CHAPTER 4: PROCESS STUDY, GEOGRAPHICAL DISTRIBUTION & E-WASTE TRADE VALUE CHAIN

4.1 Introduction

The major objective of survey findings is to identify and establish dismantling process and their geographical distribution in MMR, Pune and Pimpri Chinchwad region. This will assist in establishment of E-Waste trade value chain and E-waste movement along this chain in geographical context in both regions. The following sections describe each of these steps in both regions.

4.2 E-Waste Process Study

There are various processes involved for recycling / reusing of electronic waste. The major process for different types of electronic items in MMR, Pune and Pimpri Chinchwad region are mentioned in **Table 4.1.**

Table 4.1: Processes involved for E-waste recycling in MMR, Pune & Pimpri Chinchwad

S. No.	Process name	Process Status	
		MMR	Pune Chinchwad
1	IC's Extraction from PWB	Yes	No
2	Surface Heating of PWB and Extraction of components	Yes	No
3	Dissembling of Monitor and extraction of components	Yes	No
4	Yoke core and Copper	Yes	No
5	Metallic Core of Transformer and Copper	Yes	No
6	Rare Earth Core of Transformer and Copper	Yes	No
7	Rare Earth Core of Static Transformer	Yes	No
8	Wire PVC and Copper	Yes	Yes
9	Plastic Shredder	Yes	Yes
10	Dismantling of Refrigerator and Compressor	Yes	Yes (limited extent)
11	Gold Extractions from Pins and Comb	No	No
12	Acid Bath for PWB	No	No
13	Regunning CRT's	No	No
14	Glass Recovery from CRT	Yes	No
15	Gold Recovery	Yes	No

The process details of twelve processes are given in **Table 4.2. T**he analysis of this table shows that there is very small amount of dismantling activity occurring in Pune, Pimpri Chinchwad region. The entire amount of e-waste/ WEEE from this region is transported to MMR for dismantling and further supply to Delhi market. Therefore, MMR acts as a hub for supply of e-waste/ WEEE to Delhi and other parts of India. Photo documentation captured in different parts of MMR is given in **Table 4.3**.

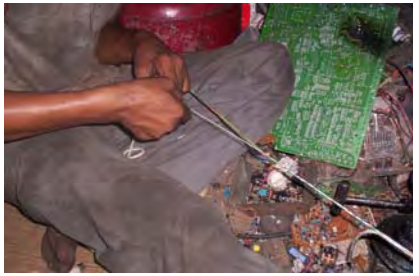
Table 4.2: E-waste Recycling/reusing Process Details

S. No.	Processing Components	Process Details	MMR		Pune, Pimpri Chinchwad	
			Processing	Remarks	Processing	Remarks
Personal Computer						
1	Cathode ray tube (CRT), Computer casing, Printed circuit boards (PCBs), Printed wire boards (PWBs), Integrated circuits (ICs), Yoke copper and Copper, Computer casing, Rare earth core and Gold from pin and comb	Dissembling of Monitor and extraction of components	Yes	In local market	No	In local market
2		Regunning of CRTs	No	Sent to Delhi market	No	Sent to MMR
3		IC's Extraction from PWB	Yes	Reselling and reuse in local market	No	Sent to MMR
4		Acid Bath for PWB	No	Sent to Delhi market	No	Sent to MMR
5		Surface Heating of PWB and Extraction of components	Yes	Reselling and reuse in local market	No	Sent to MMR
6		Wire PVC and Copper	Yes	Reselling and reuse in local market	Yes	In local market
7		Plastic Shredding	Yes	In local market	Yes	In local market
8		Gold Extractions from pins and Comb	No	Sent to Delhi market	No	Sent to MMR
9		Yoke core and copper extraction from wire	Yes	Reselling and reuse in local market	No	Sent to MMR
10		Metallic Core of Transformer and Copper	Yes	Reselling and reuse in local market	No	Sent to MMR
11		Rare Earth Core of Transformer and Copper	Yes	Reselling and reuse in local market	No	Sent to MMR
12		Rare Earth Core of Static Transformer	Yes	Reselling and reuse in local market	No	Sent to MMR
Television						
13	TV cabinet, CRT, Yoke core and PCB	Dismantling of TV cabinet and CRT	Yes	In local market	No	Sent to MMR
14		Regunning of CRTs	No	Sent to Delhi market	No	Sent to MMR
15		Yoke core and copper extraction from wire	Yes	In local market	No	Sent to MMR
16		Plastic shredding	Yes	Reselling and reuse in local market	Yes	In local market
Cellular Phone						
17	Aerials, Battery connectors, PCBs, Gold-coated edge contacts on PCBs, ICs, Keyboards, LCD screens, Lenses, Microphones, Phone housings, Screws, SIM card assemblies and Speakers.	Separate metals recovery (including precious and semiprecious metals)	Yes	Repairing and reuse in local market	No	Sent to MMR
18		Batteries repairing and reselling	Yes	Repairing and reuse in local market	No	Sent to MMR
19		Outer body plastic granulation and reuse	Yes	In local market	Yes	In local market
20		Reuse of valuable components (flash memory devices, PCBs, ICs, keyboards, LCD screens, lenses, microphones, phone housings, and speakers) with minor repairing	Yes	Repairing and reuse in local market	No	Sent to MMR
Refrigerator						
21	Casing, Cotton insulator, Evaporator, Heating rod, Condenser, Compressor, Fan and Motor	Dismantling of refrigerator and segregation of compressor and cooling box	Yes	Reselling in local market	Yes	In local market
22		Extraction of steel and copper from heating rod	Yes	Reselling in local market	No	Sent to MMR
23		Extraction and shredding of ABS plastic from fan	Yes	Reselling and reuse in local market	No	Sent to MMR

Table 4.3: Processes involved for E-waste recycling in Mumbai markets

S. No.	Process name	Process status	Photo-documentation
1	IC's Extraction from PWB	Yes	 
2	Surface Heating of PWB and Extraction of components	Yes	
3	Dissembling of Monitor and extraction of components	Yes	

S. No.	Process name	Process status	Photo-documentation
4	Yoke core and Copper	Yes	
5	Metallic Core of Transformer and Copper	Yes	
6	Rare Earth Core of Transformer and Copper	Yes	

S. No.	Process name	Process status	Photo-documentation
7	Rare Earth Core of Static Transformer	Yes	
8	Wire PVC and Copper	Yes	
9	Plastic Shredder	Yes	 

S. No.	Process name	Process status	Photo-documentation
10	Dismantling of Monitor	Yes	
11	Glass Recovery from CRT	Yes	
12	Gold Extractions from Pins and Comb	No	
13	Acid Bath for PWB	No	
14	Regunning CRT's	No	

4.3 Geographical Distribution of E-Waste Business

The second step of this assessment is to identify geographical locations of formal and informal sector of E-waste generation in MMR, Pune and Pimpri Chinchwad region, where the twelve processes identified in section 4.2 are occurring. Formal/ Organized sectors covers IT parks, BPOs, Govt. offices, manufacturer, old system shops, AMC, repair shops, etc. and informal/ unorganized sector comprises of material extractors, recyclers, scrap dealers and resale markets of refurbished materials.

Formal/ Organized Sector

The study area has been segregated into 3 broad sub-heads, namely: Commercial Areas, Industrial Areas and IT Parks. In addition to this, a list of mobile phone dealers, computer retailers, software dealers, computer repair and service centres, list of home appliances and consumer electronics goods dealers have been submitted as part of inception report.

Commercial Areas in MMR:

1. Prabhadevi
2. South-Mumbai
3. CBD Belapur
4. Nariman Point
5. Andheri

   Andheri is one of the most important commercial hubs in Mumbai. The important commercial centres in Andheri are:

   - Andheri (West)
     - Laxmi Industrial Estate
     - Shah Industrial Estate (Veera Desai Road)
   - Andheri (East)
     - CEPZ
     - MIDC (Maharashtra Industrial Development Corp.) Andheri
     - Saki Naka
     - SEEPZ (Santa Cruz Electronic Export Processing Zone)

6. Ghatkopar
7. Bandra
8. Chembur
9. Prabhadevi
10. Kalbadevi
11. Kandivali
12. Borivali
13. Ville Parle
14. Bhandap
15. Goregaon
16. Santa Cruz

Commercial Areas in Pune, Pimpri Chinchwad Region

The sales of computers and other electronic items are mainly scattered all around Pune. However, some of the important commercial areas of Pune are given below:

1. Budhwar Pheeth (Electrical Market)
2. Naryan Pheeth
3. Shaniwar Pheeth
4. Ravivaar Pheeth
5. Shivaji Nagar

6. M.G. Road
7. Deccan Gymkhana
8. Nigdi

IT Parks in MMR:

Public IT Parks

S.No.	Name of IT Park	Location
1.	Santacruz Electronics Export Processing Zone (SEEPZ)	MIDC, Andheri (East), Mumbai
2.	International Infotech Hardware Park	CIDCO, Navi Mumbai
3.	Millennium Business Park	MIDC, Mahape, Thane
4.	Airoli Knowledge Park	Airoli Navi Mumbai
5.	International Technology Centre	CBD Belapur, Navi Mumbai
6.	International Infotech Park	Vashi, Navi Mumbai

Navi Mumbai is strategically located on the Mumbai Pune 'Knowledge Corridor'. CIDCO has already set up an High Tech. IT Park at Vashi. CIDCO has also planned 2nd IT Park at CBD Belapur. About 100,000 computer professionals are expected to be stationed in Navi Mumbai. CIDCO is also planning to lay optic fibre cable in entire Navi Mumbai.

Private IT Parks:

S.No.	Name of IT Park	Location
1.	Technopolis Knowledge Park, Mumbai	Nelco Complex, Mahakali Caves Road, Chakala, Andheri (East), Mumbai
2.	Ivory Towers, Mumbai	Pocket No.10, Road No.7, Marol, MIDC, Andheri (East), Mumbai
3.	Spectra IT park (in Zenta Building Mumbai)	Building No. 5, Hirannandani Business park, Powai, Mumbai
4.	Prudential IT Park (in Titus Building, Mumbai)	Building No.4, Hiranandani Business Park, Powai, Mumbai
5.	Enterprise Centre, Mumbai	Brahmanwada Village, Andheri, Mumbai

Major IT Parks in Pune, Pimpri Chinchwad region:

S.No.	Name of IT Park	Location
1.	Pune Infotech Park	Hingewadi
2.	Software Technology Park	Bhosari
3.	Magarpatta Cybercity	
4.	Marisoft IT Park	Kalyaninagar

Informal/ Unorganized Sector

The details of the area with e-waste recycling/reusing practices in informal/ unorganized sector in MMR are given in the Table 4.4.

Table 4.4: Recycling and reused of different parts of electronic items in Mumbai

Major Location	Business area	Type of E-business
Andheri	Sakinaka	CRT dismantling, extraction of copper wire and purchasing/reselling of PCB/PWB
	Safed pull	CRT dismantling and extraction of copper wire
	Wire lane	Extraction of copper from wire and open burning of plastic for copper extraction

Major Location	Business area	Type of E-business
	Teen no. khadi	CRT dismantling, yoke core dismantling, plastic grinding and PCB/PWB surface heating
Mahim	Dharavi (slum area)	Refrigerator compressor and washing machines dismantling
	Shastri Nagar	Mobile phone parts repairing and reselling
Grant Road	Sonapur	Computers and spare parts, Mobile phones
Kamathipura	Don Taki	Computer components repairing and reselling and steel from washing machines and refrigerator reselling
Kurla	Kutubmandal	CRT dismantling, surface heating of PCB/PWB, yoke dismantling for copper extraction, dismantling of metallic transformer for yoke core and copper extraction, ST dismantling for copper extraction, reselling of silver solder from circuit boards and plastic casing shredding and reselling
	Masrani lane	Reuse of colour picture tube, CRT dismantling, surface heating of PCB/PWB and purchasing & reselling of computer components
	Wire lane (Kalpana theater)	Open burning of wire for copper extraction and manual copper extraction from wire
Lamington Road	Lamington Road	Computer and spare parts, Mobile phones
	Proctor Road	Computer and spare parts, Mobile phones
	Tara Temple Lane	Computer and spare parts, Mobile phones
	S.V. Road	Computer and spare parts, Mobile phones
	Chor Bazaar	Components of Computer, mobile phone, washing machine and refrigerator
Mankhurd (Navi Mumbai)	Mankhurd	Mother boards and floppy drives

Major hubs in unorganized sector in Pune, Pimpri Chinchwad region, where e-waste is collected and transported to MMR are given in Table 4.5.

Table 4.5: Major hubs of E-waste (collection & transportation) in Pune, Pimpri Chinchwad Region

Major Location	Business area	Type of E-business
Pune, Pimpri Chinchwad Region	Chikhali	Collection and transportation of TV, PC, Refrigerator, PCB/PWB and wires
	Kuddalwadi	Collection and transportation of TV, PC and Refrigerator.
	Pawarwasti	Collection and transportation of PWB/ PCB
	Jadhavwadi	Collection and transportation of PC and refrigerator
	Moshi	Physical extraction of copper wire from cables, collection and transportation

The geographical distribution of organized/ formal and unorganized/ informal sectors in Mumbai, Navi Mumbai, Pune & Pimpri Chinchwad Region is shown in **Figure 4.1, Figure 4.2, Figure 4.3 and Figure 4.4**. The identification of formal and informal sector in E-waste trade and their geographical distribution has assisted in developing E-waste trade value chain described below.

Figure 4.1: Geographical Distribution of Organized & Unorganized Sectors in Mumbai

Organized sector locations: **Malad**, **Andheri** and **Powai**.

Unorganized sector locations: Sakinaka, Safed pull, Wire lane and teen number khadi in **Andheri;** Kutubmandal, Masrani lane and Wire lane in **Kurla;** Dharavi slum area in **Mahim**; **Sonapur**; Don taki in **Kamathipura**; Lamington road, Proctor road, Tara temple road, S.V. road and Chor bazaar in **Lamington road**.

Figure 4.2: Geographical Distribution of Organized & Unorganized Sectors in Navi Mumbai

Organized sector locations: Airoli knowledge park, **Airoli**; Millenium business park, **Mhape**; International infotech park, **Vashi**; International technology centre, **CBD Belapur** and International IT hardware park, **Dronagiri.**

Unorganized sector location: **Mankhurd**.

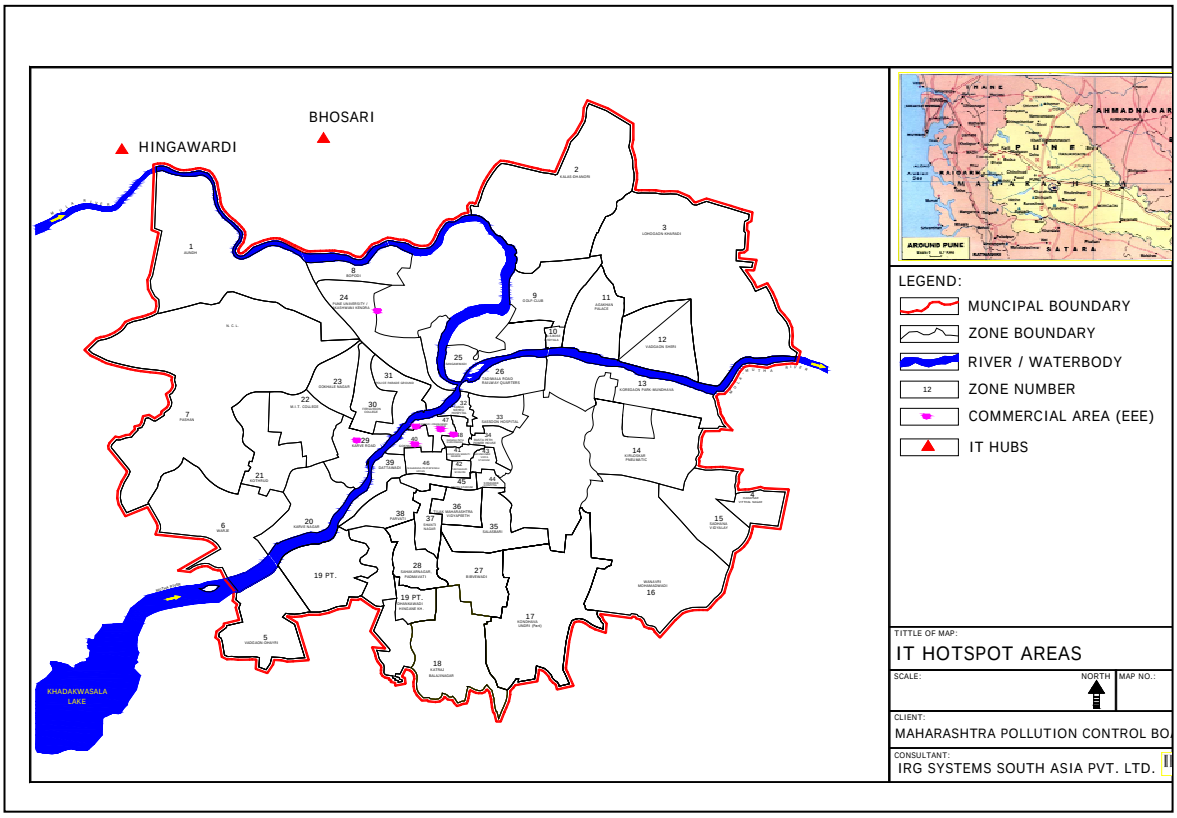


Figure 4.3: Geographical Distribution of Hotspots in Pune Pimpri Chinchwad region

4.4 E- Waste Trade Value Chain in MMR

E-waste trade value chain in MMR has been established by studying the conventional trade value chain and then customizing it to MMR, Pune and Pimpri Chinchwad region as per geographical distribution of identified process.

Conventional E-waste Value chain

Typical Value chain for e-waste as established for current study is shown in **Figure 4.5** and the conceptual version of this chain is also shown in **Figure 4.6.**

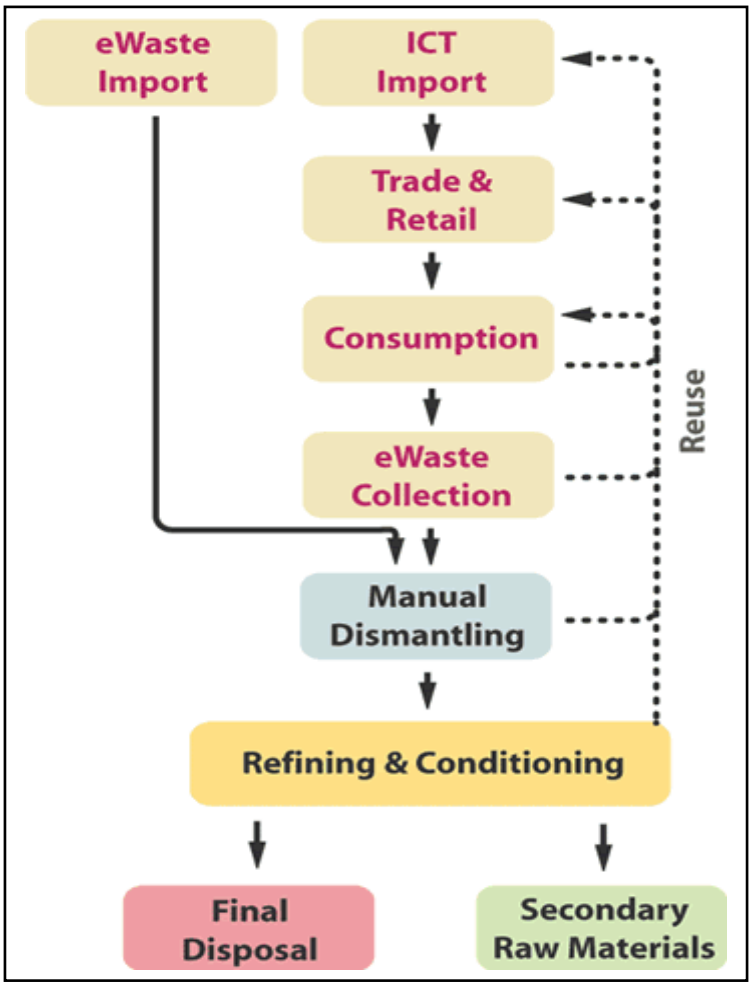


Figure 4.5: E-waste value chain

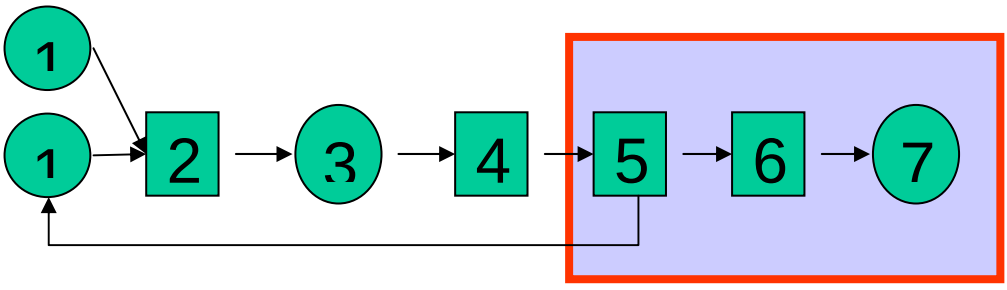


Figure 4.6: Conceptual diagram of E-waste cycle

In **Figure 4.6**, each number denotes a step in e-waste generation chain as:

1. EEE generation: import & manufacturing of EEE
2. EEE sales
3. EEE consumption (stock)
4. WEEE generation
5. Re-use / down cycle
6. Re-cycle
7. Secondary raw material / disposal

As per the scope of work, the present study has focussed on all the 12 core processes with sampling rate more than 10% of estimated total. The twelve core processes studied for MMR, Pune and Pimpri Chinchwad region are given below.

1. IC's Extraction from PWB
2. Surface Heating of PWB and Extraction of components
3. Dissembling of Monitor and extraction of components
4. Yoke core
5. Metallic Transformer
6. Rare Earth Core of Transformer
7. Rare Earth Static Transformer
8. Wire PVC and Copper
9. Plastic Shredder
10. Refrigerator breaking
11. Recovery of items containing Gold
12. Recovery of glass from CRT

In these areas, no evidence of CRT re-gunning and gold and metal extraction using acid bath process has been observed. Therefore, the step of "Refining and Conditioning" in conventional E-waste trade value chain is partly occurring in this region. The conventional E-waste trade value chain has been modified and shown in **Figure 4.7**. It is a five-step value chain covering the following aspects.

4.4.1 Generation and Stockpiling

Many different "economic actors" purchase, use, and then stockpile or discard electronic waste. These range from manufacturers such as MNCs to large and small businesses, households, institutions, and non-profit organizations.

4.4.2 Collection

There are a wide variety of possible collection alternatives for this e-waste. A variety of entities are providing these services including the electronics industry, private or non-profit recycling services, and the public sector through the solid waste management and recycling infrastructure.

4.4.3 Handling & Brokering

The next link in the cycle is the handling and brokering services. Here computers, TVs, monitors and other collected electronics are consolidated and made ready for processing and/or sorted to determine what equipment can be refurbished or reused as whole units and what equipment must be disassembled for commodity processing.

4.4.4 Processing

After electronic equipment is dismantled, it is then processed into either feedstock for new production or refurbished into new equipment. Outputs from de-manufacturing activities include scrap commodities such as glass, plastics, and metals – the primary elements from which all electronic hardware is made. For export, and to a lesser extent national processing markets, there are significant issues associated with the environmental and health practices of current service providers in this part of the cycle.

4.4.5 Production

The final step in this cycle is to turn the processed commodities or refurbished whole electronics back into new products for sale and consumption by end users. There are many different players and industries involved in this production process. The recycling fraction is miniscule compared with the production of product using virgin materials.

It may be noted that the trade value chain follows three levels of hierarchy of dismantlers. These levels are given below.

Level 1 - Preliminary E-waste generators
Level 2 - Secondary E-waste generator
Level 3 - Tertiary E-waste generator

The input to the first level comes from the formal organized markets like manufacturers, importers, offices, and organized markets, where E-waste from domestic consumers comes either in exchange schemes or as discarded items. Therefore, the major stakeholders are scrap dealers/ dismantlers who purchase E-waste from the first level in bulk quantities. They have limited capacity of dismantling and are involved in trading of E-waste with next level of dismantlers / scrap dealers. The market between the first and second level is semi-organized (i.e. part formal) while the market between the second and third levels is completely informal. The major stakeholders between the first and second levels are scrap dealers/ dismantlers who purchase E-waste from first level scrap dealers/ traders and are involved in real dismantling of E-waste. The major stakeholders between the second and third levels are electronic item extractors, glass and plastic extractors who sell the product to metal extractors and end users. Preliminary results show that there are no metal extractors in MMR, Pune and Pimpri Chinchwad region. In Pune, Pimpri Chinchwad region, Level 1 and partly Level 2 E-waste generators exist. Very limited dismantling is observed, while the major quantities of e-waste is collected and transported to MMR.

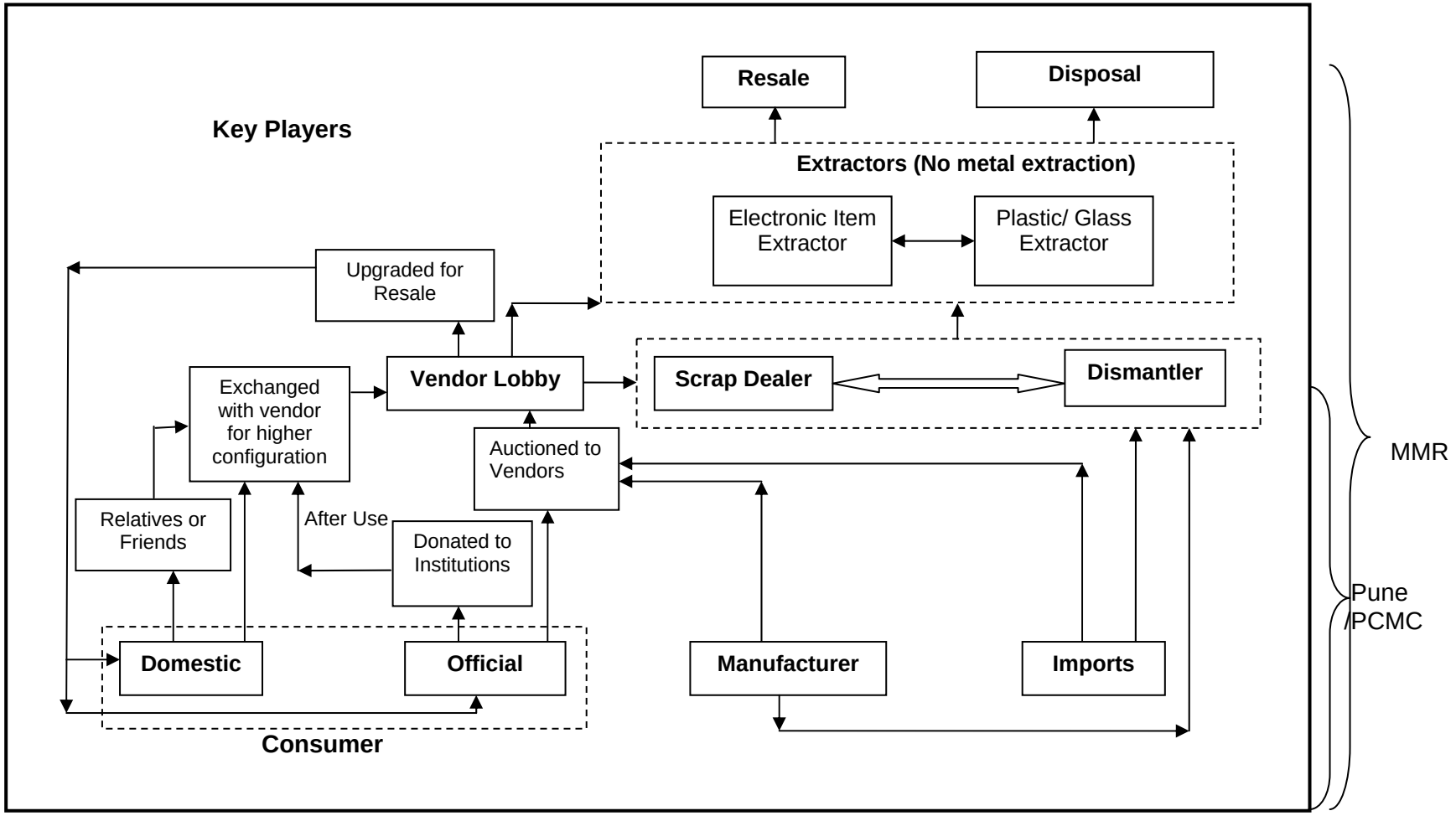


Figure 4.7: Flow chart of E-waste trade cycle

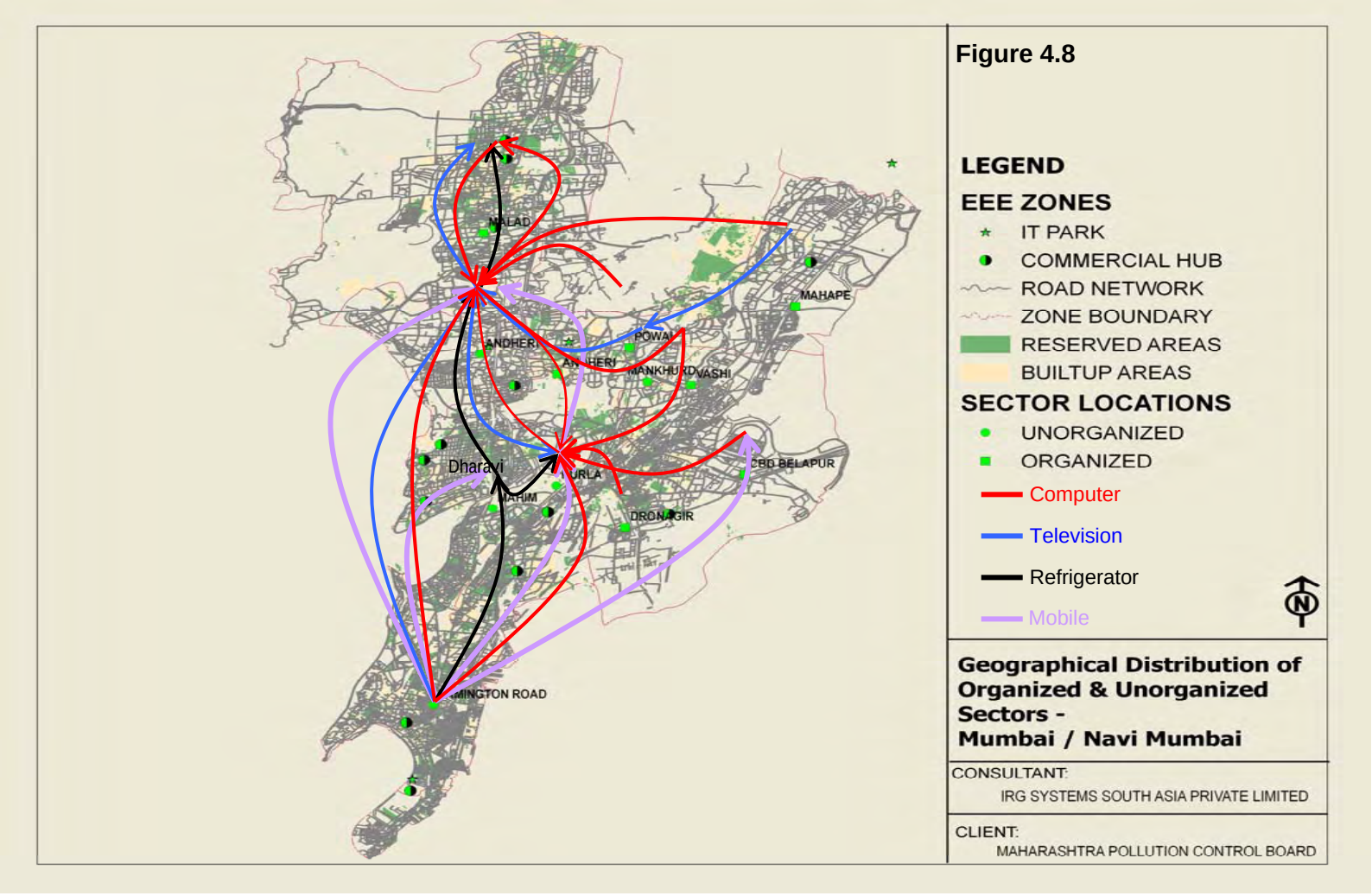
4.5 Geographical Mapping of E-waste Trade Value Chain

Using techniques like transect walk, tracer walk and hazardous process walk in MMR, Pune and Pimpri Chinchwad region, the geographical mapping of E-waste trade value chain has been carried out in both regions and shown in **Figure 4.8 and Figure 4.9.**

It has been found that Lamington Road, Chor Bazaar and Bhindi Bazaar in Mumbai, has a strong metal, and electronics scrap market. In these areas, defunct electrical and electronic equipment such as household appliances, pumps, motors, metal components such as ball bearings, bolts, nuts etc. are sold at bargain prices. Together with this the market also sells, components from PCs like mother boards, floppy drives, components from the mother boards (some de-soldered in scrap yards and sent here) printers, monitors etc. These components are bought in bulk from scavengers. The scavengers collect them from the municipal bins or from offices (typically public sector) when the machines are junked. These machines are then taken to crushing areas in the slums of Dharavi and Mahim in Western Mumbai, Mankhurd in Navi Mumbai and Masjid Bunder in Southern Mumbai. The motherboards and floppy drives are removed from the machines and sold by weight / as individual pieces to scrap dealers in Bhindi Bazaar. Sometimes they are junked even by scavengers but picked up by scrap dealers and sold at Bhindi Bazaar. None of these scrap dealers have the ability to identify the condition of these components. They are then typically sold at Rs. 75-200/- per motherboard but the price can be bargained much lower. Floppy drives are sold at Rs. 50-100/- per piece. During the field visit to Lamington Road and Chor Bazaar it was observed that one of the street shops was selling an CPU for Rs. 500/- which could be bargained to a lower price. In addition to these temporary footpath markets, there are a few regular shops, which deal with computers, and peripherals. One such shopkeeper was interviewed. The gist of the interview is given in Box 1.

Box 1: Computers (typically low end e.g., 286, 386) are bought from companies when the used machines are tendered / bid out for disposal. The computers are checked by a hardware expert associated with the shop and then sold typically at Rs.1700-2500/- per machine. Such shops also buy motherboards by weight and sell them sometimes as individual pieces (Rs. 75-200/- per piece) or by weight to customers who assemble machines. Monitors are sometimes dismantled and the picture tubes sold. No de-soldering activity takes place here. The shop owner indicated that the older machines had aluminum and other metal parts, which could be recycled in the scrap market. People who repair electronic equipments buy these motherboards and components. Some of the components are in very good condition and with some minor maintenance they are in working condition made possible at very low costs. Based on the field survey, it is found that the gold recovery, which is possible from the contacts on the motherboards, is not practiced in the market in Mumbai.

Figure 4.8 shows movement of E-waste towards two major hubs of Andheri and Kurla and sub-major hubs of Dharavi and Malad in MMR. **Figure 4.9 s**hows that Chikhali in Pimpri Chinchwad area acts as a major hub for collection, transportation and trading of e-waste in Pune and Pimpri Chinchwad region. Kuddalwadi, Pawarwasti, Jadhavwadi and Moshi acts as sub hub for e-waste. E-waste from these sub-hubs is collected at Chikhali and transported to MMR for dismantling.


MALAD
MAHAPE
ANDHERI
POWAI
MANKHURD
VASHI
Dharavi
CBD BELAPUR
DRONAGIR
MINGTON ROAD
Figure 4.8
LEGEND
EEE ZONES
IT PARK
COMMERCIAL HUB
ROAD NETWORK
ZONE BOUNDARY
RESERVED AREAS
BUILTUP AREAS
SECTOR LOCATIONS
UNORGANIZED
ORGANIZED
Computer
Television
Refrigerator
Mobile
N
Geographical Distribution of Organized & Unorganized Sectors - Mumbai / Navi Mumbai
CONSULTANT:
IRG SYSTEMS SOUTH ASIA PRIVATE LIMITED
CLIENT:
MAHARASHTRA POLLUTION CONTROL BOARD

CHAPTER 5: RECYCLING/RECOVERY SYSTEMS, TRACER ANALYSIS, E-WASTE INVENTORY AND PROJECTIONS

5.1 Introduction

E-waste trade value chain along with processes as described in chapter 4 forms the basis of recycling systems in the study area. The routes described in Figures 4.8 & 4.9 form the basis of tracer analysis. The following sections describe the recycling system along with processes and fundamental basis of tracer analysis. Further, E-waste inventory has been assessed with an approach consisting of material flow methodology, which is based on the market size of items of electrical and electronic equipment (EEE) and confirmation by tracer analysis. An inventory for MMR, Pune and Pimpri Chinchwad region has been prepared separately and cumulatively to give an idea of quantum of e-waste generation and future projections.

5.2 Recycling/Recovery System

Most of the activity in MMR, Pune and Pimpri Chinchwad region involves physical dismantling by hammer, chisel, screw driver and bare hand. The most high- tech piece of dismantling equipment witnessed was an electric drill. The immediate objective of most of the operations involves dismantling and rapid separation of primary materials. The following materials were observed being separated for further recycling:

- **Material containing copper:** Including printer and other motors, wires and cables, CRT yokes, circuit boards, etc
- **Steel:** Including internal computer frames, power supply housings, printer parts, washing machines, refrigerator, etc.
- **Plastic:** Including housings of computers, printers, faxes, phones, monitors, keyboards, etc.
- **Copper:** Extracted from transformer and CRT after their dismantling
- **Circuit Boards:** These come from many applications including computers, phones, disc drives, printers, monitors, etc.

Each of these processes has been described below.

5.2.1 Printed Circuit Boards (PCBs)

The printed circuit boards contain heavy metals such as antimony, gold, silver, chromium, zinc, lead, tin and Copper. According to some estimates, there is hardly any other product for which the sum of the environmental impacts for raw material, industrial refining and production, use and disposal is as extensive as for printed circuit boards. The methods of salvaging material from circuit boards are highly destructive and harmful as they involve heating and open burning for the extraction of metals. Even after such harmful methods are used, only a few of the materials are recovered. The recycling of circuit boards, drawn from monitors, CPU, disc and floppy drives, printers, etc. involves a number of steps.

Extraction of IC/ other components from PCB

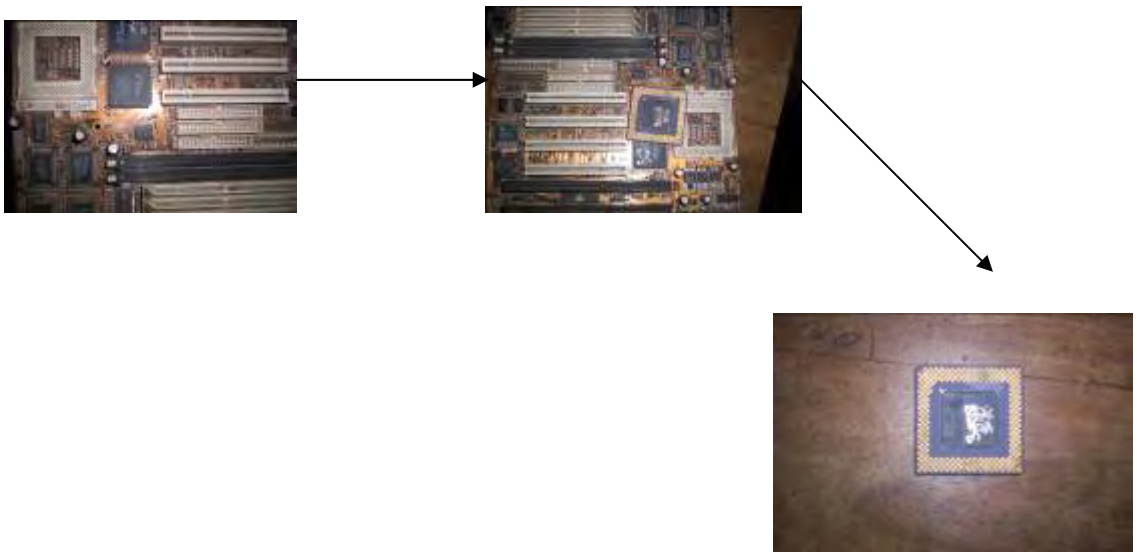
IC/other components from PCBs are manually extracted as shown in **Figure 5.1**. This process is common for PC, TV and cell-phone. The E-waste stream from cell-phone joins the E-waste stream of PC and TV.

Figure 5.1: Extraction of IC/ other components from PCB

Recovery of Gold

Gold pins are recovered from PCB manually as shown in **Figure 5.2**. First, there is manual removal of gold-plated pins. The core of each motherboard has a flat laminated gold plate. These laminated parts cut down and sold to gold-smiths for gold recovery.

Figure 5.2: Gold Recovery



Preheating of PCB and extraction of components

The preheating process is applied to remove resalable components like ICs, condensers, bearings (pulleys) from floppy drive and hard drive. Pre-heating means simply putting the motherboard on a burning stove as shown in **Figure 5.3.** Low heat is maintained to loosen only the chemical bond between solder and plastic.

Figure 5.3

Then resalable chips, condensers, etc, are plucked out from these pre-heated plates. Then the pre-heated circuit boards are taken by other dealers for recovery of solder (which consists of lead and mercury). The method of solder recovery is very rudimentary. The lead extracted due to heat application goes into a water tub – it floats due to low density.

5.2.2 Monitors

Monitors are much sought after by scrap dealers as they contain good quantity of copper yoke, besides circuit board and picture tube. The different recovery processes observed in MMR are given below.

Dissembling of CRT and Extraction of Components

The first step in monitor recycling involves physical removal of plastic casing, picture tube (cathode ray tube), copper yoke and plates as shown in **Figure 5.4.**

The intact and functional CRT is used for the manufacture of colour and black & white televisions for local brands. Re-gunning is possible only for those monitors whose terminal pin (diode pin) of electron gun has not broken in the process of removing yoke from gun. The process of re-gunning of CRT is not done in Mumbai, Pune and Pimpri Chinchwad region E-waste market and it is only done at Delhi.

Recovery of Glass from CRT

Defective CRT is broken down to recover iron frames from the glass funnel as shown in **Figure 5.5**. The iron frames are found only in color CRTs and not in black & white monitors. The glasses and iron frames from picture tubes are given to waste traders.

Figure 5.4: Dissembling of CRT and Extraction of Components

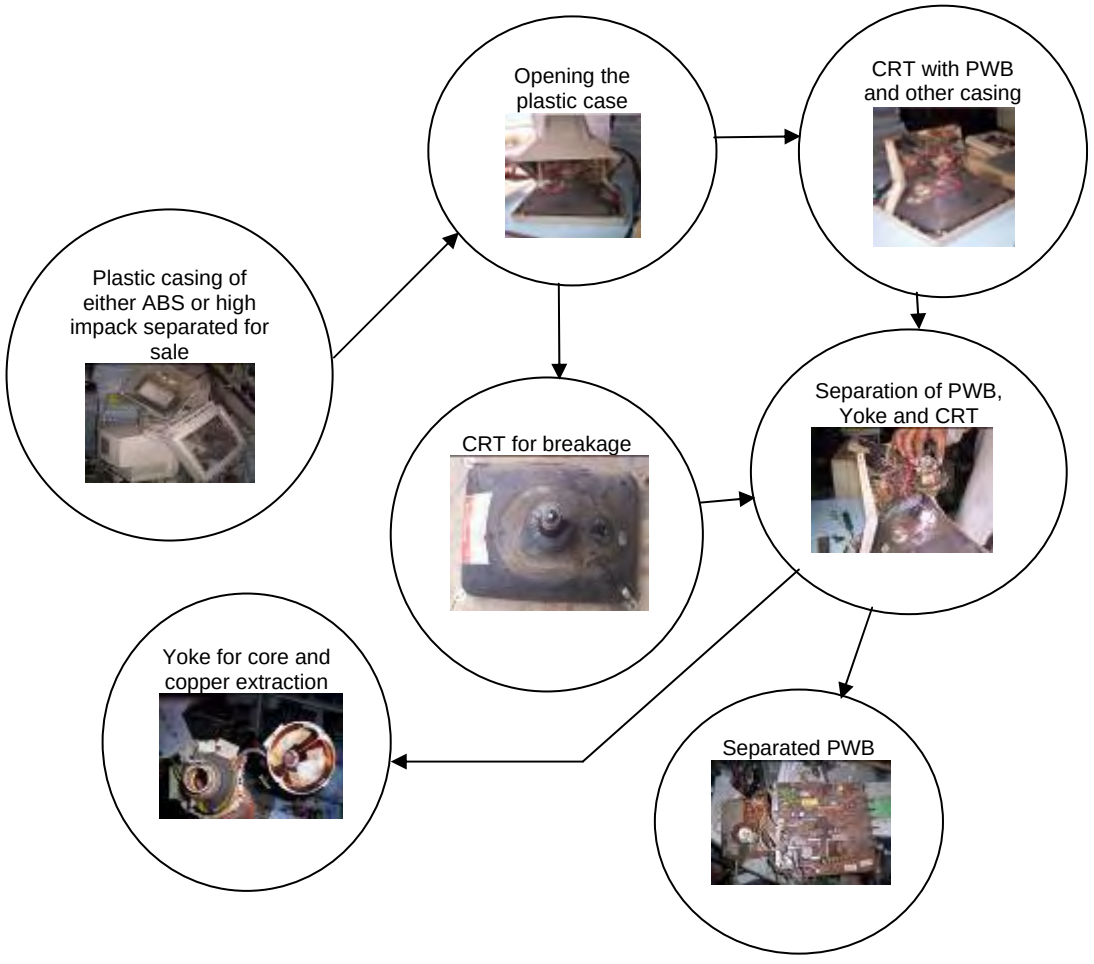


Figure 5.5: Glass Recovery by CRT Breaking

Yoke Core, Metallic Core and Copper from Transformers

The copper and yoke core recovered from yoke coils found around the picture tube end is sold to copper smelters and re-winders as shown in **Figure 5.6 and Figure 5.7**. Apart from the yoke, copper and metallic core is also recovered from transformers mounted on the circuit board of the computer. The circuit tray also contains a number of condensers of different sizes. Depending upon their condition and demand they again enter into the secondary market for reuse. If they are defective, they are sold along with the motherboard.

Figure 5.6: Extraction of Yoke Core and Copper

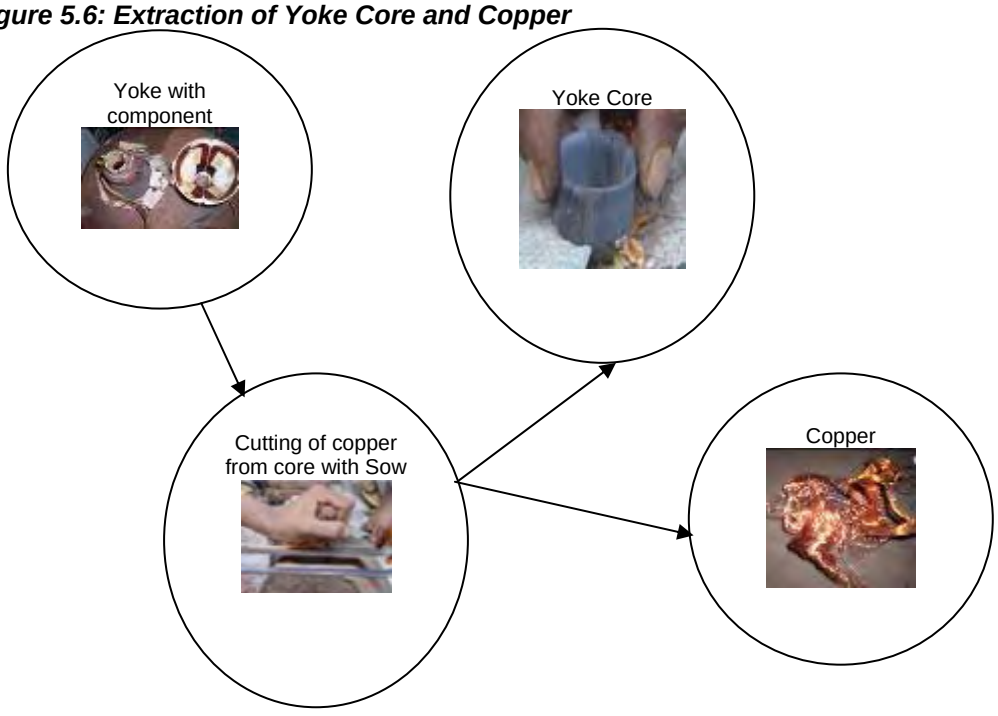
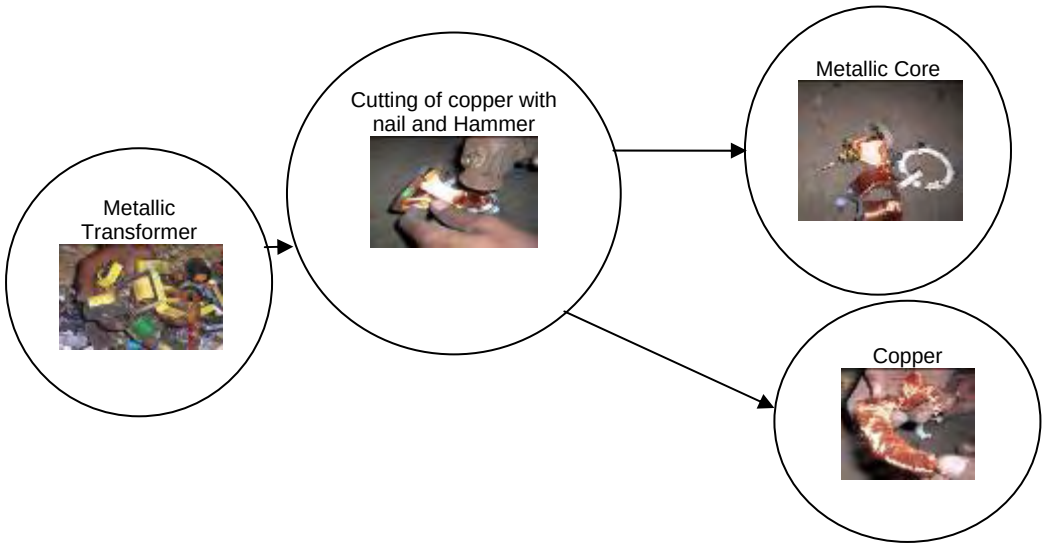


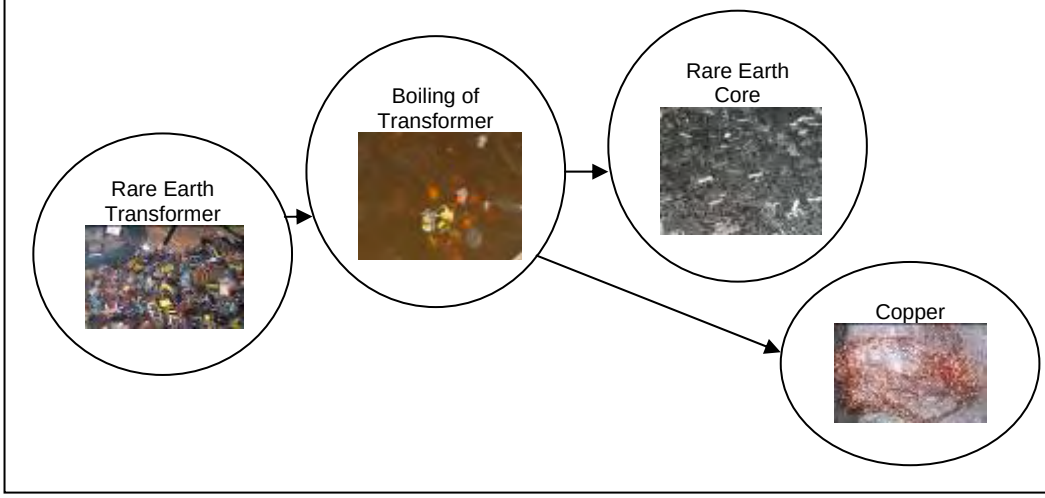
Figure 5.7: Extraction of Metallic Core of Transformer and Copper



Rare Earth Core of Transformer and Copper

These small transistors and rare earth transformers are boiled in water with small amount of caustic soda, which results in loosing of joint between the core resulting in core and copper extraction as shown in **Figure 5.8.**

Figure 5.8: Extraction of Rare Earth Core of Transformer and Copper



Copper Extraction from Wires

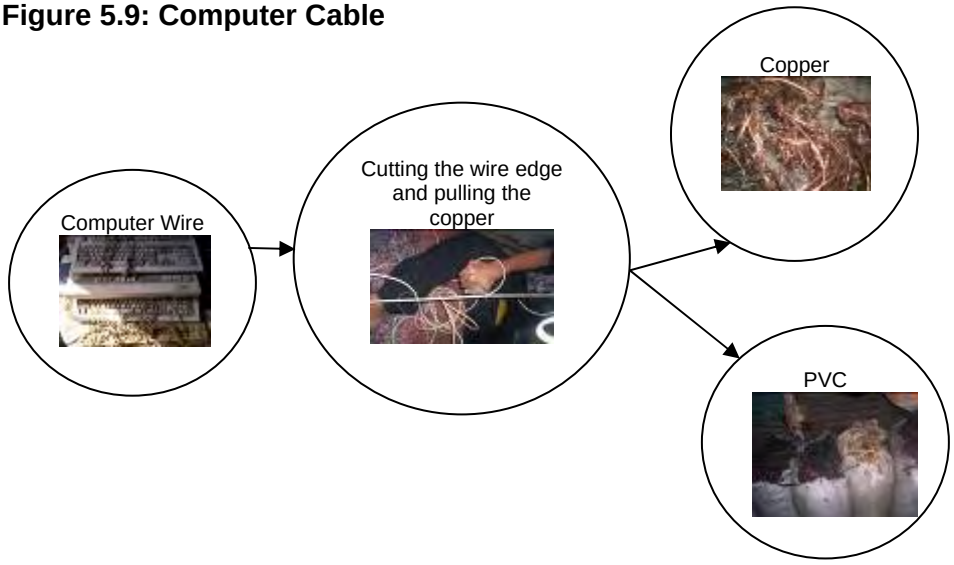
Two kinds of processes are being followed under this category as listed below:

1. Manual drawing of wires for copper
2. Extraction of copper by burning the wire

Manual drawing of Wires for Copper

Under this process with the use of knife the edge of wire is cut and then with the help of pliers the copper is extracted from PVC as shown in **Figure 5.9**. The process is as shown below copper goes for sale to copper smelters and PVC is used for plastic graining.

Figure 5.9: Computer Cable



Plastic Shredding and Graining

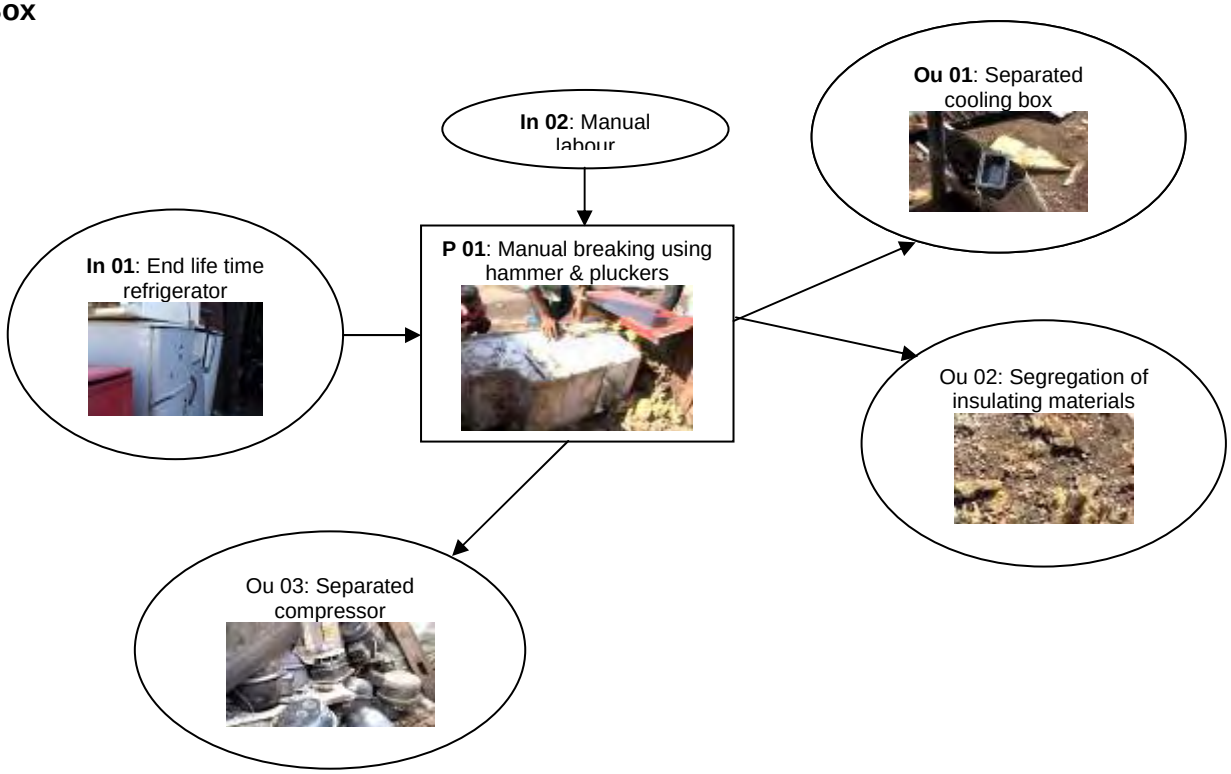
The plastic casings of monitors are made either of PVC (polyvinyl chloride) or ABS (acrylonitrile-butadiene styrene). PVC was used more commonly in the early models of computers. Now computer-manufacturing companies have shifted to ABS plastic in the production of monitors. Though both types of plastics are currently being recycled as shown in **Figure 5.10**, the PVC one cannot be recycled. This is due to the high percentage of silicate being added for making it fire retardant. The silicate plastic often ends up at kilns as an alternate source of energy. The plastic casing is recycled into EBS or High Impact Plastic. These kinds of plastics are frequently used in manufacturing toys.

Figure 5.10: Plastic Shredding

Dismantling of compressor & segregation of compressor & cooling box

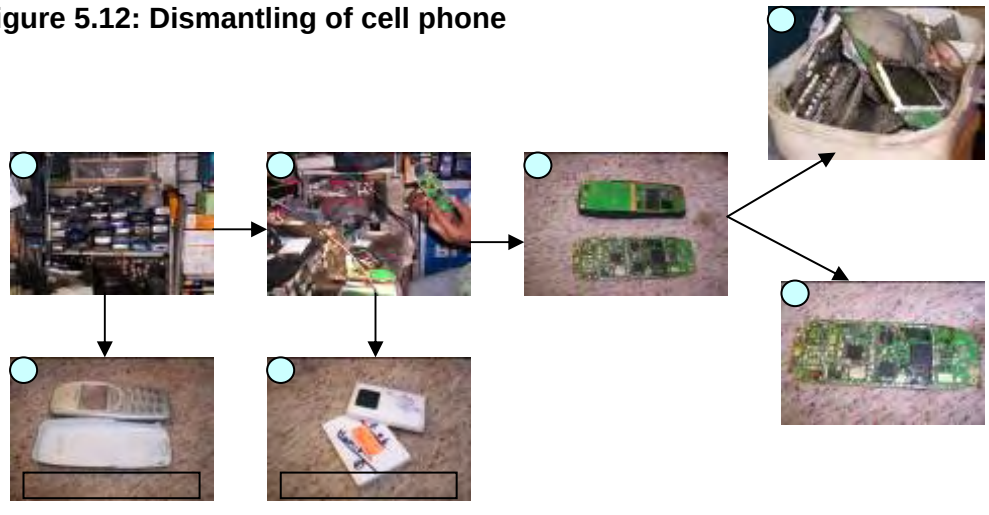
Refrigerator is dismantled for metal recovery, plastic recovery, insulating material and compressor as shown in **Figure 5.11**.

Figure 5.11: Dismantling of Refrigerator and Segregation of Compressor and Cooling Box



Dismantling of cellphone

Figure 5.12: Dismantling of cell phone



Cell phone is dismantled for plastic recovery, battery, LCD screen and PWB/ PCB as shown in **Figure 5.12**.

5.3 Disposal

Field Investigations reveal that easy and approachable method for disposal of e-waste in Mumbai is throwing in Municipal dust bin which goes for land filling sites. Most of the components get extracted and only thing, which is left for disposal in landfills are ashes and plastic residues from charred IC chips, condensers etc. In Pune, Pimpri Chinchwad region, field investigations reveal that e-waste is transported to Mumbai from where it is supplied to other parts of India. Some part of the e-waste is again sent to Delhi for further processing and dumping to the land fill site.

5.4 Approach & Methodology for Inventorization "Market Supply Method"

The market size of MMR, Pune, Pimpri and Chinchwad region has been estimated based on sales data. This sales data have been applied to a number of calculation methodologies to give theoretical waste arising for each of the selected items. Finally, using average weights and an average composition of the waste stream, total WEEE for MMR, Pune, Pimpri and Chinchwad has been extrapolated. Under this approach, the various indicators, which will represent market size, are given below:

- Market Sales data for above mentioned EEE's.
- Penetration Rate of listed EEE's
- Ownership data of listed EEE's

The first step in the material flow model is to acquire sales data for the selected items. The sources of the data include government statistics, market research companies, industry associations etc., which give the authentic data. Next step is to establish penetration rate of EEE so as to calculate the ownership data for EEE's. Sources considered, includes government statistics, market research companies, industry associations. Ownership has been taken as a derivative of penetration rate but certain organization like Registrar General, Census of India and NCAER provided exact figure for ownership of selected EEEs. The Market Supply method was first used in 1991 in Germany for assessment of WEEE (IMS, 1991). It is based on the extrapolation of waste arising by using sales figures together with the typical lifetime of an appliance. As per this method, WEEE generated in a year can be represented by the following simple equation;

WEEE Generation in year *x* = Sales *n* years previously
(*n* = average life time of item)

The method assumes that 100% of units sold in one particular year will become obsolete at the end of the average life. For example, in India **800,000** PC's were sold in 1997. A PC is assumed to have an average lifetime of 7 years, meaning that in the year 2004, 800,000 will become WEEE. This method assumes that the average variance in lifetime of items of EEE does not change very much, whereas in reality average lifetime may become shorter in the future. The variables required by the method Selected are:

5.4.1 Obsolescence Rate/Average lifetime.

Obsolescence rate/average lifetime represents the consumer behavior. It consists of two components:

- Active Lifetime
- Passive Lifetime

Obsolescence rate/average lifetime can be calculated based on depreciation and book value/economic value of the EEE. All fixed assets such as electronic / electrical equipments, building, furniture etc. gradually diminish in value as they get older and become worn out by constant use in business. **Depreciation** is the term used to describe this decrease in book value of an asset. There are a number of methods of calculating depreciation. However, the most common method, which is also approved by income tax authorities, is the **Diminishing Balance Method.** Here each year's depreciation is calculated on the book value (i.e., depreciated value) of the asset at the beginning of the year rather than original cost. Note that as the book value decreases every year, the amount of depreciation also decreases every year. Therefore, this method is also called **Reducing Installment Method** or "Written Down Value Method".
If the rate of depreciation is i% per year and the initial value of the asset is P, the depreciated value at the end of n years is $P\left(1-\frac{i}{100}\right)^n$ and the amount of depreciation is $P\left[1-\left(1-\frac{i}{100}\right)^n\right]$. The number of years, a machine can be effectively used is called its Active life time. After that it is sold as waste or scrap. In this study, the depreciated value is factored by passive lifetime of EEE to arrive at the obsolescence rate of EEE.

The obsolescence rate for electronic items has been taken as shown in **Table 5.1.**

Table 5.1: Obsolescence rate for electronic items

S.No.	Electronic Item	Obsolescence Rate (years)	
1.	Cellular Phone	2	4
2.	Personal computer	5	7
3.	Refrigerator	15	17
4.	Television	15	17

These obsolescence rates consist of both active and passive life of electronic item. Based on these obsolescence rates the E-waste inventory of MMR, Pune and Pimpri Chinchwad region has been estimated in following sections.

5.5 Obsolescence Rate & E-waste Projections for Cellular Phones

The data obtained from TRAI, Cellular Operators Association of India (COAI) and Census of India for the comparative time series growth of installed base and yearly additions of cellular phones in Mumbai, Pune and Pimpri Chinchwad region is summarized in **Table 5.2 and Table 5.3**.

Table 5.2: Comparative time series growth of cellular phone subscribers in Mumbai

Year	Penetration / 1000	Installed Base	Yearly Addition
1997	12.67578462	215002	
1998	15.08406713	262842	47840
1999	16.6883818	298744	95902
2000	26.11842556	480331	181587
2001	44.09000152	832995	352664
2002	77.97102846	1512296	679301
2003	125.9184015	2507229	994933

Year	Penetration / 1000	Installed Base	Yearly Addition
2004	175.9750263	3597138	1089909
2005	238.5259496	5005448	1408310
2006	299.7555275	6457669	1452221
2007	366.6010101	8107808.78	1650139.78
2008	448.3530354	10179611.8	2071802.97
2009	548.3357623	12780826.3	2601214.52
2010	670.6146373	16046733.8	3265907.54
2011	820.1617014	20147184.6	4100450.78
2012	1003.057761	25295430.9	5148246.34
2013	1226.739641	31759217.9	6463787
2014	1500.302581	39874708.1	8115490.12
2015	1834.870057	50063964	10189255.9

Source: TRAI and Census of India

Table 5.3: Comparative time series growth of cellular phone subscribers in Pune, Pimpri and Chinchwad region

Year	Penetration Rate	Installed Base	Yearly Addition
1997	0.34	2153.65656	
1998	0.92	5959.9854	3806.32884
1999	1.04	6961.95396	1001.96856
2000	2.46	16998.9149	10036.9609
2001	4.446	32002.5303	15003.6154
2002	8.5727	63434.5115	31431.9812
2003	20.117	149436.873	86002.3619
2004	43.49	323686.663	174249.79
2005	75.08	559560.802	235874.139
2006	115	857161.789	297600.987
2007	140.645	1077661.52	220499.727
2008	172.008835	1323108.36	245446.845
2009	210.3668052	1621297.5	298189.137
2010	257.2786028	1985531.55	364234.048
2011	314.6517312	2428539.61	443008.063
2012	384.8190672	3053266.85	624727.243
2013	470.6337192	3748675.11	695408.256
2014	575.5850386	4593514.6	844839.49
2015	703.9405022	5625474.75	1031960.15

Source: TRAI and Census of India

The analysis of table 5.2 indicates that the installed base of cellular phones in Mumbai increased from 215002 in 1997 to 6457669 in 2006. The yearly addition of cellular phones in the market increased from 47840 in 1998 to 1452221 in 2006. It again indicates that the penetration rate increased twenty four times within a period of nine years. The analysis of table 5.3 indicates that the installed base of cellular phones in Pune, Pimpri Chinchwad region increased from 2153 in 1997 to 857161 in 2006. The yearly addition of cellular phones in the market increased from 3806 in 1998 to 297600 in 2006. It again indicates that the penetration rate increased two hundred times within a period of nine years.

The data from secondary sources indicate that obsolescence rate of cellular phones prevailing in India ranges from two to five years. Since the market is growing exponentially, it is important to arrive at exact obsolescence rate. Assuming market additions every year is equivalent to cellular phones coming into market as e-waste, analysis was carried out concerning two scenarios for obsolescence rates.

1. Two years obsolescence rate
2. Four years obsolescence rate

Considering 2007 as the base year for the calculations, following inferences are drawn:

1. Years 2005 and 2003 were taken as years for evaluating obsolescence rate
2. The number of cellular phones subscribers added into Mumbai market during 2005 and 2003 was 1408310 and 994933, respectively.
3. The number of cellular phones subscribers added into Pune, Pimpri and Chinchwad market during 2005 and 2003 was 235874 and 86002, respectively.

The number of cellular phones introduced into the e-waste market from the installed base in the region was further augmented by considering the external factors. It includes the number of cellular phones brought into Mumbai, Pune Pimpri Chinchwad market from other sources, which could be either imports or cellular phones from other domestic sources existing in the country. The details of cellular phones generation as e-waste in Mumbai, Pune, Pimpri Chinchwad region is given in **Table 5.4 and Table 5.5.**

Table 5.4: Statistics of cellular phone as e-waste generation and handled in Mumbai

Year	Penetration / 1000	Installed Base	Yearly Addition	WEEE Obsolescence Rate 1 (in Numbers)	WEEE Generated 1 (in Tons)	WEEE Obsolescence Rate 2 (in Numbers)	WEEE Generated 2 (in Tons)
2006	299.7555275	6457669	1452221	1089909	111.5412871	679301	69.51966434
2007	366.6010101	8107808.78	1650139.78	1408310	144.1264454	994933	101.8214432
2008	448.3530354	10179611.8	2071802.97	1452221	148.6202971	1089909	111.5412871
2009	548.3357623	12780826.3	2601214.52	1650139.783	168.8753054	1408310	144.1264454
2010	670.6146373	16046733.8	3265907.54	2071802.972	212.0283162	1452221	148.6202971
2011	820.1617014	20147184.6	4100450.78	2601214.515	266.2082935	1650139.783	168.8753054
2012	1003.057761	25295430.9	5148246.34	3265907.543	334.2329779	2071802.972	212.0283162
2013	1226.739641	31759217.9	6463787	4100450.776	419.6401324	2601214.515	266.2082935
2014	1500.302581	39874708.1	8115490.12	5148246.343	526.8715307	3265907.543	334.2329779
2015	1834.870057	50063964	10189255.9	6463786.998	661.5039614	4100450.776	419.6401324

Table 5.5: Statistics of cellular phone as e-waste generation and handled in Pune Pimpri Chinchwad Region

Year	Penetration Rate	Installed Base	Yearly Addition	WEEE Obsolescence Rate 1 (in Numbers)	WEEE Generated 1 (in Tons)	WEEE Obsolescence Rate 2 (in Numbers)	WEEE Generated 2 (in Tons)
2006	115	857161.789	297600.987	174249.7898	17.92333338	31431.98119	3.233093585
2007	140.645	1077661.52	220499.727	235874.1385	24.26201389	86002.36186	8.846202941
2008	172.008835	1323108.36	245446.845	297600.9875	30.61123757	174249.7898	17.92333338
2009	210.3668052	1621297.5	298189.137	220499.7273	22.68060195	235874.1385	24.26201389
2010	257.2786028	1985531.55	364234.048	245446.8451	25.24666249	297600.9875	30.61123757
2011	314.6517312	2428539.61	443008.063	298189.1366	30.67173459	220499.7273	22.68060195
2012	384.8190672	3053266.85	624727.243	364234.0477	37.46511414	245446.8451	25.24666249

Year	Penetration Rate	Installed Base	Yearly Addition	WEEE Obsolescence Rate 1 (in Numbers)	WEEE Generated 1 (in Tons)	WEEE Obsolescence Rate 2 (in Numbers)	WEEE Generated 2 (in Tons)
2013	470.6337192	3748675.11	695408.256	443008.0629	45.56780935	298189.1366	30.67173459
2014	575.5850386	4593514.6	844839.49	624727.2431	64.25944423	364234.0477	37.46511414
2015	703.9405022	5625474.75	1031960.15	695408.2564	71.52969326	443008.0629	45.56780935

The following inferences are drawn from **Tables 5.4 and 5.5**:

1. The number of cellular phones entering into Mumbai's e-waste market is 3858 and 2725 per day for 2 and 4 year obsolescence rate, respectively.
2. Since the average weight of cellular phones has been taken as 102.86 gm, the total weight of cellular phones entering into Mumbai's e-waste market considering two year obsolescence rate is 144 tons per year.
3. The total weight of cellular phones entering into Mumbai's e-waste market considering four year obsolescence rate is 101 tons per year.
4. The number of cellular phones entering into Pune, Pimpri Chinchwad e-waste market is 646 and 235 per day for 2 and 4 year obsolescence rate, respectively.
5. The total weight of cellular phones entering into Pune, Pimpri Chinchwad e-waste market considering two year obsolescence rate is 24.26 tons per year.
6. The total weight of cellular phones entering into Pune, Pimpri Chinchwad e-waste market considering four year obsolescence rate is 8.84 tons per year.

Based on the secondary data review for cellular phones, considering obsolesce of 2 years the amount of e-waste in Mumbai, Pune and Pimpri Chinchwad region by year 2015 is estimated and projected to be 661.5 tons and 71.5 tons respectively.

5.6 Obsolescence Rate & E-waste Projections for PCs

The data obtained from MAIT and Census of India for the comparative time series growth of installed base and yearly additions of PCs in Mumbai, Pune, Pimpri Chinchwad region is summarized in **Table 5.6 and Table 5.7**. The installed base of PCs in Mumbai increased from 1963560 in 1999 to 5576080 in 2006. The yearly addition of PCs in Mumbai market increased from 422369 in 2000 to 659942 in 2006. The installed base of PCs in Pune, Pimpri Chinchwad increased from 33901 in 2000 to 75994 in 2006. The yearly addition of PCs in Pune, Pimpri Chinchwad market increased from 725 in 2001 to 15919 in 2006.

Table 5.6: Comparative time series growth of installed base and yearly additions of PCs in Mumbai

Year	Penetration Rate	Installed Base	Yearly Addition
1999	0.109688	1963559.58	
2000	0.129737	2385928.77	422369.194
2001	0.144748	2734732.5	348803.735
2002	0.170305	3303170.11	568437.601
2003	0.19858	3954033.16	650863.054
2004	0.213921	4372798.65	418765.495
2005	0.23427	4916137.24	543338.584
2006	0.26050824	5576079.5	659942.263
2007	0.289685163	6365536.38	789456.875
2008	0.322129901	7266763.92	901227.548

Year	Penetration Rate	Installed Base	Yearly Addition
2009	0.35820845	8295586.55	1028822.62
2010	0.398327796	9470069.05	1174482.51
2011	0.44294051	10810833.9	1340764.8
2012	0.492549847	12341423.1	1530589.21
2013	0.54771543	14088711.9	1747288.8
2014	0.609059558	16083380.4	1994668.55
2015	0.677274228	18360452.6	2277072.13

Source: MAIT and Census of India

Table 5.7: Comparative time series growth of installed base and yearly additions of PCs in Pune Pimpri Chinchwad Region

Year	Penetration / 1000 population	Installed Base	Yearly Addition
2000	9.15	33901.6802	
2001	9.251343542	34626.9	725.219816
2002	9.298013032	35254	627.1
2003	10.33736495	39704.3	4450.3
2004	12.33113889	47977.8	8273.5
2005	15.24205692	60074.5	12096.7
2006	19.03380253	75994.4	15919.9
2007	23.67100004	95737.5	19743.1
2008	29.11919435	119303.8	23566.3
2009	35.34483116	146693.3	27389.5
2010	42.31523749	177906	31212.7
2011	49.99860265	212941.9	35035.9
2012	58.36395948	251801	38859.1
2013	67.3811661	294483.3	42682.3
2014	77.02088785	340988.8	46505.5
2015	87.25457972	391317.5	50328.7

Source: MAIT and Census of India

After assessing the market penetration of PCs, it is important to estimate their obsolescence rate i.e. the total numbers of PCs entering into the market for dismantling. The data from secondary sources indicate that obsolescence rate of PCs prevailing in India ranges from five to seven years. Since the market is growing exponentially, it is important to arrive at exact obsolescence rate. Assuming market additions every year is equivalent to PCs coming into market for dismantling, scenario analysis was carried out concerning two scenarios for obsolescence rates.

1. Five years obsolescence rate
2. Seven years obsolescence rate

Therefore, as per the assumption, “market additions every year is equivalent to PCs coming into secondary market for dismantling”. Considering 2007 as the base year for the calculations, following inferences are drawn:

1. Years 2002 and 2000 were taken as years for evaluating obsolescence rate
2. The number of PCs added into Mumbai market during 2002 and 2000 was 568437 and 422369, respectively.

3. The number of PCs added into Pune, Pimpri Chinchwad market during 2002 and 2000 was 627 and 410 respectively.

Based on the available secondary market data for PCs, total amount of PCs coming to Mumbai e-waste market is estimated and given in **Table 5.8 and table 5.9**.

Table 5.8: Statistics of PCs as e-waste generation and handled in Mumbai

Year	Penetration Rate	Installed Base	Yearly Addition	WEEE Obsolescence Rate 1 (in Numbers)	WEEE Generated 1 (in Tons)	WEEE Obsolescence Rate 2 (in Numbers)	WEEE Generated 2 (in Tons)
2006	0.26050824	5576079.5	659942.263	348803.7346	9487.461581		
2007	0.289685163	6365536.38	789456.875	568437.601	15461.50275	422369.1944	11488.44209
2008	0.322129901	7266763.92	901227.548	650863.0536	17703.47506	348803.7346	9487.461581
2009	0.35820845	8295586.55	1028822.62	418765.4952	11390.42147	568437.601	15461.50275
2010	0.398327796	9470069.05	1174482.51	543338.5838	14778.80948	650863.0536	17703.47506
2011	0.44294051	10810833.9	1340764.8	659942.2628	17950.42955	418765.4952	11390.42147
2012	0.492549847	12341423.1	1530589.21	789456.8748	21473.227	543338.5838	14778.80948
2013	0.54771543	14088711.9	1747288.8	901227.5476	24513.38929	659942.2628	17950.42955
2014	0.609059558	16083380.4	1994668.55	1028822.623	27983.97534	789456.8748	21473.227
2015	0.677274228	18360452.6	2277072.13	1174482.507	31945.92418	901227.5476	24513.38929

Table 5.9: Statistics of PCs as e-waste generation and handled in Pune, Pimpri Chinchwad region

Year	Penetration / 1000 population	Installed Base	Yearly Addition	WEEE Obsolescence Rate 1 (in Numbers)	WEEE Generated 1 (in Tons)
2006	19.03380253	75994.4	15919.9	725.22	19.725984
2007	23.67100004	95737.5	19743.1	627.1	17.05712
2008	29.11919435	119303.8	23566.3	4450.3	121.04816
2009	35.34483116	146693.3	27389.5	8273.5	225.0392
2010	42.31523749	177906	31212.7	12096.7	329.03024
2011	49.99860265	212941.9	35035.9	15919.9	433.02128
2012	58.36395948	251801	38859.1	19743.1	537.01232
2013	67.3811661	294483.3	42682.3	23566.3	641.00336
2014	77.02088785	340988.8	46505.5	27389.5	744.9944
2015	87.25457972	391317.5	50328.7	31212.7	848.98544

The following inferences are drawn from **Table 5.8 and 5.9**.

1. The number of PCs entering into Mumbai's e-waste market is 3858 and 2725 per day for 5 and 7 year obsolescence rate, respectively.
2. Since the average weight of PC has been taken as 27.2 kg, the total weight of PCs entering into Mumbai's e-waste market considering five year obsolescence rate is 15461.5 tons per year.
3. The total weight of PCs entering into Mumbai's e-waste market considering seven year obsolescence rate is 11488 tons per year.
4. The number of PCs entering into Pune, Pimpri Chinchwad e-waste market is 2 and 1 per day for 5 and 7 year obsolescence rate, respectively.
5. The total weight of PCs entering into Pune, Pimpri Chinchwad e-waste market considering five year obsolescence rate is 17 tons per year.
6. The total weight of PCs entering into Pune, Pimpri Chinchwad e-waste market considering seven year obsolescence rate is 11 tons per year.

Based on the secondary data review for PCs, considering obsolesce of 5 years the amount of e-waste generation in Mumbai, Pune, Pimpri Chinchwad region by year 2015 is estimated and projected to be 31945 tons and 848 tons respectively.

5.7 Obsolescence Rate & E-waste Projections for Refrigerator

The historical data from 1986 obtained from TV Vyopaar Journal, India and Census of India for the comparative time series growth of installed base and yearly additions of refrigerator in Mumbai, Pune, Pimpri and Chinchwad region is summarized in **Table 5.10 and Table 5.11**.

Table 5.10: Comparative time series growth of refrigerator in Mumbai

Year	Penetration Rate / Household	Installed Base	Yearly Addition
1985	0.1507	339837.934	
1986	0.1788809	416699.407	76861.4736
1987	0.211079462	507931.57	91232.1626
1988	0.246962971	613891.168	105959.598
1989	0.2821	724374.18	110483.012
1990	0.315952	838071.969	113697.789
1991	0.357341712	956121.28	118049.311
1992	0.391	1080702.96	124581.684
1993	0.434401	1240282.8	159579.831
1994	0.484791516	1429832.75	189549.958
1995	0.541027332	1648351.22	218518.465
1996	0.59621212	1876427.04	228075.825
1997	0.623041665	2111607.01	235179.963
1998	0.674131082	2348159.08	236552.07
1999	0.728061568	2606652.07	258492.997
2000	0.780482001	2870691.41	264039.341
2001	0.835115741	3155578.19	284886.779
2002	0.889398264	3450085.15	294506.957
2003	0.94276216	3754368.86	304283.71
2004	0.997442365	4077780.71	323411.846
2005	1.055294023	4429052.15	351271.448
2006	1.123888134	4811279.36	382227.201
2007	1.191321422	5235614.95	424335.594
2008	1.262800708	5697375.25	461760.296
2009	1.33856875	6199860.95	502485.707
2010	1.418882875	6746663.89	546802.937
2011	1.504015847	7341692.66	595028.768
2012	1.594256798	7989200.58	647507.926
2013	1.689912206	8693816.12	704615.535
2014	1.791306939	9460575.93	766759.806
2015	1.898785355	10294960.9	834384.954

Source: TVVJ and Census of India

Table 5.11: Comparative time series growth of refrigerator in Pune, Pimpri, and Chinchwad Region

Year	Penetration Rate	Installed Base	Yearly Addition
1988	0.704	790518.643	
1989	0.715	813163.709	22645.0653
1990	0.726	836125.488	22961.7795
1991	0.737	859403.982	23278.4937
1992	0.748	882999.19	23595.2079
1993	0.7502	907196.154	24196.9649
1994	0.7568	931519.805	24323.6506
1995	0.7689	956375.535	24855.7304
1996	0.7843	982304.927	25929.3916
1997	0.7964	1008924.76	26619.8285
1998	0.8019	1038980.93	30056.1776
1999	0.80245	1074349.99	35369.0583
2000	0.8041	1111286.78	36936.7936
2001	0.803	1156006.83	44720.045
2002	0.8118	1201398.31	45391.4791
2003	0.8173	1248243.08	46844.7666
2004	0.8206	1295894.71	47651.6374
2005	0.82181	1343747.87	47853.1532
2006	0.82203	1391823.41	48075.5431

Source: TVVJ and Census of India

The installed base of refrigerator in Mumbai increased from 838071 in 1990 to 4811279 in 2006. The yearly addition of refrigerator in Mumbai market increased from 113697.7 in 1990 to 382227 in 2006. The installed base of refrigerator in Pune, Pimpri Chinchwad increased from 836125.45 in 1990 to 1391823.4 in 2006. The yearly addition of refrigerator in Pune, Pimpri Chinchwad market increased from 22961.7 in 1990 to 48075.5 in 2006. The data from secondary sources indicate that obsolescence rate of refrigerator prevailing in India ranges from fifteen to seventeen years. Assuming market additions every year is equivalent to refrigerator coming into market as e-waste, analysis was carried out concerning two scenarios for obsolescence rates.

1. Fifteen years obsolescence rate
2. Seventeen years obsolescence rate

Considering 2007 as the base year for the calculations, following inferences are drawn:

1. Years 1992 and 1990 were taken as years for evaluating obsolescence rate
2. The number of refrigerators added into Mumbai market during 1992 and 1990 was 124581.68 and 113697.7, respectively.
3. The number of refrigerators added into Pune, Pimpri Chinchwad market during 1992 and 1990 was 23595 and 22961 respectively.

The number of refrigerator introduced into the e-waste market from the installed base in the region was further augmented by considering the external factors. It includes the number of refrigerator brought into Mumbai market from other sources, which could be from other domestic sources existing in the country. The details of refrigerator generated as e-waste in Mumbai is given in **Table 5.12 and Table 5.13**.

Table 5.12: Statistics of refrigerator as e-waste generation and handled in Mumbai

Year	WEEE Obsolescence Rate 1 (in Numbers)	WEEE Generated 1 (in Tons)	WEEE Obsolescence Rate 2 (in Numbers)	WEEE Generated 2 (in Tons)
2006	118049.3113	5666.36694	110483.012	5303.184578
2007	124581.684	5979.92083	113697.7894	5457.49389
2008	159579.8311	7659.831894	118049.3113	5666.36694
2009	189549.9579	9098.397977	124581.684	5979.92083
2010	218518.465	10488.88632	159579.8311	7659.831894
2011	228075.8255	10947.63962	189549.9579	9098.397977
2012	235179.9633	11288.63824	218518.465	10488.88632
2013	236552.0696	11354.49934	228075.8255	10947.63962
2014	258492.9973	12407.66387	235179.9633	11288.63824
2015	264039.341	12673.88837	236552.0696	11354.49934

Table 5.13: Statistics of refrigerator as e-waste generation and handled in Pune, Pimpri Chinchwad region

Year	WEEE Obsolescence Rate 1 (in Numbers)	WEEE Generated 1 (in Tons)	WEEE Obsolescence Rate 2 (in Numbers)	WEEE Generated 2 (in Tons)
2006	23278.4937	1117.367698	22645.0653	1086.963134
2007	23595.2079	1132.569979	22961.7795	1102.165416
2008	24196.96488	1161.454314	23278.4937	1117.367698
2009	24323.65056	1167.535227	23595.2079	1132.569979
2010	24855.73042	1193.07506	24196.96488	1161.454314
2011	25929.39155	1244.610795	24323.65056	1167.535227
2012	26619.82851	1277.751768	24855.73042	1193.07506
2013	30056.17758	1442.696524	25929.39155	1244.610795
2014	35369.05829	1697.714798	26619.82851	1277.751768
2015	36936.79357	1772.966092	30056.17758	1442.696524

The following inferences are drawn from **Tables 5.12 and 5.13**:

1. The number of refrigerators entering into Mumbai's e-waste market is 341 and 311 per day for 15 and 17 year obsolescence rate, respectively.
2. Since the average weight of refrigerator has been taken as 48 kg, the total weight of refrigerators entering into Mumbai's e-waste market considering fifteen year obsolescence rate is 5979.9 tons per year.
3. The total weight of refrigerators entering into Mumbai's e-waste market considering seventeen years obsolescence rate is 5457 tons per year.
4. The number of refrigerators entering into Pune, Pimpri Chinchwad e-waste market is 65 and 63 per day for 15 and 17 year obsolescence rate, respectively.
5. The total weight of refrigerators entering into Pune, Pimpri Chinchwad e-waste market considering fifteen year obsolescence rate is 1132.5 tons per year.
6. The total weight of refrigerator entering into Pune, Pimpri Chinchwad e-waste market considering seventeen year obsolescence rate is 1102 tons per year.

Based on the secondary data review for refrigerator, considering obsolesce of 15 years the amount of e-waste in Mumbai, Pune, Pimpri and Chinchwad by year 2015 is estimated and projected to be 12673.8 and 1773 respectively.

5.8 Obsolescence Rate & E-waste Projections for Television

The historical data obtained from TV Vyopaar Journal, India and Census of India for the comparative time series growth of installed base and yearly additions of television in Mumbai, Pune, Pimpri Chinchwad region is summarized in **Table 5.14 and Table 5.15**.

Table 5.14: Comparative time series growth of television in Mumbai

Year	Penetration Rate / Household	Installed Base	Yearly Addition
1985	0.0404	91104.529	
1986	0.053328	124226.488	33121.9591
1987	0.067393	162171.307	37944.8192
1988	0.081919	203631.137	41459.83
1989	0.097653	250752.612	47121.4744
1990	0.114012	302420.182	51667.5702
1991	0.133813	358036.727	55616.5447
1992	0.151081	417579.756	59543.0292
1993	0.1692	483092.463	65512.707
1994	0.189016	557479.367	74386.9045
1995	0.210857	642419.287	84939.9196
1996	0.2358	742120.937	99701.6499
1997	0.255216	864975.69	122854.753
1998	0.289682	1009031.38	144055.693
1999	0.325564	1165604.82	156573.441
2000	0.363271	1336147.33	170542.505
2001	0.399264	1508663.66	172516.333
2002	0.458056	1776855.51	268191.845
2003	0.515222	2051772.46	274916.949
2004	0.578409	2364673.03	312900.574
2005	0.65027	2729172.8	364499.772
2006	0.72765213	3115023.25	385850.451
2007	0.814242733	3578430.93	463407.68
2008	0.911137619	4110777.64	532346.709
2009	1.019562995	4722319.12	611541.48
2010	1.140890992	5424836.82	702517.693
2011	1.27665702	6231864.83	807028.019
2012	1.428579205	7158950.7	927085.865
2013	1.598580131	8223954.86	1065004.16
2014	1.788811166	9447394.8	1223439.93
2015	2.001679695	10852840.3	1405445.47

Source: TVVJ and Census of India

Table 5.15: Comparative time series growth of television in Pune, Pimpri Chinchwad

Year	Penetration Rate	Installed Base	Yearly Addition
1988	0.64	729882.27	
1989	0.65	739239.735	9357.465
1990	0.66	760114.08	20874.345
1991	0.67	781276.347	21162.267

Year	Penetration Rate	Installed Base	Yearly Addition
1992	0.68	802726.536	21450.189
1993	0.682	824723.7768	21997.2408
1994	0.688	846836.1864	22112.4096
1995	0.699	869432.305	22596.1186
1996	0.713	893004.4791	23572.1741
1997	0.724	917204.3232	24199.8441
1998	0.729	944528.121	27323.7978
1999	0.7295	976681.8104	32153.6894
2000	0.731	1010260.714	33578.9032
2001	0.73	1050915.3	40654.5864
2002	0.738	1092180.281	41264.981
2003	0.743	1134766.432	42586.1514
2004	0.746	1178086.103	43319.6704
2005	0.7471	1221588.969	43502.8665
2006	0.7473	1265294.009	43705.0392

Source: TVVJ and Census of India

The installed base of television in Mumbai increased from 302420 in 1990 to 3115023 in 2006. The yearly addition of television in the market increased from 51667 in 1990 to 385850 in 2006. The installed base of television in Pune, Pimpri Chinchwad increased from 760114 in 1990 to 1265294 in 2006. The yearly addition of TV in Pune, Pimpri Chinchwad market increased from 20874 in 1990 to 43705 in 2006. The data from secondary sources indicate that obsolescence rate of television prevailing in India ranges from fifteen to seventeen years. Assuming market additions every year is equivalent to television coming into market as e-waste, analysis was carried out concerning two scenarios for obsolescence rates.

1. Fifteen years obsolescence rate
2. Seventeen years obsolescence rate

Considering 2007 as the base year for the calculations, following inferences are drawn:

1. Years 1992 and 1990 were taken as years for evaluating obsolescence rate.
2. The number of TV added into Mumbai market during 1992 and 1990 was 59543 and 51667.57 respectively.
3. The number of TV added into Pune, Pimpri Chinchwad market during 1992 and 1990 was 21450 and 20874 respectively

The number of television introduced into the e-waste market from the installed base in the region was further augmented by considering the external factors. The details of e-waste generated from television in Mumbai, Pune and Pimpri Chinchwad Region is given in **Table 5.16 and Table 5.17 respectively**.

Table 5.16: Statistics of TV as e-waste generation and handled in Mumbai

Year	WEEE Obsolescence Rate 1 (in Numbers)	WEEE Generated 1 (in Tons)	WEEE Obsolescence Rate 2 (in Numbers)	WEEE Generated 2 (in Tons)
2006	55616.54473	2013.318919	47121.47443	1705.797374
2007	59543.02915	2155.457655	51667.57025	1870.366043
2008	65512.70704	2371.559995	55616.54473	2013.318919
2009	74386.90455	2692.805945	59543.02915	2155.457655
2010	84939.91962	3074.82509	65512.70704	2371.559995
2011	99701.64988	3609.199726	74386.90455	2692.805945
2012	122854.7526	4447.342045	84939.91962	3074.82509
2013	144055.6934	5214.816103	99701.64988	3609.199726
2014	156573.4407	5667.958553	122854.7526	4447.342045
2015	170542.5052	6173.638688	144055.6934	5214.816103

Table 5.17: Statistics of TV as e-waste generation and handled in Pune, Pimpri region

Year	WEEE Obsolescence Rate 1 (in Numbers)	WEEE Generated 1 (in Tons)	WEEE Obsolescence Rate 2 (in Numbers)	WEEE Generated 2 (in Tons)
2006	21162.267	766.0740654	9357.465	338.740233
2007	21450.189	776.4968418	20874.345	755.651289
2008	21997.2408	796.300117	21162.267	766.0740654
2009	22112.4096	800.4692275	21450.189	776.4968418
2010	22596.11856	817.9794919	21997.2408	796.300117
2011	23572.17414	853.3127039	22112.4096	800.4692275
2012	24199.8441	876.0343564	22596.11856	817.9794919
2013	27323.7978	989.1214804	23572.17414	853.3127039
2014	32153.68935	1163.963554	24199.8441	876.0343564
2015	33578.90325	1215.556298	27323.7978	989.1214804

1. The number of TVs entering into Mumbai's e-waste market is 142 and 1057 per day for 15 and 17 year obsolescence rate, respectively.
2. Since the average weight of TV has been taken as 36.5 kg, the total weight of TVs entering into Mumbai's e-waste market considering fifteen year obsolescence rate is 2013 tons per year.
3. The total weight of TVs entering into Mumbai's e-waste market considering seventeen years obsolescence rate is 1705 tons per year.
4. The number of TVs entering into Pune, Pimpri Chinchwad e-waste market is 59 and 57 per day for 15 and 17 year obsolescence rate, respectively.
5. The total weight of TVs entering into Pune, Pimpri Chinchwad e-waste market considering fifteen year obsolescence rate is 776.49 tons per year.
6. The total weight of refrigerator entering into Pune, Pimpri Chinchwad e-waste market considering seventeen year obsolescence rate is 755.65 tons per year.

Based on the secondary data review for television, considering obsolesce of 15 years the amount of e-waste in Mumbai and Pune, Pimpri region by year 2015 is estimated and projected to be 6173.6 tons and 1216 tons respectively.

5.9 Tracer Analysis

The objective of tracer analysis is to verify obsolescence rate in Mumbai, Pune, Pimpri and Chinchwad region through primary data collected through tracer walk along the E-waste trade value chain. The obsolescence rate can be verified through identification of WEEE stream and WEEE processes and tracking of tracer item in WEEE stream. The tracer selected for each electronic item in the study area is given in **Table 5.18** and analysis for each item is given in subsequent section.

Table 5.18: Tracer for items of study

S. No.	Electronic Item	Tracer
1.	Cellular Phone	LCD screen
2.	Personal Computer	CRT
3.	Television	CRT
4.	Refrigerator	Compressor

5.9.1 Tracer Analysis for PCs

An attempt was made to confirm the obsolesce rate and finally establish the numbers of PCs entering into the Mumbai's e-waste market using tracer analysis. The salient feature of this technique is given below:

- One of the component of PCs i.e. CRT was identified as a tracer
- The entire movement of the tracer through the supply chain was tracked down
- Qualitative and quantitative estimations were done with the identified stakeholders across the value chain.

It was identified that two types of stakeholders are involved into CRT handling i.e. CRT receiver & supplier and CRT dismantler. The field survey results of CRT dismantler revealed that the out of the total CRTs received, e-waste industry accepts 70-80% for dismantling of CRTs, while the remaining is rejected. Out of accepted CRTs, 5-10% goes for direct resale with minor repairing and rest of 15-20% goes for CRT breaking for glass recovery.

Using the above data from the field survey, the actual numbers of PCs being dismantled everyday was estimated. The survey indicated that total numbers of dismantling units operating in Mumbai's e-waste market is 17 (seventeen). It was also found during the field survey that each unit is running with dismantling of 50-55 CRTs per day. Therefore, the total number of dismantled CRTs per day from all the units in Mumbai is 680-765. The findings of this analysis are summarized in the **Table 5.19**.

Table 5.19: Tracer analysis for personal computer CRTs

Description	Figure
Total CRT being accepted for dismantling per day in Mumbai	748
CRT breaking for glass recovery	135
% found in working condition returned to market for resale	5
Total number CRT, which found route for resale without dismantling	38
Ratio between breakage and dismantled	1:5.5
Ratio conveyed during interview with the different stakeholder in e-waste business	1:5.35

Source: Survey finding and stakeholder interview

The inferences drawn from this analysis are as follows:

1. The number of CRTs dismantled everyday is 935 for personal computers. This number is very close to the 5 years obsolescence rate, which confirms the assumption made for obsolescence rate.
2. Ratio calculation on the basis of our finding and assumption (5 yrs obsolesce) and stakeholders review matches.
3. This also indicates that e-waste of PC from Pune is arriving at Mumbai market for dismantling.

5.9.2 Tracer Analysis for Televisions

In the similar fashion and using the same tracer technique, tracer analysis was also carried out for television. It was identified that two types of stakeholders are involved into television handling i.e. monitor repairing and resale and monitor dismantler.

The field survey results of TV monitor dismantler revealed that the out of the total monitor received, e-waste industry accepts 80-90% for dismantling and glass recovery, while the remaining 8-9% goes for direct resale with minor repairing.

Using the above data from the field survey, the actual numbers of monitor being dismantled and glass recovered everyday was estimated. The total numbers of monitor operating units in Mumbai's e-waste market is 10. It was found during the field survey that each unit is running with dismantling and glass recovery of 20-25 monitors per day. Therefore, the total number of dismantled monitor for component extraction and glass recovery from all the units in Mumbai is 200-250 per day. The findings of this analysis are summarized in the **Table 5.20.**

Table 5.20: Tracer analysis for television monitor

Description	Figure
Total CRT being accepted breaking for dismantling per day in Mumbai	250
% found in working condition returned to market for resale	8-9%
Total number CRT, which found route for resale without dismantling	23
Total CRT being dismantled for glass recovery	228
Ratio between dismantled and resale	1:98
Ratio conveyed during interview with the different stakeholder in e-waste business	1:9

Source: Survey finding and stakeholder interview

The inferences drawn from this analysis are as follows:

1. The number of monitor dismantled for component extraction and glass recovery is 228 per day for television. This number is close to the 15 years obsolescence rate (210 nos.).
2. Ratio calculation on the basis of our finding and assumption (15 yrs obsolesce) and stakeholders review matches.
3. Tracer analysis also indicates that e-waste of TV from Pune, Pimpri Chinchwad region is arriving at E-waste Mumbai market for dismantling.

5.9.3 Tracer Analysis for Cellular Phones

The tracer analysis was also carried out for cellular phones in the study area. It was identified that only one type of stakeholder is involved into cellular phones i.e. for

dismantling and repairing of cellular phones. Most of the parts of the mobile phone such as LCD, battery, are not repairable and hence directly disposed into the municipal dustbin. LCD and battery from mobile waste goes to municipal dustbin, while CB and plastic casing goes for recycling.

The field survey results of cellular phone dismantler revealed that the out of the total e-waste received, e-waste industry accepts 75-85%, while 10-20% goes for direct resale with minor repairing and the remaining of 5% goes for reuse with minor repairing of the components.

Using the above data from the field survey, the actual numbers of cellular phones being dismantled and components recovered everyday was estimated. The total numbers of mobile phones operating hubs in Mumbai's e-waste market is 50 (fifty) and each hub is dealing with sixty to seventy number of mobile phones everyday. It was found during the field survey that each unit is involved with dismantling of mobile phones and components recovery. Therefore, the total number of dismantled mobile phones from all the hubs in Mumbai is 3000 to 3500 per day. The findings of this analysis are summarized in the **Table 5.21.**

Table 5.21: Tracer analysis for cellular phones

Description	Figure
Total mobile phones being received for dismantled and recovery of components per day in Mumbai (85%)	3140
% found in working condition returned to market for resale with minor repairing	10
Total number of mobile phones, which found route for resale of components with minor repairing	185
Ratio between dismantled and resale	1:16.97
Ratio conveyed during interview with the different stakeholder in e-waste business	1:16.97

Source: Survey finding and stakeholder interview

The inferences drawn from this analysis are as follows:

1. The number of cellular phone received for dismantled for component extraction and recovery of components is 3140 per day. This number is very close to the 2 years obsolescence rate (3316 nos.) of mobile phones.
2. Ratio calculation on the basis of our finding and assumption (2 yrs obsolesce) and stakeholders review approximately matches.
3. Tracer analysis also indicates that e-waste of mobile phones from Pune, Pimpri Chinchwad region come to Mumbai e-waste market for dismantling and disposal.

5.9.4 Tracer Analysis for Refrigerator

The tracer analysis was also carried out for refrigerator in Mumbai, Pune, Pimpri, and Chinchwad Region. It was also found that Pune, Pimpri Chinchwad region has also capacity for refrigerator dismantling. It was identified that many stakeholders are involved into refrigerator i.e. for dismantling of refrigerator for compressor, plastic and steel and copper extraction from compressor. The end of life refrigerator is being taken for compressor extraction. The field survey results of refrigerator dismantler revealed that the out of the total refrigerator received, e-waste industry accepts 80-85% for dismantling of refrigerator, extraction of compressor and plastic grinding, while the remaining 15-20% goes for reuse of old compressor with minor repairing.

Using the above data from the field survey, the actual numbers of refrigerator being dismantled and compressor recovered everyday was estimated. The total numbers of units for handling e-waste from refrigerator in MMR and Pune, Pimpri Chinchwad Region e-waste market is 40 spread across in different areas. On an average each unit is dealing with approximately eight to nine number of refrigerators everyday, considering 12 to 14 units in MMR and 4 to 5 in Pune, Pimpri Chinchwad region. Therefore, the total number of dismantled refrigerator from all the units in the study area is about 360 per day. The findings of this analysis are summarized in the **Table 5.22**.

Table 5.22: Tracer analysis for refrigerator

Description	Figure
Total refrigerator being received for dismantling	360
Total refrigerator being received for dismantled and recovery of compressors per day in Mumbai (85%)	306
% found in working condition returned to market for resale with minor repairing	15
Total number of refrigerator, which found route for resale of compressor with minor repairing	46
Ratio between dismantled of refrigerator and resale of compressor	1:6.6
Ratio conveyed during interview with the different stakeholder in e-waste business	1:7

Source: Survey finding and stakeholder interview

The inferences drawn from this analysis are as follows:

1. The number of refrigerator received for dismantled for compressor extraction is 360 per day. This number is close to the 17 years obsolescence rate of refrigerators.
2. Ratio calculation on the basis of our finding and assumption (17 yrs obsolesce) and stakeholders review approximately matches.

Therefore, obsolescence rate of 17 years has been taken to compute e-waste/ WEEE generation for refrigerators in the study area.

5.10 WEEE Inventory in MMR, Pune and Pimpri Chinchwad Region

Final inventory giving the quantity of E-waste from the four electronic items in MMR, Pune, Pimpri, Chinchwad region considering a combination of obsolescence rates confirmed through tracer technique is given below. Tracer analysis has indicated that WEEE/E-waste generated from cell-phones, PC and TV in Pune, Pimpri and Chinchwad region comes to MMR for dismantling, while refrigerator gets dismantled in Pune, Pimpri Chinchwad region. This scenario analysis has been described in **Table 5.22.**

Table 5.22: E-Waste Generation in 2007

Region	Items	Obsolescence Rate	Waste in Tonnes/yr
MMR			
1	Cell Phone	2	144.1264454
	Personnel Computer	5	15461.503
	Refrigerator	17	5457.49389
	Television	15	2155.457655

Region	Items	Obsolescence Rate	Waste in Tonnes/yr
	Total		**23218.58074**
Pune			
2	Cell Phone	4	24.26201389
	Personnel Computer	7	17.05712
	Refrigerator	17	1102.165416
	Television	15	776.4968418
	Total		**1919.981**

The analysis of above data shows that the E-waste generation exceeds 23, 000 tonnes / year in MMR, while it exceeds 1900 tonnes in Pune, Pimpri Chinchwad region. The E-Waste / WEEE arriving in MMR exceed 24,000 tons. This figure does not include imports.

Tracer analysis indicated that all the imports from JNPT & MPT do not enter MMR and Pune Chinchwad market for dismantling. MMR region acts as a conduit/ transit/ trading point for supply of WEEE/ E-waste to other parts of India.

The WEEE / E-Waste projections till 2015 for MMR, Pune, Pimpri, and Chinchwad Region are shown in **Figure 5.13** and **Figure 5.14.**

Figure 5.13: WEEE / E-Waste projections till 2015 for MMR

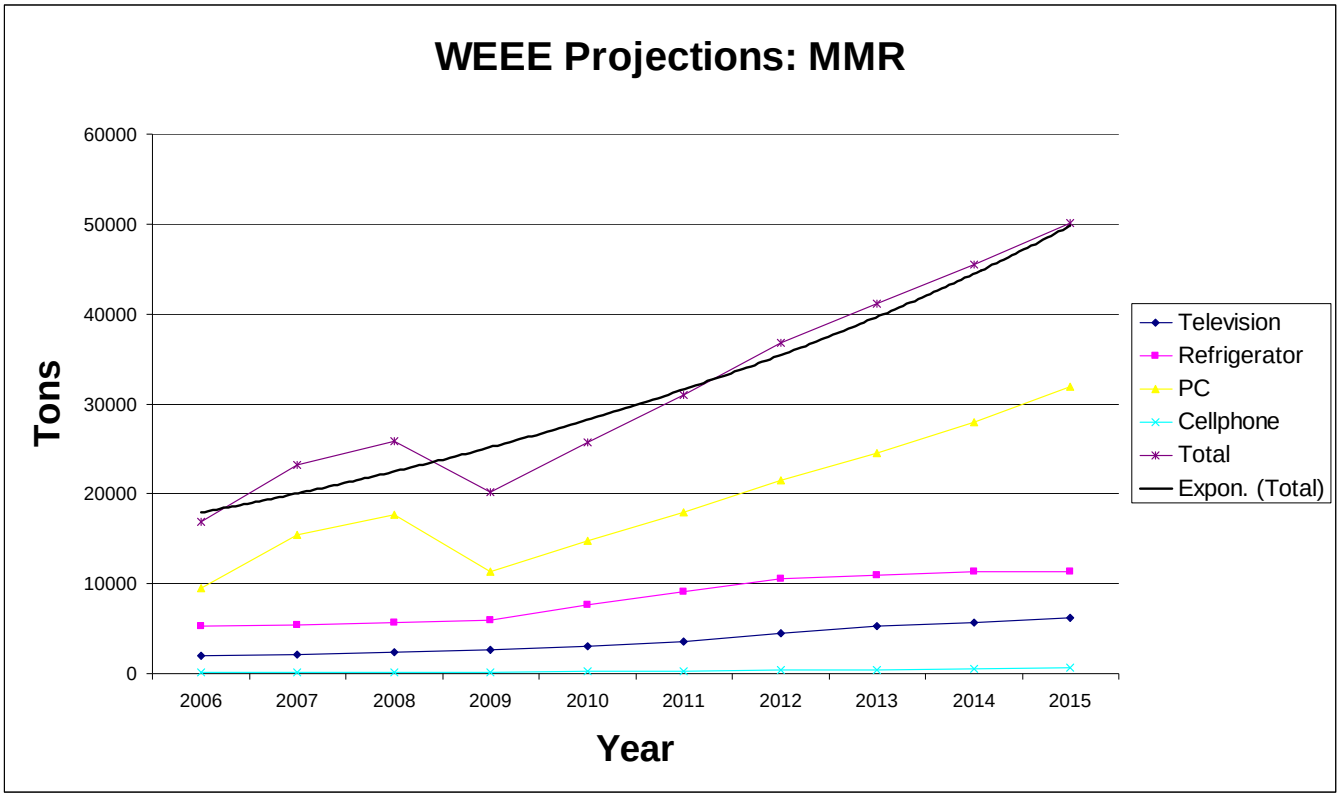
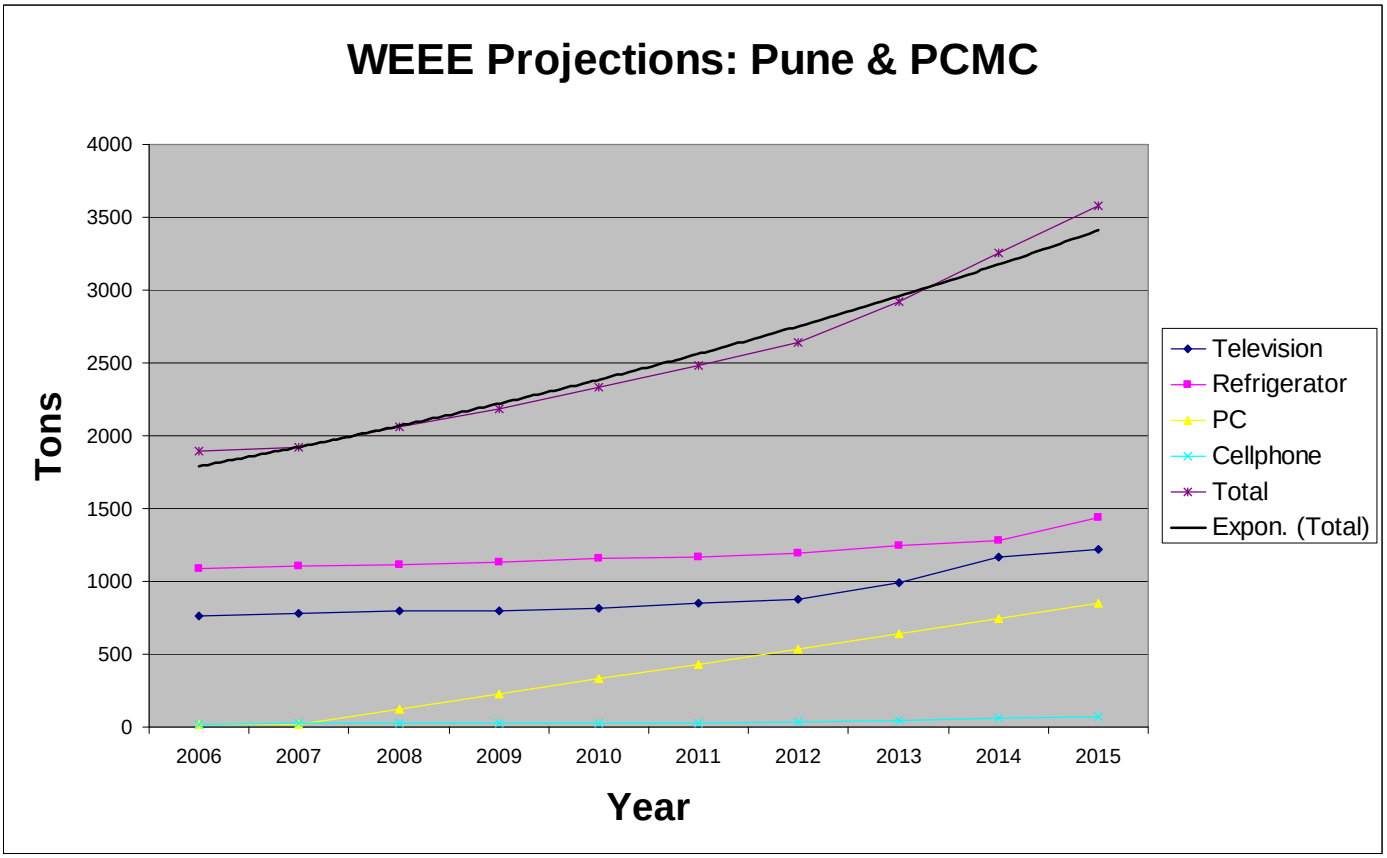


Figure 5.14: WEEE / E-Waste projections till 2015 for Pune, Pimpri Chinchwad Region



The analysis of above data shows that WEEE/ E-waste in MMR exceed 50,000 tons and 3500 tons in Pune, Pimpri Chinchwad region by 2015.

CHAPTER 6: WEEE/ TRADE ECONOMICS & ENVIRONMENTAL IMPACTS

6.1 Introduction

The trade economics governs the WEEE/ E-waste along the value chain in the study area. Since the trade starts from organized sector and ends in unorganized sector, a number of factors drive this economics. Similarly, environmental impacts are associated with WEEE/ E-waste trade. The following sections describe economics and impacts in the study area.

6.2 Trade Economics

Trade economics has been studied in terms of eleven processes, which occur along the trade value chain. Each stakeholder in the eleven processes studied is linked to the other and the trade between the two takes place based on value added. The fundamental parameters governing this trade are same as that of any other trade. These parameters are described below.

1. Total input cost
2. Total operating profit
3. Total selling price

Input costs have been classified into the following costs.

1. Raw material cost
2. Labour cost

Selling price is the price at which the products are sold. The difference between the selling price and the input costs gives the operating margin. The total selling price consisting of selling price of each of the eleven processes gives the trade turnover. Operating margin is an indicator of the profit and has been computed in terms of operating margin per kg of raw material and operating margin per day.

The efficiency in the trade has been measured in terms of labour productivity and raw material usage. The labour productivity has been computed in terms of total man hours per day and man hours used per kilogram of raw material. The entire trade economics of each of the eleven processes is summarized in **Table 6.1. Table 6.1** does not include capital, depreciation, taxation and transportation cost. Labour refers to workers involved in e-waste extraction industry only and only 300 working days in a year.

Table 6.1: Trade economics of Mumbai e-waste market

Process name	Raw material generated (Kg/day)	Labour cost (Rs/Kg of raw material)	Total labour cost/ per day	Man hours per Kg of raw material	Total man hours per day	Input (Rs/Kg of raw material)	Total input cost per day	Operating margin (Rs/Kg of raw material	Total operating profit per day	Total selling cost per day
IC's extraction from PWB*	3763.6	85.0	319906.0	0.47	1768.9	35.00	131726.0	6.80	25592.5	477224.5
Surface heating of PWB and extraction of components*	3450.9	51.0	175995.9	0.53	1828.9	40.50	139761.4	8.75	30195.4	345952.7
Dissembling of monitor and extraction of components*	16560.0	0.9	14904.0	0.09	1646.0	1.25	20700.0	2.25	37260.0	72864.0

Process name	Raw material generated (Kg/day)	Labour cost (Rs/Kg of raw material)	Total labour cost/ per day	Man hours per Kg of raw material	Total man hours per day	Input (Rs/Kg of raw material)	Total input cost per day	Operating margin (Rs/Kg of raw material	Total operating profit per day	Total selling cost per day
Yoke core	207.0	9.6	1987.2	0.49	101.4	48.70	10080.9	9.40	2681.8	19314.8
Metallic transformer	897.0	10.5	9418.5	0.36	322.9	31.75	28479.7	13.50	9363.6	38649.1
Rare earth core of transformer	276.0	8.2	2263.2	0.50	138.0	29.50	8142.0	18.30	6650.2	20335.3
Rare earth static transformer	241.5	6.5	1569.7	0.38	91.8	18.60	4491.9	2.40	757.2	8676.2
Wire PVC and Copper*	1380.0	3.9	5382.0	0.50	690.0	24.50	33810.0	10.50	18641.7	69051.7
Plastic shredder*	1932.0	2.0	3864.0	0.44	940.2	24.50	47334.0	12.85	27457.9	84083.1
Refrigerator compressor	977.5	18.4	17986.0	0.28	273.7	15.30	14955.7	5.60	5474.0	38415.7
Mobile phone	374.2	1.6	598.7	0.20	74.8	0.90	336.8	1.10	411.6	1347.1
Total	**30059.7**	**197.6**	**553875.2**	**4.24**	**7876.6**	**270.50**	**439818.4**	**91.45**	**164485.9**	**1175914.2**

*includes personal computers and black & white and colour televisions CRT.

Some major observations from **Table 6.1** are as follows:

1. The total turnover of the trade per year is Rs.352774260, which is 0.0236% of Mumbai's Gross Domestic Product (GDP).
2. The total man hours per year used in this process is 2362980.
3. The total labour cost per day in the trade is Rs. 553875. Therefore, the average labour cost per day is Rs. 563. This is much higher than Maharashtra's per capita per day income of Rs.95. Therefore, the labour finds this trade to be lucrative.
4. The total man hours per kg of raw material are highest (0.53) for surface heating of PWB and extraction of components and lowest (0.09) for dismantling of monitors and extraction of components. This indicates that surface heating of PWB is very labour intensive process, while dismantling of monitors is mechanized process.
5. The number of man hours per day of surface heating of PWB is highest (1828.9), while it is lowest for mobile phone dismantling (74.8). It indicates that surface heating of PWB is a regular operation, while mobile phone dismantling is an intermittent operation. Further, there is a continuous supply of PWBs as a raw material, while mobile phones as a raw material are available intermittently.
6. The same trend as that of point 4 has been observed for total input cost per day.
7. The total operating profit per day ranges from Rs.37260 to Rs.411.6. Rare earth core of transformer process gives the maximum operating margin of Rs. 18.30 while dismantling of mobile phones gives the minimum operating profit of Rs. 1.10 per day.

6.3 Impacts

E-waste contains a mix 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 & 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 pose serious legal and environmental implications. When computer 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 following section describes impacts due to e-waste trade.

6.4 Impacts - Health and Environment

Following are the impacts which may results on workers and environment due to hazardous e-waste recycling processes

Computer/e-waste components	Process witnessed	Potential occupational hazard	Potential environmental hazard
Cathode ray tubes (CRT)	Regunning, breaking, removal of yoke and dumping	• Silicosis • Cuts from CRT glass in case of implosion • Inhalation or contact with phosphor containing cadmium or other metals • Glass Dust inhaling	Lead, barium and other heavy metals leaching into ground water, release of toxic phosphor
Printed circuit board (PCB)	De-soldering and removing computer chips	• Tin and lead inhalation • Possible brominated dioxin, beryllium cadmium and mercury inhalation	Air emission of same substances
Printed circuit board processing	Open burning and acid bath of waste boards that had chips removed to remove final metals	• Toxicity to workers and nearby residents from tin, lead, brominated dioxin, beryllium cadmium and mercury inhalation • Respiratory irritation • Acid contact with eyes, skin may result in permanent injury • Inhalation of mists and fumes of acids, chlorine and sulphur dioxide gases can cause respiratory irritation to severe effects including pulmonary ederm, circulatory failure and death	▪ Hydrocarbons, heavy metals, brominated substances etc discharged directly into river and banks. ▪ Acidifies the river destroying fish and flora. ▪ Tin lead and contamination of immediate environment including surface and groundwater ▪ Brominated dioxins, beryllium cadmium and mercury emissions.
Chips and other gold plated components	Chemical stripping using nitric and hydrochloric acid and burning of chips	• Toxicity to workers and nearby residents from tin, lead, brominated dioxin, beryllium cadmium and mercury inhalation • Respiratory irritation • Acid contact with eyes, skin may result in permanent injury • Inhalation of mists and fumes of acids, chlorine and sulphur dioxide gases can cause respiratory irritation to severe effects including pulmonary ederm, circulatory failure and death	• Hydrocarbons, heavy metals, brominated substances etc discharged directly into river and banks. • Acidifies the river destroying fish and flora. • Tin lead and contamination of immediate environment including surface and groundwater • Brominated dioxins, beryllium cadmium and mercury emissions
Plastics from computer and peripherals e.g. printers, keyboards, monitors etc	Shredding and low temperature melting to be reutilized in low grade plastics	• Probable Hydrocarbons, heavy metals, brominated dioxins exposure	Emissions of brominated dioxins and heavy metals and hydrocarbons
Computer wires	Open burning and stripping to remove copper	• Brominated and chlorinated dioxins, Polycyclic Aromatic Hydrocarbons (PAH)	Hydrocarbons ashes including PAH's discharged to air, water and soil

Computer/e-waste components	Process witnessed	Potential occupational hazard	Potential environmental hazard
		(Carcinogenic) exposure to workers living in the burning works area • Cuts from knife in case of implosion	
Miscellaneous computer parts encased in rubber or plastic e.g. steel rollers	Open burning to recover steel and other metals	• Polycyclic Aromatic Hydrocarbons (PAH) (Carcinogenic) and potential dioxin exposure	Hydrocarbons ashes including PAH's discharged to air, water and soil
Toner Cartridges	Use of paintbrushes to recover toner without any precaution	• Respiratory tract irritation • Carbon black possible human carcinogen • Cyan, yellow and magenta toners unknown toxicity	Cyan, yellow and magenta toners unknown toxicity
Secondary steel or copper and precious metal smelting	Furnace recovers steel or copper from waste including organics	• Exposure to dioxins and heavy metals	Emissions of dioxins and heavy metals

6.5 Macro level Impacts

Looking into the state of affairs in e-waste scenario in Mumbai, the impacts with regard to health, environment and business were tabulated based on the analysis and visual interpretation (based on primary and secondary survey) at following e-waste recycling or handling industries:

- IC's Extraction from PWB (Manual plucking)
- Surface heating of PWB and extraction of components
- Dissembling of monitor and extraction of components
- Yoke core
- Metallic transformer
- Rare earth core of transformer
- Rare earth static transformer
- Wire PVC and copper (Manual Stripping)
- Plastic shredder

Each sector i.e. health, environment and business were assigned with individual score which are based on there negative and positives impacts on the workers, surroundings and economy. In case of environment and heath, three distinct values i.e. -1, 0 and +1 were awarded, wherein -1 -represents negative impact, 0 -represent neutral impact which means can be mitigated with protective equipments and +1 -represents no impacts.

In case of business, the formula used is (Rs./man hours) wherein Rs. represent the turnover of the business concerned and man hours represents total man hours involved to generate this turnover. This has been categorized as -1, 0 and +1 wherein, -1 which has a value from 0-100 represent low value or low business standing, 0 which has a value from 101-200 represent medium business standing, and +1 which has a value >200 means high business sense.

Business like yoke core, plastic shredding etc. which are lucrative streams in e-waste business attach higher business score and represents negative score in environment and health sectors. The level of impacts in relation to health, environment and business due to e-waste trade in Mumbai is as summarized in the **Table 6.2**.

6.6 Score of Impacts

Environment & health score: (-1) Negative Impacts, (0) Neutral, (+1) No Impact
Business score: (-1) 0-100 Low Value, (0) 101-200 Medium Value, (+1) >200 High Value

Table 6.2: Summary of impacts

Impact / Process	Health (score)	Environment (score)	Business (Rs./Man Hours)	Business (score)
IC's Extraction from PWB (manual plucking)	0	0	269	+1
Surface heating of PWB and extraction of components	-1	-1	189	0
Dissembling of monitor and extraction of components	-1	-1	44	-1
Yoke core	+1	0	190	0
Metallic transformer	+1	0	119	0
Rare earth core of transformer	+1	-1	147	0
Rare earth static transformer	+1	-1	95	-1
Wire PVC and copper (manual stripping)	+1	0	100	0
Plastic shredder	-1	-1	89	-1
Refrigerator Compressor	-1	0	140	0
Mobile Phone Dismantling	0	0	18	-1

Each process has its own impact and can lead to areas where further interventions may be carried out. This intervention will depend on the scale of operations and the scale of impact on account of scale of operations.

CHAPTER 7: RECOMMENDATIONS AND ROADMAP

7.1 Introduction

Recommendations have been formulated based on the major findings of the study. These findings define the risks involved in WEEE/ E-waste generation, trade, treatment and disposal. The following section summarizes each of these issues followed by recommendations and action plan.

7.2 Major Findings

Some of the major findings of the study are given below, which have been classified into strength, weakness, opportunities and threats as given below.

Strength

- In Pune, Pimpri Chinchwad region, field investigations reveal that e-waste is transported to Mumbai from where it is supplied to other parts of India. Some part of the e-waste is again sent to Delhi for further processing and dumping to the land fill site.
- No acid bath process for extraction of metals has been observed in the study area.
- Tracer tracking shows that obsolescence rate of cellular phones, PC, TV and refrigerator in the region is 2 years, 5 years, 15 years and seventeen years respectively.

Weakness

- No clear definition of WEEE/ E-waste exists in the existing regulatory regime in India. It is only partially covered under Hazardous Waste Management Rules 2003.
- Most of the activity in MMR, Pune and Pimpri Chinchwad region involves physical dismantling by hammer, chisel, screw driver and bare hand. The most high- tech piece of dismantling equipment witnessed was an electric drill.
- There is no organized mechanism for collection, transportation and disposal of WEEE/ E-Waste in MMR, Pune, and Pimpri Chinchwad region.
- No mechanism exists in the state to monitor and track its inventory, collection, transportation and disposal.

Opportunities

- MMR is a major hub for dismantling of WEEE/ E-waste
- There are twelve processes, which are involved in dismantling of WEEE/ E-waste in MMR and Pune, Pimpri Chinchwad region. The trade is scattered in the region and starts from organized sector to unorganized sector. The major dismantling occurs in un-organized sector.
- The analysis of data shows that the E-waste generation exceeds 23, 000 tonnes/ year in MMR, while it exceeds 1900 tonnes in Pune, Pimpri chinchwad region.
- The E-Waste/ WEEE arriving in MMR for dismantling exceed 24,000 tons. This figure does not include imports,
- The analysis of data shows that WEEE/ E-waste in MMR exceed 50,000 tons and 3500 tons in Pune, Pimpri Chinchwad region by 2015.
- The total turnover of the trade per year is Rs.352774260, which is 0.0236% of Mumbai's Gross Domestic Product (GDP).
- The total man hours per year used in this process is 2362980.

- The total labour cost per day in the trade is Rs. 553875. Therefore, the average labor cost per day is Rs. 563. This is much higher than Maharashtra's per capita per day income of Rs.95. Therefore, the labor finds this trade to be lucrative.
- The total operating profit per day ranges from Rs.37260 to Rs.411.6. Rare earth core of transformer process gives the maximum operating margin of Rs. 18.30 while dismantling of mobile phones gives the minimum operating profit of Rs. 1.10 per day.

Threats

- The WEEE/E-waste trade poses major environmental risks.
- Field Investigations reveal that easy and approachable method for disposal of e-waste in Mumbai is throwing in Municipal dust bin which goes for land filling sites.
- Tracer analysis indicated that all the imports from JNPT & MPT do not enter MMR and Pune Chinchwad market for dismantling. MMR region acts as a conduit/ transit/ trading point for supply of WEEE/ E-waste to other parts of India.

7.3 Recommendations

Recommendations have been formulated based on findings of SWOT analysis given below:

Findings of SWOT analysis:

1. WEEE/ E-waste emerging as major problem in the state which will pose major environmental risk due to exponential increase in generation by 2015.

2. No mechanism exists in the state to collect, transport, dismantle and dispose WEEE/ E-waste.

3. No scientifically designed facility exists in the state for its safe dismantling and disposal.

4. Lack of institutional mechanism to track and monitor its collection, transportation, disposal and inventorization.

Recommendations

1. Need for a scientifically designed dismantling facility with proven technology in the state. A cumulative risk profile of such facility in the existing scenario in the state is given below

Risk Matrix

Factors/ Intensity		**High**	**Medium**	**Low**
Regulatory Risks				
Risks due to lack of definition of WEEE in existing regulations		√		
Risks due to part inclusion of WEEE in existing Hazardous Waste Rules			√	
Risks due to lack of harmonization of WEEE in Export/ Import rules			√	
Market Risks				
Risks of availability	Short term			√

of raw material (WEEE)	Long term		√	
Risk associated with collection	Short term		√	
	Long term			√
Risk associated with transportation	Short term			√
	Long term			√
Technology Risks				
Type of raw material/ input to WEEE recycling system			√	
Scale of operation			√	
Environmental Issues			√	

2. The availability of raw material should be ensured initially for viability of any dismantling facility. A model of TSDF facility operation in MMR can be followed to ensure raw material availability to the facility.

3. Dumping of WEEE should be banned in landfill site.

4. WEEE / E-Waste inventory should be tracked / monitored regularly in MMR, Pune and Pimpri Chinchwad region.

5. Capacity building requirement of MPCB in the area of

   - WEEE inventory tracking & monitoring at local level and at ports.
   - authorization procedure for WEEE dismantling facilities
   - monitoring of WEEE dismantling facility
   - WEEE interstate movement and transfer.

7.4 Road Map / Action Plan

The following road map / action plan have been formulated and prioritized to define the road map for future interventions.

1. MPCB to initiate and formulate an institutional mechanism for tracking and monitoring WEEE/ E-waste inventory, generation, collection and transportation in association with other stakeholders like Municipal Corporation of greater Mumbai, Pune Municipal Corporation, Pimpri and Chinchwad Municipal Corporation, industry associations and MIDC.
2. MPCB should initiate a multi stakeholder study tour in countries where collection, transportation, dismantling and disposal of WEEE/E-waste is working efficiently. This tour should study the best practices adopted in these countries with respect to each of the element in WEEE/E-waste management.
3. MPCB should catalyze development of collection and transportation mechanism of WEEE/ E-waste in MMR, Pune, Pimpri Chinchwad region. Informal/ unorganized sector should be made a part of collection and transportation system to facilitate their integration into the system.
4. MPCB should catalyze development of WEEE/ E-waste dismantling facility in MMR, Pune, Pimpri Chinchwad region. It could be promoted by bringing it under infrastructure development project and subsequently taken by state infrastructure development agency or MPCB. Further, it could also be promoted under public private partnership.
5. Capacity building of all the stakeholders including MPCB officials, local municipalities, existing dismantlers, customs and port authorities and NGOs.