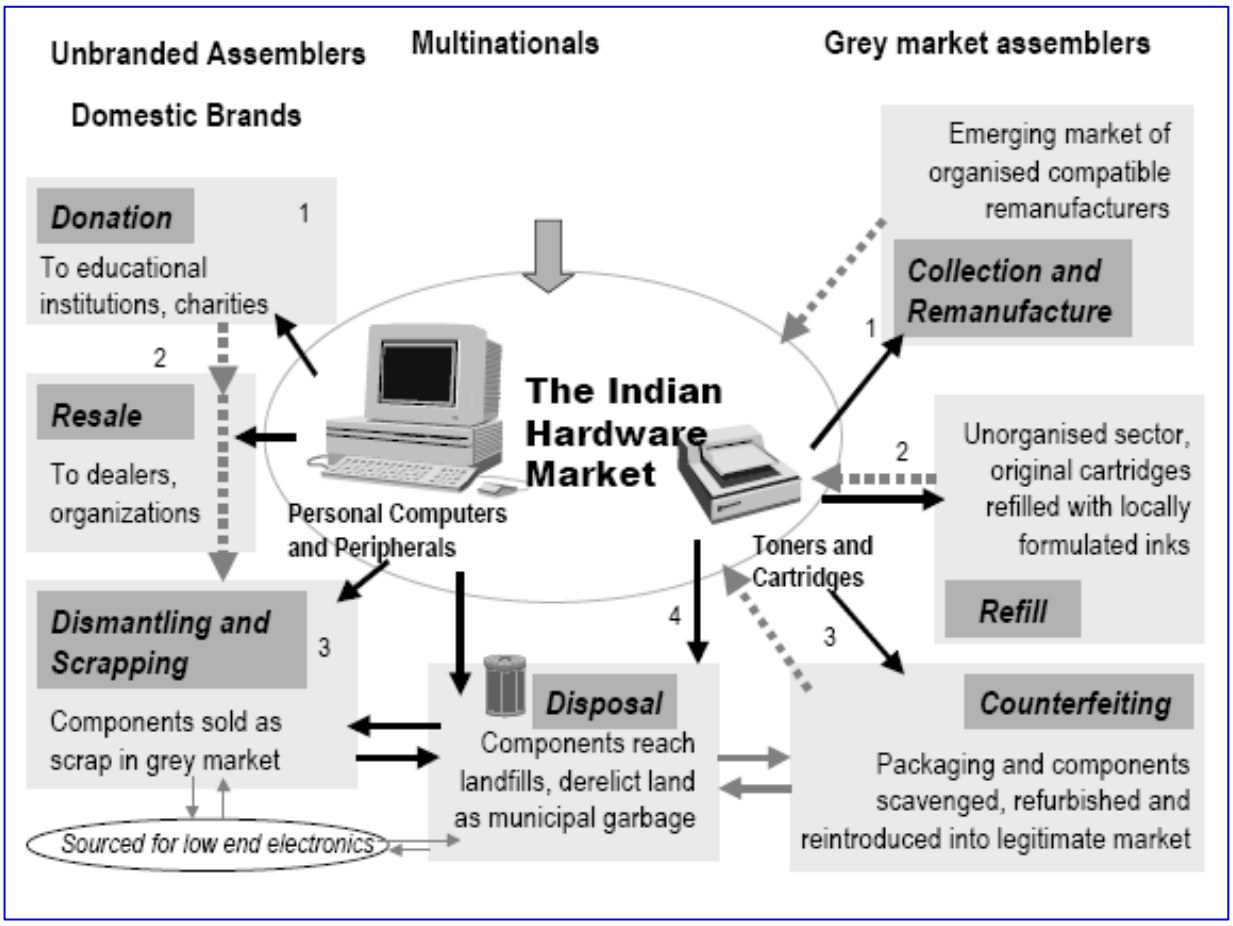


Figure1.2: The end-of-life options for computers in India.

1.7 Need for Study

Waste from Electrical and Electronic Equipments (WEEE) is stored, processed, recycled, reused and finally disposed in a manner, which is detrimental to environment. Maharashtra state ranks first among top ten states generating WEEE in India. Among Indian cities, Mumbai ranks first among top ten cities generating WEEE in India. Along with Mumbai, Pune also ranks among the top Ten Indian Cities, which are repository of WEEE. Mumbai, the financial nerve centre of India, is also India's largest port city. The Mumbai-Pune industrial belt is one of the electronic items manufacturing hubs of the country. As a result, Mumbai is not only the port of import for new and used electronics; it is also home to a large user and manufacturer base, both generating large volumes of e-waste.
As per TOR, there is hardly any attention paid to the management of the e-waste generated in this industrial belt, which incidentally also houses large number of Info-tech parks especially in New Mumbai and Pune. There is an urgent need to have a well orchestral mechanism on the collection, treatment and disposal of the e-waste in this region. Therefore, MPCB has identified e-waste as a priority area and has initiated the process to set up a formal workgroup for the Mumbai-Pune region. MPCB has taken certain initiatives to create awareness among various stakeholders on the e-waste and as a part of this exercise carried a feature article in the Indian Express. The Additional Commissioner, Municipal Corporation of Greater Mumbai has communicated to MPCB the resolution adopted by the standing committee of MCGM to manage the e-waste. This shows the keenness with which the municipality is interested in the e-waste management in Mumbai.

In the light of the initiatives undertaken by MPCB, an urgent need to prepare an inventory of e-waste generated in the Mumbai Metropolitan Region (MMR) and Pune-Chinchwad area has been identified so that an action plan for WEEE can be formulated for this region. Therefore, a rapid waste electrical and electronic equipments assessment study has been planned by MPCB for MMR, Pune and Pimpri-Chinchwad region. This report is being presented as draft final report for e-waste assessment in Mumbai, Pune and Pimpri Chinchwad region. The items covered in this assessment include personal computers, mobiles phones, televisions and refrigerators.

1.8 Objectives of the Study

The objective of the Rapid WEEE Assessment is to identify and quantify the WEEE generation, reuse, recycle and final disposal in the study area by adopting uniform approach and methodology. The main objectives of this study are as follows:

- To examine the existing WEEE recycling system
- To study the problems/risks posed by the recycling system at present/ future
- To estimate the existing and future quantity of WEEE in the city (study area)
- To evaluate the capacities/capabilities of existing stakeholders and infrastructure for reuse, recycle and disposal of e-wastes
- To analyze the environmental and social sustainability of present system
- To determine the e-trade economics

1.9 Proposed Methodology

A very comprehensive approach has been proposed to carry out this WEEE rapid assessment. The fundamental approach can be summarized in following three phases. This approach starts with field experience and knowledge gained during assessment period followed by international exposure to arrive at optimum solution to address WEEE

in the study area.

Phase 1: Mobilization and work plan
Phase 2: Data Collection/ Field Work
Phase 3: Report findings/ International and domestic training workshops/ way forward

1.10 Scope of the Work

In order to execute this assignment, it is essential to establish the WEEE business chain linking different stakeholders to understand the trade economics and associated environmental impacts. The study shall identify and describe the following:

- The stakeholders
- Their respective geographical distribution in the study area and
- WEEE generation cycle

1.11 Format of the report

The present study has been compiled in seven chapters. The first chapter describes the e-waste, problems and hazards associated with e-waste, e-waste scenario in India, objectives of the study, methodology adopted and scope of work. The second chapter describes the regulatory regime, the framework conditions and the loopholes in the existing system. The third chapter describes the approach and methodology. The fourth chapter describes the processes surveyed and trade value chain. The fifth chapter describes the recycling recovery systems, tracer analysis, obsolescence rate and quantification of e-waste generation and projections in Mumbai and Pune Chinchwad region based on obsolescence rate. The sixth chapter describes the economics, e-waste imports in MMR, Pune and Pimpri Chinchwad region. The seventh chapter describes the impacts and recommendations.

CHAPTER 2: REGULATORY FRAMEWORK/SYSTEM PARAMETERS

2.1 Regulatory Framework and Its Brief Overview

E-waste trade comes under the broad regulatory framework related to environment, foreign trade and local rules & regulations. The following section describes the relevant rules and regulations and the loopholes, which facilitate this trade.

2.1.1 Regulations and Their Scope

Electronic waste is being covered under the broad regulatory framework related to hazardous waste in India. The Ministry of Environment and Forests, Government of India, is the nodal agency at the central level for policy, planning, promoting and coordinating the environmental programs. The Environment (Protection) Act 1986, an umbrella act covers hazardous waste and provides broad guidelines to address it. The policy statement on the abatement of pollution issued by the government of India in 1992 reiterated its commitment towards waste minimization and control of hazardous wastes. India is a signatory to Basel Convention on the control of trans-boundary movement of Hazardous Wastes and Disposal. India ratified and acceded to it in 1992. The ratification of this convention obliges India to address the problem of trans-boundary movement and disposal of dangerous hazardous wastes through international cooperation.

The Ministry of Environment and Forests (MoEF) has issued the following notifications related to hazardous wastes:

1. Hazardous Wastes (Management and Handling) Rules, 1989/2000/2002
2. MoEF Guidelines for Management and Handling of Hazardous Wastes,1991
3. Guidelines for Safe Road Transport of Hazardous Chemicals,1995
4. The Public Liability Act, 1991
5. Batteries (Management and Handling) Rules, 2001
6. The National Environmental Tribunal Act, 1995
7. Bio-Medical Wastes (Management and Handling) Rules, 1998
8. Municipal Solid Wastes (Management and Handling) Rules, 2000 and 2002

The Hazardous Wastes (Management and Handling) Rules, 1989 were introduced under Sections 6, 8, and 25 of the Environment (Protection) Act of 1986 (referred to as HWM Rules 1989). The HWM Rules, 1989 provide for the control of generation, collection, treatment, transport, import, storage and disposal of wastes listed in the schedule annexed to these rules. The rules are implemented through the SPCBs and pollution control committees in the states and union territories. There were a few inherent limitations to the implementation of the HWM Rules, 1989, and amendments to this Rule were introduced in 2000 and 2002, widening the definition of hazardous waste and harmonizing the hazardous waste list with that of the Basel Convention. The following are the major amendments of the Hazardous Waste (Management & Handling) Rule made in the year 2000:

- The schedule listing 18 categories of wastes in the Hazardous Wastes (Management & Handling) Rules, 1989 has now been replaced by 3 schedules.
    - Schedule 1: Describes the processes and waste streams generating hazardous waste. Units operating these processes are now subject to the rules.
    - Schedule 2: Lists the concentration limits of constituents in the wastes. This concentration limit is to be used for classification/characterization of waste stream as hazardous/non-hazardous in case of dispute.

    - Schedule 3: Provides a separate list of wastes subject to export and import, similar to the Basel Convention Annexes VIII and IX
- Responsibility for the identification of sites for establishment of Common Treatment, Storage and Disposal Facilities (CTSDF) and individual TSDF now rests with the occupier, industrial association and the State Government alone.
- Provisions relating to the import and export of hazardous waste for recycling have been expanded to describe in detail the procedure being followed. Requirements of the re-export of illegal traffic of waste under the Basel Convention have also been incorporated.
- Rules have been worked out governing the design, set-up and closure of landfill facilities.
- A manifest system has been introduced for tracking hazardous waste from the point of generation to the disposal site.
- Authorities responsible for the regulation of imports and exports and monitoring the implementation of provisions of the rules have been mentioned in schedule 4, and
- A fee for authorization and import has been prescribed

Besides these rules, in 1991, the Ministry of Environment and Forests (MoEF), New Delhi issued guidelines for management and handling of hazardous wastes for (a) generators of waste, (b) transport of hazardous waste, and (c) owners/operators of hazardous waste storage, treatment and disposal facilities. These guidelines also established mechanisms for the development of a reporting system for the movement of hazardous waste (the manifest system) and for the first time, established procedures for closure and post-closure requirements for landfills.

In addition to these direct rules dealing with issues of hazardous waste management, the Government has moved to enact legislation and additional incentives for industries to comply with environmental provisions and bring out market forces into the business of environment. In this vein, the Public Liability Act 1991 was adopted to require industries dealing with hazards to ensure against accidents or damages caused by release of pollutants.

Batteries (Management and Handling) Rules, 2001 apply to every manufacturer, importer, re-conditioner, assembler, dealer, recycler, auctioneer, consumer and bulk consumer involved in manufacture, processing, sale, purchase and use of batteries or components thereof. These rules confer responsibilities on the manufacturer, importer, assembler and re-conditioner; they govern the registration of importers, the customs clearance of imports of new lead acid batteries, procedures for registration/ renewal of registration of recyclers and also the responsibilities of consumer or bulk consumer and responsibilities of auctioneers.

In 1995 publication of guidelines for Safe Road Transport of Hazardous Chemicals that established basic rules for Hazardous Goods Transport and provided for establishment of a Transport Emergency Plan and for provisions on Identification and assessment of Hazards.

The National Environmental Tribunal Act, 1995, provides for expeditious remedies to parties injured by environmental crimes. Legislation on the Community's Right to Know, 1996, has been adopted to provide more access to information regarding potential hazards from industrial operations.

Bio-Medical Wastes (Management and Handling) Rules, 1998, provides a ten category listing of biomedical waste there control of generation, collection, treatment, transport, import, storage and disposal of wastes listed in the schedule annexed to these rules.

Municipal Solid Wastes (Management and Handling) Rules, 2000, provides for collection, segregation, storage, transportation processing and disposal of municipal solid wastes.

A number of enforcement agencies assist the Ministry of Environment and Forests at the state level in executing the assigned responsibilities. The Central Pollution Control Board advises on the policy and enforcement. State pollution control boards carry out the enforcement at the state level.

2.1.2 Hazardous Waste Management Rules – Export & Import Issues

As per Basel Convention, India cannot export hazardous wastes listed in Annex VIII of the convention from the countries that have ratified the ban agreement. However, the convention agreement does not restrict the import of such wastes from countries that have not ratified the Basel Convention. It is through the orders of the Hon. Supreme Court of India that the import of such wastes is now banned in the country.

The HW Rules of 1989 control the import of hazardous wastes from any part of the world into India. Under the HWM Rules of 1989, the MoEF and the SPCB are the two recognised statutory organizations to ensure effective approval of import of hazardous wastes in the country. Under the new amendment of HWM Rules of 2002, List A and B of the Basel convention were introduced as Schedule 3 of the HWM Rules including the provisions relating to illegal traffic.

As per Rule 11 of HW Rules of 1989, import of wastes from any country to India shall not be permitted for dumping and disposal. However, import of such wastes may be allowed for processing or reuse as raw material, after each case has been examined on merit by the State Pollution Control Board. The SPCBs will examine applications from importers and forward such applications with its recommendations and requisite stipulations for safe transport, storage and processing/ disposal to the MoEF.

The Rules also require that hazardous wastes be packed and labelled during transport and that they will be deposited in waste disposal sites selected by the state government after an environmental impact assessment study.

Any importer wishing to import hazardous wastes must fill in the necessary information in Form 6 along with a fee of Rs. 30,000 for imports of up to 500 tonnes (extra Rs. 5000 for every additional 500 tonnes) to the SPCB/CPCB 125 days in advance.

As per the HW Rules, 1989/2000/2002, permissions to importers / exporters will be granted by the MoEF only, under Rules 13 (3) and 14 (3). Under this rule, the MoEF must satisfy itself that the importer has environmentally friendly / appropriate technology for reprocessing; that the importer has the capability to handle and reprocess hazardous wastes in an environmentally sound manner; and that the importer has adequate facilities for treatment and disposal of wastes generated.

Under Rule 14 (3), the MoEF must also consider and approve applications sent by exporters of consignments of hazardous wastes to India (Rule 11 of the un-amended HW Rules, 1989).

As per schedule 4 of the HW Rules, 1989/2000/2002, the authority, duties and corresponding rule is summarized in **Table 2.1**.

Table 2.1: The authority, duties and corresponding rule as per schedule 4 of the HW Rules, 1989/2000/2002

S. No.	Authority/(ies)	Duties and Corresponding Rule
1.	Ministry of Environment and forests, under the Environment (protection) Act, 1986	i. Identification of hazardous wastes as per Rule 3 ii. Permission to exporters as per rule 14(3) iii. Permission to importers as per Rule 13(3)
2.	Central Pollution Control Board constituted under the Water (Prevention and Control of Pollution) Act, 1974	i. Coordinate activities of the State Pollution Control Boards and ensure implementations of the conditions of imports ii. Monitor the compliance of the conditions of authorization, import and export. iii. Conduct training courses for authorities dealing with management of hazardous wastes iv. Recommend standards for treatment, disposal of waste, leachate and specifications of materials v. Recommend procedures for characterisation of hazardous wastes
3.	State Pollution Control Boards constituted under the Water (Prevention and Control of Pollution) Act, 1974	i. Grant and renew authorisation under rule 5(4) and rule 8 ii. Monitor the compliance of the various provisions and conditions of authorisation iii. Forward the application for imports by importers as per rule 13(1) iv. To review matters pertaining to identification and notification of disposal sites
4.	Directorate General of Foreign Trade constituted under the Foreign Trade (Development & regulation) Act 1992	i. Grant licence as per rule 13(5) ii. Refuse licence for hazardous wastes prohibited for imports under the Environment (protection) Act, 1986
5.	Port Authorities and Customs Authorities under the customs Act, 1962	i. Verify the documents as per rule 13(6) ii. Inform the ministry of Environment and Forests, Govt. of India of any illegal traffic as per rule 15 iii. Analyse wastes permitted for imports and exports iv. Train officials on the provisions of the Hazardous Wastes Rules and in analysis of hazardous wastes

2.1.3 Other Initiatives

In Addition to these direct rules dealing with issues of hazardous waste management, the Government of India has enacted legislation and additional incentives for industries to comply with environmental provisions and bring out market forces into business of environment. Various activities initiated by the Government of India to meet these objectives are listed below:

- State governments are in process of identifying hazardous waste disposal sites based on EIA of the potential sites.
- The CPCB has prepared a ready reckoner in 1998 providing technical information on sources of hazardous wastes, their characteristics, and the methods for recycling and disposal.
- Training programmes have been organized for concerned personnel in ports and the Customs and in pollution control boards so as to familiarize people working there with precautionary measures and testing methodologies for hazardous waste constituents.
- It has been decided to impose a ban on the import of hazardous wastes containing beryllium, selenium, chromium (hexavalent), thallium, pesticides, herbicides and their intermediates/residues based on recommendations by an expert committee constituted at the national level for advising on matters related to hazardous wastes.
- In order to control the movement of Basel Wastes, the export and import of cyanide wastes and mercury- and arsenic-bearing wastes has been banned from December 1996.
- Import of waste oil and metal bearing wastes such as zinc ash, skimmings, brass dross, and lead acid batteries for processing to recover resources will be regulated by the MoEF and allowed only by environmentally acceptable technologies.
- In the absence of standards for clean up of contaminated sites and limits for disposal of waste on land, industries which are causing contamination of land and water bodies through inappropriate waste disposal are not legally bound to clean the site unless ordered by judicial intervention to do so.
- Awareness & Capacity Building: In order to facilitate implementation of Solid Waste regulation the following documents have been issued by the MoEF /CPCB:

    - Guidelines for management of hazardous wastes - MoEF 1992
    - Guidelines for setting up of operating facilities
    - Ready reckoner for Hazardous Waste Management - 1998
    - Criterion for Hazardous Waste landfills - 2000
    - Code of practice for environmentally sound management of lead acid batteries, zinc ash/skimming & waste oil - CPCB June 2000

2.2 Current Legal System and E-Waste Trade

2.2.1 Background

Information technology as a sunrise industry and an area of growth for the millennium, the Government of India has made new PCs and their various peripherals freely importable. Such items do not require any license under the export and import policy.
Though new PCs can be freely imported in India, complexities persist in the statutory provisions for the import of old and junk PCs and their various parts. The complexity arises from confusing provisions for the import of old computers in the Custom Tariff Act. Though there is a clear reference to the import of new computers in the Act, which is in fact common for export and import transactions the world over through the universal Harmonized Tariff System (HTS), a similar provision does not exist for old computers.

The non-existence of classified categories for old computers does not imply that their trade is not allowed in India. In fact the Indian government has come up with a policy to promote the import of old computers. As per the recommendation of the National Task Force on Information Technology and Software Development, the Government of India in its 2001-02 budget has made a clear stipulation for the import of old computers as donations. This is meant to increase the IT penetration to 20 million PCs by the year 2008 and also to realize the dream of low-cost PCs for various sectors of activities, especially education.

As per the recommendation of the National Task Force on IT, the tax incentives for donations to institutions such as educational ones and hospitals have been increased. The incentives include the zero custom duty, exemption from gift and income taxes for both donors and receivers of PCs up to Rs.50, 000/-.

Under the Foreign Trade (Development and Regulation) Act of 1992, the Central Government has also provided for donations of computers and peripherals from zones which have been set up primarily for export -EOU (Export Oriented Units), EPZ (Exports Processing Zones), STP (Software Technology Parks) and EHTP (Electronics Hardware Technology Parks)-at a zero custom duty (Customs Notification No.47/98 dated 16 July 1998). Units in EOU/EPZ/STP/EHTP can donate computers and peripherals after two years of import and use, to recognized non-commercial educational institutions, registered charitable hospitals, public libraries, public funded research &development establishments, organizations of the Government of India, or Government of State or Union Territory.

Though the imported old PCs for the above-mentioned purposes are free from duty, it does not take place through the 'free' list. Import of old PCs requires a special license from the concerned authority, under an 'actual user condition '. Hence the receivers of old PCs are not to act as decanalising channel and traders. The 'actual user condition' clause of the Foreign Trade ((Development and Regulation) Act 1992 debars such sales. It stipulates: "In case of imports under license/certification/permission, the actual user alone may import such goods unless the actual user condition is specifically dispensed with by the licensing authority". Till date, Directorate General of Foreign Trade (DGFT) has not dispensed such conditionality in any instance, as revealed by the Deputy DGFT.

Finally, under the International Basel Convention on the Trans-boundary Movement of Hazardous Wastes, to which India is a signatory, the Ministry of Environment and Forests has to give prior permission to any hazardous imports. This is as per the provisions of the Hazardous Waste Management and Handling Rules 1989 as amended in 2000 (under the Environment Protection Act,1986),in Schedule –3, List A and List B. Computer waste falls under such categories, and according to the Ministry, no such permission has been granted to date.

Since this trade is taking place, it is important to address the loopholes in the present legal set up, which allows for the import of junk and obsolete technology for recycling and resale. As mentioned earlier, the computers imported must not be more than 10 year-old. When they are, they come under the category of junk computers and the Indian custom law does not recognize their trade. In fact, the term "junk computer" does not exist in the internationally accepted Harmonized Tariff System. Opportunities of such detections are Minimal, as the Custom Authorities hardly ever check the whole of containers. The Directorate General of Foreign Trade is the prime certifying authority in case of imports of second-hand goods.

2.2.2 Loopholes in the Current Legal System

On the basis of the information disclosed, it was discovered that there is a substantial scope in the present legal set up for the import of junk computers.

1. Flexible interpretations of the rules framed by the DGFT. This enables the Customs Authorities to take on-the-spot decisions and provide rules exemption. In order to check and detect the illegal import of old PCs (import without license), Customs Authorities have been delegated power to take on-the-spot decisions, going from the confiscation of goods to the imposition of fines on such imports. However, after the imposition of a fine, importers are allowed to take possession of the goods. Taking

advantage of this, an importer can release goods by paying a fine to the Customs Department. The DGFT Authority also accepts at times that the Customs Authority allows importers to escape full penalty by an under- assessment of illegally imported goods.

2. There is no Exim code for trade in second-hand computers for donation purpose or for resale. For trade purposes, the computers are classified under the same Exim code as new computers. Both second-hand and new computers are classified under chapter 84 of the Indian Customs Tariff Act. Thus, trade data for new computers includes data for old computers. Taking advantage of this, exporters sometimes club old and junk computers along with new ones.
3. Taking advantage of the flexibility in the interpretation of rules, some Port Authorities also make a distinction between capital goods and non-capital goods in order to facilitate the import of told PCs. For them, old computers imported as a donation to educational or charitable institutions come under the 'capital goods' category. Being capital goods, they are then under the free list and access various tax benefits.
4. Other old computers (less than 10-year old) imported for the purpose of resale or recycling come under the 'non-capital goods' category and can only be imported against a license. In order to avoid the burden of high taxes, in case of import under non-capital goods category, importers indulge in price under-invoicing of goods. The liberal position taken by the Customs Authority for keeping imported old PCs under capital goods in the free list (Items which do not require any license under the export and import policy have been denoted as 'free' subject to licensing notes) is in direct opposition to the position taken by the representatives of DGFT. For them, any old items should only be imported against a license and an arbitrary distinction between capital goods and non- capital goods should not be allowed. Also, keeping his identity undisclosed, one of the Customs appraisers at the Chennai port revealed that some importers procure old computers in the name of a donation to a school. In order to get the benefit of tax concession and ease in import, they get registration of school under the Society Act 1968, without actually establishing such school.
5. A number of integrated HTPFs, EOUs, EPZs, etc. have been set up by the Government of India to meet specific requirements of a globally oriented electronics hardware sector.100%Export Oriented Units can also be established outside these zones, anywhere in India, and all the incentives available to EPZs units and so on are also available to the EOUs.

2.3 Electronic Waste and Environmental Legislation in India

Despite a wide range of environmental legislations in India there are no specific laws or guidelines for electronic waste or computer waste. Overall India has so far enacted around 14 laws for governing the country's environment, but none of these have any direct reference to electronic waste or refer to its handling as hazardous in nature. However several provisions of these laws apply to various aspects of electronic wastes.

2.3.1 The Hazardous Wastes Rules, 1989, Amended 2000

The Hazardous Waste (Management and handling) Rule, 1989 and as amended in May 2000, defines hazardous waste as "any waste which by reason of any of its physical, chemical, reactive, toxic, flammable, explosive or corrosive characteristics causes danger or likely to cause danger to health or environment, whether alone or when on contact with other wastes or substances, and shall include:

- Waste substances that are generated in the 47 processes indicated in column 2 of Schedule I and consist of wholly or partly of the waste substances referred to in column 3 of same schedule.
- Waste substances that consist wholly or partly of substances indicated in Schedule 2,

unless the concentration of substances is less than the limit indicated in the same Schedule.

- Waste substances that are indicated in Part A of Schedule 3 unless they do not possess any of the hazardous characteristics in part B of the same Schedule.

2.3.1.1 Schedule 1

Although, there is no direct reference of electronic waste in any column of Schedule 1 (which defines hazardous waste generated through different industrial processes) the manufacturing as well as disposal process of computer could be characterized as hazardous processes on the basis of use of carcinogenic substances used in chip production. These include arsenic, benzene, cadmium, lead etc. In fact, Schedule I has listed some industrial process that generate hazardous waste in production as well as disposal process. Similar process and waste are also being used and generated in computer manufacturing and disposal. These are:

Process	Waste
Production or use of lead	Lead ashes, lead slags, and lead-containing filter material.
Production or use of cadmium	Lead containing filter material.
Metal working	Beryllium containing metal waste. Mercury containing metal waste.
Industrial printing and copying with liquid toner.	Printing ink residue, Silkscreen printing ink residue, Liquid toner residue.
Production or use of materials made with silicones excluding cement	Silicon containing residues
Production or use of plastics or raw materials for them	Halogen free residue of additives plastics (e.g. Dyes tuffs or flame retardants)

The above-mentioned toxic substances are used in almost every electronic goods. Lead is used in circuit boards, in monitor screens and glass. Disposal of these parts either through burning or in landfill release toxic substances. Mercury used in switches, circuit boards, in flat panel displays is released into the environment when burned or smelted. Similarly, beryllium used in every electronics assemblies and is released into the environment through dust emissions and during crushing, cutting or burning operations. Also circuit board and plastics casing that are impregnated with brominated flame retardants to prevent flammability are source of release of dioxins and furans.

As per the May 2002 draft amendment of the India hazardous waste rules, once a waste product is classified as hazardous according to industrial process listed in Schedule 1, it is exempted from the concentration limit requirement set by Schedule 2 of Act, and is considered hazardous irrespective of its concentrations.

2.3.1.2 Schedule 2

The Schedule 2 of the Hazardous Waste Management and Handling Rules, 1989, lists waste substances which should be considered hazardous unless their concentration is less than the limit indicated in the said Schedule. Even going by this computer waste can be considered hazardous in nature.

The various classes of substances listed in this Schedule are:

Class A: If 1 kg of any substances contains 50 mg of listed items than it shall be called

hazardous waste (See class A list).Following are the toxic substances present in desktop computer and which are also listed in schedule 2.

Element	Weight (lbs)
A1 Antimony &antimony compound	<0.1
A2 Arsenic and arsenic compound	<0.1
A3 Beryllium and cadmium compound	<0.1
A4 Cadmium and beryllium compound	<0.2
A5 Chromium (VI)compound	<0.1
A6 Mercury and mercury compound	<0.1
A17 Halogenated aromatic compounds (Found in casing which weigh 13.8 lbs)	Yet to established.
A7 Selenium and selenium compound	<0.00096

Class B: If 1 kg of any substances contains 5000 mg of listed items, than it shall be called as Hazardous waste (See class B list).Following are the Toxic substances present in Desktop Computer and also being listed in schedule 2 of Hazardous waste manual.

Element	Weight (lbs)
B2 Cobalt compound	<0.1
B3 Copper	<4.2
B4 Lead	<3.8
B6 Nickel compound	<0.51
B7 Tin compound	<0.6
B8 Vanadium	<0.1
B10 Silver compound	<0.1
B11 Organic halogen compound (found in plastic casing)	
B30 manganese-silicon	<0.1

(Note: Class C and class D are not applicable in case of the computer waste scraps as the listed items are not present in computer or information technology waste, and are not included in this discussion.)

The above-mentioned substances (in Schedule 2) are present in desktop computers. If the concentration of the above mention substances exceeds 50 mg and 500mg as prescribed in the limit of class A and B of schedule 2 respectively, then computer waste weighing around 30 kg can be categorized as hazardous waste. The import and export of hazardous waste is dealt with in Schedule 3 of the Rules.

2.3.1.3 Schedule 3

List of Hazardous Waste to be applicable only for imports and exports are mentioned in schedule 3 of the manual. It define hazardous waste as “Wastes listed in lists ‘A ’ and ‘B ’ of part A of schedule 3 applicable only in case(s)of export/import of hazardous wastes in accordance with rule 12, 13, and 14 only if they possess any of the hazardous characteristics in part B of said schedule”.

This clause defines hazardous waste for the purpose of import and export. It has divided hazardous waste into two parts, A and B. Part A of the schedule deals with two lists of waste to be applicable only for imports and exports purpose.

Export and import of items listed in List A and B of part A are permitted only as raw materials for recycling or reuse. It is the opinion of legal experts that the trade of wastes mentioned in list A which possess characteristic of hazardous wastes are regulated by law.

2.3.1.4 Electronic Waste and Related Items listed in part A, list A and B - Schedule 3

Following are the electronic items being mentioned in list A:
A1180 "Electrical and electronic assemblies or scraps containing components such as accumulators and other batteries included on list B, mercury-switches, glass from cathode ray tubes and other activated glass and PCB-capacitors, or contaminated with schedule 2 constituents (e.g. cadmium, mercury, lead, polychlorinated biphenyl)to an extent that they exhibit hazard characteristics indicated in part B of this schedule.(See B1110)".
A1090 Ashes from the incineration of insulated copper wire.
A1150 Precious metal ash from incineration of PCBs not included on list 'B '
A2010 Glass waste from cathode ray tubes and other activated glass.
A3180 Wastes, substances and articles containing, consisting of or contaminated with polychlorinated biphenyls (PCB) and including any other polybrominated analogues of these compounds, at a concentration level of 50 mg/kg or more.

Comments: Electronic items like glass from cathode ray tubes and PCB-capacitors exhibit hazardous characteristic in so far they are being mentioned in list A, part A of schedule. Their trade in the 'mentioned form' requires special permission from the concerned authority. The rules deal with components but not with whole computers as waste scrap. Taking advantage of this loophole, toxic substances are being dumped in name export and import of 2nd hand computers or peripheral part.

Following are electronic items placed on list B B1110:
1. Electronic assemblies consisting only of metals of alloys
2. Electrical and electronic assemblies (including printed circuit board, electronic components and wires) not valid for direct reuse but for recycling.

Comments: Trade of electronic items made out of metal is permitted both for reuse and recycling. However, PCB and PVC coated wire could be imported only for recycling and not for reuse. This provision is in direct opposition to Basel Convention and its Ban Amendment provision, which permits import and export only for reuse and not for recycling. This provision also overlooks crude and rudimentary methods of recycling which is highly polluting.

2.3.1.5 List of Hazardous Characteristics Mentioned in Part B of List A - Schedule 3

This list contains 14 sub clauses for categorizing handling/trade/recycling of any substance as hazardous. Each sub-clause may be interpreted in a much wider context to cover any substance, their handling and recycling as hazardous if listed characteristics may be applicable in categorizing trade and recycling of computer waste as hazardous and beyond the regenerative capacity of environment:

H6.1 Poisonous (Acute): Substances or wastes liable either to cause death or serious injury or to harm health if wallowed or inhaled or by skin contact.
H8 Corrosives: Substances or wastes which, by chemical action, will cause severe damage when in contact with living tissues, or, in the case of leakage, will materially damage or even destroy, other goods or the means of transport; they may also cause other hazards.
H10 Liberation of toxic gases in contact with air or water: Substances or wastes, which, by interaction with air or water, are liable to give off toxic gases in dangerous quantities.

H11 Toxic (delayed or Chronic): Substances or wastes which if they or inhaled or ingested or if they penetrate the skin, may involve delayed or chronic effects, including carcinogenicity.
H12 Ecotoxic: Substances or wastes which if released present or may present immediate or delayed adverse impacts to the environment by means of bioaccumulation and/or toxic effects upon biotic systems.
H13 Capable, by any means after disposal, of yielding another material, e.g., leachate which possesses any of the characteristics listed above.

Comments: Ambit of these sub clauses is so comprehensive that it will cover each steps of computer recycling from pre heating to final roasting of motherboard to recover mercury and other material from it. However each step of recycling involves occupational health risk to workers, people residing in surrounding area and environmental degradation in general. Open burning of the PVC coated wire and motherboard of computer for material recovery emits many toxic gases like Dioxin and Furan. Coming into direct or indirect contact of these gases causes various forms of cancer in human being.

Analysis of schedules 2 and 3 of the Hazardous Wastes Rules, 1989 categorized some part of computer scraps as hazardous waste. However, the act is vague in dealing with import of whole junk computer sets. The rules do not clearly mention that it can be applied for import and export of e-wastes in form of junk desktop computers. In fact, whole of part A of the schedule 3 mentions at length items that could be traded irrespective of being of hazardous nature. The only provision is the ban on dumping.

Any import or export must be carried out with prior permission of concerned authority. The new Schedule 6 added in May 2002, which prohibits trade of 28 listed items does not have any reference of junk computer or its parts. The sole purpose of act seems to be of regulatory nature and that too only to control indiscriminate and illegal tariff of hazardous waste.

Part B of schedule 3 mentions lists of hazardous characteristic. The law prohibits trade of any substances having or showing resemblance to the hazardous characteristics as mentions in list. Import and export of hazardous waste/substances listed in part A of schedule 3 shall be prohibited if any of items have resemblance with items listed in Part B of same schedule.

2.3.2 Basel Convention and its Application to E-waste

The Basel Convention defines waste by disposal destination or recovery processes. These various processes are listed in Anne IV of the Convention. For example, virtually any material that will be recycled or processed in order to reclaim a metal, or to reclaim an organic or inorganic substance for further use, is deemed a waste. Electronic components that are used without further processing are likely to not be defined as a waste.

The convention has provided for two lists. List A found in Annex VII is presumed to be hazardous and thus covered by the Basel convention; and list B, found in Annex IX, is presumed to be non-hazardous and thus not subject to Basel convention. The waste listed in list A is waste that poses serious threats to environment and human health. As a result of their adverse effects these substances require special handling and disposal processes.

The Basel Annex-VII hazardous waste lists the following applicable entries to e-waste:

A1010 Metal wastes and waste consisting of alloys of any of the following: antimony, arsenic, beryllium, cadmium, mercury, selenium, tellurium, thallium.
A1020 Waste having as constituents or contaminants, excluding metal waste in massive form, any of the following: antimony compounds, beryllium, beryllium compounds, cadmium, cadmium compound, lead, lead compounds, selenium, selenium compounds, tellurium, tellurium compound.
A1030 Wastes having as constituents or contaminants any of the following: arsenic, Arsenic compounds, mercury, mercury compound, thallium, thallium compounds.
A1160 Waste lead-acid batteries, whole or crushed.
A1170 Unsorted waste batteries excluding mixtures of only list B batteries. Waste batteries not specified on list B containing Annex I constituents to an extent to render them hazardous. [Note: List B batteries include: waste batteries conforming to a specification, excluding those made with lead, cadmium or mercury]
A1180 Waste electrical and electronic assemblies or scraps containing components such as accumulators and other batteries included on list A, mercury- switches, glass from cathode ray tubes and other activated glass and PCB- capacitors, or contaminated with Annex 1 constituents (e.g. cadmium, mercury, lead, polychlorinated biphenyl) to an extent that they exhibit hazard characteristics contain in Annex III.
A2010 Glass waste from cathode ray tubes and other activated glass destined for direct reuse and not for recycling or final disposal.

It is also important to note that the Basel convention's list B includes:

B1110 Electrical and electronic assemblies (including printed circuit board, electronic components and wires) destined for direct reuse and not for recycling or final disposal.

From the above we can conclude that at the very least, circuit board, CRTs, and other electronic boards or components and assemblies containing lead based solders and copper beryllium alloys (which include most computer circuit boards and much other electronic equipment), are indeed hazardous wastes according to Basel convention. Likewise, whole, used, discarded computers, printers, and monitors that contain such circuit boards or CRTs that are not to be reused directly are to be considered as hazardous waste and subject to the Basel convention.

2.3.3 Basel Convention and the Indian Rules

The Annex VII of Basel convention includes almost same entries applicable to E- waste as it is in schedule 3 of Indian hazardous waste manual. However, there are some provisions, which stand in direct opposition to what has been in the Basel convention.

One of such conflicting provision is grant of trade in electronic assemblies like printed circuit board, electronic components and wires for recycling and not for direct reuse. (List B No 1110).This provision is contradictory with similar provision for BASEL charter, which allow trade only for reuse and not for recycling. There is another confusing provision in entry No A1150 on trade of precious metal ash from the incineration of printed circuit boards. There no such analogous provision in Basel convention. These imply that ash containing many carcinogens could be imported for reuse or recycling against a license from concerned authority.

The Indian rules provide detailed procedures to be followed for import and export of listed waste. All trade in listed in part A of schedule 3 shall be illegal if there is any laxity in compliance of the procedures mention in the rule 12, 13, and14 of Basel. Though hazardous in nature, waste placed in list B do not required any permission for import and export under H-waste rules. This provision is analogous of Annex 9 of Basel. However

import and export of substance mentioned in this list require adherence to concentration limits prescribed in Annex III of Basel Convention.

Both the Basel convention and Indian Hazardous Waste Rules define wastes as substances that need to be controlled in their movement, disposal, recovery or reclamation and recycling operation. However these rules, including the Basel Convention fails to specify any sound method of disposal and does not mention the transfer of environmentally sound technology for recycling or reclamation.

The present Indian law ensures safe disposal of all hazardous waste, produced within the country. It does not impose a complete ban on the movement of hazardous waste, and is more in nature of insuring control movement so that there could be safe disposal facility. However, safe disposal facility could be possible only when there is option of sound technology of disposal. To our best knowledge India do not have any technology for e-waste disposal.

CHAPTER 3: APPROACH, METHODOLOGY, KEY STAKEHOLDERS AND TEST METHODS/ TOOLS USED

3.1 Introduction

The major objective of this assessment is to address the e-waste for the regions of Mumbai, where the handling of e-waste is distributed over a large area. In order to execute this assignment, it is essential to establish the E-Waste Business chain linking different stakeholders to understand the trade economics and associated environmental impacts. The following section describes the approach and methodology, identification of key stakeholders in Mumbai and the customized test methods/ tools used to carry out this study.

3.2 Approach and Methodology

IRGSSA has applied a very comprehensive approach to carry out this study. The fundamental approach to carry out this study can be summarized in following three phases. This approach starts with field experience and knowledge gained during assessment period followed by international exposure to arrive at optimum solution to address WEEE in the study area.

Phase 1: Mobilization and work plan
Phase 2: Data Collection/ Field Work
Phase 3: Report Findings/ International and domestic training workshops/ Way Forward

This approach uses a technique, which allows for entering data with a geographical context (where things happen) and for representing facts on maps or for using data further in complex modelling contexts. This approach was developed based on the fact, that e-waste "flows" through a region such as Mumbai, Pune and Pimpri Chinchwad region and on its way it is disintegrated and processed in numerous steps until it re-joins the raw material streams or ends in a final disposal. The following methodology has been used by implementing the identified tasks under each phase.

Phase 1: Mobilization and Work Plan

Task 1 - Mobilization:
A multidisciplinary team consisting of key personnel and field staff will be selected, organized into city teams and will mobilize for carrying out this study.

Task 2 - Establishment of geographical limit of the study area:
This task will include the establishment of geographical limits of study area i.e. MMR area. This will include assessment of land use maps of the study region and fixing up of rural and urban boundaries.

Task 3 - Work plan:
A work plan will be prepared and defended before the working group/ expert committee

Phase 2: Data Collection/ Field Work

Task 4 - Identification of WEEE and establishment of WEEE trade value chain:
This task will include identification of study items/ WEEE tracer (TV/ Personal Computer/ Cell phone/ any other after discussion with working group) and tracking its geographical movement within the identified geographical limits of the area to its final end of life, ex. Places where tracers are unloaded, traded, transported, dismantled, recycled, reused, repaired, processed and disposed. Each city team will proceed as per the following steps.

- Identify all the organized and unorganized market of a tracer in a geographical area.
- Carrying out transect walk and surveys in a district. Start transect walks from identified markets i.e. electronics/ computer/ white good market. Identify the buyer and seller in these markets to link the chain.
- Track the route of the tracer geographically.
- Establish the extent of dismantling happening in a geographically and fix the boundaries.

The different stakeholders (1st, 2nd and 3rd level as identified in TOR) will form key links in the material flow chain of output input analysis. Some of the major stakeholders, whom the study will cover include:

1st Group:
Importers, manufacturers, distributors, traders, retailers and consumers (end users and super users as per TOR)
2nd Group:
Collectors (traders, scrap dealers, collectors, dissemblers, dismantlers, recyclers, road side vendors, authorized and unauthorized auctioneers)
3rd Group:
Regulators like MPCB

The team will geographically map the area, where generation, stockpiling, collection, handling and brokering, processing and production of other items from WEEE are happening. A typical, WEEE trade chain will be established in a geographical context. This WEEE trade value chain will be mapped on the map of Mumbai using GIS platform.

Task 5 - Estimate the WEEE through secondary data by estimating obsolescence rate and confirming it through primary survey

This task will involve identifying the WEEE streams followed by identification of the tracer item and tracking the tracer item through the process in the WEEE stream. At first obsolescence rate will be established through secondary data followed by confirmation/ verification through primary data.

By using secondary data e.g. Market research data like market supply, industry wastage and imports data installed base of the tracer and obsolescence rate will be established. The key to estimate WEEE is fixing up of obsolescence rate based on either industry data or consumer behaviour followed by tracer item analysis. One of the methods used to establish installed base is “Market Supply” method. In this method, externalities like temporary storage of WEEE with different stakeholders and its lead-time for dismantling can be factored through primary survey and available secondary data. This method has also been used to estimate WEEE from personal computer (PC) in Delhi.

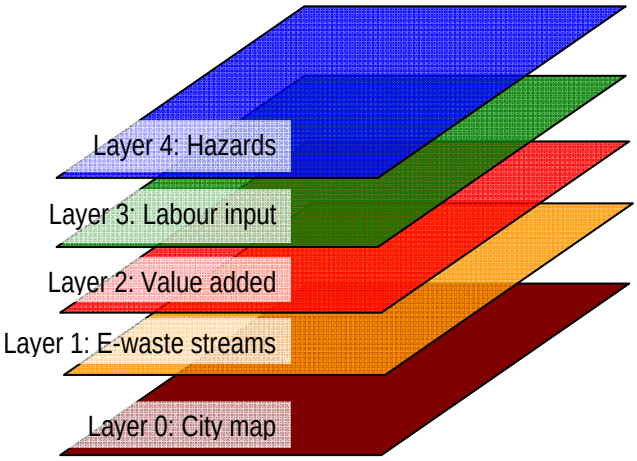


Figure: Conceptual methodology for mapping

Task 6 - Identify the products, by products and waste products
Tracer item tracking technique will be used to identify products, by products and waste products. This can be carried out by estimating qualitative and quantitative estimations with the identified stakeholders across the value chain using photo documentation of sampled WEEE tracer.

Verification of obsolescence rate through primary data

The obsolescence rate will be verified through identification of WEEE stream and WEEE processes and tracking of tracer item. The primary survey methodologies to be used and outputs are described in **Table 3.1**.

Table 3.1: Methodology for estimation of WEEE quantity

Objectives	Details	Primary survey methodologies	Output
WEEE stream	Material flow	• Follow tracer materials[1]: semi-structured interviews about quantities, quality, economics, labour	• Key-players are known (dealers, disassembly-persons, recycler) • Material flow (quantities / qualities) from input to output are identified • Labour in WEEE streams are identified
	Input quantities/ Import	• Interviews with WEEE producers (manufacturers / retailers, auctions) to find out WEEE quantities • Survey of key-players for import: semi-structured interviews	• WEEE quantity input is estimated • Percentage of imported / household WEEE is known
	Reuse	• Surveys of scrap dealers, retailers, computer repair shops: semi-structured interviews	• Quantities of reused entire equipment are estimated • Quantities of reused equipment parts are estimated

Objectives	Details	Primary survey methodologies	Output
	Disposal	• Sampling on different landfills	• Existence of WEEE fractions in landfills is known
Recycling technologies	Recycling technology	• Transect walks in different districts (semi-structured interviews)	• Applied recycling technologies are known • Labour needed for different recycling processes is known
	Hazardous processes	• Semi-structured interviews in districts, where potentially hazardous processes take place	• Hazards in different recycling processes are identified

3.3 Output/ Findings of Phase 1

Phase 1 was completed in July 2006. The land use maps of Mumbai, Pune and Pimpri Chinchwad region were procured and the study area was fixed up based on reconnaissance survey. Further, the reconnaissance survey helped to identify key stakeholders involved in e-waste trade.

3.3.1 Key Stakeholders

This section describes about various stakeholders involved in e-waste trade, a brief introduction to these stakeholders and their areas of operations.

3.3.1.2 Regulatory Bodies

These organizations or bodies are constituted under different acts and regulatory/legislative support to safeguard the environmental and as regulators for various trades which directly or indirectly effects the environment and general health. These bodies are:

1. Ministry of Environment and Forest (MoEF)
2. Central Pollution Control Board and Maharashtra Pollution Control Board (CPCB and MPCB)

3.3.1.3 NASSCOM

The National Association of Software and Services Companies (NASSCOM) is India's premier trade body and the chamber of commerce of the IT software and services industry in India. NASSCOM is a truly global trade body with around 850 members, of which nearly 150 are global companies from the US, UK, EU, Japan and China. NASSCOM's member companies are in the business of software development, software services, and IT-enabled/BPO services. NASSCOM was set up to facilitate business and trade in software and services and to encourage advancement of research in software technology. It is a not-for-profit organization, (funded entirely by its members) registered under the Societies Act, 1896. NASSCOM has been the strongest proponent of global free trade in India. NASSCOM is committed to work proactively to encourage its members to adopt world class management practices, build and uphold highest quality standards and become globally competitive. In India and around the world, NASSCOM members are participants in the new global economy and are reputed for their cutting-edge business practices and social initiatives.

3.3.1.4 MAIT & OTHER ASSOCIATIONS/AGENCIES

Manufacturers' Association for Information Technology (MAIT) has set up in 1982 for purposes of scientific, educational and IT industry promotion and it is emerged as an effective, influential and dynamic organization. Representing actively Hardware, Training, Design/R&D and the associated services sectors of the Indian IT Industry, MAIT's charter is to develop a globally competitive Indian IT Industry, promote the usage of IT in India, strengthen the role of IT in national economic development and promote business through international alliances. The organization's special focus is on domestic market development and attracting foreign investment in the Indian IT Industry. MAIT is represented on all concerned Government of India forums and works in close association with the Department of IT, Ministry of Communications & IT, Ministry of Commerce & Industry, DGFT, Ministry of Finance, NCAER, BIS, ESC, NIC, STQC, CII, TEMA, ELCINA, CETMA, etc. for the advancement of the IT Industry in India.

3.3.1.5 NGOs

NGOs like Toxicslink, which are working in a major way in e-waste in Mumbai, have been consulted.

3.3.1.6 Consumer

Consumers sector contributes to the major share of E-waste in MMR, Pune and Pimpri Chinchwad region. This sector compromises of the following categories as mentioned below.

Individual Households

As far as PCs emanating from individual households are concerned, it is difficult to know their condition after leaving the user, as most of them do not directly sell obsolete computers into the scrap market. The preferred practice is to get it exchanged from retailers while purchasing a new computer, or pass it to relatives or friends. In former case, it is the retailer's responsibility to dispose off the computer.

Business Sector

The business sector (government departments, public or private sector, MNC offices, etc) were the earliest users of IT and IT products; today they account for a sizable amount of total installed PCs. Hence they are the major producers of obsolete technology in India. The incompatibility of old systems to cater to present needs and requirement prompts them to pass the obsolete technology to the recycling chain.

Manufacturers and Retailers

Manufacturer and retailers are next on the list of contributor to e-waste in India. The waste from this sector comprises defective IC chips, motherboards, CRTs other peripheral items produced during the production process. It also includes defective PCs under guarantee procured from consumers as replacement items.

Imports

Among the highest sources of PC scraps are imports. Huge quantities of e-waste like monitors, printers, keyboards, CPUs, typewriters, projectors, mobile phones, PVC wires, etc are imported. The computers thus exported are of all ranges, models and sizes, and are functional as well as junk materials. Existence of international as well local trade

network and mushrooming of importers of old computes in far flung areas indicate the huge import of obsolete technology in India.

Traders / Scrap dealers / Dissemblers

The journey from consumer to recycler is long and complex. It moves in a zigzag fashion. It involves players not only from the informal sector that is, the recycling stream, but also players from the formal sector, that is, manufacturers and retailers of electronic items. Immediately after securing computers from various sources, scrap dealers face the dilemma of deciding which item ought to be dismantled and which to be retained for resale. This dilemma arises because only a few models are in demand as second hand products. Once the decision is made, the not-to-be-resold item components find their way to the storehouses for dismantling. Sometimes, even an item meant for direct reuse may ultimately end up in the storehouse as dealers cannot wait long for a prospective buyer.

Recyclers

The e-waste recycling market exists in a major way in Mumbai, while it is very limited in Pune and Pimpri Chinchwad region. The market of e-waste in Mumbai is not concentrated in a single place, but spread over different areas, each handling a different aspect of recycling. In spite of the absence of proper technology, each component is disassembled and recycled or reused in Mumbai. The general practices observed in India in case of recycling of the most complex parts of PCs, for instance, circuit boards and PVC wires, is open roasting and acid bath to recover different metals. However, this practice has not been observed in Mumbai, Pune and Pimpri Chinchwad region. Similarly, only limited plastic recycling exists in Pune and Pimpri Chinchwad region. Most of the WEEE generated in this region is transported to MMR for further treatment and distribution.

Disposal

Thus, every component of an electronic item is extracted through recycling. The item, which require extraction through wet processes are sold to traders from Delhi. At present nothing is dumped in open fields. Though not dumped, the hazards involved in product recycling cause environmental damage.

3.4 Test Methods/ Tools Used

The identification of stakeholders led to customization of test methods and tools used for carrying out this study. A customized Participatory Rural (Urban) Appraisal (PRA) technique was used for data acquisition. The salient feature of using this technique is described below.

- Learning from and with people, directly, on the site and face-to-face.
- To make a pictorial representation of all the things that need to be taken into consideration or are important to a particular situation.
- To quickly gain a lot of ideas from a group without getting caught up in detailed discussion.
- To gain information from a large number of people in a structured way according to specific questions.
- To cluster similar ideas, to see links between them and to pick out the most important issues when discussing or brainstorming.
- To identify the strengths, weaknesses, opportunities and threats in relation to study.
- To illustrate the extent to which individuals, organizations, projects or services

interact with each other or overlap and the importance of each, and their efforts.

The knowledge of local people is taken as the starting point, and visiting planners and administrators learn from them, by using many different locally adapted methods.

Following tools were used for data acquisition considering local situations:

- Secondary Data Review
- Communication
- Tools for exploring time (Temporal dimension)
- Tools for exploring space (spatial dimension)
- Tools for exploring social world (social dimension)

3.4.1 Secondary Data Review

Relevant maps, literature, statistics and report available were consulted in the preparation phase. The agencies, which have been consulted for secondary data collection included agencies identified in section 3.3. Some verification was carried out to check the authenticity of existing secondary data.

3.4.2 Communication

The tools used under this head included

- **Interviews:** Structured/ semi structured interviews with individuals, key-persons, and establishment owner in case of Informal sector and structured questionnaires were used for organized sector.
- **Discussion:** with focus groups, communities.
- **Workshops and meetings:** To share and verify data and information collected.
- **Models/Charts/Photographs:** as a good aid for assisting communications, for visualizing results and activities and for linking cause and effect and quantity flows.

The key stakeholders described in **section 3.3** are classified into two categories formal and informal. The formal sector was covered using a questionnaire as per the format given below.

Questionnaire:

Dated	
Survey Type	
Area	
Name of Shop	
Number of persons	
Area of establishment	
Repair facility	
Waste Generation	
Waste Quantity	
Who purchase the waste	
Type of Business	
Source of Material supply	
Major Findings	
Next Steps	

The informal sector was covered using semi-structured interviews, focused and community discussions. This was carried out through preparation of interview guide, one to one direct contact and telephone. The purpose, principle and application of semi-structured interviews are given below.

Semi-structured interviews

Purpose	Learn from the interviewed people about their situation
Principle	A semi-structured interview does not involve a formal questionnaire, but instead makes use of a flexible interview guide to help ensure that the interviews stay focused on the relevant issues, while remaining conversational enough to allow participants to introduce and discuss issues that they deem relevant.
Application	Interviewed people comprised repair-shop keeper, scrap-dealer, dissembler, recycler and government representatives.

3.4.3 Tools for exploring time

Time line and daily activity chart method was used for exploring temporal dimension to e-waste. This included the historical record of installed capacity of e-waste items, number of items added each year into the installed capacity, estimation of obsolescence rate and its changing pattern over the years.

3.4.4 Tools for exploring space and social world

Spatial and social dimensions were explored using transect, tracer and hazardous process walk. The purpose, principle and application of these three walks are described below.

Transect walk

Purpose	Get an idea about applied practices, geographical patterns, system understanding, etc.
Principle	During a transect walk, a kind of exploratory walk is undertaken by the team along a pre-defined path with the stakeholders to observe and send in minute details of the differences of a particular area.
Application	Different transect walks through recycling districts were defined by the investigation team. During the transect walk, the team observed, interviewed the people and described in detail what happened along the path.

Tracer walk

Purpose	Get an idea about the routes of different tracer items
Principle	Tracer items of the object of investigation are defined and followed along there life cycle. During this walk, the team observes and describes in detail what is seen.
Application	Tracer items, such as plastic casings, keyboards, CRT's, were defined by the investigation team. During the tracer walk, the team followed the defined tracers and observed in detail what happened in different places along the route.

Hazardous processes walk

Purpose	Get an idea about the hazards caused by the investigated object on the environment and the human being
Principle	Places, where potentially hazardous processes take place are identified and visited. Stakeholders are interviewed using semi-structured interviews
Application	Socio-economic mapping

These tools have been used to quantifying E Waste as material flows approach is followed. Material flow models are normally based on accounting methods for the activities or processes being examined, and networks to connect the activities or processes being examined, thus indicating the flow of material. The format used is described below.

Format:

Visited Processing Site

Name, Address, Contact Person

Date:

Person Responsible for Survey

Name; Company

Coordinate (GPS)

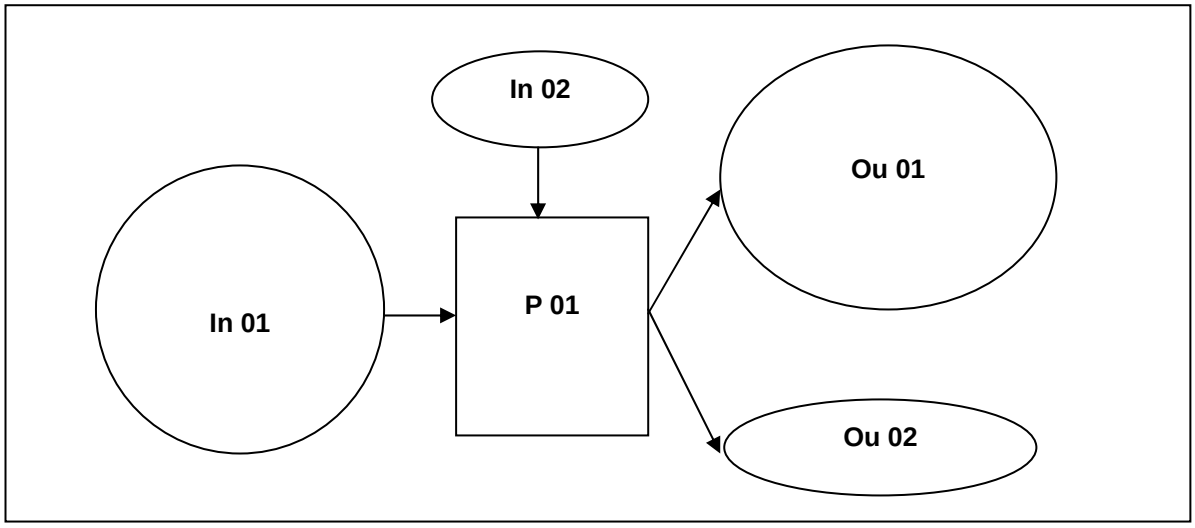
Type of Processed Material

Quantity of Processed Material

Number of Employees/

Working Hours

Processing Diagram



Processes

Code	Name	GPS	Description Detailed Description of the Technologies applied; thermal recovery, landfill, environment, open burning, transport (Vehicle Type, Distance)….. • Health and Safety Measures • Labour intensity (Persons*hours/ Processed Material) • Average Wages of employees, taxes paid to public authorities, cost of equipments, etc	Photo Documentation
P 01				

Inputs				
Code	**Material/Energy/**	**Price Rs/Unit**	**Description** Supplier, Specification	**Photo Documentation**
In 01				
In 02				

Outputs				
Code	**Material/Energy/**	**Price Rs/Unit**	**Description** Costumer, Specification	**Photo Documentation**
Ou 01				
Ou 02				

This format describes material flow methodology based on the sales of items of electrical and electronic equipment. These sales figures have been applied to a number of calculation methodologies to quantify waste arising for each of the selected items. Using average weights and an average composition of the waste stream extrapolation has been done to arrive at total E-Waste arising for Mumbai, Pune and Pimpri Chinchwad region.

The out of phase 1 led to establishment of survey plan of both formal and informal sector in the month of August, September and October. The following chapters describe the in-depth analysis of the survey findings in the Mumbai, Pune and Pimpri Chinchwad region.