Responsible management of E- waste to reduce Health risk in case of East Delhi

Thesis submitted in partial fulfillment of the requirements for the award of the degree of

Master of Planning
(Environmental Planning)

By
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Declaration

I **Priyanka Ahirwar**, Scholar No. **2018MEP008** hereby declare that the thesis titled Responsible management of E- waste to reduce Health risk in case of East Delhi submitted by me in partial fulfilment for the award of Master of Planning (Environmental Planning), at School of Planning and Architecture, Bhopal, India, is a record of bonafide work carried out by me. The matter/result embodied in this thesis has not been submitted to any other University or Institute for the award of any degree or diploma.

Priyanka

Signature of the Student

Date: 10-07-2020

Certificate

This is to certify that the declaration of **Priyanka Ahirwar** is true to the best of my knowledge and that the student has worked under my guidance for one semester in preparing this thesis.

RECOMMENDED

Signature of the Guide

ACCEPTED

10/7/20

Signature of the Head,

Department of Environmental Planning

Date: 10/7/2020

Place: Bhopal

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Abstract

The market is expanding due to innovations in technology & different types of gadgets, electronics. Production and consumption of electrical & electric equipment are high. Due to this, the waste of electrical & electronic equipment is also more. E- waste is the waste producted by used electronics that are not fit for future use. Globally, the generation of e- waste is 44 million tons per year. From this e- waste, Only 20% of E- waste is recycle properly in the world.

India is the fifth largest country in the generation of e- waste. Components of E- waste contain heavy metals like arsenic, cadmium, lead, nickel, etc. In India, e- waste collection, transportation, segregation, dismantling, recycling, & disposal are done manually by untrained laborers in the informal sector. The improper disposal of E- waste is very harmful to the environment as well as human health which leads to diseases like asthmatic bronchitis, DNA damage, endocrine and hormone disorders, lung and liver cancers, fertility problems, genetic mutations, etc.

To reduce these issues responsible management is required. Responsible management is a target for a sustainable development goal that is responsible for production & consumption. Most of the cities in India is required infrastructure to followed the e- waste management rules 2016.

In Delhi, the generation of E- waste is high, its still lacking in the management of e- waste. Only 5 % of e- waste is handled by formal sectors & 95 % of e- waste is handled by the informal sector without using any protection measures which is harming our environment as well as human health. The formal sector is not efficient enough to cater to the e- waste. Also, the informal business of E- waste handling is the livelihood for the poorer people who are migrated from other states. This study focused to reduce the harmful impacts of e- waste on human health. This study provides strategies for better management to reduce the health risk.

सार

प्रौद्योगिकी और विभिन्न प्रकार के गैजेट्स, इलेक्ट्रॉनिक्स में नवाचारों के कारण बाजार का विस्तार हो रहा है। बिजली और बिजली के उत्पादन और खपत का अधिक उपयोग होता है। इसके कारण, इलेक्ट्रोइफ़ इलेक्ट्रिकल और इलेक्ट्रॉनिकइपॉइंट्स भी अधिक हैं। ई-कचरे का उपयोग इलेक्ट्रॉनिक्स द्वारा किया जाता है। भविष्य के उपयोग के लिए उपयुक्त नहीं है। वैश्विक स्तर पर, ई-कचरे की पीढ़ी प्रति वर्ष 44 मिलियन टन है। इस ई-कचरे से, दुनिया में ई-कचरे का केवल 20% रीसायकल ठीक से होता है।

भारत ई-कचरे का उत्पादन करने वाला पांचवा सबसे बड़ा देश है। कंपोनियॉफ ई-कचरे में भारी धातुएँ जैसे आर्सेनिक, कैडमियम, लेड, निकल इत्यादि शामिल हैं। भारत में ई-कचरा संग्रहण,परिवहन, अलगाव, ध्वस्त,अनौपचारिक क्षेत्र में अप्रशिक्षित मजदूरों द्वारा मैन्युअल रूप से रीसाइक्लिंग और निपटान किया जाता है। ई-कचरे का अनुचित निपटान पर्यावरण के साथ-साथ मानव स्वास्थ्य के लिए बहुत हानिकारक है जो अस्थमा संबंधी ब्रोंकाइटिस, डीएनए क्षति जैसे रोगों की ओर जाता है, अंतःस्रावी और हार्मोन संबंधी विकार, फेफड़े और यकृत कैंसर, प्रजनन समस्याएं, आनुवंशिक परिवर्तन आदि।

इन मुद्दों को कम करने के लिए जिम्मेदार प्रबंधन की आवश्यकता है। जिम्मेदार प्रबंधन एक सतत विकास लक्ष्य के लिए एक लक्ष्य है जो उत्पादन और खपत के लिए जिम्मेदार है। भारत के अधिकांश शहरों में ई-कचरा प्रबंधन नियमों 2016 का पालन करने के लिए बुनियादी ढांचे की आवश्यकता है।

दिल्ली में, ई-कचरे की पीढ़ी अधिक है, इसका अभी भी ई-कचरे के प्रबंधन में कमी है। केवल 5% ई-कचरा औपचारिक क्षेत्रों द्वारा संभाला जाता है और 95% ई-कचरा बिना किसी सुरक्षा उपायों का उपयोग किए अनौपचारिक क्षेत्र द्वारा नियंत्रित किया जाता है जो हमारे पर्यावरण के साथ-साथ मानव स्वास्थ्य को भी नुकसान पहुंचा रहा है। औपचारिक क्षेत्र ई-कचरे को पूरा करने के लिए पर्याप्त कुशल नहीं है। साथ ही, ई-वेस्ट हैंडलिंग का अनौपचारिक व्यवसाय उन गरीब लोगों के लिए आजीविका है जो अन्य राज्यों से पलायन कर रहे हैं। इस अध्ययन ने मानव स्वास्थ्य पर ई-कचरे के हानिकारक प्रभावों को कम करने पर ध्यान केंद्रित किया। यह अध्ययन स्वास्थ्य के जोखिम को कम करने के लिए बेहतर प्रबंधन के लिए रणनीति प्रदान करता है।

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CHAPTER 1. INTRODUCTION

In this developing world, the requirement for electronics is increasing. Due to this, the electronics industry has become the globally largest & fastest growing industry. The last decade has seen tremendous growth in the production and consumption of electronic and electrical equipment all over the world. As a result of which, combined with rapid product development, and reduced costs, discarded electronic and electronic equipment commonly referred to as 'E- waste'. Now e- waste is the most fastest growing problem in the globally. Most organizations today structure their items for arranged or updated quality (Borthakur & Govind, 2019).

1.1 E- waste

By E- waste, we generally refer to the waste generated from used electronics which are not fit for their further use during their whole life span. It is also termed as E- waste which means waste electrical & electronic equipment (Cpcb, 2016). Broadly 'E- waste' also name as electrical & electronic equipment which is discarded as a waste through local consumer and bulk consumer as a whole or in part as well as rejected from production, refurbishment, and repair process in comparison (Cpcb, 2016).

E- waste are globally recognized as hazardous material, even though they comprise a full range of valuable and dangerous metals. The term 'waste' is associated with the residue and remains are dumped from the buyer after recycled, repaired or reused (Balde & Forti, 2017). Several public policies advocate the term 'e- waste' or e- scrap' broadly to all waste electronics. CRTs have a relatively huge composition of hazardous substances i.e. lead and phosphors, as both are required for a display to work. Many international environmental agencies have included overused CRT monitors in the category of "hazardous household waste" (Borthakur & Govind, 2019).

Due to development in Information & Communication Technology the use of Electronic components has grown rapidly. The technology gets outdated regularly which results in the discarding of old technology in the form of E- waste. The approach of consumer-targeted growth policy combined with rapid product

demand and the advancement of technology has generated a new environmental challenge (hemkhaus & hanzlar, 2018).

1.1.1 Categories of E- waste.

It includes a wide range of household products as well as business use products.
Categories of electrical & electronic waste include (Balde & Forti, 2017):

1. Household appliances (Small) include coffee maker, irons, toasters, Small hairdryers.
2. Household appliances(Large) include washing machines, dishwashers, refrigerators /freezers
3. Consumer Equipment consists of Tv, Stereo, electrical toothbrushes
4. Fluorescent lamps lighting equipments.
5. Telecommunications equipment & Information technology (IT) consist of personal computers, mobile phones, scanners ,laptops, printers, & photocopiers.
6. Toys and sports equipment
7. Monitors & Controls equipments like CCTV cameras.
8. Tools include handheld drills, saws, screwdrivers which are used in machinery.

From all these eight categories, each product has a lifetime of reuse & waste, that means each product from all these categories has different quantities of waste & their values (Balde & Forti, 2017).
According to E- waste management rules & regulation 2016, it includes only two categories of E- waste as **Information technology & telecommunication Equipment & Consumer electrical & electronics**. It also states that any gadget that works through can make harm the environment & human health if it is disposed of improperly (Cpcb, 2016).

1.1.2 Composition of E- waste

It contains quite a thousand different substances, that comprise “hazardous” & “non-hazardous” classes.
This is made, generally, of ferrous and non ferrous metals, plastics , glass, wood & plyboard, electronic circuit boards, concrete and ceramics, rubber and other

item. Iron and steel compose nearly 50 percent of e waste followed by plastics (2 1 percent), nonferric metals (13 percent) and other constituents. Non ferrous met als include metals such as copper, aluminum and valuable metals such as silver, gold, platinum .

The composition of e- waste hang on upon various reasons such as type of electrical equipment, manufacturing date & age of the scrap material. The components of E- waste have different types of metals as shown in Table 1. They also have heavy metals like arsenic (As), cadmium (Cd), chromium (Cr), lead (Pb), mercury (Hg), and other toxic chemicals (Mnereki & Li, 2016).

Table 1: Composition of E- waste with components

Composition of E-waste		
Ferrous Metal	Iron and Steel	36%
Non-ferrous Metal	Aluminum, Copper, Lead, Cadmium, Mercury, Gold, Silver, Palladium,Indium, Arsenic, Selenium	19%
Plastic	Brominated and Non-brominated Plastic	23%
Glass	Lead glass and normal glass	15%
Others		7%

Source: The Generation, Composition, Collection, Treatment & Disposal System, and Impact of E-Waste(2016)

All these metals with categories of e- waste are also shown in Table 2.

Table 2: Composition of E- waste with Categories

Material	Household Appliance (Large)	Appliance (Small)	Consumer Electronics	Lamps
Ferrous Metal	43	29	36	-
Non-ferrous Metal	27.67	26.19	9	14.3
Plastic	19.31	37.75	30	3.7
Glass	0.02	0.16	19.3	77
Others	10	6.9	5.7	5

Source: The Generation, Composition, Collection, Treatment & Disposal System, and Impact of E-Waste(2016)

1.1.3 Sources of E- waste.

Data from the Research Unit Under Rajya Sabha Secretariat, India, shows that the highest contributor to e- waste in India is the government, Public and Private (Industrial) Sectors, which contributes about an estimate of 70% of the total e-waste generation as shown in Table 3. (Rajyasabha, 2011).

Table 3: Sources of E- waste

Home	Hospital	Government	Private sector
PC	PC	PC	PC
Television	Monitors	CPU	Boilers
Radio	ECG device	FAX machine	Mixer
Cell phones	Microscope	Xerox machine	Signal Generators
Washing machine	Incubator	Scanner	Incubator
Microwave oven		Fan	
CD player		Tube light	
Fan		Air conditioner	

Source: E-waste in India, Rajya sabha(2011)

1.2 Background

1.2.1 E- waste Scenario in World

Today, because of the innovations of technological and market enlargement, categories of electrical & electronic equipments being produced and consumed worldwide are fast considerably (Balde & Forti, 2017). The fast innovation expansion, production & consumption demand leads to a big improvement in various electrical & electronic equipments, wherever the quantity of E- waste generation increasing proportionately to its production. As an example, the size of the Chinese& Indian marketplace for electrical & electronic equipment, particularly these countries' demand for client electronics are a few things engaging to the international electrical & electronic equipment giants (Borthakur & Govind, 2019). With the increase of knowledge of technology, a major part of E- waste is additionally generated in rural areas which harmful consequences.

The global amount of e- waste generation in 2016 was around 44.7 MMT, or 6.1 weight unit per person. It's calculable that in 2017, the globe e-waste generation can exceed 46 Mt. The quantity of e- waste is predicted to grow to 52.2 Mt in 2021 with associate degree annual growth rate of 3 -4 percent are shown in Figure 1 (Balde & Forti, 2017).

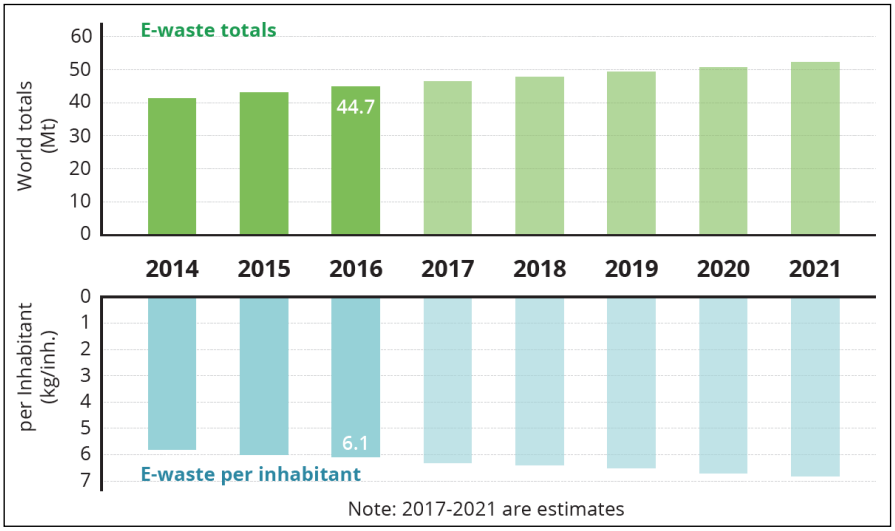

Figure 1:Global generation & growth rate of E- waste

Source: Global E- waste monitor (2017)

In 2016, the greater part of the e- waste was produced in Asia of apporoximately 18.2 Mt. Roughly 2.7 Metric ton were recorded as a gathered & recycled.

The European landmass, including Russia, created a measure of e- waste per occupant practically identical to Oceania is 16.6 Kg/inh. The least measure of e-waste per occupant produced in Africa; 1.9 kg/inh (Balde & Forti, 2017).

1.2.2 E- waste Scenario in India

In 2016 , India ranked itself as the world's fifth largest producer of e- waste.

An analysis conducted by India's Associated Chambers of Commerce and Industr y and KPMG in 2016 put India among the top five e-waste nations, with an estimated1.85 million tons produced annually.

All inclusive, annual figure is a staggering 40- 50 million tons. India accounts for about 4 percent of the annual ewaste produced. The US ranked Ist in waste, gen erating 11.7 million tons of ewaste annually.6.1million tons of waste is generated by china which is 2nd in rank as shown in Figure 2 (Assocham, 2017).

Figure 2: Top 5 E- waste Generating Countries in World

Source: ASSOCHAM- KPMG (2017)

The ASSOCHAM-KPMG study recognized that PC & cell phones are the important e- waste generators in India. As per study, PCs contributes towards 70 % of the complete e- waste created in India, while media transmission gear represented 12 percent. Among urban communities, Mumbai beat the rundown it produced an expected 1,20,000 tons of e- waste every year. The position of Delhi & Bengaluru is 2nd and 3rd with 98,000 and 92,000 tons of e- waste age individually. Around 70 percent of unidentified metals are found in landfills are represented by E- waste (Assocham, 2017) . E- waste Generation in India for all the states are shown in Table 4.

Table 4: E- waste Generation in India

S.No	State	E-waste Generated in MTA	Metropolitian cities	E waste generated in MTA
1	Maharashtra	20270.59	Mumbai	11017.1
2	Tamil Nadu	13486.24	Delhi	9729.15
3	Andhra Pradesh	12780.33	Bengaluru	4648.4

4	Uttar Pradesh	10381.11	Chennai	4132.2
5	West Bengal	10059.36	Kolkata	4025.3
6	Delhi	9729.15	Ahmadabad	3287.5
7	Karnataka	9118.74	Hyderabad	2833.5
8	Gujarat	8994.33	Pune	2584.2
9	Madhya Pradesh	7800.62	Surat	1836.5
10	Punjab	6958.46	Nagpur	1768.9

Source: Assocham, 2017

At present, 50-80% of E- waste is collected annually for recycling & exported to developing countries. E- waste recycling hotspots in Asian countries such as China, India and Pakistan have been reported. Informal Sectors include Scrap & Kabadiwalas markets (Manish & Chakraborty, 2019).

1.3 Policy & Regulatory framework for e-waste in the World.

In India, while laws are governing the disposal and management of E- waste in India, these laws are not being fully enforced (Gnoni & Grazia, 2019). The legislation is present around the world for managing e-waste but some countries have no laws to handle the e- waste as shown in Figure 3.

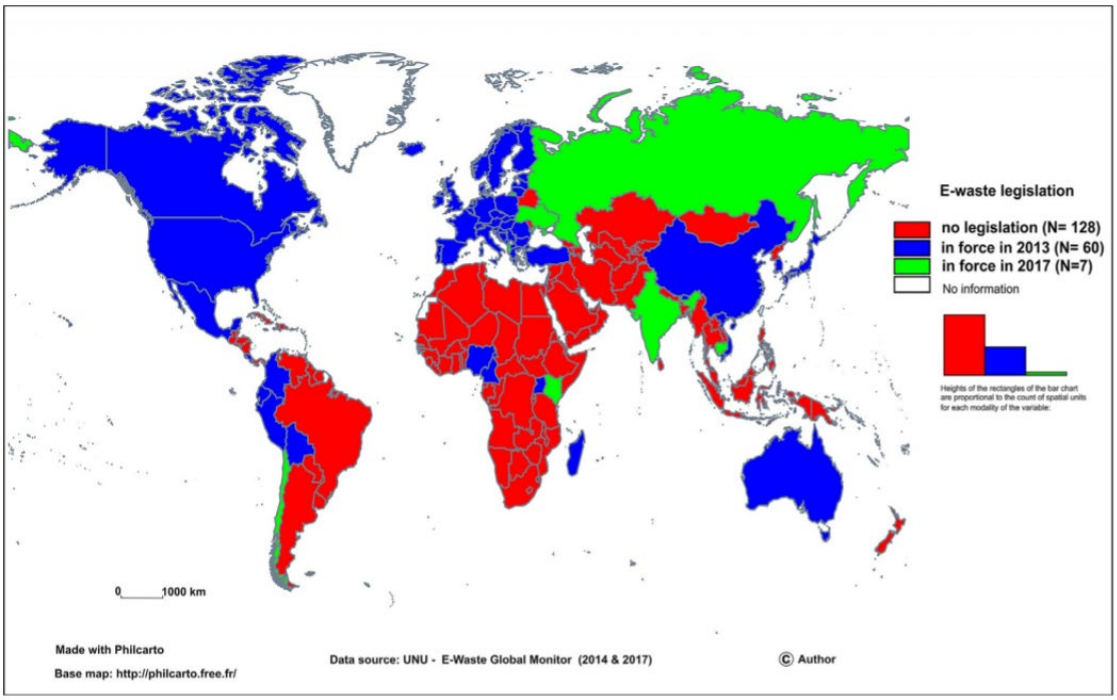

Figure 3: E-waste legislation coverage in World 2013-2017

Source: UN,2017

The various legislations in place by the Government of India are: -

The Hazardous Waste (Management and Handling) Amendment Regulations, 2003; E- waste management guidelines, 2008; E- waste (Management and Handling) Laws, 2011; E-waste (Management and Handling) Regulations, 2016.

Within so many years, the e- waste management system has evolved in the form of rules & regulations as shown in Table 5. In which certain features should also be integrated such as disposal of hazard material. This applied to every E-waste containing hazardous elements. The law also came up with the image that E-waste was included in the hazardous waste and that anyone who wanted to process or recycle the same had to register with the Central Pollution Control Board.

In view of the increasing concern about healthy and environmentally friendly disposal of e- waste, the government sponsored several initiatives to assess the issue, and e-waste management guidelines were implemented in 2008. These later led to the formulation of the Management and Handling of E- waste Rules, 2011. To order to make the system more stable to the face of this fast-growing waste stream's the threat, the regulations have been updated to the new E- waste management rules, 2016. Extended product transparency (EPR) has been a pillar of the law (hemkhaus & hanzlar, 2018).

Table 5: Progressive Account of the E- waste Rules in India

Year	Title of the Rule	Definition of E Waste	Applicability
2003	The hazardous Wastes (Management and Handling) Regulations on modification	The definition given here for 2003 is identical to that given in the Basel Convention. E-waste included only briefly with no detailed explanation in the Rules.	Not defined
2008	Guidelines for environmentally sound E Waste management	It classified the E- waste according to its different components & compositions and mainly emphasizes the E- waste management and treatment practices. The guidelines contained terms like "Extended Producer Responsibility."	Producer and End of line player in the supply chain

2011	The rules regulating e-waste (management and handling)	'Electrical & electronic equipment' means equipment that is dependent on electrical or electro-magnetic currents Fields to be completely usable and 'e-waste' means, in whole or in part, waste of electrical and electronic equipment or rejection of their production and repair processes expected to be discarded. These guidelines are intended for everyone in the sector	Producer, retailer or bulk user, storage point, recycler and dismantler
2016	E- Waste (Management) Rules, 2016	Same as above	Expanded to Organization for Maker, Händler, Refurbisher and Supplier Duty (PRO)

Source: GIZ report,2019

1.3.1 Management of E- waste

In the past few years, the conventional solutions to waste management in developing countries have accumulated which is becoming a issue due to the rapid growth. This traditional waste management system is not only locally fatal for the environment and health but also for the surrounding area. Due to the inappropriate methods of generation and disposal which create a risk from infectious diseases, the e-waste disposal has a dangerous significance. The growing issue of e-waste has been attributed to population development , urbanization, industrial growth and changing patterns of consumption (Jalal and Uddin, 2012). There are five steps to E- waste management as shown in Figure 4. Collection, transport, decommissioning & segregation, recycling, refining & disposal. A manufacturer is to blame for his product that he should also be responsible with finishing using electronic and electrical equipment inside the institution of the take-back program.

The responsibility of the producer can be human or collective. The individual model needs to blame every producer for handling the e-waste that their product

produces. The manufacturer advertises a take-back scheme (Jalal and Uddin, 2012).

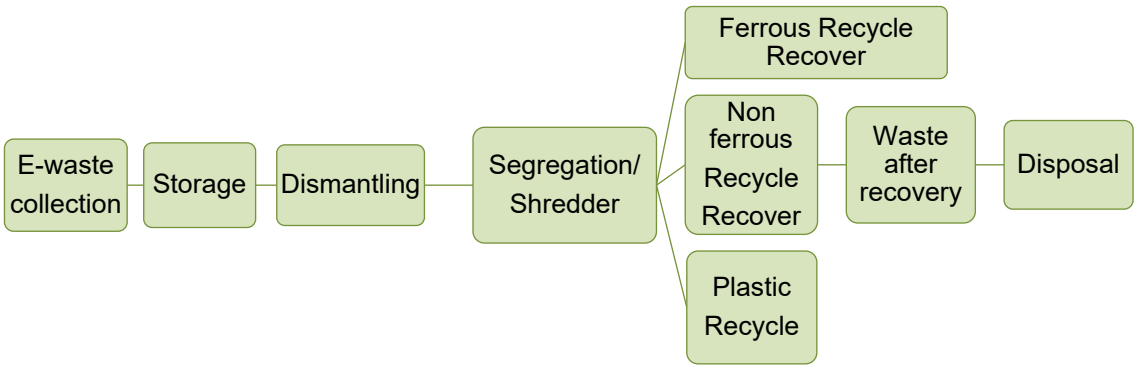

Figure 4: Flow diagram of E-waste management

Source: Meity(2017)

1.3.2 The Formal sector of E- waste

The formal sector is the sector that handled e-waste through government agencies that can manage e- waste in an environmentally sustainable way by using Best Available Technologies (BAT) to enhance environmental protection and resource recovery in compliance with e-waste management rules (Chaturvedi & Mehra, 2016).

1.3.3 Informal sector of E- waste

The informal sector is the sector that handled e-waste without any environmental initiatives, without the govt agency and recycling the e- waste. The informal e-waste recycling industry provides jobs for thousands of people in urban and peri-urban areas of developing countries (Chaturvedi & Mehra, 2016).

1.4 Disposal of E- waste

As the above-mentioned E- waste management process, The current E- waste treatment and Disposal methods involve:

1.4.1 Incineration

Full combustion of high temperature waste material (900-1000OC). This method of e-waste management is kind of beneficial since the amount of waste is significantly decreased and the energy collected is not used seriously. Additionally,

however, the release of toxic gases mercury and metallic material within the atmosphere is not free of disadvantages. (UNEP, 2013)

1.4.2 Recycling

It is possible to dismantle recycling monitors, CRT, keyboards, modems, telephone boards, mobile, fax machines , printers, memory chips, etc., and its parts can be used elsewhere.

Removal of dangerous substances such as PCB, Hg, Rubber, Ferrous and Non-ferrous metal segregation, etc., is typically used to eliminate heavy metals such as copper, lead, gold, etc (UNEP, 2013).

1.4.3 Re-Use

This can be inferred as selling a product to the second party as a second-hand product with slight modifications to the original product. This is the most effective method in reducing the quantity of E- waste.

1.4.4 Landfilling

Currently this is the widely used disposal method of E- waste. Landfilling trenches are built on earth and are then buried and protected by a dense layer of soil filled with waste material. Current methods involve a plastic or clay impermeable membrane, and the leachates are collected and moved to the wastewater treatment facility. Care should be taken when collecting leachates because they contain toxic metals such as mercury, cadmium , lead, etc. which can contaminate soil and groundwater (UNEP, 2013).

1.5 Hazard substances in E- waste

From the above-mentioned disposal methods, we found that e- waste is full of a variety of toxic materials that pose a significant risk to human health and the environment, if they are discharged throughout the process, use, or disposal.

The key constituents are metals that are ferrous and non-ferrous, plastics , glass, electronic circuit boards, concrete and ceramics, rubber, and other items. Iron & steel make up 50% of E- waste followed by plastics (21%), non-ferrous metals (13%), and various constituents.

Non-ferrous metals include metals such as copper, metallic elements and precious metals such as silver, gold and platinum. In addition to these resources, significant metals and organic compounds such as lead, cadmium , mercury, arsenic, beryllium, polyvinyl chloride (PVC), brominated flame retardants (BFRs) and phthalates are also found in e-waste. (Chaturvedi & Mehra, 2016) Some possible hazard contents are present in E- waste as shown in Table 6.

Table 6 : Possible hazardous substances in E- waste/E- waste components

Component	Possible Hazardous Content
Motor/compressor	ODS
Plastic	Phthalate plasticize, BFR
Insulation	Insulation ODS in foam, Asbestos, refractory ceramic fiber
CRT	Lead, antimony, mercury, phosphors
LCD	Mercury
Rubber	Phthalate plasticizer, BFR
Winning/Electrical	Phthalate plasticizer, lead, BFR
Circuit board	Lead Beryllium, antimony, BFR
Fluorescent Lamp	Mercury, Phosphorus, Flame retardants
Thermostat	Mercury
BFR – containing plastic	BFRs
Batteries	Lead, lithium, Cadmium, Mercury
CFC, HCFC , HFC , HC	Ozone-depleting substances
External electric cables	BFRs, plasticizers
Electrolyte capacitors (over L/D 25mm)	Glycol, other unknown substances

Source: CPCB

1.6 Impacts of E- waste hazardous substance on Human health

As it is mention in the report that E-waste is characterized as hazardous when it contains mercury, lead, cadmium, polychlorinated biphenyl(PCB), etc (Assocham, 2017).E- waste is very tricky to handle as it is made up of numerous components. These components are of varying sizes, also some are of toxic substances that adversely affect human health and environment if not handled properly as shown

in Table 7. Due to this, there is a need for appropriate technology to handle and dispose of the chemicals (grant, 2013).

Table 7: Hazardous components & their effects on human health

Hazardous components	Effects of hazardous components on Human health
Arsenic	It can affect the human skin & also decrease the nerve conduction velocity.Chronic exposure can cause lung cancer.
Lead	It can affect kidneys, female reproductive systems & nervous connections. It can also cause brain damage.
Barium	It can affect the heart muscle.
Chromium	It can damage the liver, Kidney & also cause asthma & lung cancer.
Beryllium	It can cause lung disease.
Mercury	It can damage the central nervous system, kidney & immune system.
Cadmium	It may cause server pain in the joints, spine & soften bones.
Brominates flame retardants	It can damage the reproductive & immune system. I may also cause the hormonal disorder.
Chlorofluorocarbon	It can cause skin cancer & genetic damage in organisms.
Polyvinyl chloride	PVC contains about 56% of chlorine & when it's burnt, it produces hydrochloric acid which is dangerous for the respiratory system.

Source: Health consequences to exposure of E-waste(2013)

1.7 Need for the study

Due to the increases in population, the generation of e- waste also increases. E-waste is a specialized waste stream; it requires proper logistic support for its processing. Electronic items after reaching the end of their usage go through an informal network of dealers & end up getting recycled which poses danger to environment & related workers. In India, there are e- waste management & handling rules to manage the E- waste. But due to many factors these, rules & regulations are not being followed up strongly. These factors are Lack of infrastructure, Lack of environmentally sound management of e- waste, Importation of large volumes of e- waste, and also People are not aware of the E-

waste & disposal of e- waste. In Delhi NCR, due to the most populated city in India, the consumption & generation of E- waste is high. About 5% of waste is recycled by the Formal Sectors and around 95% of the E- waste is handled by the Informal Sector (Manish & Chakraborty, 2019).

Unscientific means of e-waste management are being practiced leading to negative health & environmental impacts. This study is required to reduce the harmful impacts of e- waste on human health This study provides strategies for better management to reduce the health risk.

1.8 Sustainable Development goals

The need to prepare or reduce the adverse impacts on human health due to improper, unsafe treatment & disposal of e- waste has also been recognized in the sustainable development goals set to achieve by 2030.

The SDG 12, namely, **Responsible consumption and Production** lists its target12.4 'aims to achieve environmentally effective management for chemicals and all other waste products generated during the life cycle of the electronic, by agreed international frameworks, which focuses on significantly reducing the release of pollutants in the air, water and soil to minimize their adverse effects on human health and environment'. In Target 12.5 focus lies on substantially reducing waste generation through the means of prevention, reduction, repair, recycling, and reuse (Balde & Forti, 2017).

1.9 Research Question

What are the major shortcomings of E- waste management leading to the rise of Informal sector and tracing its effects on human health and environment?

1.10 Aim

Developing strategies to reduce the impact of E- waste on Human health in the case of East Delhi.

1.11 Objectives

To achieve the above-mentioned aim, the objectives of the study are:

1. To review the existing E- waste management & practices.
2. To understand the e- waste management & role of the formal sector in the Study area.
3. To analyze the management & impact of informal e- waste disposal on human health.
4. Recommendation to reduce the impact & make responsible management.

1.12 Scope

The current scenario of E- waste management shall be considered with the role of the formal & informal sector. In the study, the effects of E- waste processing on human health shall be considered. Also, Environmental degradation shall be considered due to improper E-waste handling cause health risk.

1.13 Limitation

The study was covered in the East Delhi municipal area. Other municipal areas of Delhi are equally responsible for this problem are not considered. For the informal sector, only four clusters of E- waste processing are taken into consideration for detailed analysis. Only air & groundwater quality is considered as the environmental indicators of improper e-waste handling cause health risk.

1.14 Expected outcome

Current picture of managing e- waste in Delhi & the harmful impact of e- waste on human health as well as environment.

1.15 Methodology

The primary aim is to analyze the impact of e- waste dismantling or recycling causing health risks directly & indirectly with the contact of the environment. The Methodology of this study is shown in Figure 5. The first step is to understand the terminologies, their cause & impacts on human health. Also, develop its relevance with the Indian context. For this various literature were reviewed to understand the concept of responsible management of waste. E- waste is a threat to sustainable development & how can we reduce the health risk

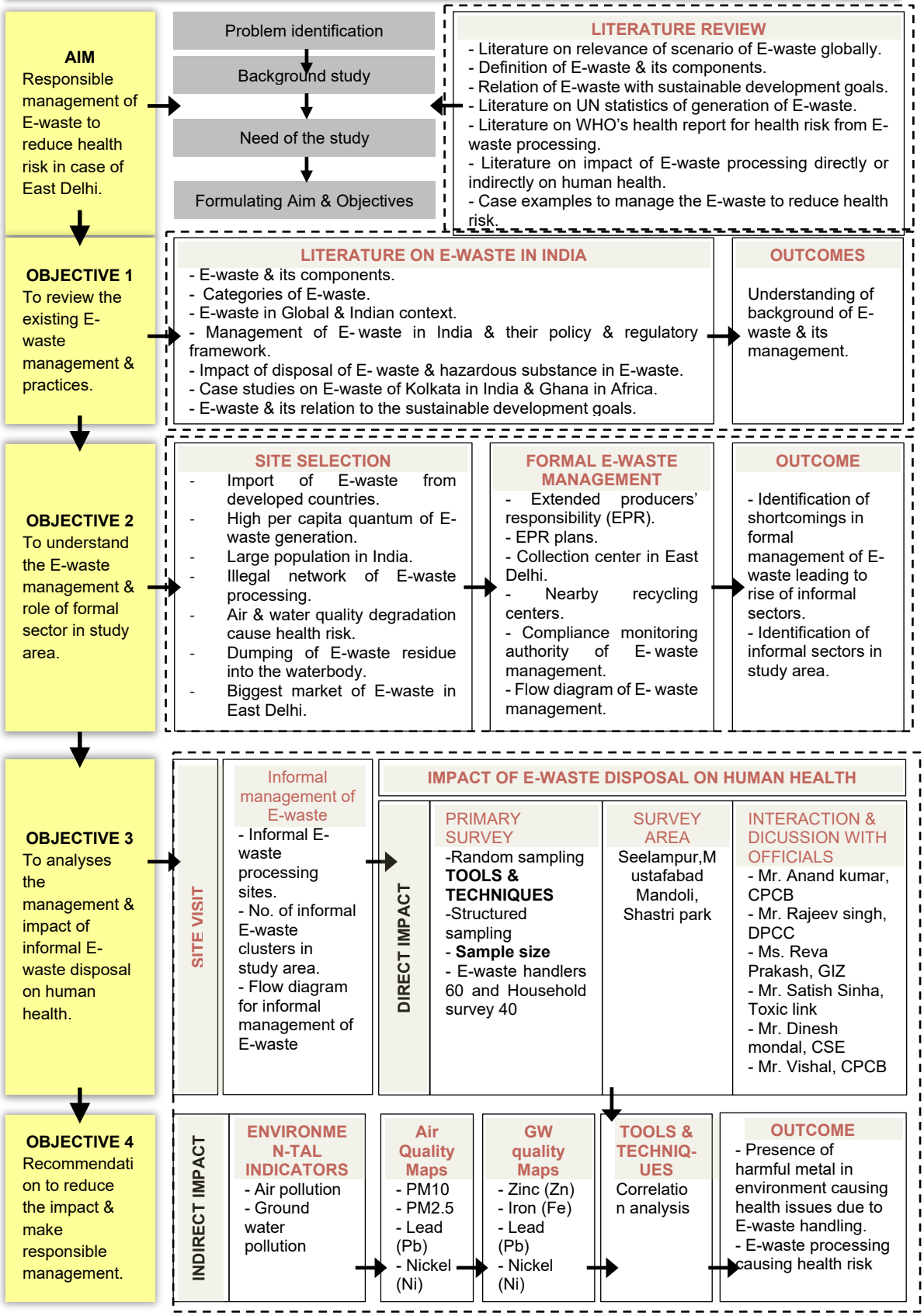

Figure 5: Methodology

Source: Author

After that informal recycling locations are mapped for the whole city area how it is spreading. Based on the location of informal processing a ward level clusters were selected & stretches was marked with land use of the area, to identify which land use is involved spatially. The next step is to show a correlation analysis of air & water pollution of informal processing sites.

For this, the data from secondary sources & primary surveys for a micro-study area was used. The flow of e-waste in informal sectors & health issues they are facing was captured by the primary survey. The relation was also established with the environment & human impact on the people living or working there. Based on the analysis direct & indirect link with human health was identified. To reduce health risk recommendations will be provided.

CHAPTER 2. LITERATURE REVIEW & STUDY AREA PROFILE

2.1 Introduction

E- waste also known as Electronic waste is a growing problem in recent years. So a need for study is eminent. With this reference, we take to understand the role of each component in the proper disposal of E- waste. How they affect the Disposal at different stages and their direct and indirect effects on human health and the environment. This study elaborated on the growing problem of E- waste in Ghana (South Africa), its impact on the environment and the measures being taken to address it.The focus of the study is based on Delhi capital city of India, hence faces the Biggest challenge in the issue of E- waste management. Through the study, we understand the Physiology of the city its connectivity its issues in regards to E-waste which will help us generate the Demographic Profile for the city which will help us create a base-map for the city.

2.2 Production & consumption of Electronic goods in India

In India, the electronic industry is the largest & fastest growing industry all over the world. By 2020, the demand for electronic goods is expected to increase with a compound annual growth rate of 41% between 2016-2020 as shown in Figure 6. Also, the domestic production of goods is expected to increase through the make in India initiatives & digital India mission by the Government of India.

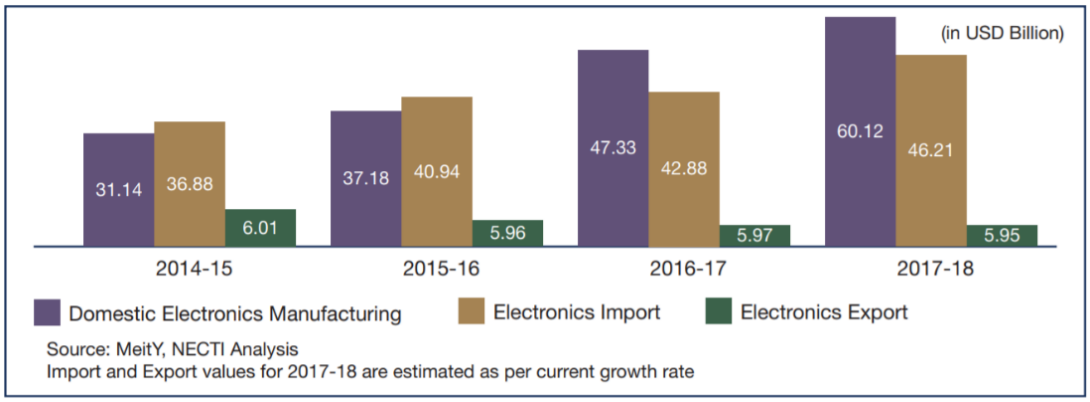

Figure 6: Import and Export values for 2017-18 are estimated as per current growth rate

Source: Meity, 2018

In India, other electronic items are also increasing rapidly which boost our Indian economy as shown in Figure 7.

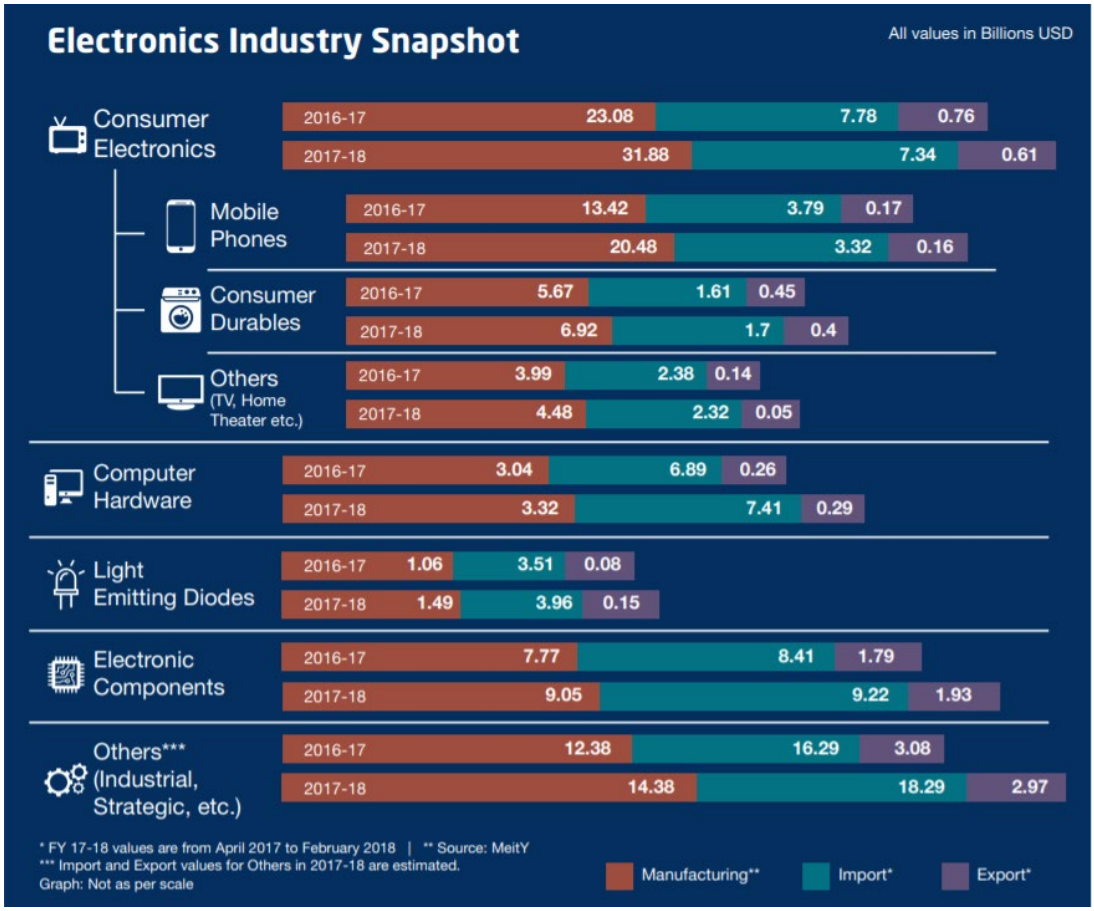

Figure 7: Import & export values of other electronic goods

Source: Meity, 2018

2.3 E-waste management policy 2016

The rules focus on the provisions necessary to introduce an Extended Producer Responsibility (EPR) system and a set and recycling system, and to manage hazardous substance reduction (RoHS) management.

To further strengthen the E waste (Management) Rules 2016, the replacement rules lay the producers primary responsibility for e-waste management (Cpcb, 2016) . There are some responsibilities also in rules for collections, storage & transportation.

2.3.1 Responsibility of collection centers.

E- waste collection is of prime importance for e- waste management and is environmentally friendly. The collection center will be set up to collect the E- waste

on a individual basis or placed together. A collection center may be a store/warehouse wherever the manufacturer- established E- Waste collected from customers, bulk customers, urban native entities and retail outlets / collection points / mobile units, etc., will be received and kept securely for necessary dismantling / use management.

The producer is liable for 'either separately or collectively setting up collection centers or take-back systems.' Collection centers can be set up in many ways, where a community center is made up for a particular manufacturer. It should be called an individual collection centre. If the collection centers meet multiple producers' EPR needs. All collection centers need authorisation from various states' SPCBs / PCCs (Cpcb, 2016).

2.3.2 Responsibility of Transportation of E- waste

The sender of E- Waste, that will be a producer, manufacturer, recyclers, dismantler, bulk consumer, refurbisher, and collection center ought to determine transporter or create arrangements for transporting e- waste in such a way that environmental consequences of hazards related to its transport can be kept at a minimum (Cpcb, 2016).

2.3.3 Responsibility of Disposal of E- waste

According to the rules, any person involved in the exercise and recovering of electrical waste and equipment or assemblies or their part may be a recycler. Recyclers may arrive at their collection centres, details of which must be entered in their authorisation. No separate authorization is needed for these collection centres.

Recyclers will obtain raw material such as e- waste assemblies or parts or used parts from manufacturers / PRO / e-waste exchangers / dismantlers and consumers / bulk consumers (Cpcb, 2016).

2.3.4 Extended Producers responsibility (EPR)

The legislation requires Extended Producer Responsibility (EPR) as a key strategy to keep producers responsible for skilled waste collection, care and disposal. EPR

is a widespread policy principle under which producers are given responsibility for the post-consumer product end-of - life phase. EPR distinguishes between three types of responsibilities are physical, financial & informative responsibility.

Globally, the implementation of EPR schemes has proven highly effective in waste reduction, reuse & recycling across many industrialized companies (hemkhaus & hanzlar, 2018). The plan of the Extended producer's responsibility is shown in Figure 8.

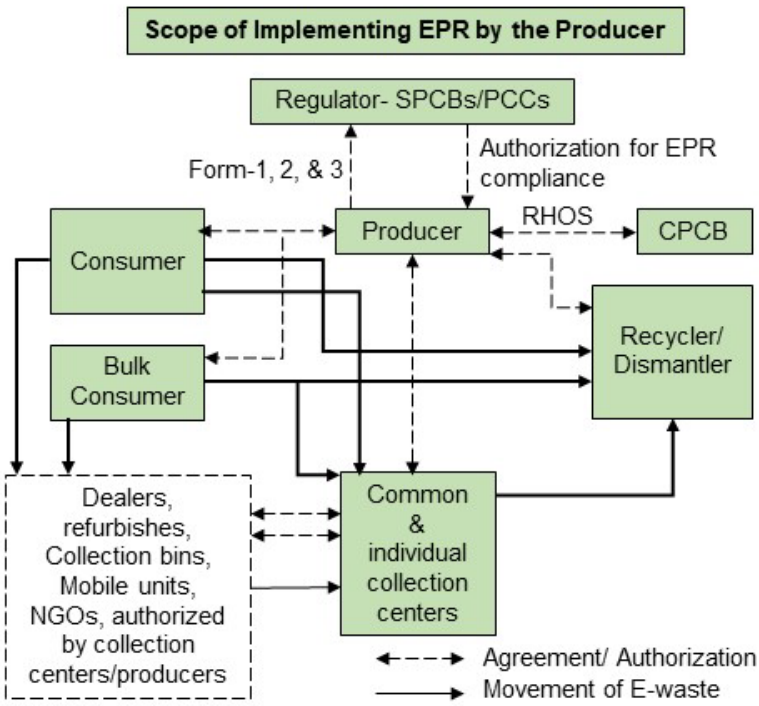

Figure 8: Extended producers responsibility

Source: Cpcb,2016

2.3.5 EPR authorization procedure

The rule's main aim is to provide in situ a good mechanism for managing the production , processing, storage , transport, import , export, environmentally sustainable recycling, e-waste treatment and disposal.

For the EPR authorization, all stakeholders should have to consult their designated authorities as shown in Table 8.The required provisions of the principles are to implement the related Extended Producer Accountability (EPR) program and collection program, to coordinate dismantler and recycler authorisation and to supervise the reduction of hazardous substances (RoHS) (Chaturvedi & Mehra, 2016).

Table 8: EPR authorization procedure

Stakeholder	Authorization	Form	Issuing Authority
Producer	EPR authorization	Form-1	CPCB
Manufacturer	Authorisation	Form- 1 (a)	SPCB
Dismantler/ Recycler	Authorisation/ Renewal	Form- 4	SPCB
Refurbisher	Authorisation/ Renewal	Form- 1 (a)	CPCB

Source: MoEFcc(2018)

2.3.6 Collection targets in EPR

For the collection of E- waste, there are collection targets also in the EPR form for the generated waste. These targets apply to all EPR authorized collection centers. Yearly based collection targets in EPR are shown in Table 9. Every year these targets should be achieved & report to the central pollution control board (Cpcb, 2016).

Table 9: Collection Targets in EPR

Year	Target
2017-2018	10%
2018-2019	20%
2019-2020	30%
2020-2021	40%
2021-2022	50%
2022-2023	60%
2023 onwards	70%

Source: MoEFcc(2018)

2.3.7 Governance structure

Since those products are sold nationwide, the SPCB / PCC concerned would inform the CPCB of the details of the authorization granted by granting the authorization. CPCB would maintain a centralized database that will be available to all stakeholders on its web site. Producers will also post this information on their website and provide details of products sold to the SPCB from which they obtained authorisation. SPCBs will provide CPCB with annual consolidated details, which CPCB will retain on a centralized database (Cpcb, 2016).

2.4 Impact of E- waste disposal on Human health.

2.4.1 Direct impact

Since e- waste is a particular mixture of various forms of toxic parts that can have an adverse effect on the environment and human health unless properly treated. Because of its composition E- waste is extremely complicated to handle.

Thus, there is a need for suitable processing and disposal technologies for these chemicals. Thus there is a need for suitable processing and disposal technologies for these chemicals. Since the method of recycling is done near the community, the population cluster that is vulnerable to dangerous chemicals, such as infants and children, is equally affected in terms of their health. Also, an E- waste handler is the most vulnerable to a hazardous chemical due to open burning, acid bath and manual dismantling cause cuts in their hands. Mostly, People of lower-income groups are involved in this processing. It is a livelihood for them. In this processing, people of lower-income groups are mostly involved. An E- waste handler is also the most vulnerable to a hazardous chemical due to open burning, acid bath, and manual dismantling causing cuts in its hands. In this processing, people of lower-income groups are mostly involved. It is their livelihood (Sankhla & Nandan, 2016).

2.4.2 Indirect impact

Owing to different kinds of toxic components in E- waste, the disposal of this waste through the atmosphere is also hazardous for human health. It has been under attack in recent years because of its negative environmental and human health consequences.

2.4.3 E- Waste disposal negatively Impacts the Soil

To begin with, e- waste can damagingly affect the dirt of an area. As e-waste separates, it discharges harmful substantial metals. Such overwhelming metals incorporate lead, arsenic, and cadmium. When these poisons drain into the soil, the plants and trees that grow from this soil are affected. Thus, these poisons can enter the supply of human nutrition, which can cause birth defects as well as various other problems with well-being. (Green Ewaste Recycling, 2018).

2.4.4 E- Waste disposals negatively Impact the Water

E- waste that is inappropriately discarded by occupants or organizations additionally prompts poisons entering groundwater. Numerous creatures depend on these channels of water for life. In this manner, these poisons can make these creatures wiped out and cause lopsided characteristics in the planetary environment .E- waste can likewise affect people that depend on this water (Green Ewaste Recycling, 2018).

2.4.5 E-Waste disposal negatively Impacts the Air

Until the point where e- waste at the landfill is recycled, it is usually burned on-site by incinerators. This procedure can discharge airborne hydrocarbons that dirty the air on which numerous creatures and people rely. Furthermore, these hydrocarbons can add to the ozone-depleting substance impact, which numerous researchers believe is the main supporter of an Earth-wide temperature boost. In certain pieces of the world, individuals filter through landfills to rescue e-waste for cash. However, a portion of these individuals consumes undesirable parts like wires to extract copper, which can prompt air contamination too (Green Ewaste Recycling, 2018).

2.5 Case study- E-waste problem in Ghana (South Africa)

2.5.1 Introduction

Ghana lies in the western part of Africa, bordered by the Gulf of Guinea, Togo, Burkina Faso and Coted'Ivoire as shown in Figure 9. It is also becoming the first country to gain independence in sub-Saharan Africa in 1957. It has a total area of 238,540 sq. km of land. Economy of Ghana is largely depend on agricultural production, and is one of the world's leading cocoa exporters.The climate of Ghana is tropical, they experience both wet and dry periods and has two rainy periods in the year except the northern region.

The average annual temperature is about 26oC and its Annual Rainfall is 736.6mm. The official language of Ghana is English which is a legacy of British colonial rules (Silva and Jo da, 2016).

Figure 9: Location of ghana in South Africa

Source: World atlas

2.5.2 E- waste in Ghana

The demand for electronic and electrical equipment has been on the rise in the last decade, accelerating economic growth with worldwide urbanization. Any of the equipment in Ghana is consumer electrical or electronics such as kitchen blenders, fridges, personal computers, stereo systems, televisions, cell phones, etc.Since the mid-1990s, Consumption of electronic equipment has grown noticeably. Ghanaians have access to both Information Technology & Telecommunications Equipment & Consumer Electrical & Electronics that promote Ghanaian economy growth and serve a good purpose in their daily lives. Due to the advancement of technology, these electrical & electronic equipment have short life time. So, In Ghana, large volumes of mixed electrical & electronic waste are generated annually (Faabeluon & Atiemo, 2018).

2.5.3 Management of e- waste in Ghana.

With the advancement in technology, People replace their old electronic items to the new items which are an increasing stem of the developing world. Ghana does

not manufacture electronic goods, but they import both new and old electronic items into the country.

The informal e-waste disposal practice is famous in all the regional capitals as well as in municipal towns. Also, many people are involved in this informal business. There is no statistical data as regards the quantity of generated waste after recycling and recovery for re-use or export. They use a rudimentary method for E-waste disposal. The resulting waste contains dangerous materials. They discharged / dumped / stocked this waste along the streams , rivers, and dispersed over large land stretches. This could have serious consequences for human health and the environment (Faabeluon & Atiemo, 2018).

2.5.4 Impact of e- waste in the Ghanaian environment

E-waste includes many components including a toxic chemical that is detrimental to human health & the environment. E- waste comprises many components of harmful chemicals capable of impacting human health and the environment. They burnt E- waste which emits toxic gases & then dumps into the water body. Water bodies of Ghana are also contaminated due to this E- waste. Long-term health effects are involved in the processing of E- waste due to exposure to toxic chemicals on people (Faabeluon & Atiemo, 2018).

2.5.5 Inferences

E-waste generation is very high in Ghana but E-waste management is very poor. They face serious challenges in E- waste management. There are no pollution-prevention measures in Ghana. They don't have the E- waste management legislation. Infrastructure is lacking. The disposal of e- waste is also not known to Ghana 's people.

2.6 Case study – Banglore, India

Banglore is the capital of Karnataka, located in India. Banglore is also known as the silicon valley of India due to the location of the major IT hub of India. According to the ASSOCHAM report, the Generation of E- waste in Banglore is 18000 tones in a year. The formal sector recycles only 5-10 per cent of e- waste from the total generation of e- waste and the informal sector recycles 90% of e-waste (Borthakur

& Govind, 2019). In Banglore a middle-class family also generates 21 kg of E-waste in a year, according to e-parisar research. Karnataka state pollution control board also says that the e-waste recycler burned the e-waste in open which is hazardous for health & dumped the toxic liquid which cannot be extracted from the water body. This can leach into ground & pollution the groundwater of the city (Chaturvedi & Mehra, 2016).

2.7 Site selection

From the above-mentioned current E- waste scenario in India, most of the e- waste imported for India's informal recycler from developed countries. While it is prohibited in the rules on e-waste management, 2016 (Mahesh & Mukharjee, 2018). All imported E-waste is come in Delhi due to Asia's biggest computer market. This market is located in Nehru Place. Also, Delhi has the largest population in India. From this, Most of the industries are in the Delhi NCR region. Due to this, the per capita generation of E- waste is also high (Manish & Chakraborty, 2019). It has a big network of illegal E- waste dismantling & recycling, although e-waste recycling is ban in Delhi. Air pollution is also there due to the informal recycling of E- waste that contributes about 30% of the city's air pollution. After dismantling & recycling, E-waste gets dumped into a nalah & leads leach into the water table causing a health problem. Also, Raw sewage of the city which is mixed with the E-waste components like acids, wires, plastic & glass pieces after dismantling is dumped in the river Yamuna which causes water pollution. (Mahesh & Mukharjee, 2018).East Delhi municipal area is chosen as a study area. As most of the informal recycling is happening in East Delhi. It is one of the municipal corporations of Delhi. It consists of two districts that are Northeast district & East district as shown in Figure 10. It is bounded by the river Yamuna river, Ghaziabad & Noida district of Uttar Pradesh. It is well connected with Uttar Pradesh from which the EWS population as cheap labor is coming here for employment. Also, it has the biggest E-waste market in Delhi (Mahesh & Mukharjee, 2018).

2.8 Study Area

Delhi is the largest commercial hub in northern India. As per the economic survey in India, Delhi has its primary sector, secondary sector & tertiary sector which

contributes 70%, 25% & 5 %. In Delhi, The Bulk population is occupied with exchanging, account, open organization, proficient administrations, and social administrations. Asia's largest computer market is also there which is famous for sale & purchase.

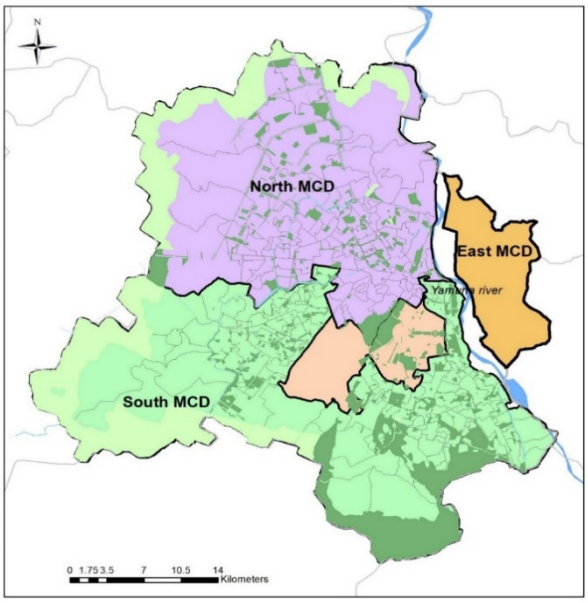

Figure 10: Municipal corporation boundary of Delhi

Source – Author generated based on Delhi Development Authority

The capital city consists of three administrative bodies as statutory cities as Delhi municipal corporation, New Delhi municipal corporation & cantonment cantonment. MCD is an elected body which is responsible for municipal functions.NDMC is a special kind of body for New Delhi and its adjoining areas. Now MCD is replaced by the three municipal corporations which are the municipal corporation of North Delhi, the municipal corporation of South Delhi & the municipal corporation of East Delhi.

Our study area is East Delhi Municipal corporation. It is one of the municipal corporations of Delhi. It consists of two districts that are Northeast district & East district. It is bounded by the river Yamuna river, Ghaziabad & Noida district of Uttar Pradesh (Neelima and Risbud, 2016).

2.9 Regional setting and connectivity

Delhi is the National Capital Territory, and is connected by Haryana and east by Utter Pradesh. It is located at 28.24 28.53 degrees at North Latitude, and 76.50-

77.20 degrees at East Longitude. Delhi covers 1483 sq of area.Delhi is well connected with air, road & railway so that anyone can easily access to other states also as shown in Figure 11. It has In India 's strongest transit network. Delhi has its South-West Delhi International Airport which is the Indira Gandhi International Airport. Capable of handling 48 million passengers at a time (Neelima and Risbud, 2016).

Its road density is 2103 km per 100km2. It is also connected with other cities by five national highways as NH1, NH2, NH8, NH10 & NH24. The Bus transport system can cater to 60% of the total demand for Delhi and also three interstate bus terminal like Kashmiri gate isbt, Sarai kale khan & Anand vihar.

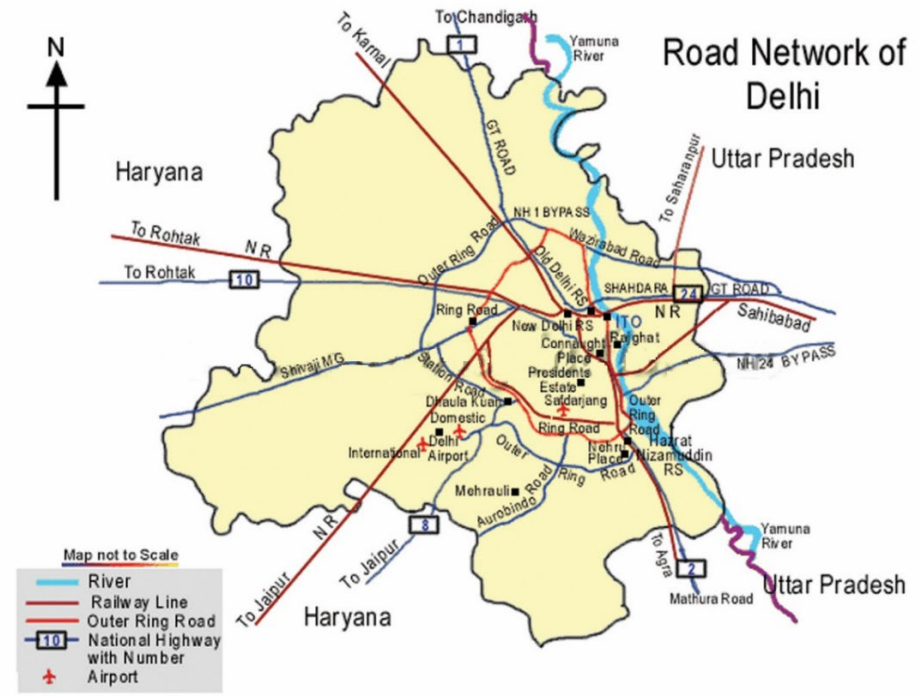

Figure 11: Regional setting map

Source: Maps of India

Delhi is the Northern Railway headquarters of New Delhi Railway Station, Hazarat Nizamuddin Railway Station, Old Delhi Railway Station, Sarai Rohilla Railway Station and Delhi Railway Station (Neelima and Risbud, 2016).

2.10 Background of the city

Delhi was ruled by the Britishers before the independence of India. In 1958, a unified corporation to establish both urban & rural areas. After that, Delhi has designated the national capital region in 1991. Delhi is consists of both urban

agglomerations as well as villages. It consists of more than 200 villages across the area.

2.11 Administrative and Governance set-up of the Study

MCD is replaced by the three municipal corporations which are the municipal corporation of North Delhi, the municipal corporation of South Delhi & the municipal corporation of East Delhi.As per district Census hand book,there are 9 districts in Nct Delhi. These districts further subdivided into 33 tehsils. In East Delhi municipal corporation, It is divided into two districts that is, North east & east district. It is further subdivided into 11 tehsils with 74 wards (Census, 2011).

2.12 Physiography

Delhi's physiography is overwhelmed by the Yamuna waterway, the Aravalli going, and the fields in the middle of framed by Recent Age alluvial stores. The SSW-NNE slanting Aravalli Ranges are assigned as Delhi Ridge, involve Delhi 's southern focal piece, and extend to the Yamuna River west bank near Okhla in the south and Wazirabad in the north-east. Naturally, the Aravalli Ridge runs in the western part of India as a barrier between the Thar desert and the fields and hinders the development of desert residue and wind (CGWB, 2018-2019) .

2.12.1 Topography

The alluvial thickness overlying the quartzites rises from the outcrops. Alluvium thicknesses in many areas of the South West, West, and North West regions are 300 m or greater. The depth to the bedrock on the east side of the edge is inside 30 m with a progressive downward slant towards Yamuna waterway. To the west of the edge near Mall Street and Vikramaditya Marg, the depth to be. Further west of it and East of Najafgarh channel, there is an abrupt increment top to bottom to 100 m. (CGWB, 2018-2019).

2.12.2 Climate

The atmosphere of NCT Delhi is for the most part impacted by its inland position and the predominance of quality of the mainland type during the significant piece of the year. Extraordinary dryness with the seriously hot summer and cold winter

is the qualities of the atmosphere. In the three-storm months of July , August and September, maritime airs infiltrate this state, causing widespread humidity, darkness and precipitation. The date on long term normal climatologic parameters covering month to month greatest/least temperature, relative moistness, evaporation and precipitation (CGWB, 2018-2019).

2.12.3 Geomorphology

The groundwater accessibility in NCT of Delhi in a roundabout way relates with its unmistakable landforms units, which thusly speak to basic characteristic topographical highlights. All these NCT, Delhi landforms can be assembled into three vast geomorphic units: Rocky surface in particular, Older Alluvial Plain and Yamuna River Flood Plain in particular (CGWB, 2018-2019).

2.13 Demographic Profile of Study Area:

Delhi is among the nation's fastest evolving urban communities. Due to the rapid pace of urbanization, the Delhi scene has experienced a shift from a dominant rural part to an urban one. Delhi is among India's fastest-growing city. According to the census 2011 , total populationof delhi is 16 349 831 (Census, 2011).

2.13.1 Population

The Population of Northeast district is 2,241,624 & East district is 1,709,346. So, the total population of East Delhi municipal corporation is **3,950,970** as shown in Table 10. Constitutes with a male population of 55% & female population of 45% (Census, 2011).

Table 10: District wise population of NCT Delhi 2001,2011

S.No.	Districts	2001		2011	
		Population	Percent	Population	Percent
1.	North West	2860869	20.65	3656539	21.78
2.	South	2267023	16.37	2731929	16.27
3.	West	2128908	15.37	2543243	15.15
4.	**North East**	**1768061**	**12.77**	**2241624**	**13.35**
5.	**East**	**1463583**	**10.57**	**1709345**	**10.18**

6.	South West	1755041	12.67	2292958	13.66
7.	North	781525	5.64	887978	5.29 7
8.	Central	646385	4.67	582320	3.47
9.	New Delhi	179112	1.29	142004	0.85
	Total	13850507	100.00	16787941	100.00

Source: Census of India(2001,2011)

2.13.2 Population Density & growth rate

Population density, Literacy rate & decadal growth rate of 2001-2011 of both the districts are shown in Table 11.

Table 11: Population Density, Literacy rate & Growth rate

Municipal Area	District	Population	No. of household	Population Density	Literacy rate	Growth rate 2001-2011
East Delhi	North East	2,241,624	406,125	36,155	83.1	26.73
	East	1,709,346	358,937	27,132	89.3	16.68.

Source: Census of India(2011)

2.13.3 Age-sex composition

The age-sex division of the population is the strongest predictor of future human development, the scale of the labor force 's obligation to deal with young people and their mature guardians in particular (Census, 2011).The data concerning the agewise appropriation of the population in Delhi during the last two evaluation time frame as shown in Table 12.

Table 12: Age -sex ratio composition

Area	District	Sex ratio		Child population			% of child population
		2001	2011	Person	Male	Female	
East Delhi	North East	849	886	301,947	160,583	141,364	13.5
	East	843	884	194,357	103,902	90,455	11.4

Source: Census of India(2001,2011)

2.13.4 Migration

Migration assessments in Delhi are dependent on birth and death rates, and the population increase all out.The regular increment in population during 2017was 2.31 lakh, while the movement has been assessed at 1.31 lakh (Delhi, 2018-2019).

2.14 Basemap of the study area

Basemap of the study area is shown in Figure 12.

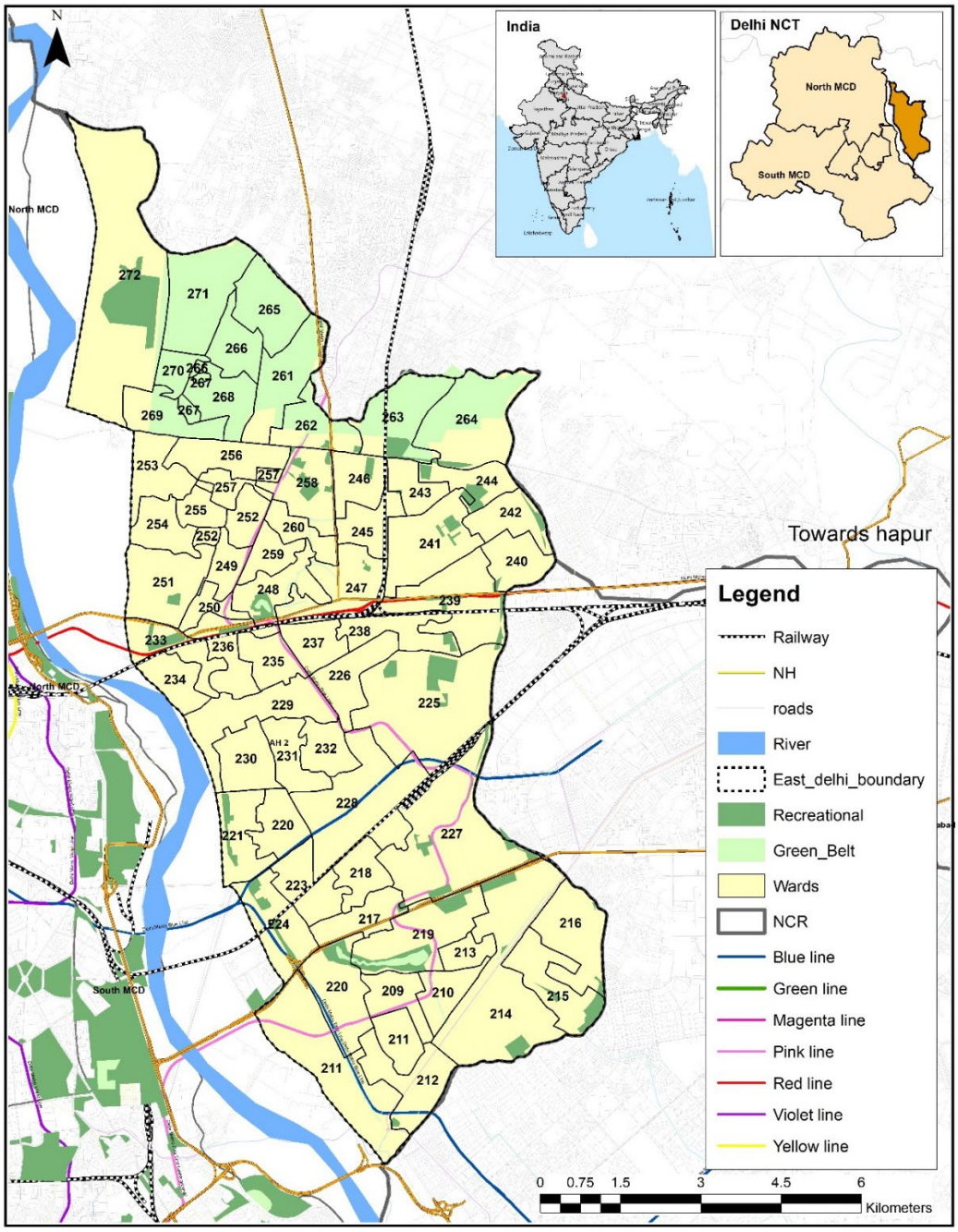

Figure 12: Basemap of the Study area

Source: Author

CHAPTER 3. DATA COLLECTION & ANALYSIS

3.1 Data required & sources

To achieve the study objectives, primary & secondary data is required. The Data checklist for the required data to complete the objectives with sources is as shown in Table 13.

Table 13: Data Checklist

S. No	Topic	Data to be collected	Department	Purpose
1	Existing management of e-waste in India	●List of collection centers ●Generation of E- waste ●Transportation ●List of recycling centers	CPCB	To understand the management scenario of E-waste in India to achieve **objective-1**
2	Formal Management of e-waste in Delhi	●List of collection centers ●Generation of E- waste ●Transportation ●List of recycling centers ●Sample of EPR authorization	DPCC	To understand the formal management of E-waste in study area & identification of gaps in it to achieve **objective -2**
3	Identification of micro study area	●Location of the informal hotspot in Delhi. ●Graph of maximum generation	Toxics Link	Mapping of Identified location of informal e-waste handling clusters in the study area for **objective-3**
4	Demography	●Population ●Area ●Ward population ●Workers Distribution	Census of India	Social characteristics of each district to understand the pattern If any & the population, literacy rate, growth gate & age sex ratio for **objective-2, 3**
5	Master plan of Delhi	Land use	DDA	For mapping the spatial pattern of impacted areas of informal E- waste

				handling clusters for **objective-3**
6	Informal management of e- waste	• Source flow •Collection •Transportation •Recycle •Issues		To understand the informal management of E-waste & its impacts on human health through Primary survey for **objective-3**
7	Health data	• Types of disease •No. of male/ female admitted •No. of Death	DHS	For health problems of the area & sort out % of health problems related to the symptoms faced by the Informal E-waste handlers to achieve **objective 3**
8	Impact on the Environment	Air quality, water quality	CPCB ,CGWB	Comparing pollution level in Informal E- waste clusters with the health of the E- waste handlers & surrounding areas to achieve **objective-3**

Source: Author

3.2 Data collection tools & techniques

3.2.1 Primary survey

For the Collection of Data from Informal sectors of E- waste, Primary surveys were conducted to E-waste handlers & the surrounding areas of these clusters. The task includes the questionnaire, interview, observation, asking questions, taking photographs, and recording audios and videos.

3.2.2 Types of Sampling

The type of sampling adopted in this research is **stratified random sampling**. In this type of sampling there is an equal chance of selection for everyone from a wide range of populations. It has been tried to collect responses from various age groups, gender and people engaged in E- waste handling.

For stratified random sampling, The total number of surveys conducted are 106 in number out of which, **60 surveys** are of informal e-waste handlers, **40 surveys** of nearby households & **6 surveys** of experts.

A **semi-structured interview** method is adopted to understand informal management of e-waste. The types of E- waste they are taking, source of the e- waste, the process used, city to transfer e-waste, exporting city, type of vehicles used for transportation, storage of waste, a material extracted, selling of material, dumping of residual waste, type of health issues faced by the people & type of treatment they are taking. Also environmental issues they are facing, health issues & type of treatment taken by nearby residential areas due to E-waste processing & recycling.

3.2.3 Selection & location of survey sites

Delhi, is a center point of e-waste informal recycling. The maximum informal recycling is in the Eastern region of Delhi. The laborers in Delhi are uneducated and jobless youth, children and ladies who have moved from the neighboring conditions of Uttar Pradesh and Bihar. There are 6 sites for significant disassembling and recycling destinations are Seelampur, Shastri Park, Mustafabad, Jafrabad, Mandoli, and Brijpuri as shown in Figure 13. No.of units in **Seelampur, Mustafabad, Shastri park, Mandoli** is more. The ward population of these sites is shown in Table 14. These 4 areas are practicing this business since two or three decades. So, these four areas are chosen for detailed study. Location of these sites is shown in Figure 14.

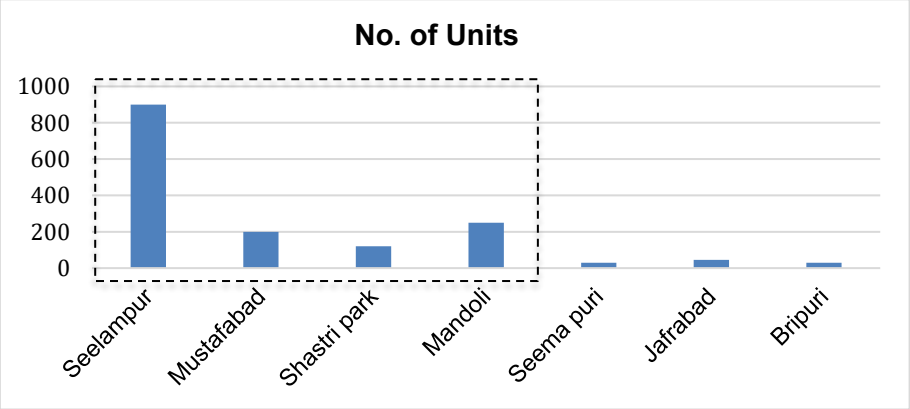

Figure 13: Informal E- waste processing clusters in East Delhi

Source: Author

Table 14: Population Density of specific wards

Ward no.	Location	Area (sq km)	Population
233	Shastri park	2.27	65050
235	Seelampur	2.76	63220
264	Mandoli	5.87	120417
266	Mustafabad	1.29	127167

Source: Census of India,2011

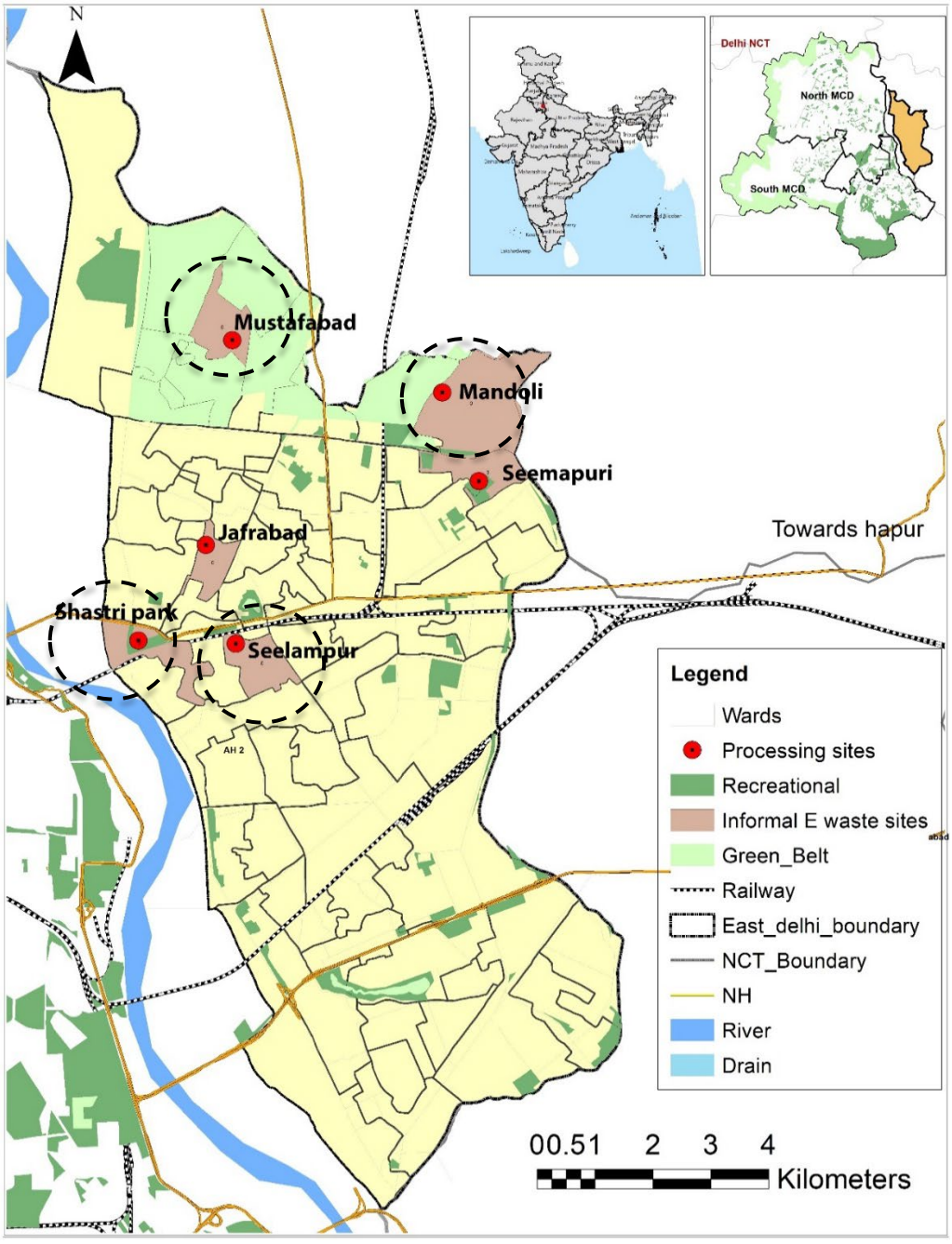

Figure 14: Location of survey sites

Source: Author

3.2.4 Sample size & techniques

The total population of East Delhi municipal corporation is **3,950,970** (Census, 2011)Total Population of selected wards for the survey is **3,75,854** (Census, 2011) The sample size for the survey is shown in Table 15.

Table 15: Calculation of Sample size for the survey

Population	Confidence level %	Margin error%	Sample size
375854	95	3	1065
375854	95	5	384
375854	95	10	96

Source: NCBI,2010

3.3 Data Analysis

From chapter two in the literature review various indicators were identified related to responsible management of e- waste to reduce the health risk. Chapter one & two achieves **objective one** by understanding the concept of e- waste, its composition & the management of e- waste with harmful impacts on human health in India.

This chapter deals with **objectives two and three** by assessing the formal & informal management of e- waste in the study area & studying impacts of informal management of e- waste on the human health & their neighborhood.

For objective two that is the assessment of formal management of e- waste in the study area considered population & growth rate of the study area which shows the quantum of the generation of e- waste, location of collection centers for e- waste, transportation of e-waste to the disposal sites & the capacity with the location of disposal sites for the e-waste to identify the gap in the system leading to the rise of the informal sector.

For achieving objective three, the assessment of informal management of e- waste in the study area considered the source of the e- waste in informal clusters, the collection mode of the e-waste & disposal practices that cause harmful impact on human health directly or through the degradation of the environment. Landuse analysis is considered for the analysis of impacted areas spatially. Health-related cases were shown in the study area similar symptoms faced by the informal e- waste cluster. Detailed study is conducted on the disposal practices of e- waste in

the informal sector that have impacts on human health. Through the detailed study of causes of health problems was identified directly & through environmental degradation like air & ground water quality on human health.

3.3.1 E-waste scenario in the study area.

As already mentioned in the introduction, there are two systems of E- waste handling in India. In Table 4, the total generation of E- waste in India & Delhi is tabulated. But now, the scenario is changing. E- waste management in Delhi is handled by the central pollution control board. Now, 30% of the total E- waste is handled by the formal sector as per EPR collection targets & 70% of E- waste is handled by the informal sector. It is estimated that the total generation of E- waste in Delhi is 97000 MTA out of which, it is estimated that 29100 MTA is handled by the formal sector & 67900 MTA is handled by the informal sector Table 16.

Table 16: Quantity of E- waste in Delhi is handled by formal & informal sector

Total Generation of E-waste in Delhi	Handled by formal sector	Handled by the informal sector
97000MTA	29100 MTA	67900 MTA

Source: Author generated based on CPCB data

From This Total generation of 97000 MTA, 35% of E-waste is Generated by East Delhi that is 33,950 MTA.

3.4 Assessment of Formal E- waste management in the study area.

For achieving objective 2, assessment of formal management of e- waste is considered with all the steps to identify the gaps in the management.

The study area followed EPR Under E- waste management rules & regulation,2016. The handling of e- waste by the Formal sector is a very scientific & technology-oriented process as shown in Figure 15. In the study area, e- waste is entered into formal recycling through EPR authorization provided by CPCB. The collection center to collect e- waste from consumer & bulk consumers. These collection centers sent E- waste to producers under the takeback system. The producer transport this E- waste to the authorized recycling/dismantling center.

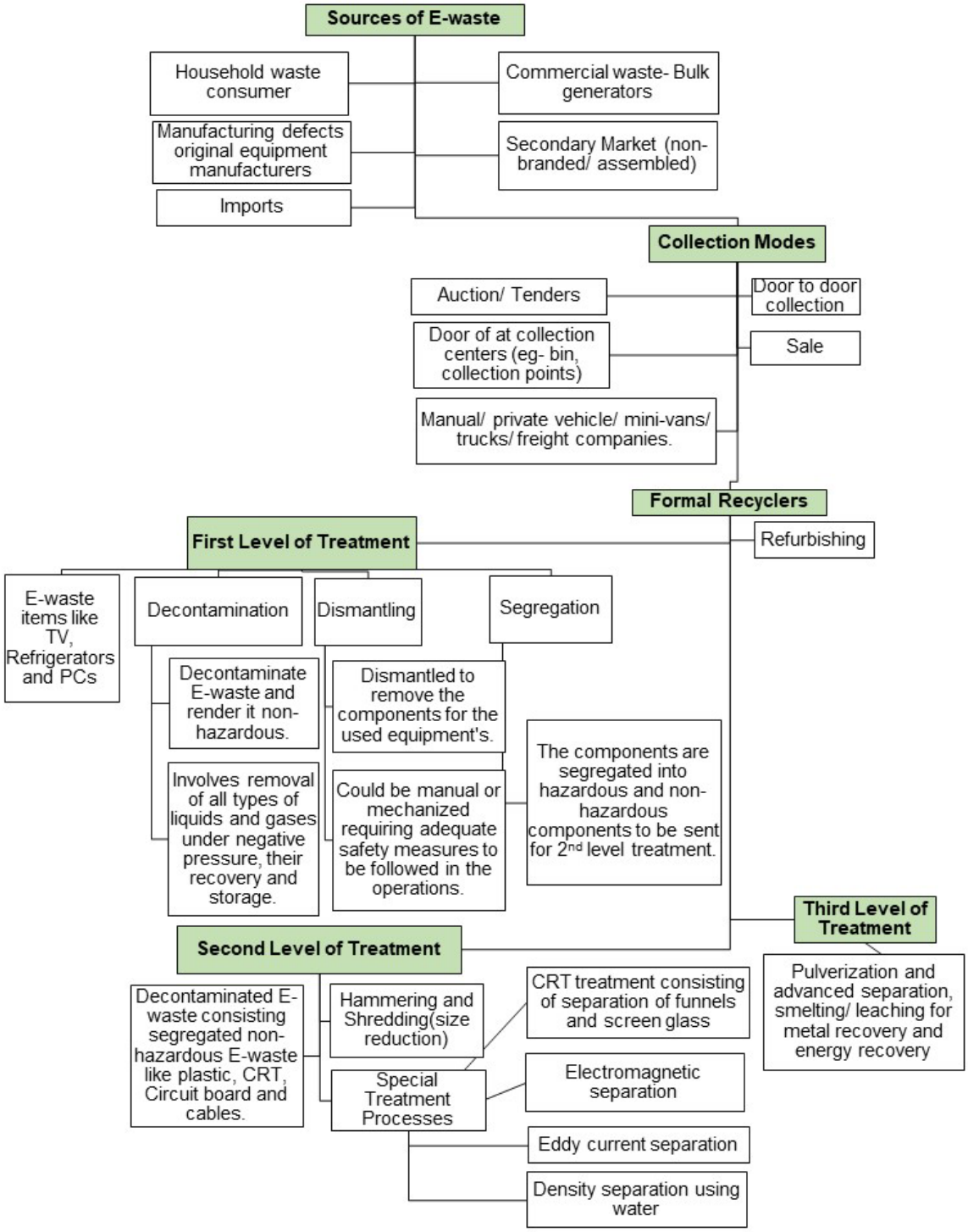

Figure 15: Process Diagram of Formal e-waste management in the study area

Source: Author

This process emits pollutants so careful implementation is required. Almost 95 % of metals can be recovered from this process.

3.4.1 Collection of E-waste

There are 34 collection centers in the East Delhi municipal corporation area. All the collection centers in the area are under EPR authorization of the central pollution control board as shown in Figure 16.

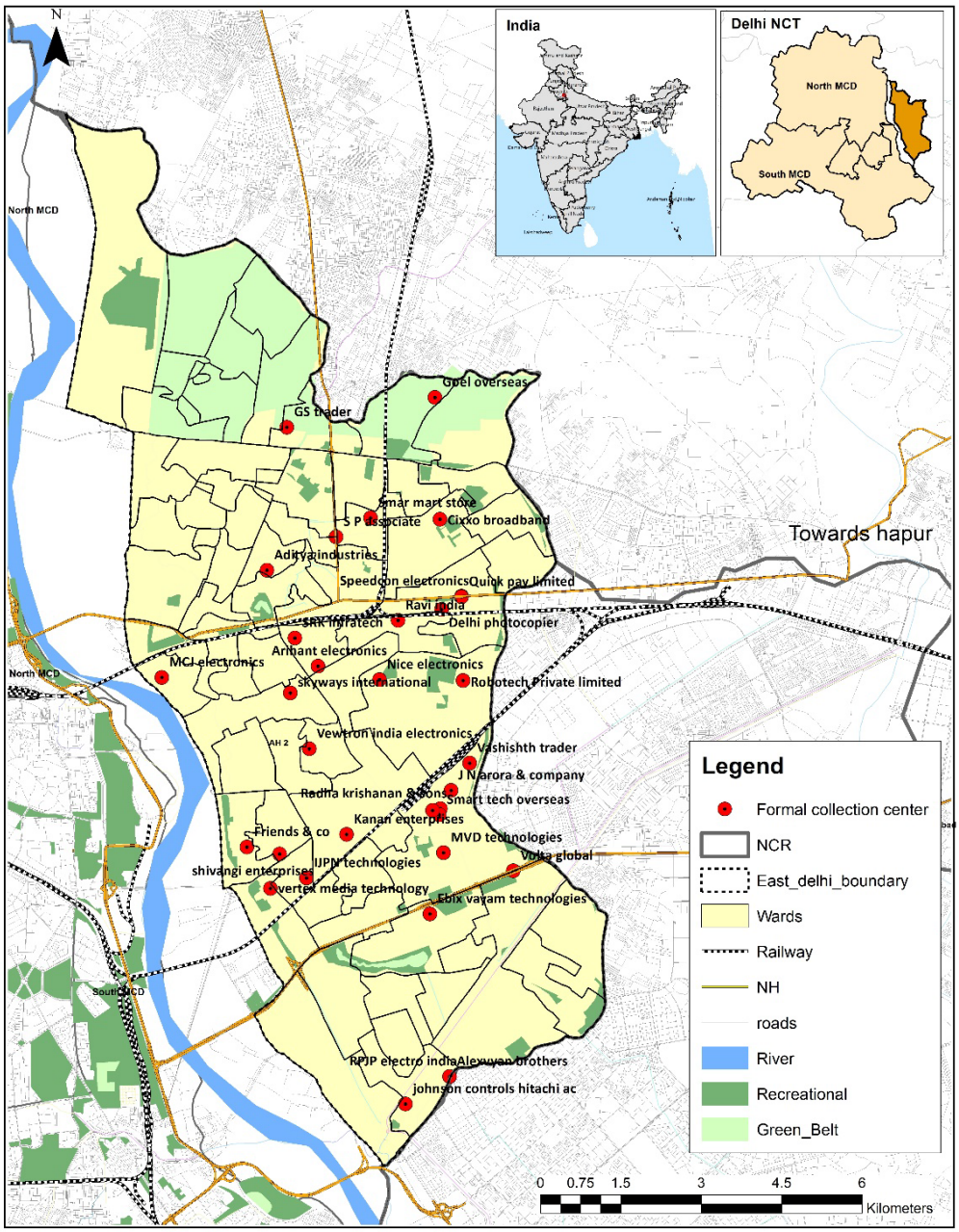

Figure 16: Collection centers of E-waste in East Delhi

Source: Author generated based on CPCB

These collection centers are registered with terms like the type of E-waste & collection targets under EPR specified by CPCB. In Delhi, E-waste handling is restricted only to collection, segregation & storage only by EPR authorization from

CPCB. E- waste recycling is strictly banned in NCT Delhi by the Delhi pollution control board. Producers, manufacturers, Dismantler & recycler have authorization from CPCB & SPCB

3.4.2 Transportation of E-waste

Collected E-waste from collection centers & producers arranges transporter through Tender Under CPCB authorization. To transport the e-waste from collection centers to recycler carefully

3.4.3 Disposal of e- waste

There are 35 recycling centers in the NCR as shown in Figure 17.

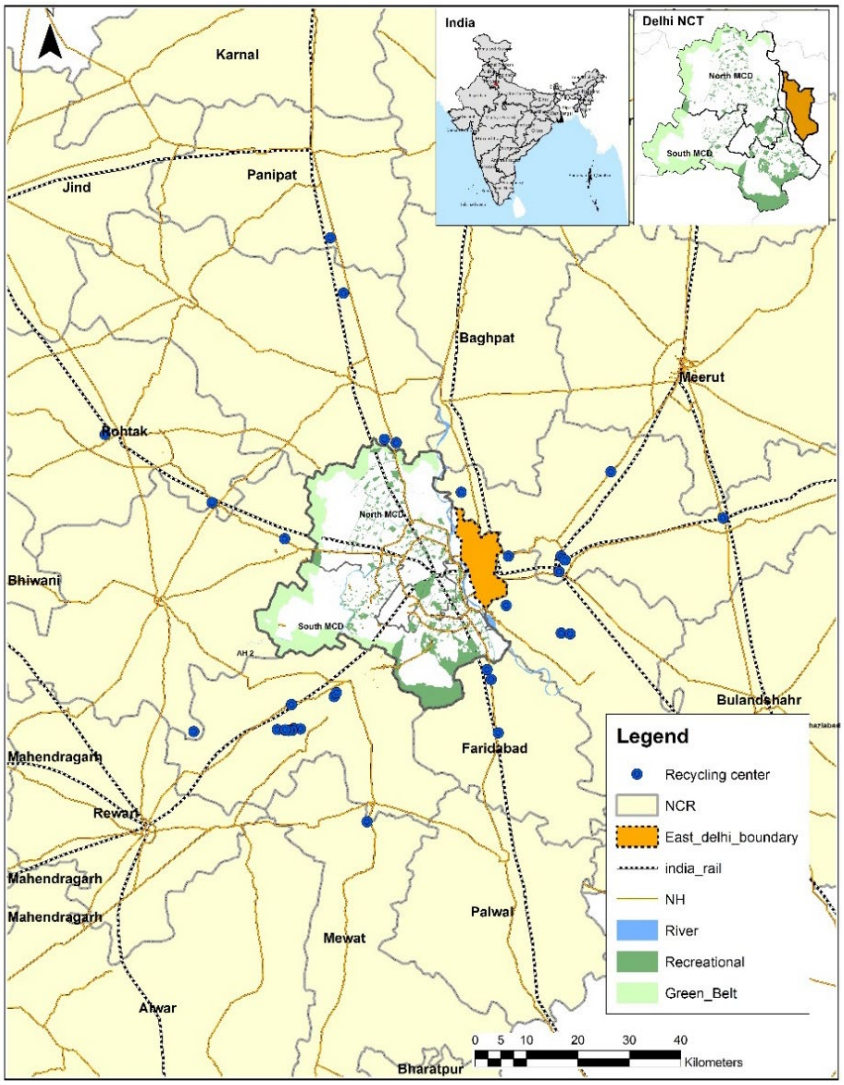

Figure 17: Formal Recycling Centers in Delhi NCR

Source: Author generated based on CPCB Data

In Delhi, there are no recycling centers so that they transfer to the nearest recycling center. So, the authorized collection sent their waste to the nearest recycling center. The capacity of these E- waste recyclers are as shown in Table 17.

Table 17: List of E- waste recycler With capacity

State	s.no	Name & Address	Installed capacity(MTA)
Haryana	1.	M/s A2Z E-waste management Ltd, Nuh Mewat	2000
	2	M/s Giriraj.metal, Rohtak	2200
	3	M/s. Earth Waste Management (P) Ltd. Distt. Rohtak	600
	4	M/s. Exigo.Recycling Pvt. Ltd., Panipat	6000
	5	M/s. Green World International, Pvt. Ltd., Bahadugarh	5000
	6	M/s. R. K. .Enterprises (P) Ltd., Jhajjar	14640
	7	M/s. Green Vortex Waste Management, Manesar	1500
	8	M/s. Eco Friendly Metal Pvt. Ltd., Faridabad	1500
	9	M/s. E-Waste Solution, Faridabad	1000
	10	M/s. SMS Enterprises, Gurgaon	360
	11	M/s. Earth Sense Recycle, Pvt. Ltd., Gurgaon	2160
	12	M/s. Nirvana Recycling Pvt. Ltd., Gurugram	6030
	13	M/s. Namo E-Waste.Management Ltd., Faridabad	5796
	14	M/s. Deshwal Waste.Management Pvt. Ltd, Gurgaon	10000
	15	M/s. Tes Amm (India) Pvt. Ltd., Sonepat	12000
	16	M/s. 3R.Recyclers, Manesar	850
	17	M/s 3 R Recycler, Manesar Gurgaon	2994
	18	M/s. Satellite.Vision India, Sonipat.	4500
	19	M/s. Dlila Systems, Gurugram	474
	20	M/s. Apicem.Recyclers Pvt. Ltd., Gurugram	510
	21	M/s. KM Global E-Waste Private Limited, Gurugram	510
	22	M/s Global.waste Solutions, sonipat	2600
Uttar Pradesh	23	M/s. Auctus – E Recycling Solutions, Ghaziabad	1800
	24	Mahaluxmi metal Alloys (India), Ghaziabad	30000

	25	M/s. N.K. Products, , Ghaziabad	9000
	26	M/s Bharat Oil Co.E-18, Ghaziabad	4000
	27	M/s Plant Green Recycling Pvt. Ghaziabad	1500
	28	M/s. Rocket.Sales, Hapur	300
	29	M/s. Arsh Recycling Pvt. Ltd., Ghaziabad	15000
	30	M/s. Auctus.Recycling Solutions, Greater Noida	19500
	31	M/s. Sims Recycling Solutions Greater Noida	1250
	32	M/s Greeniva.Recycler Pvt. ltd., Hapur	1500
	33	M/s Life E-Recycling (p) Ltd, Hapur	9000
	34	M/s Rudra Interprises, Ghaziabad	6000
	35	M/s Faiz Recycling, Hapur	11000

Source: Author generated based on CPCB data

3.4.4 Inferences

From the overall concept of EPR, There is no monitoring & auditing is present to regulate the management. In the study area, there are government-provided collection centers as per EPR authorization to the manufacturer & the producers. But they do not prepare an inventory of the total collection of E- waste. Also, they don't have any records of the total collection. The annual report is prepared by CPCB. But, the authorized manufacturers & producers don't take it seriously.

For the formal sector of the study area, major challenge is the issue of awareness among consumers both business/IT as well as households. People are unaware of the E- waste and its consequences pertaining to that. Due to this reason, the actual e-waste collection & recycling by the formal sector is very low. The government spends around 80 % of their overall revenue on the awareness program rather than the recycling of more number of E- waste. Also, their awareness program restricted to high-income groups. so that, more than half of the population are unaware of the E- waste & they sell their E- waste to local kabadiwalas.

For the recycling of the E- waste, the Study area does not have any recycling centers as per the Delhi government. Due to this, the producers & manufacturers transfer this waste to the nearest recycling centers of NCR. But as compared to the generation of E- waste, the capacity of E- waste recycling centers is low to cater

to the extra E- waste of other cities. So, there is a gap in all stages of managementof E- waste which rise the informal sector. Also, these informal sectors handle maximum e-waste of the city in unauthorized areas.

3.5 Assessment of Informal E- waste management in the study area.

For achieving objectives 3, assessment of informal management in the study area & studying the impacts of informal disposal of e- waste on the human health of e-waste handlers & their neighborhood. The process of e- waste handling by the informal sector in the study area are shown in Figure 18.

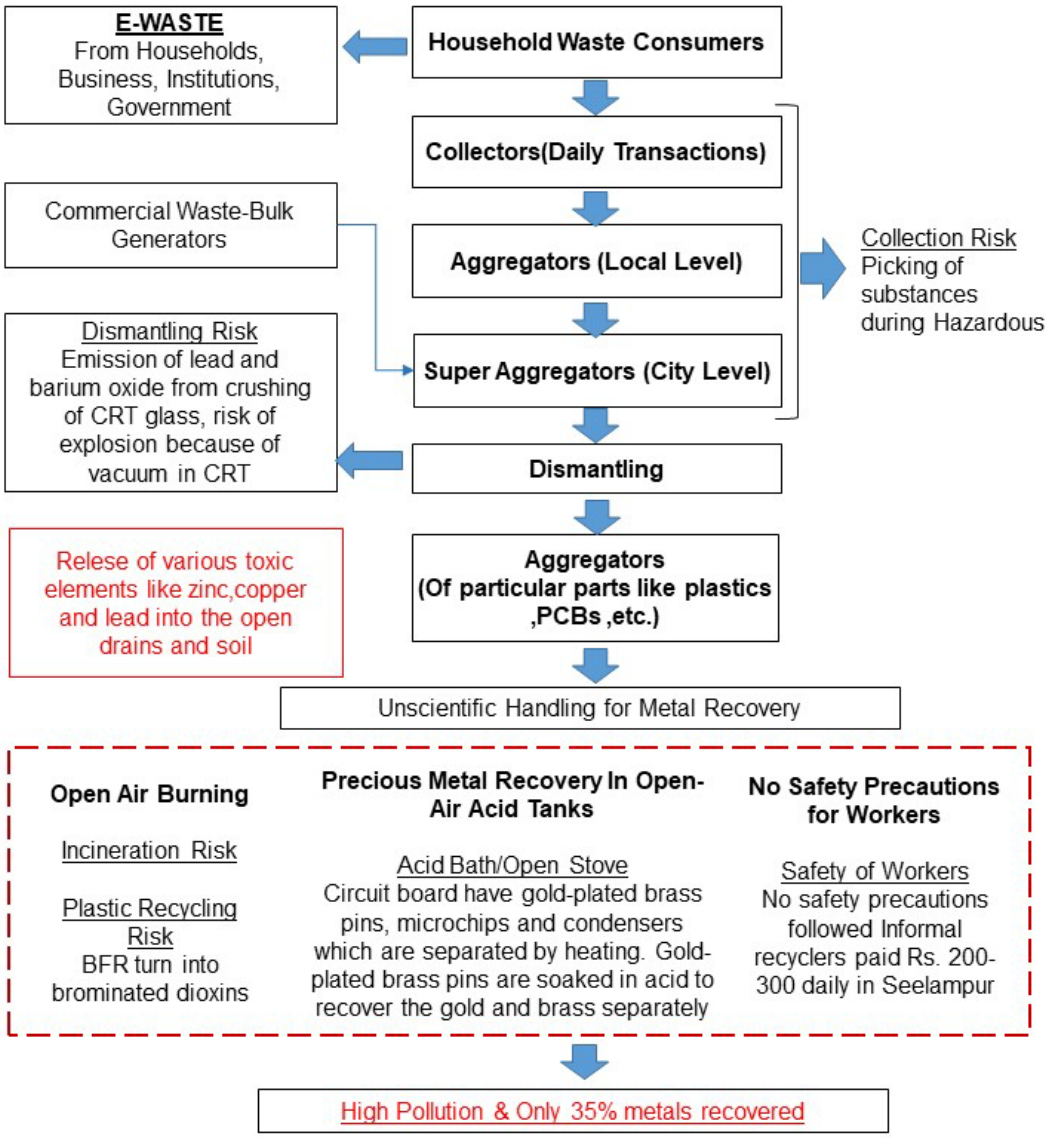

Figure 18: Process diagram of Informal E- waste handling in Study area.

Source: Author

For this, we are considering the analyses of direct impact of informal e- waste disposal on human health through primary survey & also indirect impacts by environmental indicators like air & water quality.In the study area, basic steps involved in the recycling of e- waste are the same as the formal sector but the manner of collection, segregation, dismantling & metal recovery is different.

These super aggregators are located in Seelampur, Shastri park, Mustafabad, Brijpur, Jafrabad, Seemapuri, and Mandoli as shown in Figure 19.

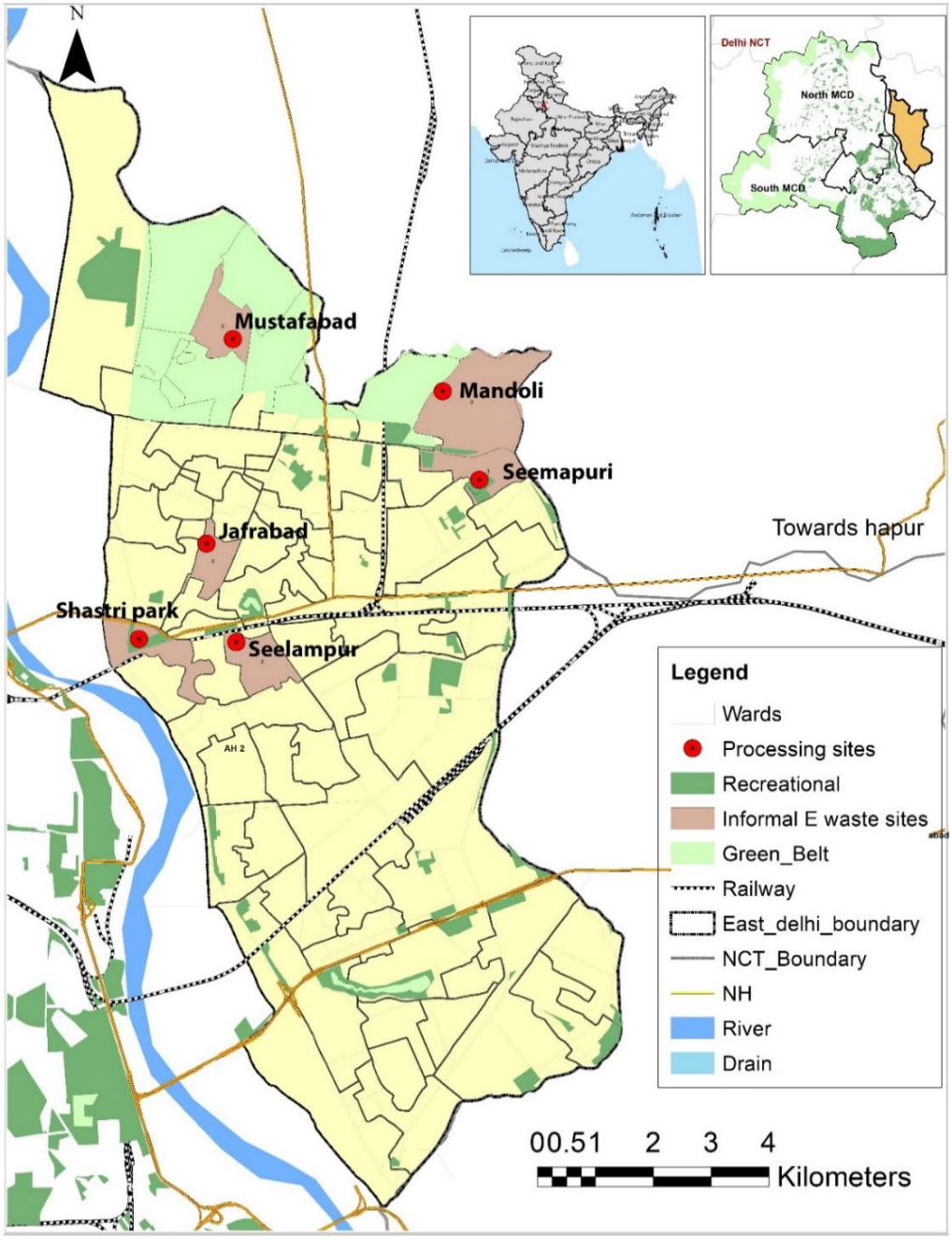

Figure 19: Location of Informal E- waste processing sites in study area

Source: Author

In this system, waste is taken from households, government institutions by collectors of E-waste household is the first level of collector. Then the local scrap dealers sell this waste to the super aggregators who especially deal with electronic waste. The super aggregators are also taking e-waste from consumers & bulk consumers by tender process or by private dealing. The collection is the toughest part of the informal sector recycling handlers. No one actually knows where all the electronic waste reached its endlife. Even if it has reached its end life, people would not dispose it off & keep hoarding it in their premises. Hence, the collection becomes a big step & no one from the formal sector can penetrate so much that they can go to each house collecting end of life electronic products.

These super aggregators then dismantle the electronic waste manually into raw material like metals, plastics & glass. Then, it is sent to specialized aggregators of particular parts like plastics, PCB, etc These aggregators try to extract metals from these parts which includes various unscientific measures causing danger to human health & environment.

3.5.1 Informal E- waste processing clusters

To understand the informal e- waste management, Semi-structured interviews were structured for selected detailed study sites as mentioned in section 3.2.3. Also, to understand the issues faces by the E-waste handlers & surrounding areas of all four sites that is **Seelampur, Shastri park, Mustafabad & Mandoli.** All these sites are located in East Delhi.

3.5.1.1 Seelampur

Seelampur is a business opportunity for a wide range of electronic pieces due to the broad disassembling of PCs, TVs, and telephones. Seelampur is overwhelmed by traders who utilize laborers normally migrant population for segregation, reuse and disassembling of electronic items.

3.5.1.2 Shastri park

In the Shastri Park area, The dismantling and recycling business utilizes around half population(in each second place) of Shastri Park which incorporates ladies

and children moreover. They are principally occupied with segregation and disassembling activities of PC and its peripherals, fridges, stabilizers and climate control systems. A portion of the dismantlers in this zone is doing this business for a few decades.

3.5.1.3 Mandoli

In mandoli, this is an Industrial area with reusing and handling of e-waste utilizing wet extraction forms with little command over the vapor and discharges of strong and fluid waste. The units are little scope enterprises with high divider and channel entryways. The business proprietors were either inaccessible at the local or if present, they were not prepared to talk on the issue. The spot was tarnished all around with yellow exhaust of water Regia utilized for extraction of metals and dark shaded emanating and deposits overflowed.

3.5.1.4 Mustafabad

In Mustafabad, there are lanes for the E-waste dismantlers. They were also primarily occupied with the segregation, dismantling & recycling of E- waste parts. It's a huge market place that deals only with the e-waste components & spare parts. They extracted the metals from E- waste

3.5.2 Source of E- waste

In all four sites, Sources of E- waste is different in categories & the cities of the Imported E- waste. Also, the type of E- wastes is mainly information & technology equipment & consumer electronics.

3.5.2.1 Categories of E- waste

As per the responses of the interview, it is observed that the type of e- waste in the informal sector is mainly consumer electrical & electronic equipment like television, motors, inverters, cables & refrigerator & IT equipment like mobiles & computers as shown in Figure 20. In Seelampur & Mustafabad areas, It is also observed that the inflow of Consumer electronics waste is more like tv, motors, invertors & cables. Also, Information technology & telecommunication equipment are also handled by both areas. The inflow of consumer electronics & IT equipment

is lesser in Shastri park & Mandoli areas. It is observed that Seelampur & Mustafabad areas are very older areas of informal e- waste processing.

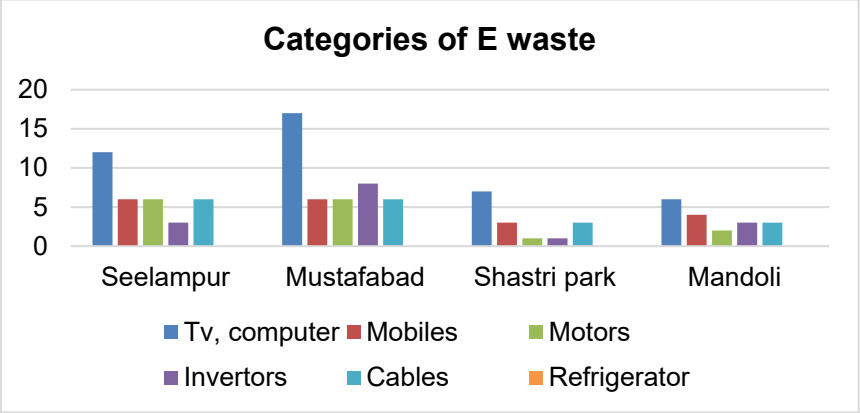

Figure 20: Categories of E-waste handled by Informal sector

Source: Author

3.5.2.2 Imported e-waste

It is also observed that in the survey, the E- waste is coming from different cities all over India & some of the waste is imported from other developed countries. Some of the interviewees were saying in the interview that e-waste is coming from cities like Chennai, Kerala, Uttar Pradesh, Haryana, Mumbai, Kanpur, Delhi & also from seelampur which is in Delhi for dismantling & recycling as shown in Figure 21.

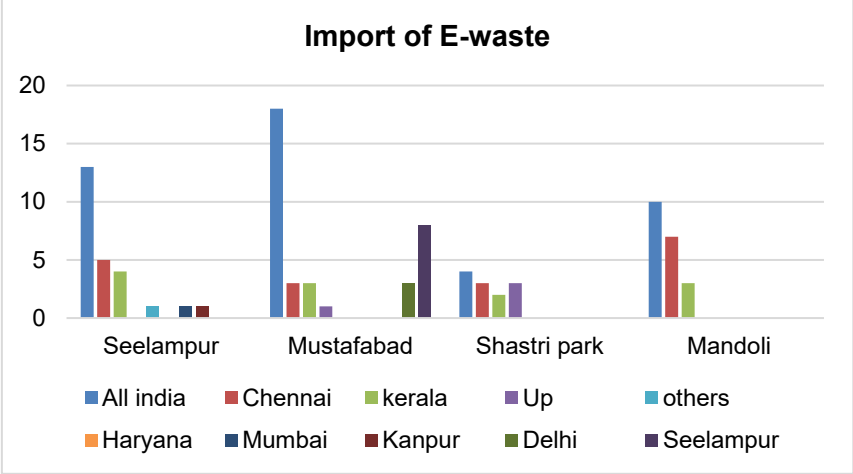

Figure 21: Imported e-waste from states of India

Source: Author

It is found that in Seelampur most of the e-waste is coming from all over India, Chennai & Kerala. In mustafabad, the situation is the same as seelampur but

seelampur is also sent parts of e-waste for further dismantling & metal extraction to mustafabad. In shastri park, mostly e-waste comes from Chennai, Kerala & Uttar Pradesh.

3.5.3 Collection of E- waste

As per interview, it is found that e-waste comes through bulk consumers is in all the areas & also from the individual consumers as shown in Figure 22. It is also found that the e-waste coming in all areas is through private suppliers. But some of the e-waste is also coming from local colonies through kabadiwala due to lack of awareness in the community. so they sell all the e-waste to kabadiwalas.In Seelampur, Bulk consumers are more than the individual consumers for the collection of E- waste. Scenario is the same in all four sites.

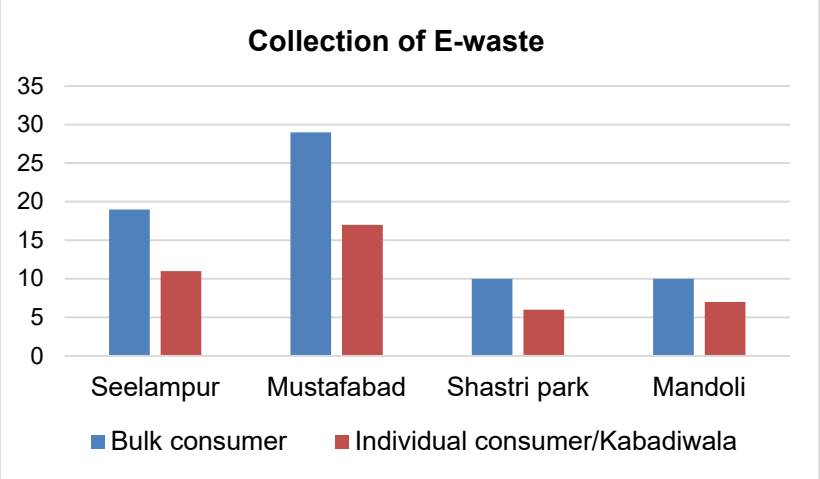

Figure 22: Collection of E-waste in Informal sector

Source: Author

3.5.4 Storage of E-waste

As we observed in all four sites, Handlers of E- waste has stored this e-waste in open shops or plastic whites bags as shown in Figure 23. Some pieces of motherboards, metals, plastics & wires are also found out outside the shops & in the open drains.

In seelampur , most e-waste is stored in bags & less in shops as shown in Figure 24. In mustafabad , most of the e-waste is stored in open shops. In Shastri park & mandoli area, Ewaste is found in open shops & in bags also.

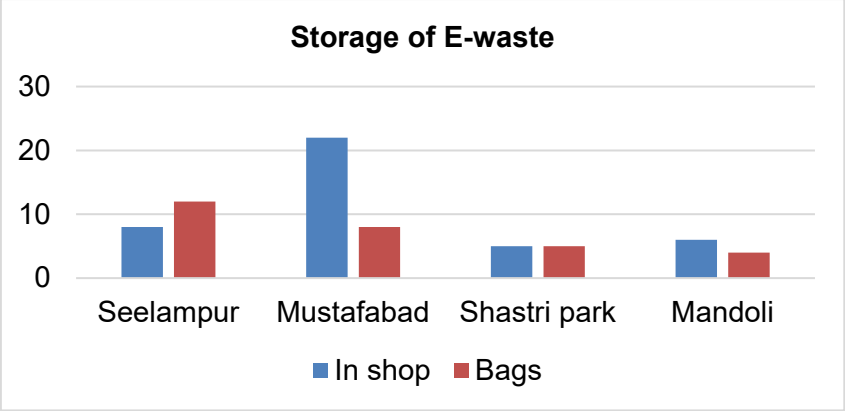

Figure 23: Storage of E-waste

Source: Author

Figure 24: Storage of E-waste in Seelampur

Source: Author

3.5.5 Disposal of E-waste

3.5.5.1 Processing of E- waste

In the interview, it is found that dismantling & recycling is happening in all four areas on the informal clusters. Mode of the processing of the E- waste is manual dismantling, dismantling by machine & recycling through acid bath & burning as shown in Figure 25. In manual dismantling utilizing simple tools like hammers, screwdrivers, chisel, etc. These e-waste handlers do not use any protective

equipment like gloves or masks and believe that there is no exposure to hazardous materials. Also, in some of the shops they were selling components of E- waste like wires and plastics. Manual dismantling & dismantling by machine is happening more in seelampur & mustafabad area as shown in Figure 26.

They break the e-waste into pieces of plastic & metals. In shastri park, all the activities like dismantling, recycling is happening equally. In seelampur & mandoli areas, recycling through burning/acid wash is more to extract the material without any safeguards.In shastri park , The recycling/dismantling units are located in the backyards or *godams* inside the houses.

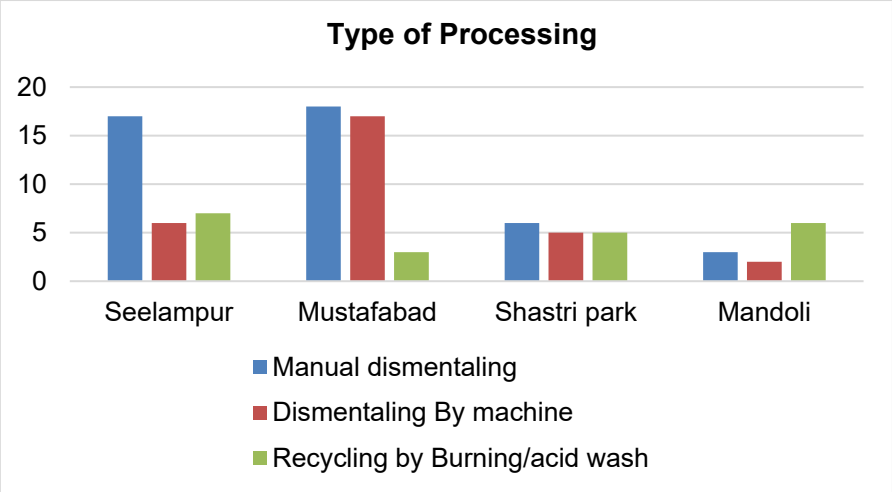

Figure 25: Types of processing in e-waste disposal

Source: Author

Figure 26: Manual Dismantling & dismantling of E-waste through compressor in Mustafabad

Source: Author

3.5.5.2 Metals Recovery

In all four sites(Seelampur, Mustafabad, Shastri park, Mandoli), After dismantling & recycling of e-waste maximum metal is extracted is copper, plastics, glass & gold as shown in Figure 27. They extract the metals from E-waste through dismantling, by the acid wash & burning of components as shown in Figure 28. And then they sell to the industries & in the local market for their benefit.

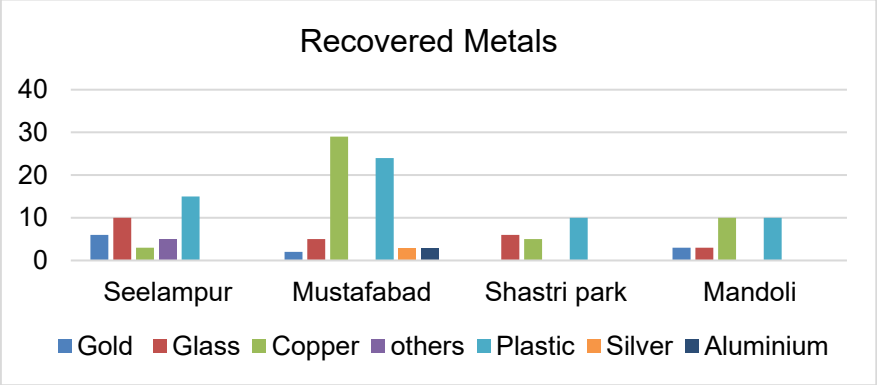

Figure 27: Recovered metals from E-waste

Source: Author

Figure 28: Metal Recovery from Acid Bath & smelting; dumping of residue in nalah.

Source: Author

3.5.5.3 Exporting of dismantled & extracted materials.

Dismantled e-waste & extracted materials are further sent to all over India & cities like Uttar Pradesh, Delhi, Ghaziabad, Mandoli, Mustafabad, Loni, Moradabad & Jaipur as shown in Figure 29. In seelampur , maximum Dismantled & extracted material sent to all over India, Ghaziabad, Mandoli & mustafabad. In Mustafabad , maximum Dismantled & extracted material sent to all India, Delhi, Uttar Pradesh & also in Moradabad. In Shastri park, they are sending this waste or components to the mustafabad & mandoli for recycling. Also in Seelampur & mustafabad, maximum dismantled waste like plastics, metals & wires are sell to industries. Handlers of Shastri park & mandoli areas are selling this material to industries as well as local people equally as shown in Figure 30.

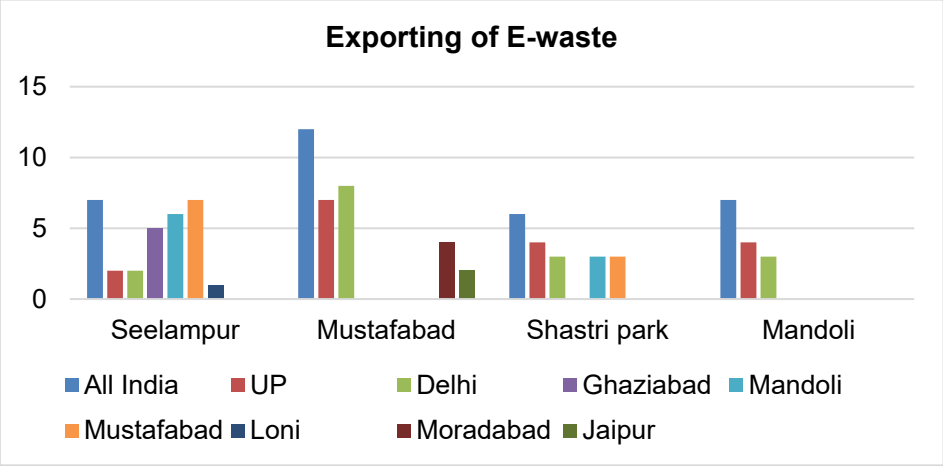

Figure 29: Exporting of E-waste to the states in India

Source: Author

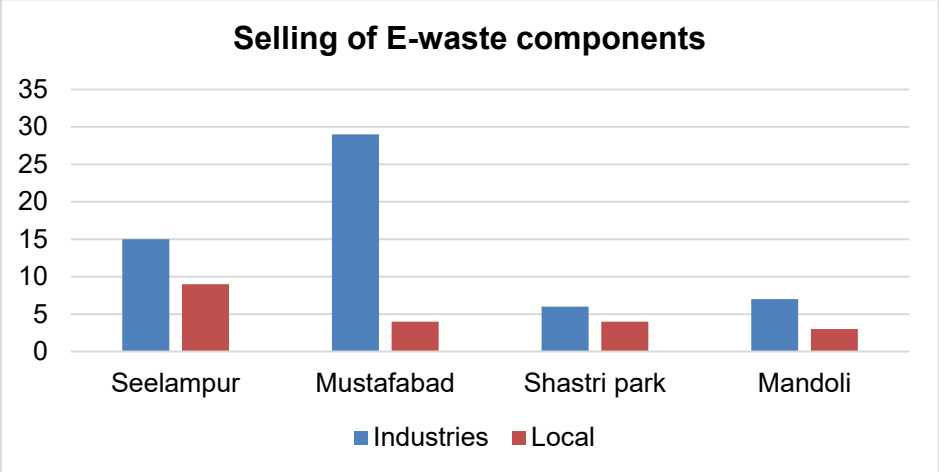

Figure 30: Selling of E-waste components

Source: Author

3.5.5.4 Dumping of Residue of E-waste

In the site survey, we observed that during dismantling & recycling through the acid wash & burning of waste the handlers are dumped it to the open drains & nalah as shown in Figure 31. In seelampur , most of the parts like plastics & metals, they sell it to the local dealers & also to the industries for the manufacturing of goods. Also in mustafabad , most of the parts they sell it to the industries & some residue they dump into the open drains.In shastri park & mandoli, they are selling the parts & also they dump the residual to the drains.

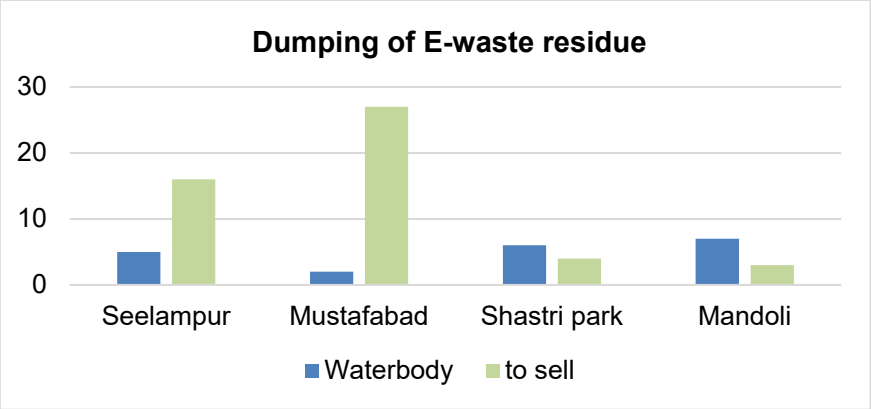

Figure 31: Dumping of E-waste residue

Source: Author

3.5.6 Supply & production chain of E-waste in the Informal sector

In the informal sector, local collectors & kabadiwalas play a major role in the supply chain. In this management, dismantling is involved first rather than recycling the product. People involved in this management collect the waste from the household consumers & institutes that come from the states like Punjab, Uttar Pradesh, Haryana, Banglore, Gujrat, Mumbai & Kanpur.

All the E-waste is stored in the open shops in Seelampur, Mustafabad, shastri park & mandoli in the East delhi. After that they dismantled this waste through the hammer, shredding & extract the metals from this waste.

The procedure they are using in this dismantling is very harmful. Then they sell the extracted metals to the industries in states like Uttar Pradesh, Chennai, Haryana, Jaipur, etc. The residue of the waste is dumped into the drains & water body. So they follow this chain as a regional level as shown in Figure 32.

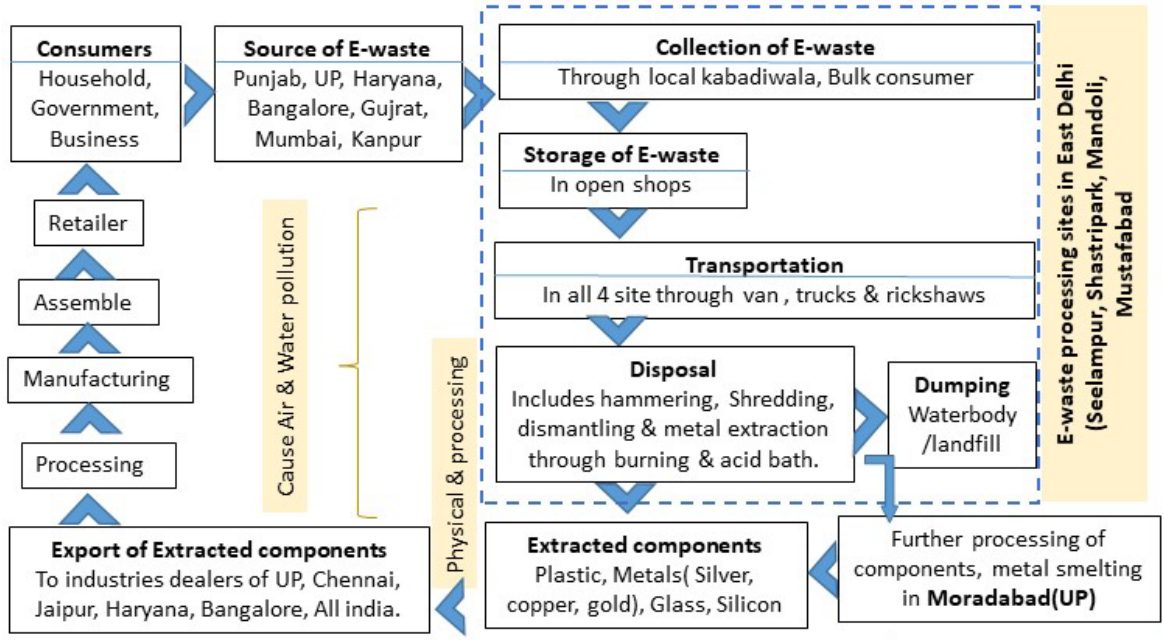

Figure 32: Supply & production chain of the informal sector

Source: Author

Route map of supply & production chain of informal sector as a regional level in india as shown in Figure 33

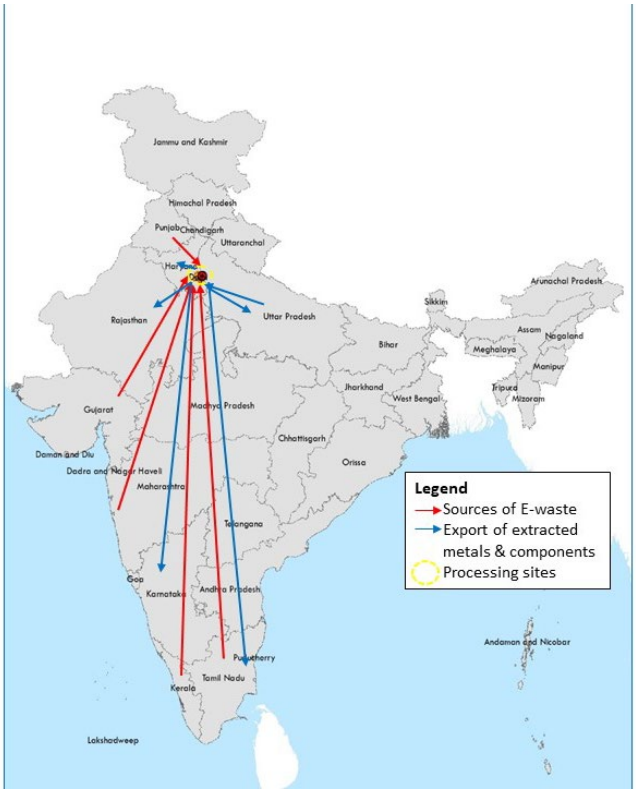

Figure 33: Supply & production chain in India

Source: Author

3.5.7 Role of NGOs for E-waste in Study Area.

NGOs for e-waste in study area are Sristi, Teri, Chintan environment & research, Toxic link, centre for science & environment which is located in Delhi.

Initiatives by the NGOs in study area- Management of e-waste provided by the NGOs with PRO, reverse logistics, Data destruction; Campaigning on the issue of safe management of e-waste ; Awareness building exercises;'Creating Safe Workplaces: E-waste Recycling Industry';Workshop on e-waste system failure ;Encouraged them to dispose

3.5.8 Inferences

In the informal sector, the availability of cheap labor along with the lack of implementation of rules & regulation has made the study area handle the E-waste informally in the unauthorized areas for the benefits of lower-income groups as a livelihood.In the study area, thousands of people are involved in the recycling of E-waste without registration. These people don't have enough money to register their shops. In most cases all family members are involved in this business. Based on participant observation and interviews of e-waste workers at all four sites during collection, dismantling/recycling, and disposal as shown in Table 18.

Table 18: Observed E-waste related activities & risk exposer.

E-waste activities	Characteristics of the Practices	Potential risk to health & environment
Collection	Collection of E-waste through bulk consumer & through local kabadiwalas, buying & searching discarded e-waste in pushcarts & mini-vans	Exposure to hazardous chemicals; potential health issues to skin & eye irritation due to cuts & burning.
Dismantling /Recycling	Manual dismantling; the process used in dismantling is rudimentary in which equipment such as stones, chisels & hammer to separate the material. Burning of cables & wires to extract metals	Lead dust fumes cause multiple disorders.

Disposal	Open burning of waste, dumping of waste & dumping of residue to the waterbody.	Exposure to dust fumes, burn, inhalation of dust fumes, dermal contact

Source: Author

People in these areas are unaware of the rules & regulations provided by the govt. It is a chain from bulk consumers & the industries through local people. People sell their e- waste to the kabadiwalas due to the unawareness of E- waste. Through these local kabadiwalas, people earn money by selling their waste. Informal e-waste handlers collect this E-waste through local kabadiwalas. People involved in this, break the end of life electronics outside the shops & on the roads.

Hazardous materials present in the E- waste is dismantled without any masks & gloves. They do not follow safety measures. Due to lack of infrastructure for dismantling & recycling of E- waste, they are doing these practices in houses & residential areas which is harmful to the whole community as shown in Figure 34. Also, they believe that they are not polluting the environment by just dismantling, recycling & segregation of the components & then sell to the small industries.

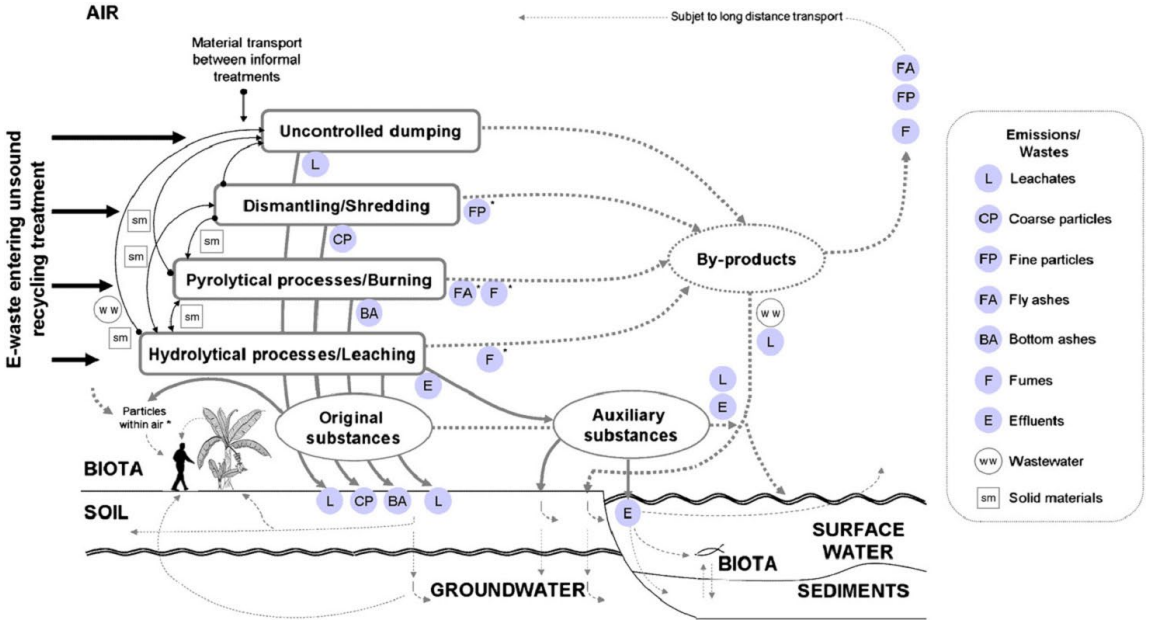

Figure 34: Emission of pollutants from informal recycling

Source: Toxic link (2018)

They accept that the open burning of wires or wet extraction chemical processes they are using is harmful to the environment but it is their livelihood. They also

believe that if these practices are noticed by the government, they will lose their livelihood.

3.6 Analysis of Environmental indicators of improper E-waste Processing on human health using comparative analysis of Standards.

3.6.1 Air Quality

The e- waste recycling activities from the above study can pose high risk to the environment and human health. E-waste consists of toxic metals such as Lead(Pb), Nickel(Ni), Cadmium(Cd), Chromium(cr), and precious metals such as gold, silver & aluminum. Because of their resistance to decomposition in natural conditions heavy metals are the most persistent pollutants in the environment. These activities may affect people exposed to such hazardous substances, including acute lung damage from heavy metal fumes such as Pb and Cd inhalation. Combustion from e-waste burning produces fine particulate matter which is linked to pulmonary and cardiovascular disease.

PM10 and PM2.5 have a clear association of these fractions of PM to adverse health effects. PM10 has heavy metals including lead, cadmium , Nickel, etc. Particulate contamination is a significant environmental problem primarily due to the prevalence of hazardous chemicals and trace metals in the atmosphere and its adverse effects on human health. Informal e-waste recycling activities such as open burning, dismantling, incineration, ash washing and acid baths, etc. release many toxic or hazardous substances such as heavy metals (Pb, Cd. Ni, Cu, and Zn), brominated flame retardants (BFRs), neurotoxins , and nitrogen and chlorine volatile compounds, etc. For the correlation analysis, from Cpcb & dpcc simultaneously collected samples of PM2.5, PM10 and its heavy of Lead(Pb) & nickel(ni) from all six East delhi stations.

Two station are under cpcb & four stations comes under dpcc. The mean concentration of PM10, PM2.5, Pb & Ni of a year is shown in Table 19

Table 19: Air quality data of East delhi

Stations	PM 10	PM 2.5	Ni	Pb
Sonia Vihar, Delhi - DPCC	175.43	101.47	16	0.5
IHBAS, Dilshad Garden, Delhi - CPCB	250	51.9	23	0.5
Vivek Vihar, Delhi - DPCC	169.86	100.39	26	0.3
East Arjun Nagar, Delhi - CPCB	160	90	25	0.8
Anand Vihar, Delhi - DPCC	325.79	176.46	38	0.31
Patparganj, Delhi - DPCC	162.95	92.47	28	.41

Source: Cpcb report,2019

3.6.1.1 Permissible limit for pollutant PM10, PM2.5, Lead(Pb) & Nickel (Ni)

In India, the Ministry of Atmosphere, Forestry & Climate Change revised its air quality standards. National environmental air quality standards (NAAQS) were laid down by the Government of India for pollutants such as PM10, PM2.5, sulphur dioxide (SO2) , carbon monoxide (CO), ground level ozone (O3) , nitrogen dioxide (NO2), ammonia (NH3), lead, arsenic, nickel, benzene and benzene (a) pyrene. The relevant national ambient air quality standards (NAAQS) are as shown in Table 20. National ambient air quality standards (NAAQS) help is an assessment of air quality concerning pollutants towards the environment as well as human health.

Table 20: National Ambient Air Quality Standards

Pollutant	Time Weighted Average	Concentration in Ambient Air- Industrial, Residential.
PM10 µg/m3	Annual*	60
	24 hours**	100
PM2.5µg/m3	Annual*	40
	24 hours**	60
Lead (Pb) µg/m3	Annual*	0.50
	24 hours**	1.0
Nickel (Ni), ng/m3	Annual*	20

Source: Ministry of Environment, forest & climate change

3.6.1.2 Mass concentration of PM10

In the study area, All the informal E- waste processing sites are near to the Anand Vihar station as shown in Figure 35. Maximum PM 10 concentration was recorded in the Anand Vihar station which is 325.79 ug/m3. After that, IHBAS, Dilshad garden station were recorded 250 ug/m3.

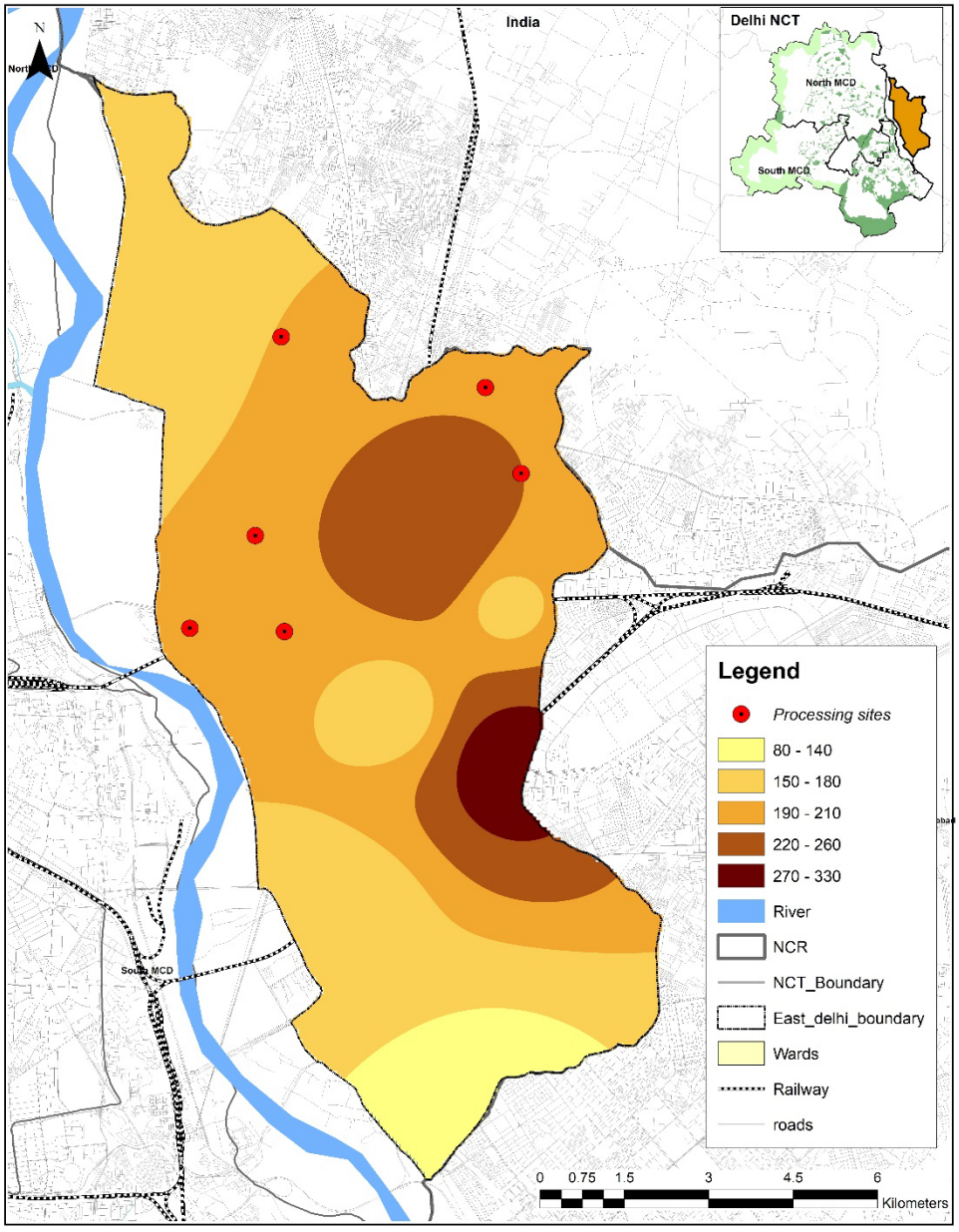

Figure 35: Air quality map of PM 10

Source: Author

Higher PM10 concentrations at the Anand vihar station could be induced by emissions from rough and incomplete e- waste processing activities such as

demolition, combustion, incineration and open burning. During the mechanical separation and dismantling of PCBs, fine particulate matter is released into the air which has negative environmental impacts.

3.6.1.3 Mass concentration of PM 2.5

In the study area, Maximum PM 2.5 concentration was recorded in the Anand Vihar station which is 176.46 ug/m3. After that, Vivek vihar station was recorded 100 ug/m3 as shown in Figure 36.

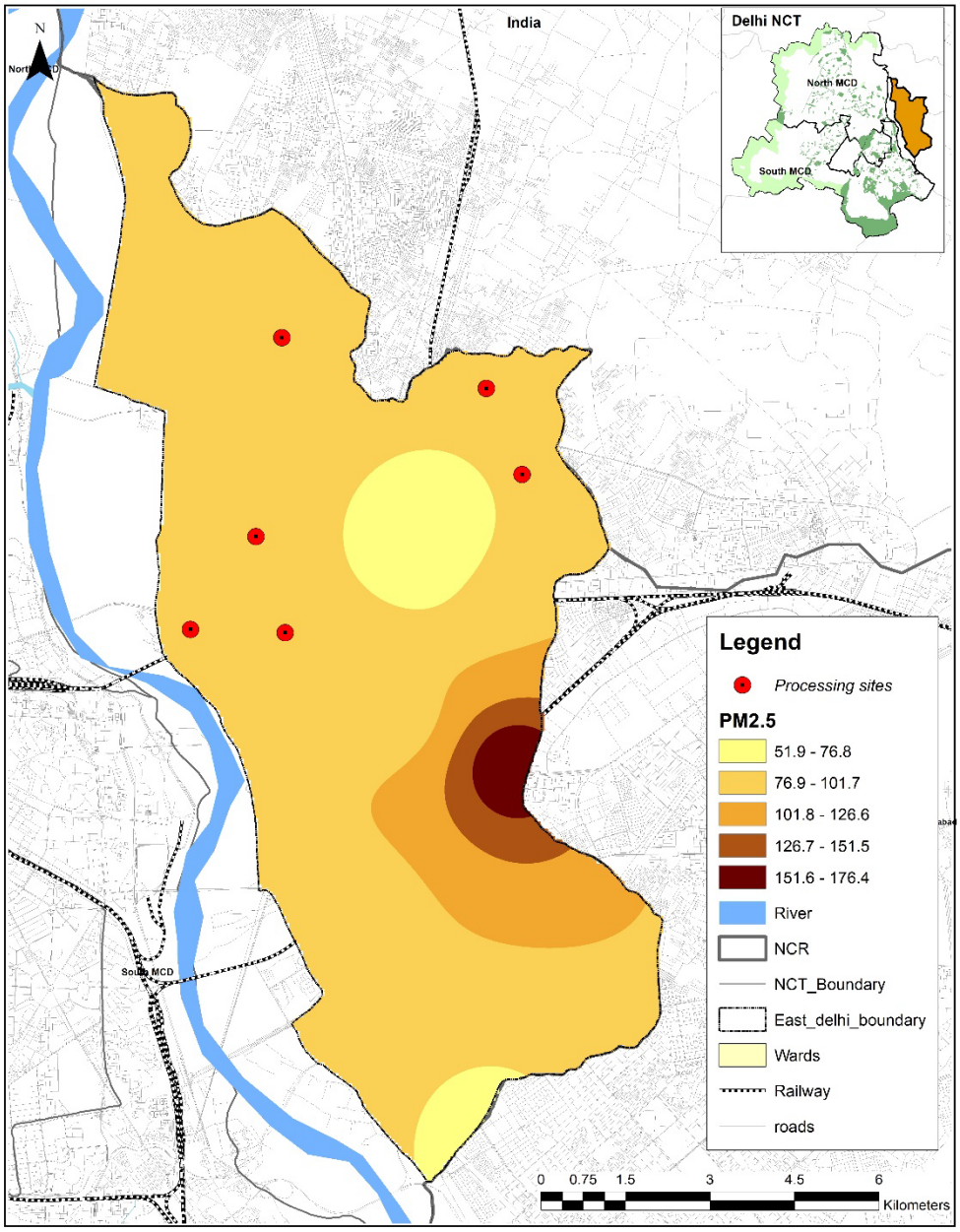

Figure 36: Air quality map of PM2.5

Source: Author

In all stations which exceeded the NAAQS (National Ambient Air Quality Standard) value , i.e. 100 µg / m3 (PM10) given by CPCB, high mean PM10 concentration was reported as shown in Figure 37. Which is harmful to human health.

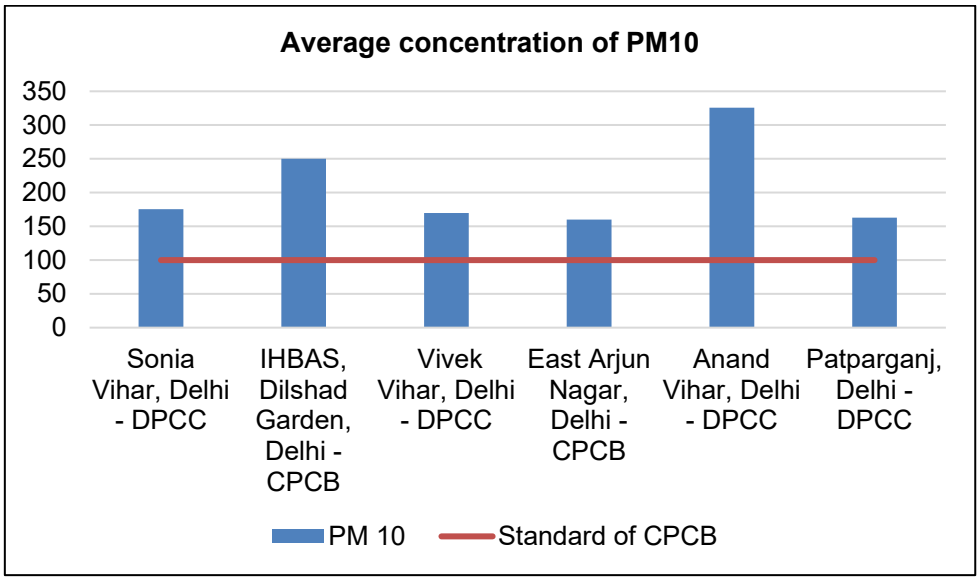

Figure 37: Average concentration of PM10 correlation with NAAQS

Source: Author

High mean PM2.5 concentration was reported at all stations except for IHBAS, dilshad garden, which exceeded the NAAQS (National Ambient Air Quality Standard) value , i.e. 60 µg / m3 (PM2.5) provided by CPCB as shown in Figure 38. Which is harmful to human health.

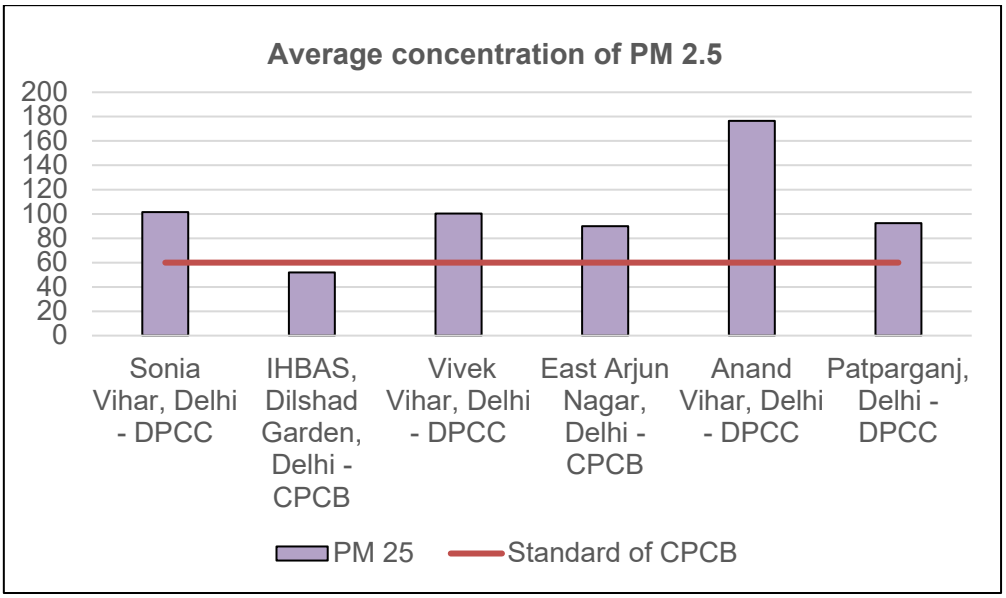

Figure 38: Average concentration of PM2.5 correlation with NAAQS

Source: Author

3.6.1.4 Mass concentration of Pb & Ni

The higher concentration of Pb at East Arjun Nagar station as shown in Figure 39. Mainly due to the burning of PCBs because Pb is the main component of e- waste.

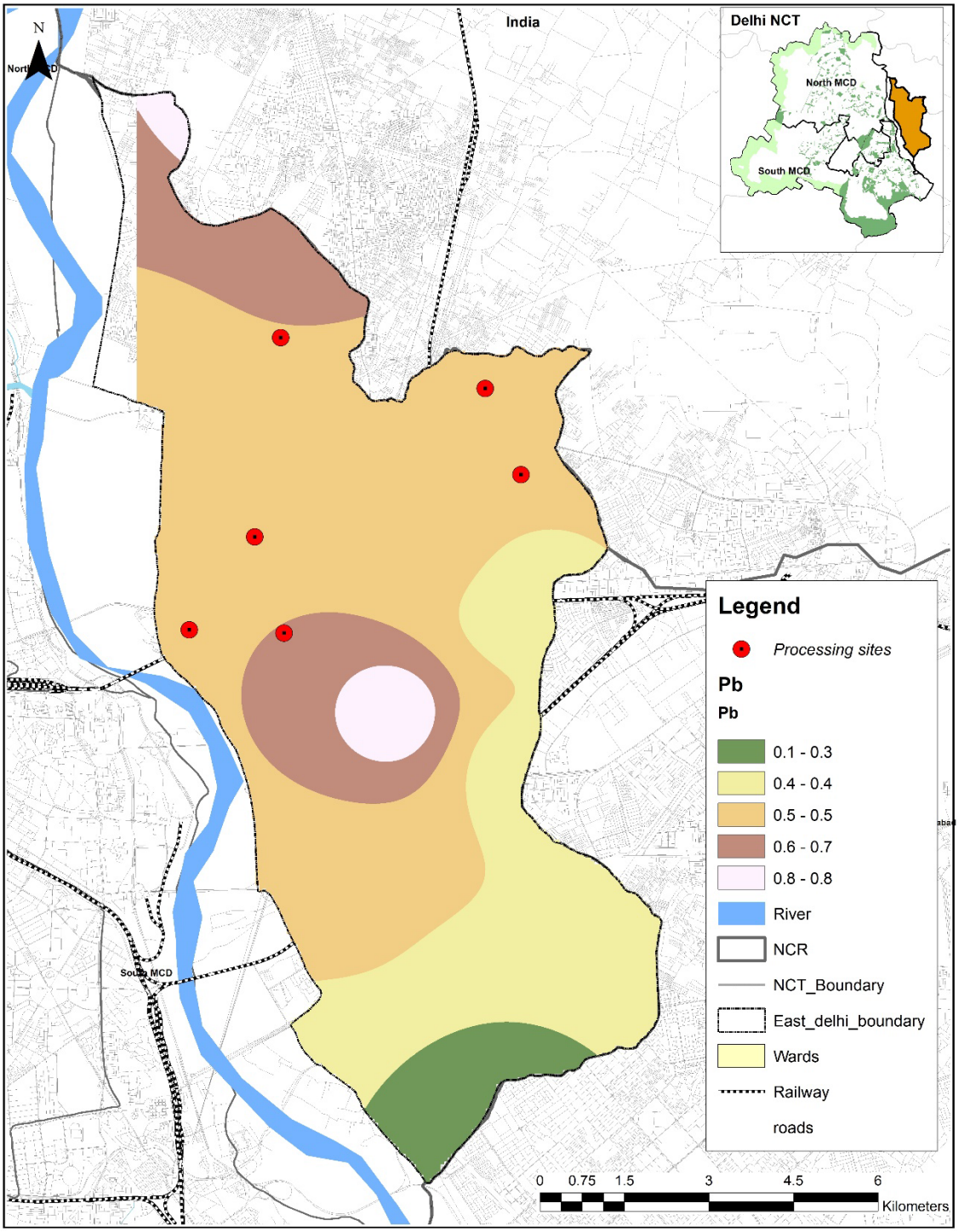

Figure 39: Air quality map of Lead (Pb)

Source: Author

Pb is released into the environment during burning process. So, lead is harmful to kidney & lung disease causing human health. Generally, informal recyclers use crude methods, such as burning and acid baths, to extract precious metals from PCB.The highest mean concentration of Ni was found at Anand vihar station as shown in Figure 40. Besides the processing of e-waste, Ni in the atmosphere originates from the smelting and combustion of fossil fuel , particularly oil.

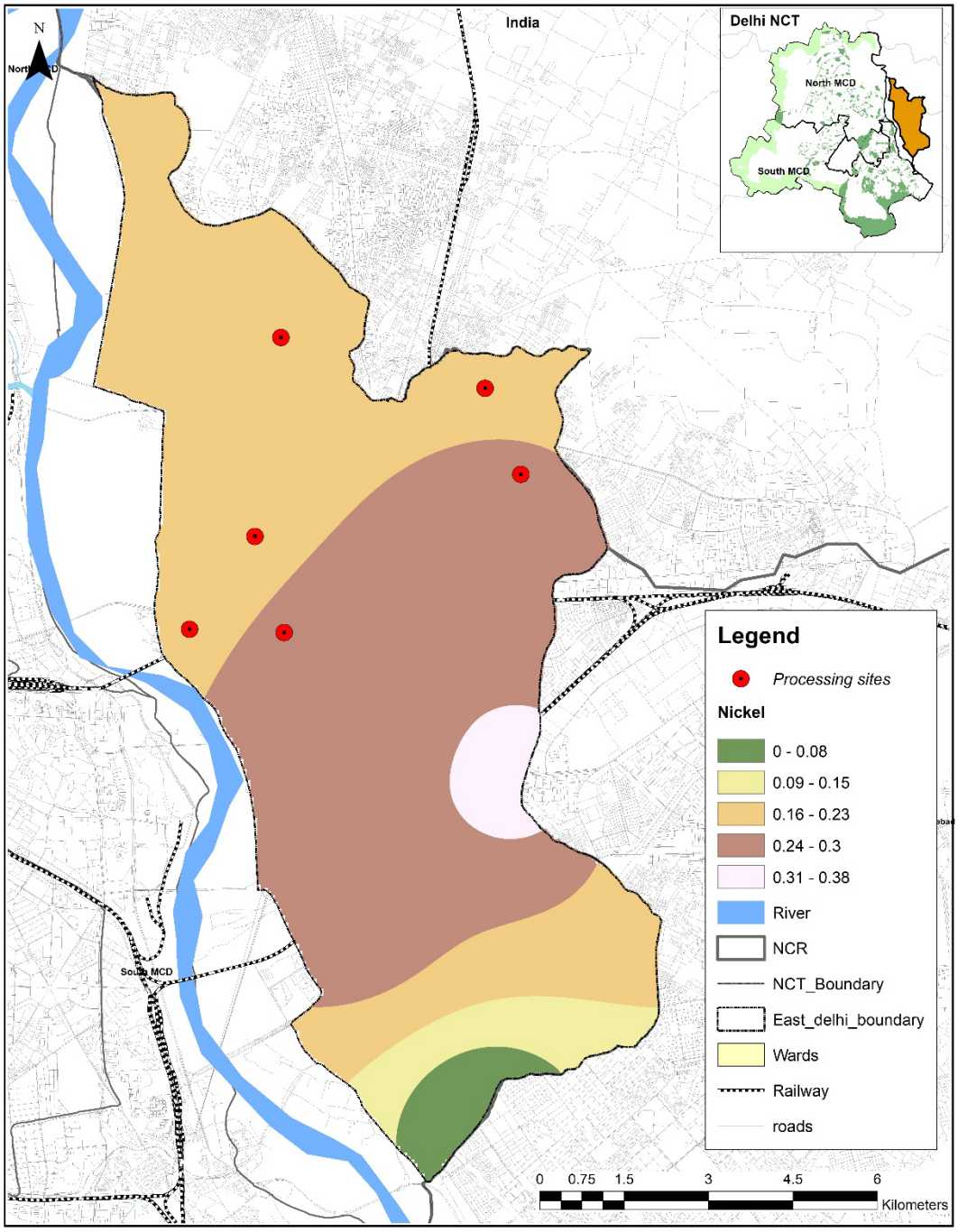

Figure 40: Air quality map of Nickel (Ni)

Source: Author

High Mean heavy metal Lead (Pb) concentration was recorded in East Arjun nagar station which exceeded the NAAQS (National Ambient Air Quality Standard) value i.e. 0.50 μ g/m3 given by CPCB as shown in Figure 41. Which is harmful to human health. Exposure to high levels of lead may cause anemia, weakness, kidney and brain damage.

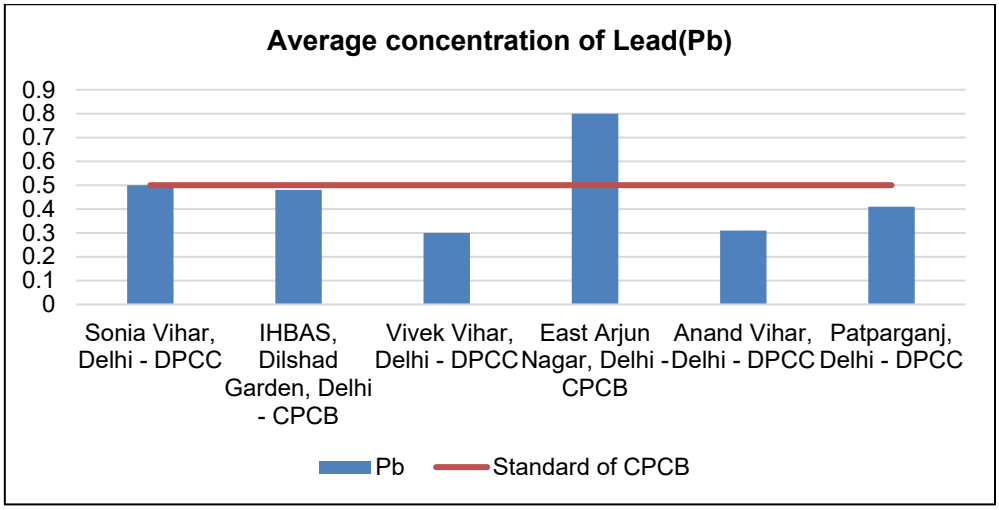

Figure 41: Average concentration of Lead(Pb) with NAAQS

Source: Author generated by CPCB data

High-mean concentration of heavy metal Nickel (Ni) was reported at the East Arjun Nagar station exceeding the NAAQS (National Ambient Air Quality Standard) value , i.e. 20 µg / m3 of CPCB as shown in Figure 42. Which is harmful to human health. Exposure to high levels of Nickel may cause eye & skin damage

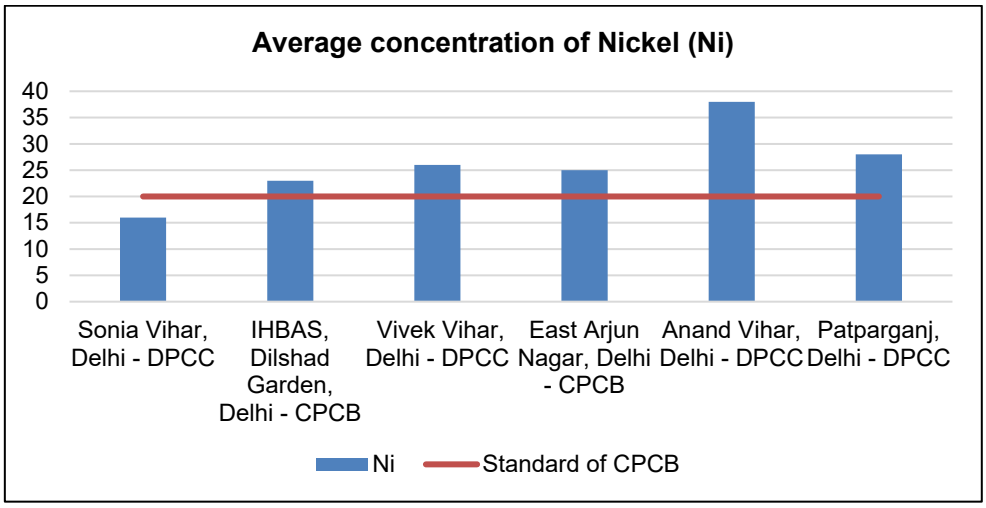

Figure 42: Average concentration of Nickel (Ni)

Source: Author generated by CPCB data

3.6.2 Inferences

Illegal e-waste recycling was an important reason to increase the focus of PM10, PM2.5, Pb & Ni, which exceeded the NAAQ standard given by CPCB at the recycling site for e- waste. In an illegal burning area, crude and simple e- waste preparation strategies by the casual area have all added to the elevated levels of air particulate matter , particularly substantial metal levels. Air contamination exposer due to e-waste preparation was in turn responsible for the residents' alarming levels of toxic heavy metal exposure, which was associated with a significant prevalence of cardiovascular morbidity, namely hypertension in the local residents. Such heavy metals affect human health.

3.6.3 Groundwater quality

From the above study, E-waste is consists of heavy metals that are toxic & could be hazardous for the environment as well as human health especially groundwater. E-Waste is one of the major up and coming contamination issues for the whole world in light of an assortment of poisonous substances present in it .The recovering of important and base metals is conceivable by reusing e-waste.

Informal e-waste disposal practices such as open burning, decommissioning, incineration, ash washing and acid bath, etc. produce many harmful or dangerous contaminants such as heavy metals (Pb, Cd, Ni, Cu, and Zn).After that residue dumped into the water body & the drain which is harmful to human health.Samples of heavy metals of Lead(Pb), nickel(ni), Arsenic(Ar), Cadmium(Cd), Chromium (Cr) were collected from all seven sampling sites of East Delhi are shown in Table 21 from central groundwater board. The mean concentration of Pb, Ni, Ar, Cd, Cr is shown in Figure 43.

Table 21: Groundwater quality data of East Delhi

Sampling sites	Chromium (Cr)	Nickel (Ni)	Arsenic (Ar)	Cadmium (Cd)	Lead(Pb)
Balbir Nagar DW	0.005	0.002	1	<1	<1
CBD Shahdara	0.005	0.002	1	<1	<1
Chilla Regulator	0.005	0.002	1	<1	<1
Gazi Pur Crossing	0.005	0.002	3.17	<1	<1

Jagatput Pz 1	0.005	0.002	1	<1	<1
Jheel Khoh DW	0.005	0.002	1	<1	<1
Mayur Vihar B Block Ph II	0.005	0.002	2.12	<1	<1

Source: Central Ground Water Board Annual report, 2019

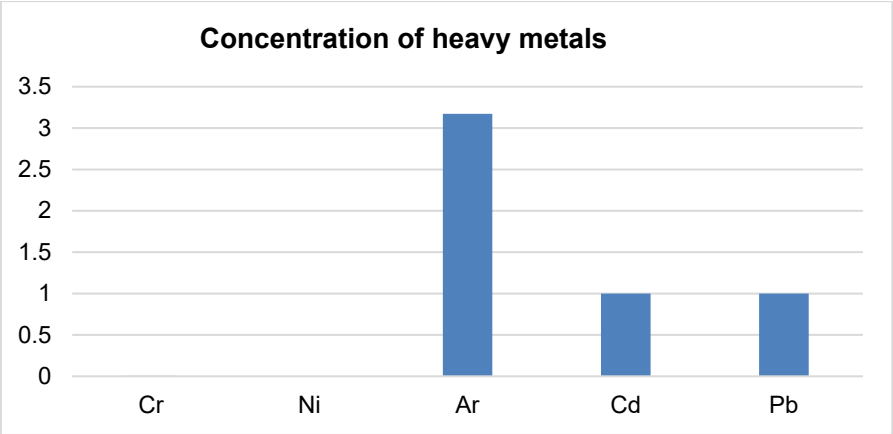

Figure 43: Concentration of heavy metals

Source: Autthor

3.6.3.1 Permissible limit for heavy metals in drinking Groundwater.

The drinking water quality standards describe the drinking water parameters that are set. Standards for the amount of heavy metals found in groundwater that is detrimental to human health have been established. This norm sets reasonable limits and permissible limits in the absence of alternates sources as shown in Table 22 .

Table 22: Permissible limit for heavy metals in drinking groundwater

S.No	Characteristics	Requirement (Acceptable Limit)	Permissible Limit in the Absence of Alternate Source
1	Cadmium (as Cd), mg/l, Max	0.003	No relaxation
2	Lead (as Pb), mg/l, Max	0.01	No relaxation
3	Total arsenic (as As), mg/l, Max	0.01	0.05
4	Total chromium (as Cr), mg/l, Max	0.05	No relaxation
5	Nickel (as Ni), mg/l, Max	0.02	No relaxation

Source: Central groundwater board

3.6.3.2 Mass concentration of Cadmium & lead.

In the study area, the concentration of heavy metals like cadmium & lead is uniform in the whole study area which is <1 mg/l as shown in Figure 44.

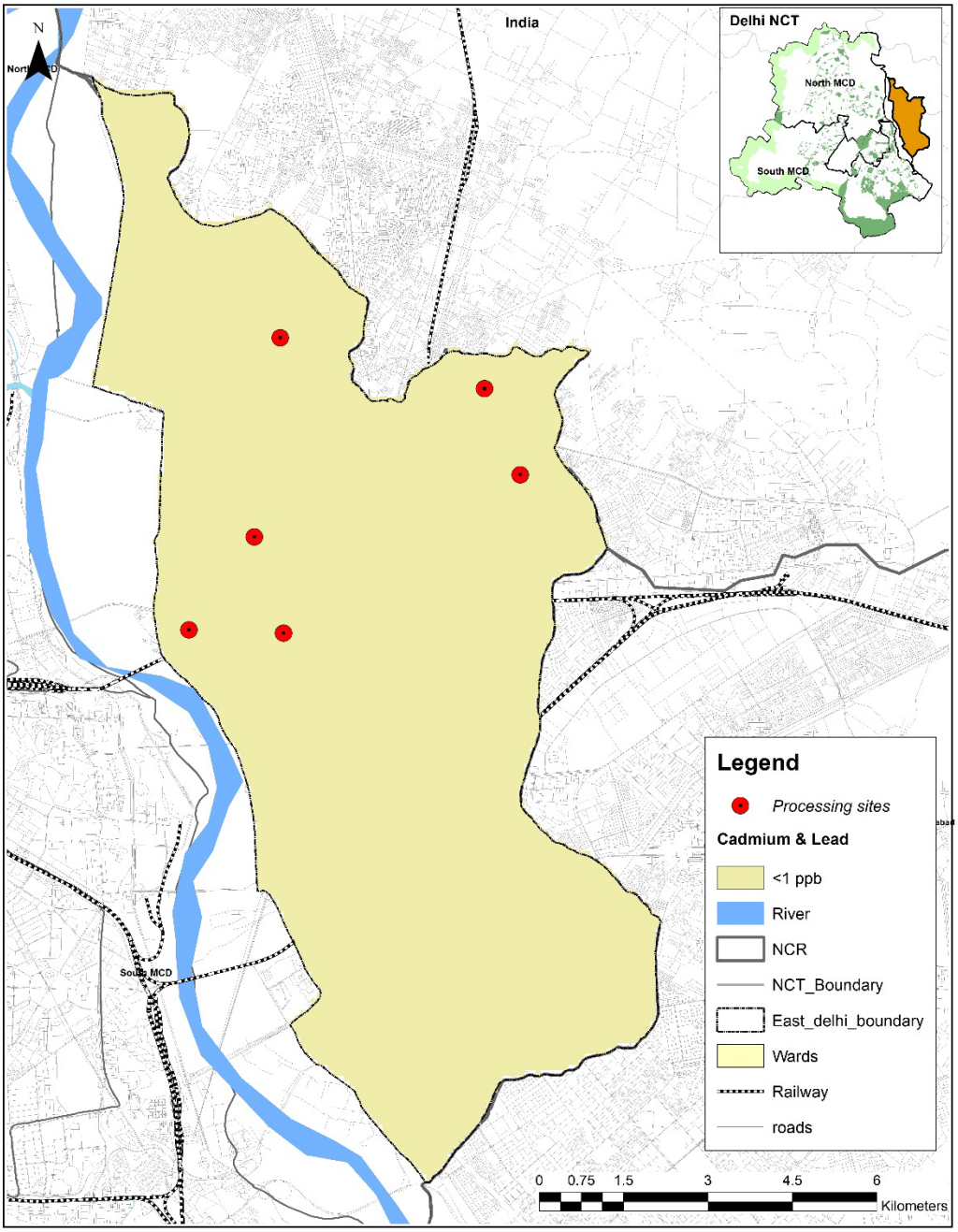

Figure 44: Groundwater quality map of Cadmium & lead

Source: Author

3.6.3.3 Mass concentration of Nickel

In the study area, the concentration of heavy metal like Nickel is uniform in the whole study area which is 0.02 mg/l as shown in Figure 45.

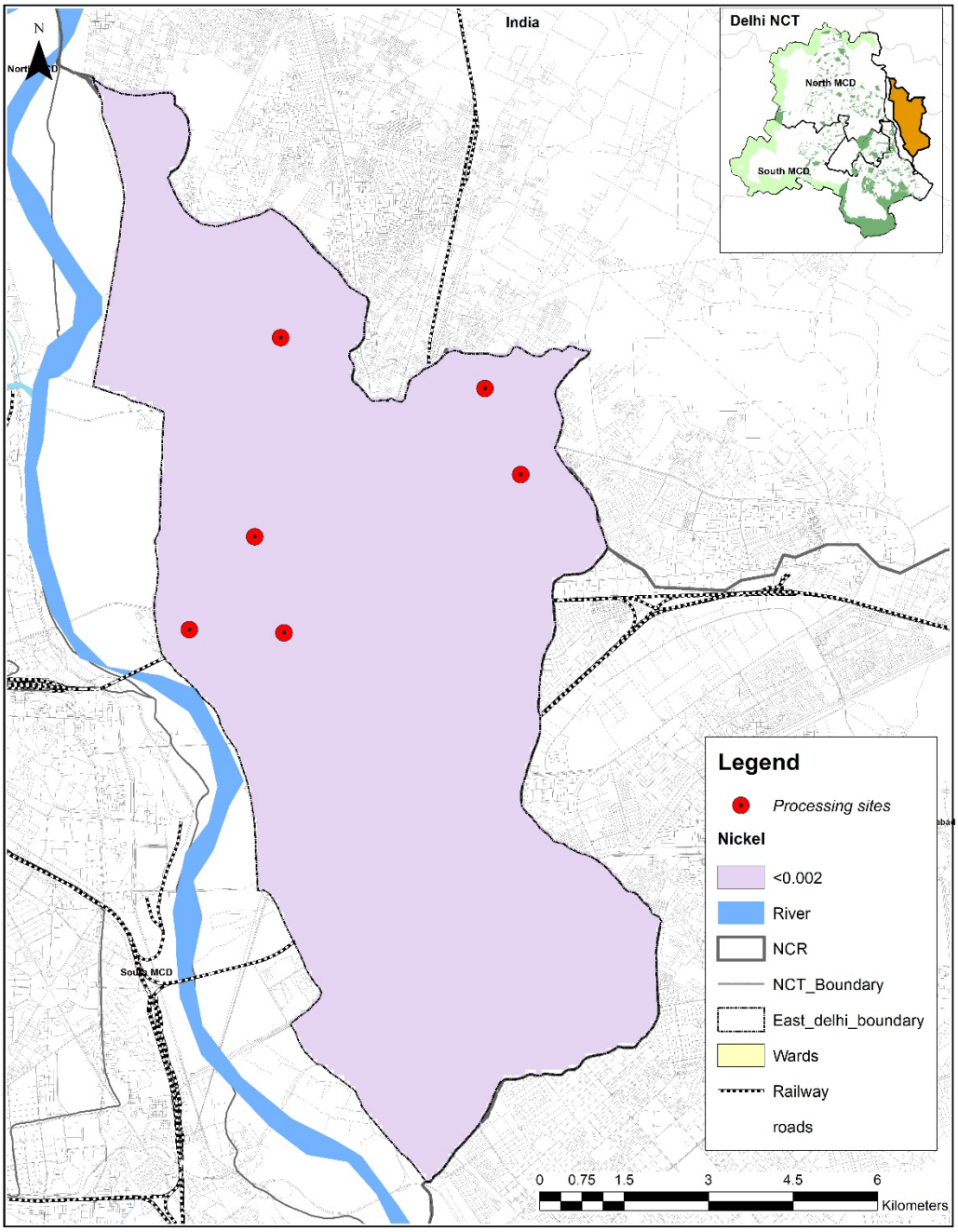

Figure 45: Groundwater quality map of Nickel

Source: Author

3.6.4 Inferences

Groundwater quality is degraded due to many factors like an increase in the generation of waste and through air pollution. From the above study, it is observed that the groundwater quality of the study area is degraded due to the informal e-waste practices.

It is also concluded that the rudimentary process used for the dismantling of E-waste is harmful to the environment & human health. Due to this process, After dismantling & recycling E-waste gets dumped into a nalah & leads leach into the water table causing a health problem. Also, Raw sewage of the city which is mixed with the E-waste components like acids, wires, plastic & glass pieces after dismantling is dumped in the river Yamuna which causes water pollution.

From the central groundwater board data, It is identified that theconcentration of heavy metals like lead(Pb), cadmium(Cd), arsenic(Ar), Chromium(Cr), And nickel (Ni) is high in groundwater of the study area. These heavy metals are also present in the components of E- waste. Due to the informal e- waste practices concentration in high & It is going beyond the standard set by the central groundwater board for drinking purposes which is harmful to human health. Also, it is identified that the informal processing of E- waste is harming human health indirectly through groundwater quality.

3.7 Direct impact analysis of E- waste Processing on human health

3.7.1 Health issues on E-waste handlers during dismantling & recycling

In the primary survey, it has been traced that during the recycling & dismantling of e- waste handlers are facing different health issues like skin & eye irritation, fever, headache, wounds & weakness as shown in Figure 46. Collection & transferring of E- waste cause wounds on hands, skin irritation, burning of hands due to handling of glass, sharp metals & acids present in the inverter batteries.

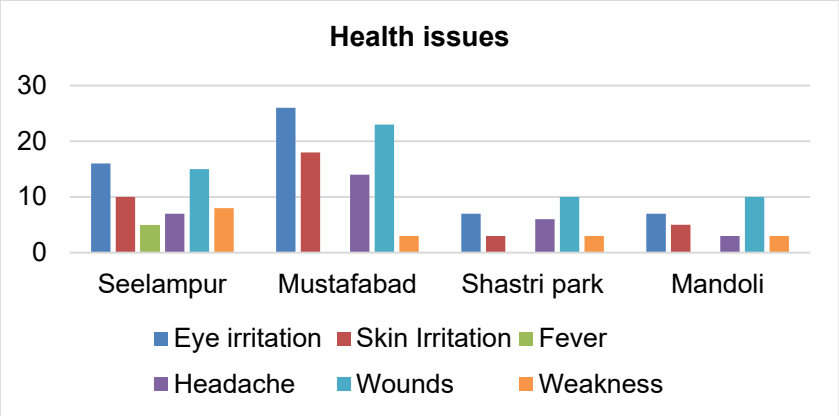

Figure 46: Health issues faced by the E- waste handlers

Source: Author

During dismantling & recycling of E- waste practices like cutting of metals through Liquified petroleum gas, dismantling of E-waste through chisel & hammer, metal extraction from burning & acid bath. All these practices are harmful to human health. These cause health issues like deep cuts on hands through glass, wires & sharp metal during the dismantling of components. Also, during metal extraction, they faced issues like eye irritation due to fumes in air, skin irritation & weakness. From all these health issues, after a long period, it will take the form of major health issues like skin cancer, lung cancer, breathing problem & brain damage due to its slow process.

In Seelampur, it is observed that the e-waste handlers during dismantling faced cuts in hands. Eye & skin irritation due to fumes or gases & acid presents in the e-waste. Due to these issues, they are facing weakness also due to this pollution which is harmful to the lungs & also for the brain. These health issues are found high in Seelampur area. In Mustafabad, major issues they are facing are eye & skin irritation, cuts on hands & headache. In Shastri park & Mandoli, acid wash & burning is high, so they faced cuts on hand & also eye & skin irritation.

They are dismantling & recycling the e-waste without any precautionary measures.

3.7.2 Health impacts on surrounding areas

In the survey of nearby surrounding areas, People facing different issues due to the processing of e-waste. Some of them were saying that due to loading unloading of e-waste from the truck causing noise pollution. Also, beating of hammer on the waste for dismantling causing noise pollution. People also said that most of the time roads are also block due to the movement of trucks full of e-waste. They are complaining about the littering of broken pieces of glasses on roads & also the burning of wires & plastics for metal extraction which cause air pollution. People complain that they through this waste in open drains & nalah that is connected with the Yamuna river.

Residential areas of Seelampur faced major health issues like headache due to noise pollution, also eye irritation, headache & shortening in the breath as shown in Figure 47. Most of the people are live here on rent on the upper floors of the shops. In Mustafabad, people faced eye irritation & headache due to the welding machine for cutting of metal without taking precautionary measures. In Shastri

park, people facing shortening of breath due to the burning of wires. In this area, handlers of e-waste are dismantling & recycling this waste inside their houses.

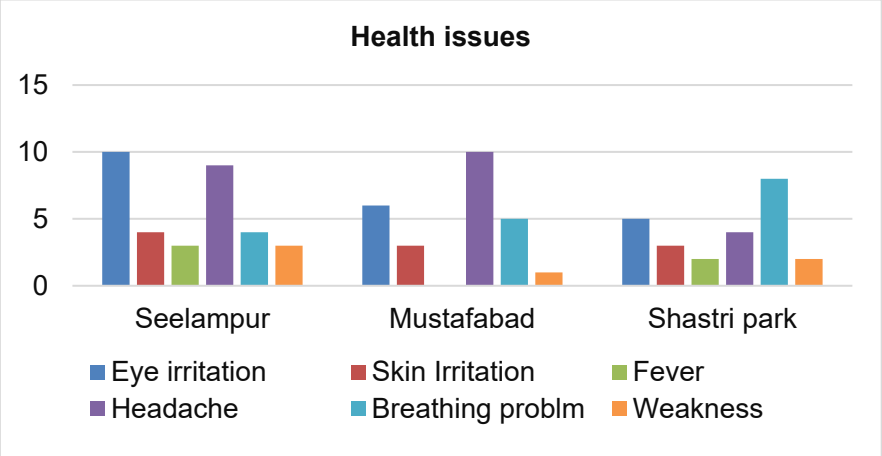

Figure 47: Health issues faced by the surrounding areas

Source: Author

3.7.3 Treatment

For the above mention health issues, handlers of e-waste taking care of them by treatment through health centers & self-medication as shown in Figure 48.

In Seelampur, handlers of E- waste are taken care of them by self-medication & through the health centers. But most of them are prefer to go to the health center for medication. In Mustafabad, most of the E- waste handlers are relay on self-medication rather than health center for treatment.In Shastri park & Mandoli, handlers take care of them by going health centers but some of them prefer self-medication.

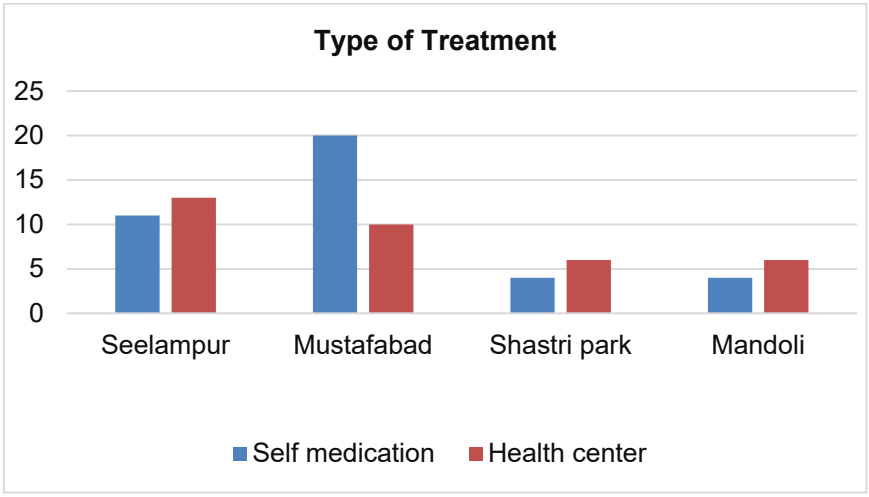

Figure 48: Type of treatment take by handlers of E-waste

Source: Author

3.7.4 Landuse Analysis

The Existing Landuse of the East Delhi municipal area is as shown in Figure 49.

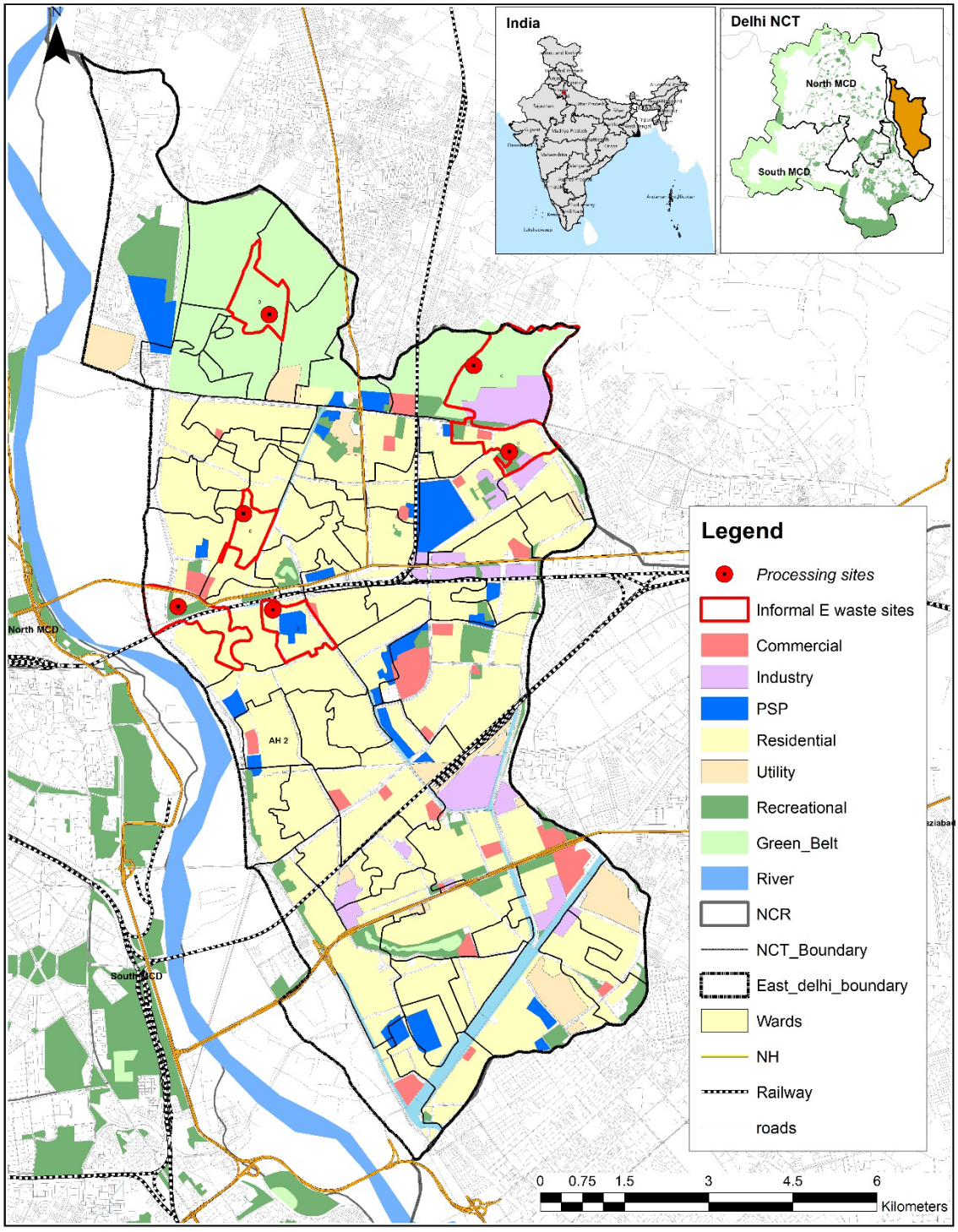

Figure 49: Landuse of East Delhi

Source: Author

3.7.4.1 Shastri Park

The maximum land use in this area is residential. Total residential character is hampered by a high percentage of commercial & industrial activities & a low percentage of recreational activities, reducing the quality of life. E-waste handling used is closed to the schools, recreational & religious places As shown in Figure 50. These places have high footfall density & also these places are highly vulnerable to particulate emission.

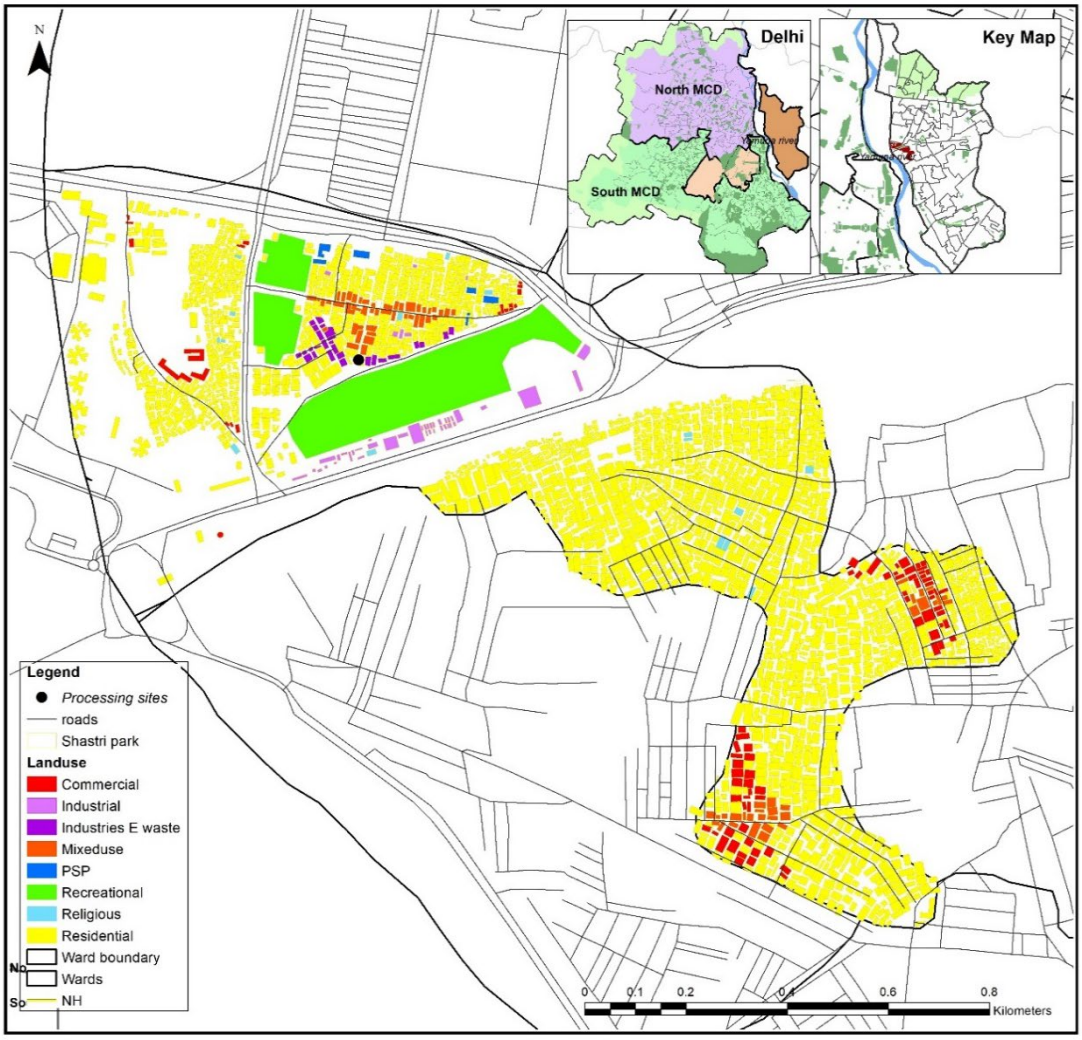

Figure 50: Landuse map of Shastri park

Source: Author

This residential area is congested with narrow lanes. In this area, E- waste handling is happening inside the residential areas. So, these people are more vulnerable.

The residents, because of the furtive idea of their tasks, were hesitant to discuss any issues identified with recycling or old electronic items. The greater part of them knew about the changing situations of e-waste exchange and was hesitant to receive any adjustments in their method for working

3.7.4.2 Mustafabad

In the landuse of Mustafabad, there is a high percentage of the residential area. Inside it, there is a commercial & industrial area in the center of residential areas. Schools & religious places are also there in this area as shown in Figure 51.

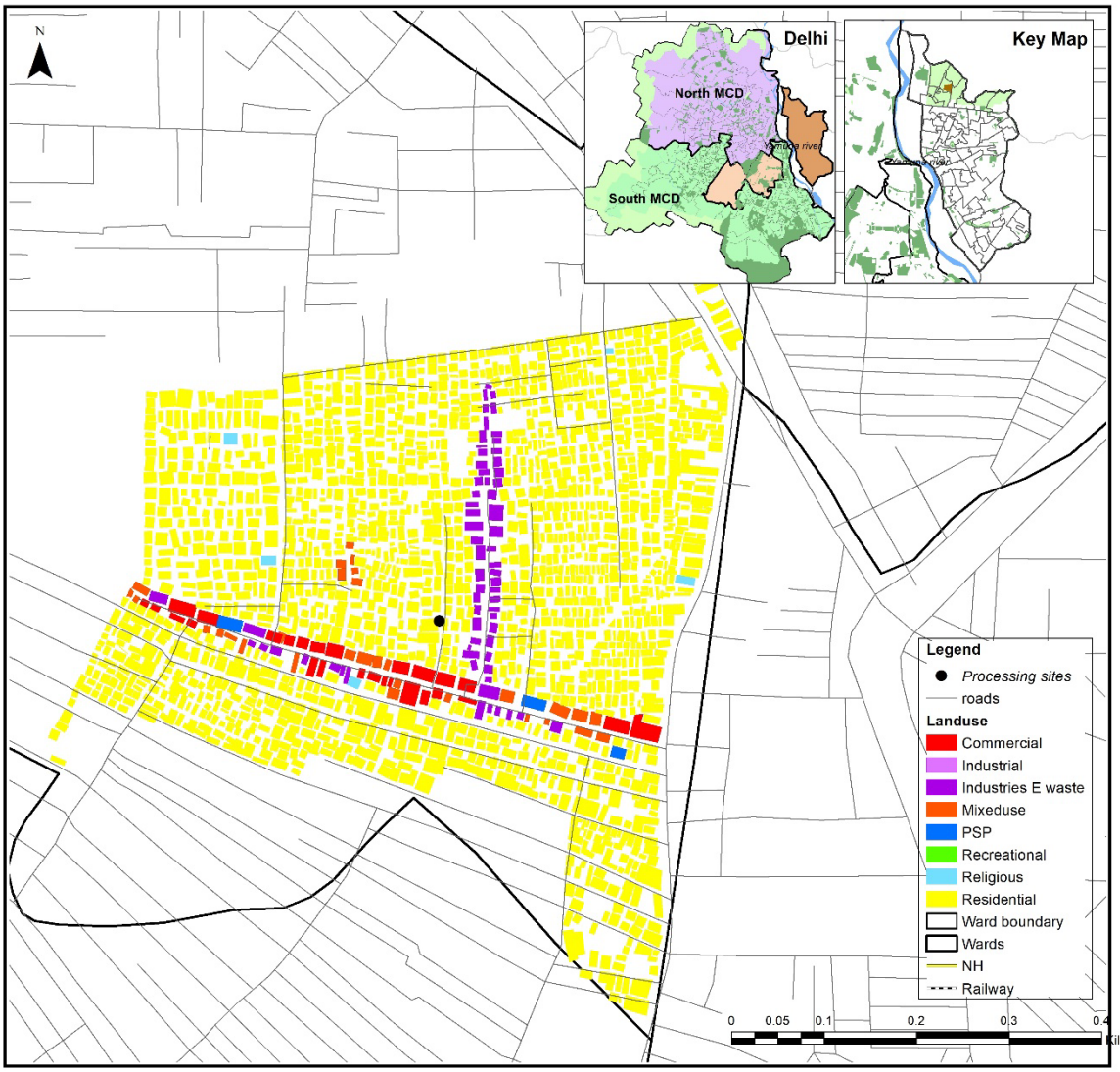

Figure 51: Landuse map of Mustafabad

Source: Author

Along with that, e-waste handling is also taking place. There is a proper lane inside the residential area of E-waste handling. Footfall in this area is high due to schools, religious places & commercial markets. So, the residential area is most vulnerable due to E-waste processing & recycling. People in this area are facing a high amount of air pollution, water & noise pollution.

3.7.4.3 Seelampur

In the landuse of Seelampur, most of the area is residential & commercial areas in the middle of the residential area as shown in Figure 52. High footfall due to the commercial market is also there in the center. The proximity of Primary schools is close to the commercial area. E-waste handling units are also spread in the residential area. Religious places are there between the e-waste handling units.

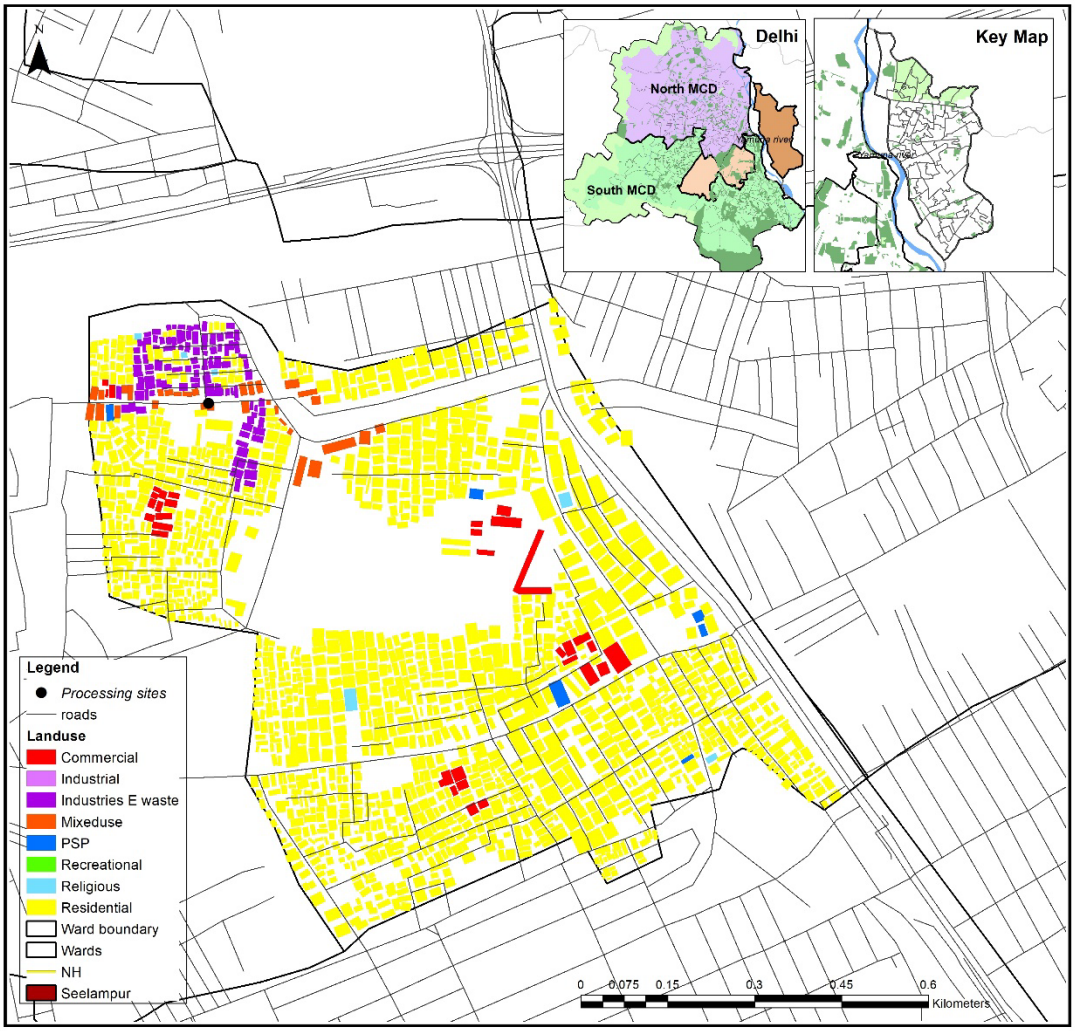

Figure 52: Landuse map of Seelampur

Source: Author

Footfall density is also high in this area due to the loading & unloading of e- waste & also due to the presence of the commercial market.

The area is situated in a clustered residential area location with destroying workshops in the basement, lawns or front room areas of the houses. The occupants were worried about the decrease of their business and benefit because of the progressions just as the conversations about e-waste recycling in the media. All the inhabitants were uninformed about medical problems like harmfulness because of groundwater contamination, air contamination because of open consuming, use of individual defensive supplies and so on.

3.7.4.4 Mandoli

Mandoli is famous for its steel industry. In the landuse of mandoli , the residential area is more along with the industrial area as shown in Figure 53.

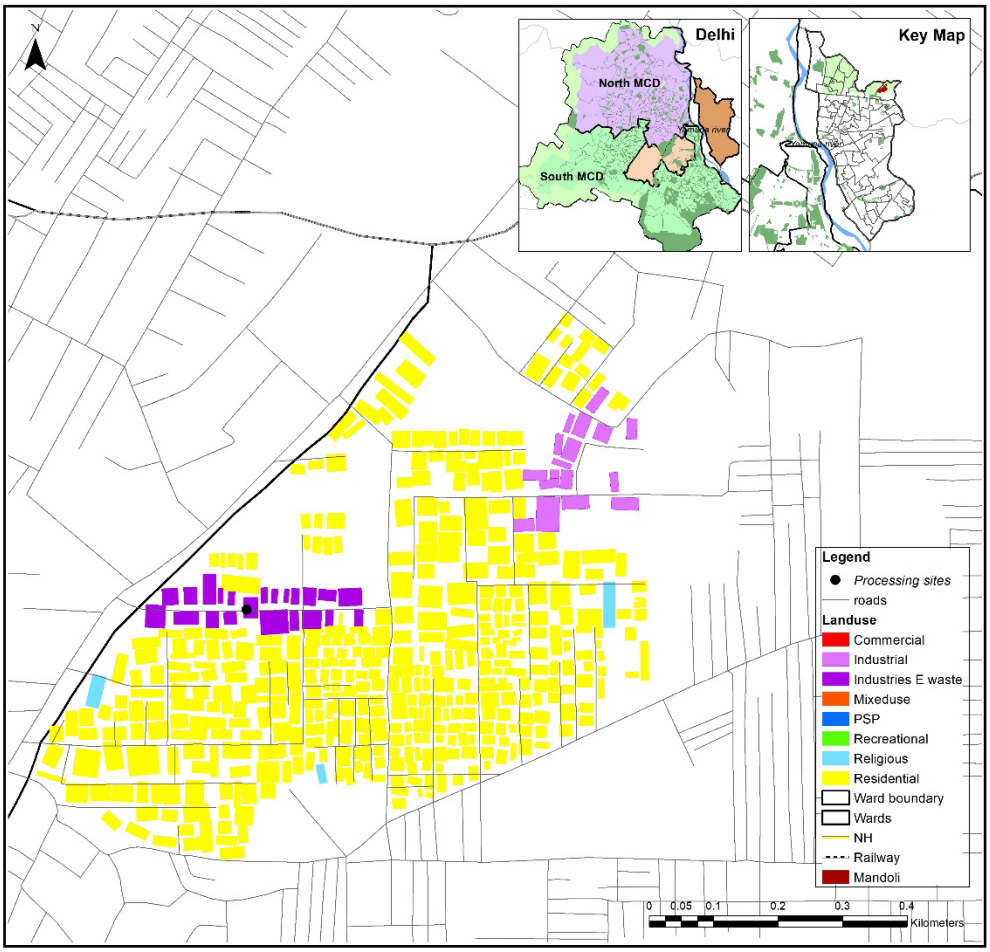

Figure 53: Landuse map of Mandoli

Source: Author

E-waste handling units are also there in the residential area which is hampering the quality of life of the people. The area is also dominated by many small scale battery recycling units for the extraction of lead from the old batteries.
In all these sites, E- waste handling majorly happening in Residential areas. These areas are the most vulnerable areas due to this E-waste processing. People in these areas facing health issues due to e-waste processing as well as through air pollution & water pollution.

3.7.5 Population Density

Net population density is one of the main indicators to assess the environmental condition of an area. The net population density gives a clear picture of the environmental condition of the area and the impact on the health of the people by comparison with environmental amenities like open spaces and green spaces.

The population density of each ward is calculated by first calculating the total area of each ward. The census 2011 population of each ward is divided by the area of each ward to calculate the population density for each ward in person per sq km. Wards showing high population density means that in a particular ward, the number of people pr km is more facing congestion in the area as shown in Figure 54.

Wards in the central area having high population density in the study area. Compact & unplanned growth in the wards has led to poor environmental conditions & infrastructure. Wards whose handled informal processing of e-waste like Seelampur, Shastri park, Mustafabad, Zafrabad, Seemapuri & mandoli are showing relatively high population density in comparison to the surrounding wards. Due to the unplanned & compactness of the area with high population density is more vulnerable from informal e-waste processing.

In these wards, the maximum area is the residential area with a high population density has a high impact of open processing of the e- waste on the people of these wards. Also footfall density is high in these wards. So, these wards are more vulnerable than the other wards.

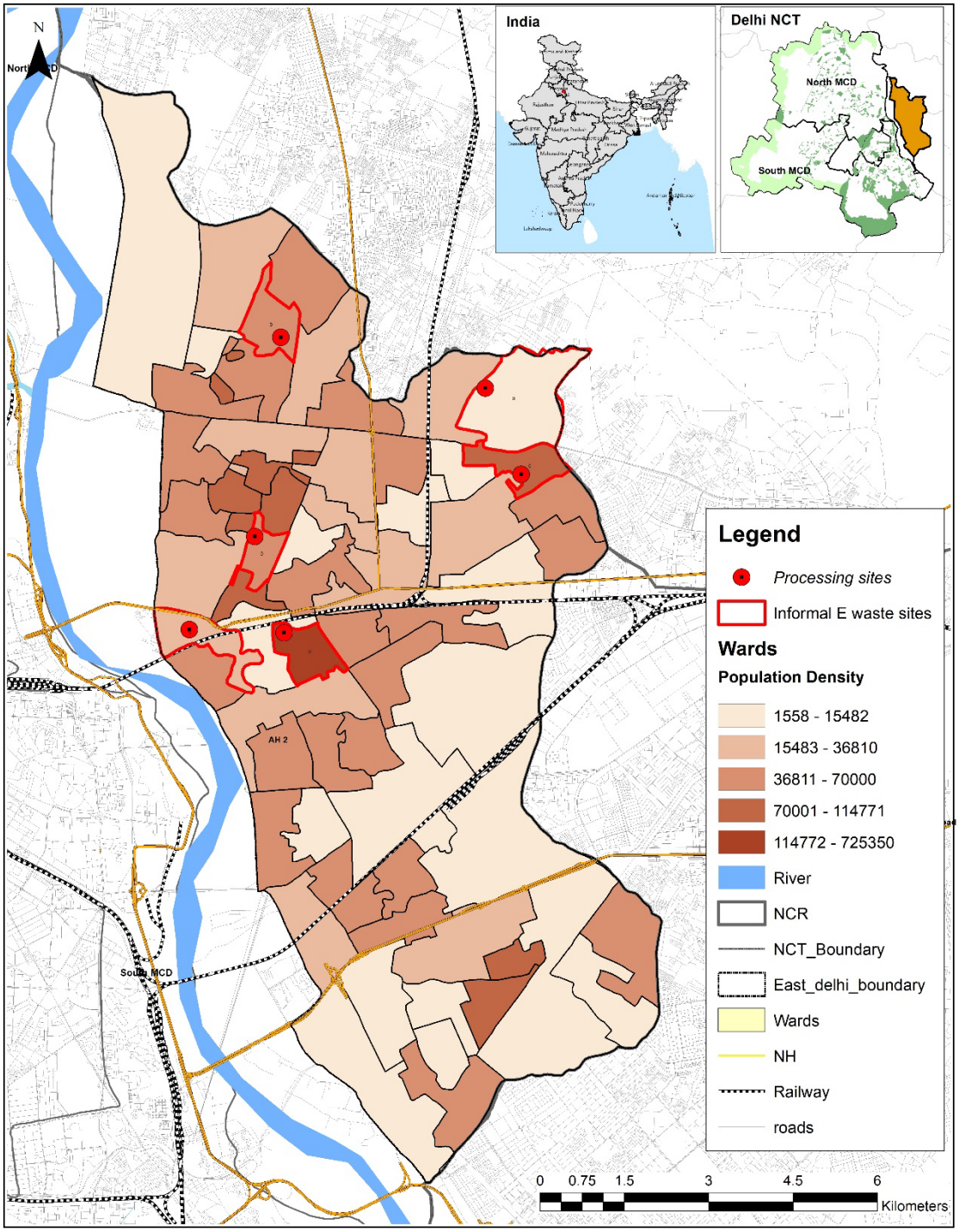

Figure 54: Population density map of the study area.

Source: Author

3.7.5 Inferences & analysis

In the informal sector of the study area, People who are practice E- waste processing & people live in nearby areas both facing health issues due to E- waste. People complaining that, Handlers of E- waste dismantle this waste without any

precautionary measures. Also after the dismantling, they through small pieces of wires and Glasses in open drains & ashes after burning of Plastics to extract the metal, they dumped into nalah which causes air pollution as well as groundwater pollution due to leach in the groundwater table which harmful for human health.

During transport the e-waste they through pieces of glass of television tubes, wires & pieces of the motherboard on the roads which is harmful to the surrounding people also. Neighboring residential areas is also disturbing due to noise pollution, traffic jam and also due to loading & unloading of E- waste. In the expert interview, it is also found that after a long time these small health issues will turn into a huge health risk like lung cancer, brain damage, skin cancer etc.to the e-waste handlers and the neighboring areas.

From the interviews of informal E- waste & surrounding areas, we found that these areas facing health issues due to E- waste as shown in Figure 55. It is also analyzed that the major health issues they are facing are Eye irritation which is 27%, wounds faced by e-waste handlers 20%, headache & skin irritation.

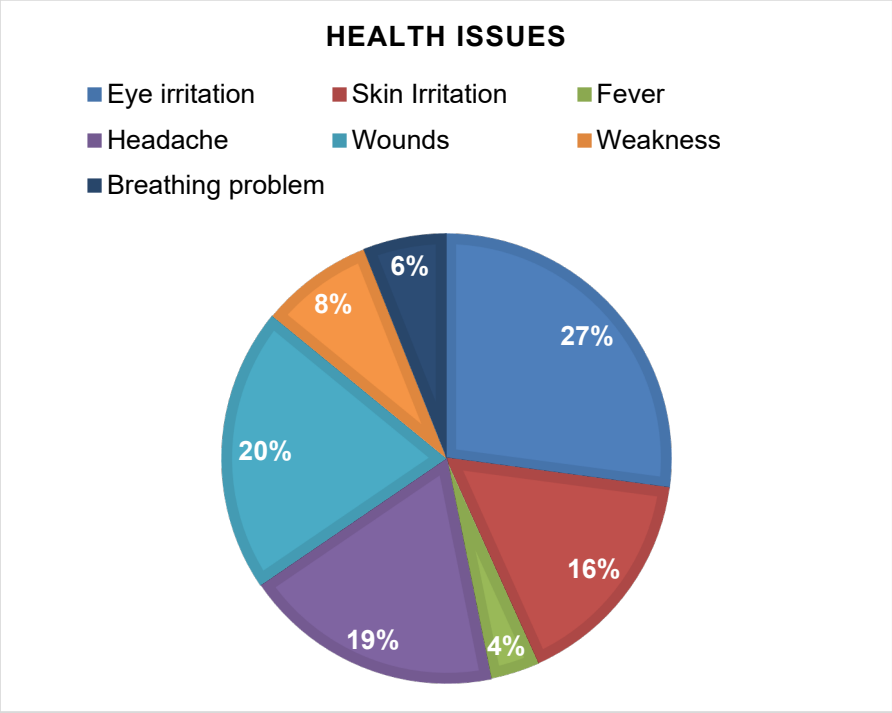

Figure 55: Health issues faced by all areas

Source: Author

PM10, PM2.5, Pb & Ni is high with the symptoms of weakness, skin & eye irritation, headache, breathing problem, hand & legs wounds & itchiness. These symptoms are usually faced by the residents of the area as shown in Figure 56.

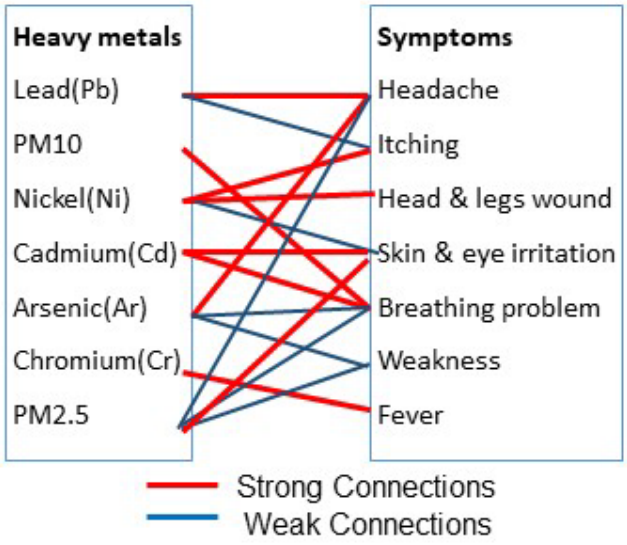

Figure 56: Linkages between heavy metals & symptoms

Source: Author

Also, These symptoms cause diseases like eye & ear problem, cancer, kidney damage, Lung cancer & brain damage.According to the Directorate General of Health Services, Diseases like kidney disease, Respiratory problems, cancer, blood cancer, brain disorder, eyes & throat disease, digestion, weakness, skin disease & injuries are the major cases in East Delhi as shown in Table 23. It is not specified that these cases are from informal E-waste processing. But the number of cases is high.

Table 23: No. of cases with disease name in East Delhi

S.no	Disease name	No. of cases
1	Kidney infection	138
2	Respiratory problem	556
3	Cancer	343
4	Blood cancer	12106
5	Brain disorder	274
6	Eye & ear problem	7163
7	Breathing problem	114

8	Digestion	1851
9	Weakness	8864
10	Skin disease	1320
11	Open wound injuries	55

Source: Directorate general of health services Annual report,2019

It is concluded that ,All the above mention diseases in East Delhi symptoms of these diseases are the same as the symptoms faced by the people of Informal sectors. So, it is proved that the practices of informal e-waste processing are harmful to human health.

CHAPTER 4. PROPOSALS & CONCLUSION

4.1 Introduction

The proposals were prepared to take into consideration, the objectives of the study analysis to achieve our aim and preparation of The responsible management of E-waste to reduce the health risk. There are many issues in the formal & informal management of E- waste which harm our environment & also human health. Proposal & strategies are based on the following objectives.

- Formal management of E- waste
- Informal management of E- waste.
- Impact of informal e- waste disposal on Human health.

4.2 Proposal & interventions.

- Modification of the E- waste management rules 2016
- Health impact assessment for E-waste
- Introduction of Reduce-reuse-recycle
- Integrate formal & informal sector
- Blockchain framework for e- waste
- Formalizing the informal sector.
- Encourage the informal sector for awareness regarding e-waste & use of PPE.
- Subsidy from the formal sector to the consumer for the recycling of waste.
- Proposal of training centers to address the community knowledge related to hazards & practices for recycling of e- waste.

4.2.1 Modification of E- waste management rules 2016

In the E- waste management rules 2016, responsibilities for the collection, storage, transportation & disposal are already there. But these responsibilities are for formal sectors. This e-waste handling rules include safety measures for the formal sector to the environmentally ound management of the e- waste.

But some modification is required in the e- waste handling rules, 2016. These rules include only the formal sector. Nothing is mention about the informal sector which is a major sector. The informal sector caters around 80 % of the e- waste. so, the

responsibilities for the informal sector should also include in the E-waste management rules

4.2.2 Health impact assessment for E-waste

E-waste is a major concern in the developing world due to growing health & environmental issues. There is a lack of infrastructure & implementation of regulation to manage the problem of E- waste. Also, emissions during recycling have a major impact on health & the environment. To tackle this crisis, we can propose a health impact assessment to address the environment & health impacts from e-waste. Steps for health impact assessment(HIA) will be performed based on input from the local communities. HIA is an approach, tool to protect & promote health by the assessment of population health & provide appropriate recommendations. Its aim is to draw attention towards the health sector on non-health sector-related activities. So, it is recommended that the HIA should be incorporated into the recycling policy of E-waste to educate the public about the health & environmental impact of E- waste.

4.2.3 Introduction of reduce –reuse- recycle

The advancement of technology along with reuse & recycling of electronics can enhance the life of electronic equipment. Strategies to reduce waste in the long run by spreading awareness about harmful effects of e-waste disposal and improper recycling due to excess generation of E-waste, as well as benefits of upgrading devices without replacing and discarding, should be mandatory in all campaigns for the public.

So, the model is proposed for the production of a computer system with a tracer. This depicts the tracer's life cycle which includes production to consumption, reuse, refurbish & metal recovery. This model works on the Pre & post recycling of E-waste. In Pre recycling, the model will inform about the reuse & refurbishment of the product. In post recycling, will work on dismantling & recycling. It will also inform about the recyclable for physical & chemical process & non-recyclable parts for incineration & dumping in landfills.

4.2.4 Formalize the informal sector

For the formalization of informal sector, government should run the program to upgrade skills, build capacity to create an understanding of safety, health & environment for linking both the sectors.Eco-park can be proposed to integrate the formal & informal sector. Through this, we can improve the collection technique and environmental safeguard and some other benefits. Initial financial support can be provided by the government for equipment and other facilities can be provided by the state government like land, subsidized power, water & local approval. The formalization of informal sectors can also take contribute to revenue generation. Existing processing centers act as collection centers & for storage of E-waste. For dismantling & recycling, the steel industry located in mandoli will be proposed as a recycling center under public-private partnership as shown in Figure 57.Eco-park can be provided near the commercial centers in East Delhi.

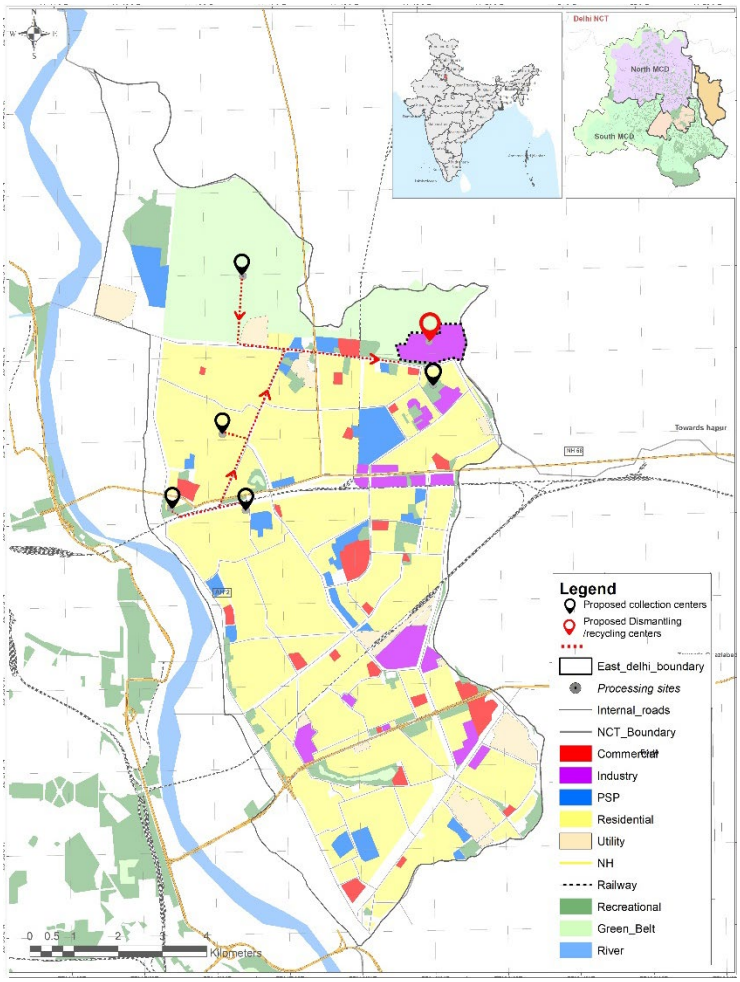

Figure 57: Proposed collection & recycling center for informal sector

Source: Author

4.2.5 Blockchain framework for E-waste

It is the technology introduced behind the bitcoin in 2009, The bitcoin blockchain was developed as an alternative to the existing financial system, where banks act as trusted intermediaries for conducting valid transactions and preventing frauds. This blockchain can store all the transactions on the network. It can make our system transparent. Thes Connected blocks are labeled as blockchains, it is a decentralized form of data that is not connected to a central authority or organization, but it is directly connected to the users of the network.

Blockchain can be implemented in satellite recycling machines where people can exchange their old gadgets and non-working electronics for digital tokens. Blockchain can record and secure invaluable data at any point during the recycling process. The framework is proposed for the management of e- waste to reduce the impact on the environment as well as on human health as shown in Figure 58. In the proposed framework, E- waste is collected from the households, consumers & bulk consumers by the informal sectors through which all the consumers earn their digital token as a reward.

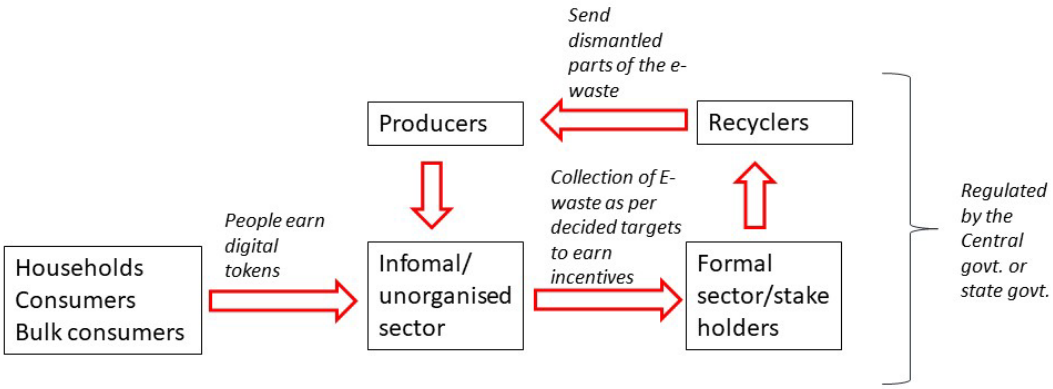

Figure 58: Proposed framework for E-waste to reduce health risk

Source: Author

After this collected e- waste sends to the formal sector/stakeholders for processing. Through the formal sector, the informal sector earns there incentives by the designated targets. All the collected e-waste will transfer to the recyclers for dismantling & recycling. Both sectors like formal sectors & recyclers regulated by the central government or the state government. After recycling or dismantling,

processed e- waste parts sell to the producers. This process will work as a chain & make the system transparent.

4.2.5.1 Benefits of blockchain

Through this framework, the informal sector stabilized their livelihood in any kind of crisis like natural & man-made. Also, people in our country are not very much aware of the e-waste & its impacts. So, they sell their old electronic items to the local kabadiwalas or the informal sectors and earn money through them.

4.2.6 Integrating Formal & informal sector.

From the above study, it is reflected that due to the low capacity of recycling of e-waste by the formal sector. Maximum e-waste is handled & recycled by the informal sector. Also, the informal sector is growing due to the failure of the formal sector. E-waste dismantling & recycling is a livelihood for the people engaged in this business. Due to this, Integration of the informal sector is an intervention to secure their livelihood & community from hazardous risk.

In the management of E- waste, the informal sector is a chain of unauthorized collectors, segregator, dismantlers & recycler. The activities of the management of E- waste need to be synchronization between the formal & informal sector as shown in Figure 59. People creating their livelihood from a large sector of rural & urban poor

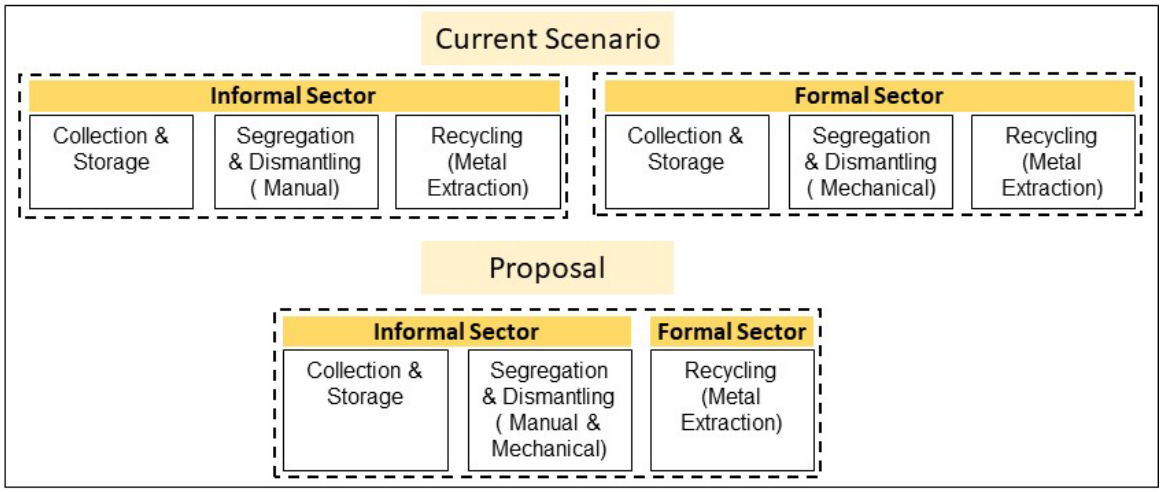

Figure 59: Proposed integrated formal & informal management of E-waste

Source: Author

4.2.7 Encourage the informal sector regarding e-waste & use of PPE.

In the interviews, it is observed that the people engaged in the informal sectors are unaware of the impact & hazards of the recycling of e-waste. so, it needs to encourage the community about the basics, recycling practices of e-waste & its harmful impacts. It also needs to aware of the requirement of PPE & its use.

4.2.8 Subsidy from the formal sector for the recycling of waste.

Most of the people in India are not aware of the disposal of E- waste and where to send the E- waste. In the take-back policy provided by the government, the formal sector does not provide any subsidies or incentives to their consumers. Also in formal sector, recycling is costly too. Due to this, people are more concerned to sell their e-waste to the informal sector that is easy to access. So, the formal sector should provide subsidies to the consumers & also encourage the people so that they can aware to the others.

4.2.9 Proposal of training centres for awareness.

As it is mentioned earlier, the people engaged in the informal sector are unaware of the recycling procedure & practices. It is required to aware of the community about the e-waste & towards the impacts of e-waste recycling that is harmful to human health. E-waste has hazardous elements in it. People should aware of those elements.

To manage the e-waste, there are many practices to deal with it. So, the lack of knowledge is a major issue. To tackle these issues, we can propose training centers near their processing sites to aware of the community as well as handlers of e-waste to address the community knowledge related to hazards & practices for recycling of e- waste.

The location of training centers ar shown in Figure 60.Through this, they can learn the techniques to process e- waste in an environmentally friendly manner, and also they can save their health.

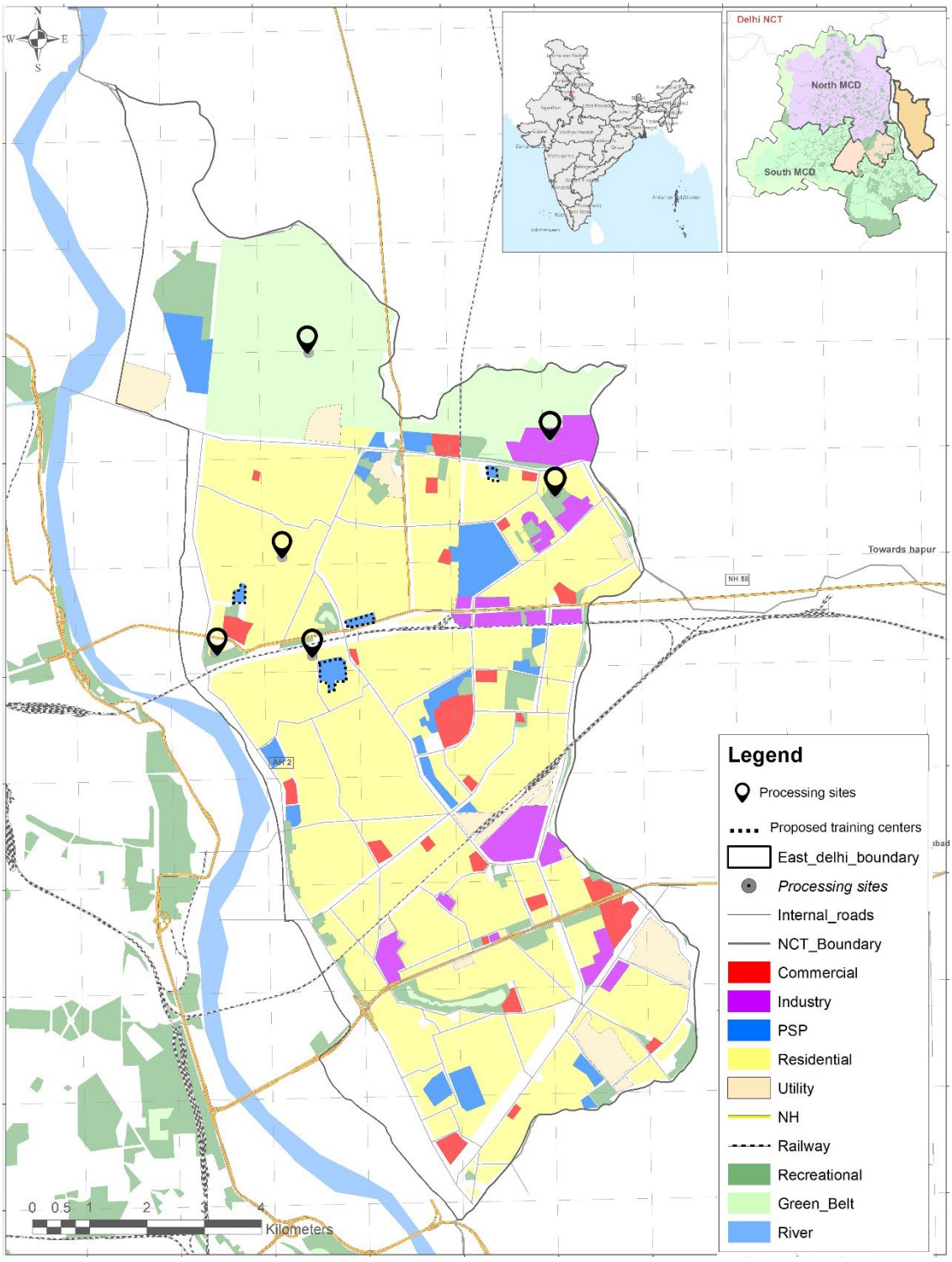

Figure 60: Proposed training centres for informal sectors.

Source: Author

4.3 Conclusion

The understanding of secondary data, qualitative analysis, observations & field visits of the study area proved the need for the responsible management of E-waste due to the harmful impacts of informal e- waste recycling causing health risk in East Delhi. The study area is found to satisfy the improper management of E-waste causing health risk indicators are informal sector, air pollution, groundwater quality, Livelihood, insufficient capacity of the formal sector, Lack of infrastructure and health risk. The conclusions are drawn in terms of the strengths, challenges, opportunities, and threats considering the management & impacts of e- waste causing health risk in East Delhi as shown Table 24.

Table 24: Strength, Challenges, Opportunity & Threat identified from the study

Strength	Challenges	Opportunity	Threat
- Regulatory enforcement. **- Access to waste and flexibility.** **- Development of the online system.** **- Clarity on funding mechanism.** **- Voluntary consenses standards.** **- Initiatives by NGOs.**	- Poor information on e-waste generation rates. - Friction in the market for end of life product. - Inadequate regulation design & enforcement. - E-waste impact - Invisibility of the informal sector. - Poor logistics complicated by geographic realities. - Insufficient recycling process. - Insufficient waste management capacity. - Poor infrastructure.	- Informal sector. - Capacity & responsibility of the states - Goods & service tax. - Waste inventorization & data generation.	- Unsustainable informal sector practices. - Lack of awareness. - Hazardous process. - Absence of finance for monitoring & control. - Groundwater contamination. - Air pollution - Lack of govt. intervention.

Source: Author

It has been traced that the responsible management of E- waste can be achieved by the above-mentioned strength & opportunities, but we have challenges also. It is identified that current management practices are not the best. In the formal management handled by the government have some loopholes which make it insufficient to cater all the waste & it rise the informal sector. Due to this, only 20 % of E-waste is handled by the formal sector & 80% of e-waste is handled by the informal sector.

In the informal sector, mostly crude methods are used for the dismantling, recycling & recovering of materials. The recycling of E-waste activities includes manual dismantling in open streets in residential areas, open burning of e- waste dismantled parts to recover metals & open dumping of residue. Such kind of practices released hazardous chemicals into the environment which cause groundwater pollution & air pollution in the study area. Also, it creates a direct impact on human health. We can also consider the fact that trading & recycling of E-waste provide livelihood opportunities to the poor people & also considering the risk of human health.

We need to minimize the informal e- waste disposal & its adverse impacts on human health. It required proper management of e- waste with an efficient way to dispose of and suitable dumping sites to reduce the contamination of water & in the air quality.
Management of E- waste is a major problem all over the world. So, we need to initiate the awareness programs of e-waste management, its disposal & its harmful impacts on human health.

So, strategic planning is required to tackle the current situation of e-waste as it leads to a threat to the human health & environment. Various stakeholders are required to involved in the handling of e-waste for proper collection, storage & recycling. The government should provide strong regulation enforcement for better management to remove the impact of E- waste.

To tackle the issues identified in the study area through the following proposals are there

- Formal management of E- waste
- Informal management of E- waste.
- Impact of informal e- waste disposal on Human health.

Through these proposals, we can bridge the gap between the formal & informal sectors to reduce the unorganized activities for disposal of e-waste causing a health risk.

Annexure-1

Survey Form

Name of the Respondent & Age_____

Address & Type of Land use_____

E- WASTE INFORMATION

1. Type of operation
   - Collector
   - Trading/ sale purchase
   - Refurbishing
   - Dismantling
   - Metal recycling
2. What is the Source of inflow material?
   - Industries
   - Bulk consumers
   - Individual consumers
   - Household, institutions, offices
3. What are the types of e waste handling?
   - TV, computers, printers & their parts
   - Mobiles
   - Electrical motors, transformers, Invertors
   - AC, refrigerators, washing machine
   - CFL
   - Cables & wires
4. Operation
   - Manual
   - By machine
   - Burning / Acidic
5. Where do you transfer the waste? (city)
6. Specify the location from where e-waste usually comes.

7. Maximum industries in this area.
8. What time of the day does it come?
9. Type of vehicle used
10. Who pays the transportation?
11. How do you store E waste?
12. What are the waste material generated during the process/operation?
13. What is the total quantum of e waste kg/ton per day?
14. Where do you sell the extracted material?
15. What are the harmful impact of extracted material?
16. Where you dump the waste?
17. How many years in this business.
18. Type of workers
    - Male
    - Female
    - Children
    - No. of workers
19. What is wage of worker (average per month /day)?
20. Are you aware of the CPCB guidelines for E waste management & handling 2016?
21. Do you have any registration?
22. Is there any change in the quantity of material flow after 2016?
23. Is there any case of water contamination in this area?
24. Is there any health disease you are facing?
25. Which of the following sickness do you normally report at the health centre or hospital?
    - Eye Irritation
    - Skin Irritation
    - Kidney Problems
    - Fever
    - Blood and Brain disorders
    - Flu-like symptoms Headaches
    - Lung Cancers

- Wounds

26. How long has this symptom been with you?
27. How do you treat some of the health issues identified?
    - Self-medication
    - Health centres/Hospitals

Annexure-2

Stakeholders survey Form

1. Name of expert_____
2. Designation_____
3. Type of organisation
4. NGOs ☐
5. Private ☐
6. Institution ☐
7. Government ☐
8. Name of organization_____
9. Which government body is handling the management of e-waste in Delhi?
10. What is the system of E-waste in Delhi?
11. Are people aware of e- waste & its guidelines?
12. Yes ☐ No ☐
13. Are people aware its harmful effects?
14. Is your organisation is doing any awareness program regarding e- waste?
15. How much E- waste is managed in Delhi?
16. Where is the collection and disposal centre?
17. Are they doing environmentally sound management of e-waste?
18. Are they transport the e- waste by government transport?
19. What are the techniques they are using for recycling?
20. Are people facing any health issues due to informal processing or recycling?
21. What are the harmful metals being there in e-waste?
22. What are environmental issues due to e-waste?
23. Are there any best practices to manage e-waste?
24. Any proposal to reduce the impact on the environment and human health.

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