Module 1

Sustainable development and e-waste management

Importance of electrical and electronic equipment in a nation's development, and e-waste as toxic companion of digital era

- A country's development or any modern society is often epitomized(incorporate) with the communication revolution of 1980s and the digital revolution since the 1990s.
- **Communication Revolution of the 1980s**
- Transformations in Society
    - Changes the in the way we organize our lives, economies, and industries and institutions.
    - The revolution is observed in form of Enhanced development, comfort, and technological advancement
    - Increased product sales

Digital Revolution Since the 1990s

- The digital technology facilitates
    - Transformation in information, communication, and transportation
    - Improvements in energy supply, health, and security systems
    - Increased productivity and development
- This technology is proliferated with different electrical and electronics equipment (EEE) or e-products, such as
    - PCs, Internet, Satellite TV
    - Standardized containers, fiber-optic cables
    - Electronic barcodes, global supply chains (making human lives more convenient and work more efficient)
- A broad range of goods is classified as EEE, which include large and small household appliances (consumer appliances)
- such as refrigerator, washing machine, air conditioner, microwave oven, etc
- information technology (IT) equipment including computers, computer games and peripherals cellular telephones and other telecommunication equipment;
- portable electronic devices such as, video and audio equipment and their peripherals; and electrical tools.

E-Waste: A Growing Concern

- Rise of Electronic Waste
    - Fastest-growing waste stream (The rapid growth of technology, upgradation of technical innovations, and a high rate of obsolescence(outdated) in the electronics industry)
    - Described as a "toxic companion" of the digital era
    - Challenges in E-Waste Management (focuses on)
    - Life Cycle Impact Assessment (LCIA) and End-of-Life (EoL) solutions
    - Efficient use of resources, waste minimization ,development of cleaner products.
    - Environmentally sustainable recycling and disposal
- **Statistical Overview of E-Waste**
- E-Waste Generation and Recycling Statistics
    - 2017: 44.7 Mt(metric tonnnes) of e-waste (equivalent to 4,500 Eiffel Towers)
    - 2019: 53.6 Mt generated, 17.4% recycled
    - 2016 vs. 2019: Increase in total e-waste and recycling activities
- **Global E-Waste Trends**
- Growth and Recycling Challenges
    - 3-5% annual increase in e-waste volumes
    - 35% of e-waste recycled, 65% not managed properly
    - E-waste growing three times faster than municipal solid waste

Understanding E-Waste: Challenges and Solutions

- **Future Directions**
- Improving E-Waste Management
    - Better data and statistics for effective management
    - Legislative and producer responsibility initiatives
    - Emphasis on resource efficiency, circular economy, and job creation

E-waste generation between 2013-2019

TABLE 1.1 E-waste generation between 2013 and 2019 across the globe

		E-waste related details			
No.	*Year of e-waste data, source*	*Generated in Mt (kg/inh)*	*Formally treated[a] (%)*	*Intrinsic value of secondary materials estimated*	*No. of country having national legislation (% of world population covered)*
1.	2013 (*GEM 2014*)	41.8 Mt (5.8 kg/inh)	6.5 Mt (15.5%)	Approx. 48 billion EUR	61 (44%)
2.	2016 (*GEM 2017*)	44.7 Mt (6.1 kg/inh)	8.9 Mt (approx. 20%)	Approx. 55 billion EUR	67 (66%)
3.	2019 (*GEM 2020*)	53.6 Mt (7.3 kg/inh)	9.3 Mt (17.4%)	Approx. 57 billion USD (48 billion EUR)	78 (71%)

limitation of the e-waste statistics

- It is important to know that the generation of e-waste and its 'distribution is uneven: richer countries produce more.
- Norway, for example, produces 28.5 kg per person per year, compared to an average of less than 2 kg in African countries.
- GEMs (2014, 2017, 2020) provide e-waste generation and estimate of intrinsic value of secondary materials recovered from the e-waste generated.

they do not provide statistics on production of EEE and their contribution to nation's development or development index of a nation. This is the intrinsic limitation of the e-waste statistics

Understanding E-Waste: Challenges and Solutions

What is E-Waste?

E-products become e-waste when discarded after their useful life

Possibility of repair or refurbishment before reaching end-of-life (EoL)

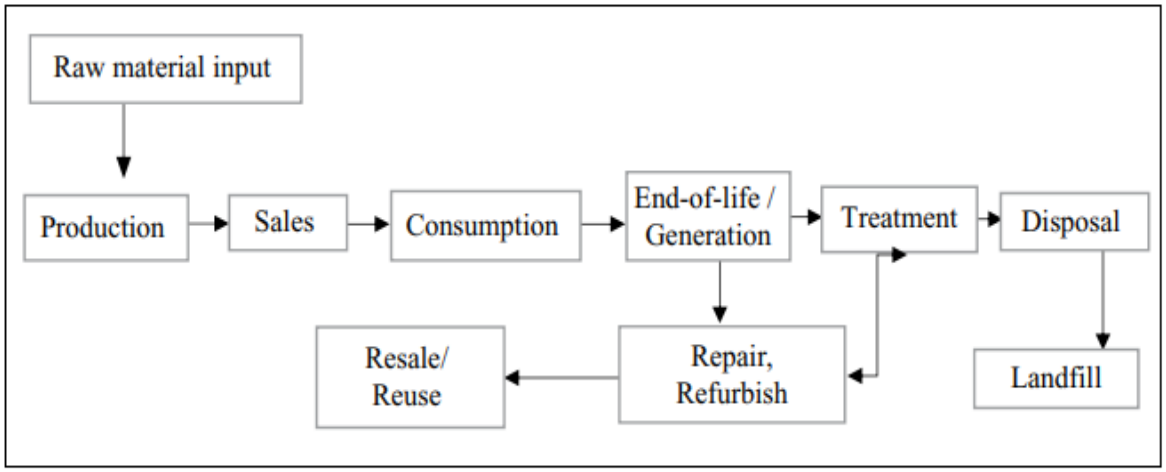
(Refurbishing is a process to make devices functional in a way that they work according to new standards vis-à-vis obsolete technology. For example, old parts are replaced by new ones, new software could be installed)

Lifespan can be extended through repair and reuse

- Accepted Definitions and Terminology
    - E-waste: Discarded e-products with no intention of reuse (Miliute-Plepiene and Youhanan 2019)
    - Anything with a plug, cord, or battery reached at end-of-life (PACE and WEF 2019)
    - Includes whole products or parts, rejects from manufacturing, refurbishment, and repair (Bhardwaj 2016)

- Terms: WEEE (Waste Electrical and Electronic Equipment) and e-scrap

Life cycle of an e-product



Unique Characteristics of E-Waste

- E-Waste Differences from Other Waste Types (solid, liquid, bio-medical, and construction waste)
    - 1.**Contains hazardous substances** (toxic waste stream)
        - Potential for environmental contamination(soil and water) and health risks
        - improper management of e-waste contributes to global warming.
    - 2. **Complexity in composition**: materials used in e-products can be classified into four main groups
        - metals, rare earth elements , plastics and other petroleum-based materials, and minerals and non-metallic materials

(metals, plastics, rare earth elements, minerals)

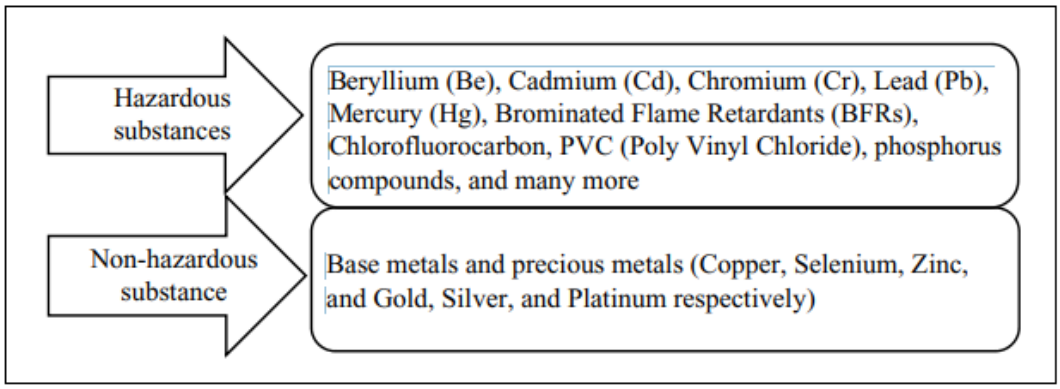


FIGURE 1.2 Hazardous and non-hazardous substances in e-products

- **Environmental and Health Impacts**
  - Contamination of soil, air, and water
  - Harm to microorganisms and ecosystems(entering food chains though complex bio-accumulation mechanisms.)
  - Health issues for exposed workers (e.g., organ failure, diseases)
- **Sustainable Management of E-Waste**
  - Environmental and health concerns drive the need for sustainable methods
  - Shift from rudimentary recycling (acid baths, open burning) to scientific methods
  - Importance of proper treatment and recycling to prevent harm

The 6R Framework for E-Waste

- Every government aims at optimal and efficient use of natural resources, minimization of waste,
- development of products having longer life and lesser use of hazardous substances, and environmentally sustainable recycling, and disposal system of waste are some of the issues which need to be addressed by all concerned .
- while ensuring the economic growth and enhancing the quality of life, as part of e-waste management
- the municipal solid waste (MSW) management considers the framework of 3Rs – reduce, reuse, recycle;
- its recycling is associated with energy generation and other by-products related benefits.
- E-waste requires additional considerations in this existing framework of waste management, mainly because of presence of hazardous substances, metals, glass, plastics and other elements

- e-waste management has started recognising need for adding three more Rs (repair, refurbish, resource recovery) to the existing 3Rs framework (reuse, recycling, and recovery) for waste management, making 6R framework
- another model focusing on e-product users/consumers, by adding 3Rs, that is
- release (spread the information, awareness), realise (know the importance of e-waste management), and responsibility.
- The components of recycling and resource recovery in e-waste management are seen as a process of 'problem to resources', bringing circular economy (CE) and resource efficiency (RE) to centre-stage along with safe environment and human health.
- The CE and RE are associated with social and economic benefits including job creation, investment in technology development and infrastructure building.

E-waste management thinking across the globe

- Overview of E-Waste Management Thinking
    - Focus on environmental damage and risks to human, workers and communities
    - Past policy recommendations have focused overwhelmingly on the introduction of environmental legislation and regulation .
    - Increasing role of various stakeholders: enterprises, workers, and governments cooperatives and other social and solidarity organizations, as well as ministries of labour or employment, and labour market policies all have a key role to play in advancing decent work in the management of e-waste
- Transition in E-Waste Management Thinking
    - **Early focus on safe environment , human health through legislation and EPR (extended producer responsibility) strategies**
    - Recent yrs thinking has **shifted to include consumer roles**(consumer is the purchaser of electronics as well as the generator of e-waste) and
    - **digital era impacts** (e-products are epitome of development, efficiency, and comfort and transforming entire production and market system of various products as well as activities in various sectors, such as, education, healthcare, entertainment and so on. Therefore, consumption of electronic gadgets is likely to increase multiple folds, and in turn increase in e-waste generation)
- Increased e-waste generation due to shorter **product lifecycles and fewer repair options.**
- thus ,introducing resource recovery, REs and CE link with recycling/treating e-waste.

    Spreading awareness among users of e-products, user roles in minimising e-waste, and contribution to tax regime/fees for recycling also have become the agenda of e-waste management

Components of E-Waste Management Thinking

- Governance(control) of e-waste includes
    - Increasing e-waste collection and recycling
    - Harmonizing global statistics and expanding legal frameworks
    - Urban mining(recovery from building) and economic potential through resource recovery
    - Protecting worker health and addressing environmental concerns

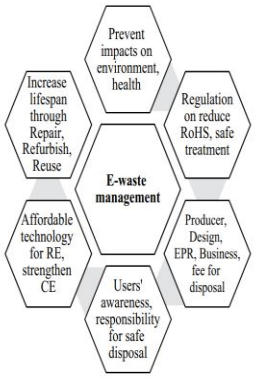


FIGURE 1.3 Components of e-waste management

To be more accommodative and able to incorporate the evolving ideas and practices regarding e-waste, the term is used, ‘e-waste management thinking

Evolution of Legal Definitions of E-Waste

- Development of Legal Definitions
    - Lack of a global standard definition of e-waste before 2007
    - With evolution of legal frameworks, e-waste has been defined based on its hazardous characteristics , such as use of hazardous elements, chemicals, and organic persistent pollution and
- transboundary movements (transboundary movement means any movement of hazardous wastes or other wastes: from an area under the national jurisdiction of one State.)
- **international Regulatory Frameworks**

  Three sets of legislation/regulatory frameworks exist for e-waste management
    - **European Union** applicable to EU countries **:** RoHS Directive (Restriction on Hazardous Substances), WEEE Directive (,), REACH (Registration, Evaluation, and Authorization of Chemical Substances)

- **Multilateral Agreements:**
    - Basel Convention (on the Control of Transboundary Movements of Hazardous Wastes and their Disposal),
    - Rotterdam Convention (on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade),
    - Stockholm Convention on Persistent Organic Pollutants (2001);
- **Strategic Approach to International Chemicals Management:** SAICM

The definition of e-waste as per the WEEE Directive(under EU Legislation)

- Defined by Directive 75/442/EEC
- E-waste includes all components, subassemblies, and consumables of discarded electronic equipment
- Defined by Directive 2002/96/EC (WEEE)
- 'EEE' means equipment which is dependent on electrical currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such current and fields falling under this directive and designed for use with a voltage rating not exceeding 1,000 volts for alternating current and 1,500 volts for direct current.
- (Equipment dependent on electrical currents or electromagnetic fields)

Basel Convention Definition(Definition under International Agreement)

- Covers discarded materials with hazardous characteristics
- Definition of waste includes all components , subassemblies and consumables which are part of the product at the time of discarding
- It further clarifies that 'national provisions concerning the definition of waste may differ, and the same material that is regarded as waste in one country may be non-waste in another country.(National variations in the definition of waste)

The Solving the E-waste Problem (StEP) establishes importance of definition of e-waste, (The definition of e-waste that has been agreed by StEP is)

- Global inconsistency in e-waste definitions
- StEP's definition of EEE is : Any household or business item with circuitry or electrical components with power or battery supply (discarded EEE with no intention of reuse)
- 'E-Waste is a term used to cover items of all types of electrical and electronic equipment (EEE) and its parts that have been discarded by the owner as waste without the intention of reuse.

- item - circuitry or electrical components with power or battery supply" qualifies it for inclusion. considered excess or waste by the owner.
- nature of the item changes from a useful product to that of waste
- "parts"- within the definition refers to parts that have been removed from EEE by disassembly and are electrical or electronic in nature…
- "discarded"- meaning to throw away or get rid of as useless.
- The term implies that the item in question is considered excess or waste by the owner.

E-Waste Categories (WEEE Directive)

- The concept of e-waste or e-scrap has evolved from different types of devices and their classification as per the
  - WEEE Directive (enforced in the EU states), and
  - the recast of the WEEE Directive .
- The recast of the WEEE Directive comprise of six categories of e-waste
- categories are followed in the GEMs – 2014, 2017 and 2020.
- They are: (i) temperature exchange equipment
- (ii) screens and monitors
- (iii) lamps
- (iv) large equipment
- (v) small equipment and

(vi) small IT and telecommunication equipment (Forti et al. 2020: 14–15)

II. E-Waste Statistics: Quantities, Collection, and Recycling

- GEM- The Global E-waste Monitor Reports by UNU - United Nations University (2014, 2017, 2020) - documents that capture e-waste statistics
- Authentic source for global e-waste quantities
- 54 EEE product categories grouped into six general categories
- Categories: Small equipment, large equipment, temperature exchange equipment, lamps, etc.
- Based on these categories,
- e-waste generation, Sustainable development collection, recycling, intrinsic value, number of countries having e-waste legislations, etc. statistics are generated
- and harmonised across the world.

- **Global E-Waste Collection Trends**
- 2016: Collected from 190 countries
- 2019: Collected from 193 countries

E-waste categories and harmonising statistics

TABLE 1.2 E-waste quantities as per its categories – comparing 2016 and 2019

E-waste category	*Amount of e-waste (in Mt)*		*Quantity change (%)*
	2016	*2019*	
Small equipment	16.8	17.4	+4
Large equipment	9.1	13.1	+4
Temperature exchange equipment	7.6	10.8	+7
Screens and monitors	6.6	6.7	−1
Lamps	0.7	0.9	+4
Small IT and telecommunication equipment	3.9	4.7	+2
Total	**44.7**	**53.6**	

Source: Baldé et al. (2017), Forti et al. (2020). Compiled by the author.

- The Table 1.2 provides and overview on e-waste quantities, recycling and flow in each region, also describing the trends and characteristics of each region in dealing with e-waste
- E-Waste Volumes and Recycling Trends
  - Highest e-waste: Small equipment
  - Followed by: Large equipment, temperature exchange equipment
  - Smallest portion: Lamps
  - Comparison of e-waste generated and recycled in 2016 and 2019

TABLE 1.3 E-waste generation, collection and recycling across regions – comparing 2016 and 2019 data

Continent / region	*No. of countries*	*Total e-waste generated (in Mt)*		*Total e-waste generated kg/inh*		*Documented e-waste – to be collected, recycled (in Mt) (in %)*	
		2016	*2019*	*2016*	*2019*	*2016 (in %)*	*2019 (in %)*
Africa	53	2.2	2.9	1.9	2.5	0.004 (0.0)	0.03 (0.9)
Americas	34	11.3	13.1	11.6	13.3	1.9 (17.0)	1.2 (9.4)
Asia	46	18.2	24.9	4.2	5.6	2.7 (15.0)	2.9 (11.7)
Europe	39	12.3	12	16.6	16.2	4.3 (35.0)	5.1 (42.5)
Oceania	12	0.7	0.7	17.3	16.1	0.04 (6.0)	0.06 (8.8)
Total	**184**	**44.7**	**53.6**			**8.944 (73.0)**	**9.29 (83.3)**

Source: Baldé et al. (2017), Forti et al. (2020: 25). Compiled by the author.

- Table 1.3 presents data on e-waste generated (in Mt and in kg/inh) and formally collected and recycled, comparing across five regions in 2016 and 2019.
- Overview of E-Waste Statistics Comparison
  - Comparison between 2016 and 2019 data

    - Regional variations in e-waste generation, collection, and recycling
    - Focus on key regions: Africa, Americas, Asia, Europe, Oceania
- Regional E-Waste Generation Changes
    - **Africa:** Increase in generation
    - **Americas:** Increase in generation, decrease in collection and recycling
    - **Asia:** Significant increase, with China as a major contributor
    - **Europe:** Minor drop in generation, improved recycling rates
    - **Oceania:** Status quo in per capita generation, reduction in collection
- **E-Waste Collection and Recycling Trends**
- Changes in Collection and Recycling Rates
    - **Americas and Asia:** Drop in formal collection and recycling
    - **Europe:** 7.5% increase in formal recycling
    - **Asia:** China produced 10.1 Mt of e-waste; low collection rates
    - **Oceania:** Low collection and recycling rates; reliance on informal practices
- **E-Waste Generation by Region (2019)**
- Quantities and Key Contributors
    - **Africa:** 2.9 Mt (5% of global e-waste)
    - **Americas:** 13.1 Mt (25% of global e-waste)
    - **Asia:** 24.9 Mt (40% of global e-waste)
    - **Europe:** 12.0 Mt (25% of global e-waste)
    - **Oceania:** 0.7 Mt
- **Regional E-Waste Statistics (2019)**
- Detailed Statistics by Region
    - **Africa:** Top generators – Egypt, Nigeria, South Africa
    - **Americas:** High generation in North America and Brazil
    - **Asia:** Major generators – China, India, Japan, Indonesia
    - **Europe:** Top generators – Germany, Great Britain, Italy
    - **Oceania:** Top generator – Australia
- **E-Waste Management Practices**
- Regional e-waste Management and Legislation

- **Africa:** Mixed practices; reliance on informal sector
- **Americas:** Variation in legislation; high informal recycling
- **Asia:** High generation but low recycling rates; some legislation
- **Europe:** Advanced practices in Northern and Western Europe
- **Oceania:** Low collection and recycling; reliance on informal practices

Environmental and Health Concerns Impact of Undocumented E-Waste Flows

- **Environmental Impact:** CO2 emissions, mercury deposition
- **Health Concerns:** Persistent organic pollutants (POPs)
- The data from undocumented flows of e-wastes revealed substantial emission of CO2 and BFRs, and deposition of mercury.
- Brominated flame retardants (BFRs) are mixtures of man-made chemicals that are added to a wide variety of products, including for industrial use, to make them less flammable. They are used commonly in plastics, textiles and electrical/electronic equipment.
- The link between emission of CO2 and global warming leading to climate change is well-established.
- Mercury is persistent and bio-accumulative in the environment and retained in organisms.
- Most of the mercury found in the environment is inorganic mercury, primarily entering the environment through emissions to the air from several sources.

The GEM 2020 has presented a list of suggestion, which are purely curative waste management aspects (collection and recycling

- Suggested Improvements for E-Waste Management
  - **EPR Implementation:** Extended Producer Responsibility
  - **Monitoring and Compliance:** Strengthen legal enforcement
  - **Investment Incentives:** Encourage formal recycling sector
  - **Financing Models:** Upfront fees, consumer responsibility, market share approach
- The occupational health and conditions of workers, especially children that are getting exposed to hazards of e-waste have been reported by the GEM 2020.
- The associations between exposure to informal e-waste recycling and health problems, such as, adverse birth outcomes (stillbirth, premature birth, lower gestational age, lower birth weight and length, and lower APGAR scores), increased or decreased growth, altered neurodevelopment, adverse learning and behavioural outcomes, immune system function, lung function and DNA damage, changes in gene

expression, cardiovascular regulatory changes, rapid onset of blood coagulation, hearing loss, and olfactory memory are reported (Forti et al. 2020: 65).

- GHG emissions, contribution of e-waste to global warming, contamination of air, water and soil are major concerns expressed for safe environment.
- The prevalent scenario has become a part of discourse on e-waste management across the globe

E-waste flow and data on transboundary movement

- **Transboundary Movement of E-Waste-** Transboundary movement is considered to be a way of dumping waste / e-waste from one country to another.
- Historical and Current Trends
    - **Historical Trends:** Significant internal and regional trade
    - **Early 2000s:** Africa exported e-waste to Korea and Spain
    - **Post-2006:** Asia becomes dominant recipient of global exports
    - **Examples:** Guiyu, China and Agbogbloshie, Ghana
- **E-Waste Export Statistics (2002-2012)**
    - **2004-2006:** Over 10 million tonnes exported per year
    - **Increase:** 15% in exports by 2006
    - **Hazardous Wastes:** Increase of 4%
    - **'Other Wastes':** Gradual decrease
- **E-Waste Flow from USA (2010)**
    - **Generation:** 258.2 million units (1.6 Mt)
    - **Collection:** 171.4 million units (0.9 Mt)
    - **Exports:** 14.4 million units (0.027 Mt)
    - **Destinations:** Latin America, Caribbean, Asia, Africa

Transboundary E-Waste Issues Observations and Problems

- The ILO report (Lundgren 2012: 14–17) has described important observations about transboundary movements of e-waste; wherein four aspects or phenomena are described:

(i) illegal trade which has intensified corporate, or 'white collar' crime

(ii) use of 'second hand goods' label – to disguise mislabel containers and mix waste with legitimate consignment, and lack of reliable data on illegal waste activity

(iii) recent emergent field of 'green criminology' – e-waste trade as an example, which poses environmental risk and expected to be compliant to regulatory norms, though not criminalised as such; and

(iv) security implications – more research is needed in order to find out more about the networks behind the illegal export that is taking place.

- **(Transboundary E-Waste Issues**
    - **Illegal Trade:** Corporate crime and mislabeling
    - **'Second-Hand Goods' Label:** Misleading waste management
    - **Green Criminology:** E-waste trade's environmental risks
    - **Security Implications:** Need for more research)

Creating and updating statistics, datasets: opportunities and challenge

- Three GEMs (2014, 2017 and 2020) at the regular interval of three years is considered to be trendsetting and promising initiative for statistics and exploring existing e-waste scenario.
- Advantages and disadvantages of every method are elaborated, challenges of creating and updating data are also articulated – gaps are identified,
- Sustainable development processes that lead to misinformation or wrong labelling and misleading data (especially on transboundary movements) are identified
- The GEM 2020 has begun build up to data on three important aspects of e-waste management – Future Focus
- CE, toxicity and impact on children and workers.
- More information on different aspects of environment and human health built through national registry or micro studies,

for example, on extent of toxicity, types of toxicity, every aspect of environment (energy in LCIA approach to e-waste, fossil use, carbon prints, contamination of air, soil and water).

- As more countries are adopting e-waste legislation/regulatory policy, it is important to provide data that facilitate the complexities of decision-making,
- for example, whether to treat e-waste domestically or through export, issues that are of environmental, political, economic and ethical nature and how to address them by legal framework.

III. An overview on status of e-waste related legislation across the globe

- Most legislative instruments aim at resource recovery through recycling and focus on countermeasures against environmental pollution, and adverse impacts on human health, at the EoL of products.

- The laws and policies concerning the proper management of electronic devices are continuing to evolve in different parts of the globe.
- The legislation does not imply complete legal compliance, as in many countries, policies are non-legally binding strategies,
- The legislation largely focusses on regulating guidelines for collection, reuse and recycling of e-waste, except New York city of USA which has introduced landfill bans of scrap.
- Other initiatives include setting up take-back channel, initiating programmes for collection and recycling and appointing private companies for recycling or regulating e-waste through a directive or administrative regulation
- Legislative Coverage (2014-2019)

Growth in Legislative Frameworks

- 2014: 61 countries (44% of global population)-In 2014, 61 countries were covered by legislation/ regulation/policy with 44% of world's population;
- 2017: 67 countries (66% of global population)
- 2019: 78 countries (71% of global population)
- Recent Additions: 11 countries(including the state of Alabama in the USA, Argentina, Cameroon, Nigeria, South Africa, Sri Lanka, Zambia) with new or updated legislation

Extended Producer Responsibility (EPR**)-**EPR is a common feature in these legislations

- **EPR Focus:** Put Responsibility on producers for e-waste

Producers are tasked with extensive reporting and monitoring procedures to demonstrate compliance with the regulation.

The waste hierarchy has been extended and prioritised as prevention, reuse, recycle, recovery and, as a last resort, disposal of waste

(Waste hierarchy: Prevention, reuse, recycling, recovery, disposal)

- **Prevention:** Avoiding waste generation
- **Reuse:** Extending the lifecycle of products
- **Recycle:** Processing waste into reusable materials
- **Recovery:** Extracting energy or materials
- **Disposal:** Last resort for waste management

- Dominance of the informal sector in collection, refurbishing, and recycling
- Minimal government control on e-waste sector and inadequate infrastructure
- Impact on formal recycling operations

Regional Variations in E-Waste Management

- **Eastern Europe:** Private sector-led recycling in Poland, Czech Republic, Hungary, Bulgaria
- **North America:** Effective management through legislation (e.g., California Electronic Waste Recycling Act)
- **Asia:** Varying levels of e-waste collection; penalties for non-compliance in China
- **Africa:** Issues with illegal imports and informal recycling practices

Challenges in E-Waste Recycling

- Difficulties in Global Monitoring and Compliance
  - Lack of uniformity in legislation
  - Varied levels of collection and recycling
  - Need for improved regulatory frameworks and monitoring

E-Waste in Africa

- Issues in Western Africa (Ghana and Nigeria)-a dumping yard destination for e-waste from various regions of the world
- two concerns are highlighted:

1. illegal import of e-waste,
2. recycling activities carried out in informal basis and the residues are landfilled, impacting the health of recycling workers and local environment

Relevance of international legislative frameworks across the globe: trends and challenges

Overview of Global E-Waste Legislation

1. EU Legislation: Regulations and directives for member states
2. Multilateral Environmental Agreements: Global agreements on waste management
3. SAICM: Strategic Approach to International Chemicals Management

1. EU Legislation EU legislations applicable to EU countries

- **RoHS Directive:** Restriction on hazardous substances
- **WEEE Directive:** Waste Electrical and Electronic Equipment management
- **REACH Regulation:** Registration, Evaluation, Authorisation, and Restriction of Chemicals

WEEE Directive (2002/96/EC) -The WEEE directive is set out over 19 articles, among them the important ones are

- **Scope:** Categories of WEEE and definitions
- **Collection and Treatment:** Separate collection, treatment, recovery, and recycling
- **Stakeholder Responsibilities:** Registration, reporting, and compliance requirements
- The WEEE Directive sets out the financial responsibilities

Five areas of e-waste management are addressed under the EPR, namely:

- (i) production, including improved product design;
- (ii) distribution
- (iii) consumption (by domestic and business consumers) and separate collection of e-waste with targets specified for recovery, reuse, and recycling of different classes of WEEE (creating take-back channel by the producer)
- (iv) e-waste handling – reuse, recycling, and recovery
- (v) e-waste treatment and disposal including specifications for exporting e-waste for treatment.
- The WEEE Directive has covered aspects of financing and electronics user awareness

RoHS Directive (2002/95/EC)-Restriction of Hazardous Substances

- **RoHS1:** Restrictions on six hazardous substances -Lead, Mercury, Cadmium, Hexavalent Chromium and Sustainable development Flame Retardants – Poly Brominated Biphenyls (PBB) or PBDE)
- and its weight;
- the company (manufacturer, importer, or distributor) placing the product on the EU market should maintain records to show compliance;
- and these restricted substances need to be substituted by safer alternatives
- **RoHS2:** Extended requirements and recordkeeping -(including a conformity assessment, CE marking, maintenance of compliance throughout production, and self-reporting of non-compliance).
- **RoHS3:** Addition of four new restricted substances- Di (2-ethylhexyl) phthalate (DEHP) (0.1%) Butyl Benzyl phthalate (BBP) (0.1%) Dibutyl phthalate (DBP) (0.1%) Di-isobutyl phthalate (DIBP) (0.1%)

REACH (registration, evaluation, authorisation and restriction of chemicals)

- **Purpose:** Protection of human health and the environment through the better and earlier identification of the intrinsic properties of chemical substances, deals with 197 Substances of Very High Concern (SVHC)
- **Processes:** The regulation impacts almost every product made in or imported into the European Economic Area (EEA). This is done by the four processes of REACH, namely the registration, evaluation, authorisation and restriction of chemicals and places the burden of proof on companies
- **Impac**t:REACH manages the databases necessary to operate the system, co-ordinates the in-depth evaluation of suspicious chemicals and is building up a public database in which consumers and professionals can find hazard information.

Link between RoHS, WEEE and REACH

- **1. RoHS (Restriction of Hazardous Substances):**
    - Restricts hazardous substances in EEE.
    - Applies to components like wiring, components, circuit boards, displays, subassemblies, cabling.
- **2. WEEE (Waste Electrical and Electronic Equipment):**
    - Regulates disposal and recycling of e-waste.
    - Covers collection, treatment, and recycling.
- **3. REACH (Registration, Evaluation, Authorisation, and Restriction of Chemicals):**
    - Controls chemicals used in EEE.
    - Manages databases of chemical properties and risks.

- **RoHS and WEEE Directives**
- Focuses on reducing hazardous substances in electronic products.
- Applies to substances identified as carcinogenic, mutagenic, etc.
- **WEEE:**
- Addresses disposal and recycling of e-waste.
- Mandates collection, treatment, recovery, and recycling of e-waste.
- **Interaction:**
- RoHS reduces hazardous chemicals, impacting WEEE by minimizing hazardous waste.

Both directives work complementarily for effective e-waste management

REACH Regulation

- **Purpose:**
- Manages chemicals throughout their life cycle.
- Ensures safe handling and assessment of chemical substances.

Impact on EEE:

- Controls chemicals used in EEE components.
- All RoHS restricted substances are also on the REACH restricted list.

Synergy:

- Enhances RoHS by ensuring safer chemicals in the manufacturing process.
- Complements WEEE by controlling the substances that end up in e-waste.

Extended Producer Responsibility (EPR)

- **Common Feature:**
- EPR is integral to RoHS, WEEE, and REACH.
- Producers must handle e-waste management, including reporting and monitoring.
- **Waste Hierarchy:**The waste hierarchy has been extended and prioritized as
- Prevention
- Reuse
- Recycle
- Recovery
- Disposal
- **Focus:**
- EPR emphasizes responsibility for e-waste from production through disposal.

2. Multi-Lateral Environmental Agreements (MEAs)

1. Basel Convention (1989):
    1. Controls transboundary movements of hazardous waste.
    2. Aims: Prevention, reduction, resource recovery, and final disposal.
2. Rotterdam Convention (1998):
    1. Manages hazardous chemicals and pesticides in trade.
3. Stockholm Convention (2001):

1. Addresses persistent organic pollutants.

Application:

- Basel Convention regulates e-waste shipping and ensures environmentally sound disposal.
- Regional agreements complement Basel's objectives.

The Basel Convention

- The Basel Convention is an initiative of UNEP, which focuses on controlling transboundary movements of hazardous wastes and its disposal.
- In 2006, the EU transposed the Basel Convention and the OECD Council Decision into European regulation with the European Waste Shipment Regulation (WSR).
- The WSR implements the international obligations of the two regulations and includes the internationally agreed upon objective that wastes shall be disposed of in an environmentally sound manner
- The regulatory system under the Basel Convention includes prior informed consent for export and import; and the intended movement is possible only after receiving written consent from both the concerned state authorities

There are four important aims of the Convention related to e-waste, as follow

- (i) prevention – to reduce hazardous waste generation at its source; (ii) reduction – to promote and ensure the environmentally sound management of hazardous waste; (iii) resource recovery – to promote the proximity principle, advocating disposal as close to the source as possible; and (iv) final disposal – to regulate and monitor the remaining transboundary movements of hazardous waste.
- In order to combat illegal traffic of e-waste, the Convention provides for the development of tools and training activities through the Green Customs Initiative (GCI).
- The importance of the Basel Convention is that if it properly implemented and enforced, negative impacts of treating waste at the importing state could be prevented.
- The procedures for legal cross-border movements have set up mechanisms for avoiding ecological disasters and maintaining a high level of protection of workers and the public.
- The shipment can only take place if the state of transit and the state of import give their written consent.

3. Strategic Approach to International Chemicals Management (SAICM)

Strategic Approach to International Chemicals Management (SAICM)

- **Objective:** Its objectives are grouped under five themes
- Promote sound management of chemicals throughout their life cycle.
- **Key Themes:**

- Risk reduction
- Knowledge and information
- Governance
- Capacity building
- Technical cooperation
- Illegal international traffic
- **Linkage:**
  Complements RoHS, WEEE, and REACH by enhancing chemical safety and management

regulatory frameworks have impacted three strategic points of e-waste management in India

1. acceptance and implementation of EPR;
2. recover resources and enhancing CE;
3. improvement in environment and human health.

The existing regulatory frameworks have promoted institutional mechanism, guidelines for implementation of legal provisions, widening net of stakeholders and defining their responsibilities, and spreading awareness about use of chemicals (hazardous and non-hazardous) and their impact on environment and human health

Increasing thrust on circular economy

- **Concept:**
- Focuses on restorative and regenerative systems for handling e-waste.
- Emphasizes recycling, reuse, and resource recovery.
- **Strategies:**
- Product design improvements.
- Efficient collection and recycling practices.
- Reverse logistics and supply chain strategies.
- **Impact:**
- Reduces new material extraction.
- Creates economic opportunities through resource recovery.
- **Challenges and Future Directions**
- **Current Challenges:**
- Inconsistent implementation across countries.
- Informal sector dominance in e-waste management.
- Need for better awareness and compliance.

- **Future Directions:**
- Strengthening international cooperation.
- Enhancing compliance and monitoring.
- Promoting circular economy practices.

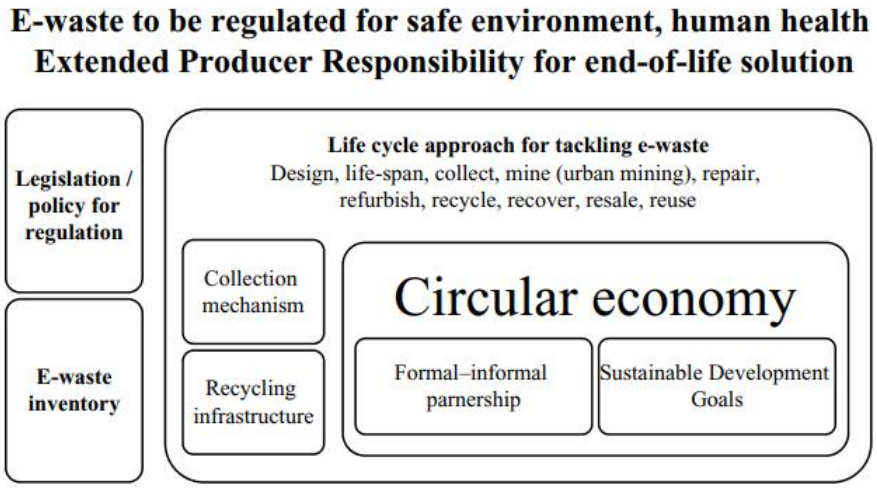


FIGURE 1.4 Tackling e-waste

IV. UN initiatives for e-waste management: creating partnerships and achieving Agenda 2030

- **UN Initiatives Overview (**UN has undertaken various initiatives)
    - Formation of Global E-waste Statistics Partnership (GESP) in 2017 -to address e-waste challenges by improving e-waste data.
    - Collaborative efforts with global agencies
- **Key UN Programs and Agencies -**Each programme or agency contributes to e-waste management in a specified manner
- **Programs:**
    - Environment Management Group (EMG)
    - Solving the E-waste Problem (StEP) Initiative
    - Sustainable Cycles (SCYCLE) Program
    - UNU-ViE SCYCLE
- **Achievements of UN Initiatives**
    - GEM 2017 Report Publication – second edition
    - Global E-waste Indicators Website: www.globalewaste.org
    - Training in 60 countries for e-waste data collection

Agenda 2030/SDGs, more specific targets and their sub-indicator have been recognised for monitoring growth of e-waste, taking cognisance of its potential hazardousness, and its high residual value.

- **E-Waste and Agenda 2030/SDGs** Sustainable Development Goals.
- **Relevant SDG Targets:**
    - SDG 3.9: Hazardous chemicals and health impacts
    - SDG 8.3 & 8.8: Job creation and labor rights
    - SDG 11.6: Urban waste management
    - SDG 12.4 & 12.5: Hazardous waste management and recycling
- **SDG Indicators for E-Waste**
- **Key Indicators:**
    - SDG 12.5.1: National recycling rate and material recycled
    - SDG 12.4.2: Hazardous waste management
    - The e-waste sub-indicator in SDG 12.5.1 has been defined as follow:

SDG 12.5.1 sub-indicator on the e-waste =

Total e-waste recycled/ Total e- waste ated

- **UNEMG Report on E-Waste Initiatives (2004-2017)**
- **Focus Areas:**
    - Regional distribution of initiatives
    - Breakdown of initiatives: Recycling, Education, Policy
    - The UNEMG report (2017) has documented UN systems' response 154 initiatives53 covering ten focus areas, and 12 types of interventions, and their focuses, types and performance across different regions; along with various partnerships and collaborative efforts put in by the UN systems in 14 years (between 2004 to 2017) by the 23 entities associated with UN systems.54 However, those most active UN agencies including UNU and the UNU-led StEP initiative, UNIDO, UN Environment, DFS and UNICEF; the secretariat of the Basel Convention, ITU, and the GEF (Global Environment Facility) are left absent due to their focus on internal corporate e-waste management rather than the provision of direct support to member states on e-waste matters (UNEMG 2017: 23) (Table 1.8).

TABLE 1.8 UN initiatives to tackle e-waste across different regions during 2004 and 2017

Region	*Focus of the initiative*		*Total number*
North America	Shipment of e-waste	01	01
South America	Knowledge sharing	01	13
	E-waste management and disposal	06	
	Chemicals	03	
	Others	03	
Europe	Legal/regulation/patents	04	19
	E-waste management and disposal	06	
	Education/Employment/Health	02	
	Knowledge sharing	01	
	Shipment of e-waste	03	
	Material/Design	01	
	Others	02	
Africa & Sub-Sahara	Knowledge sharing	01	25
	ICTs	02	
	Chemicals	06	
	E-waste management and disposal	12	
	Legal/regulation/patents	03	
	Other	01	
Asia & Oceania	Shipment of e-waste	02	34
	Knowledge sharing	03	
	ICTs	01	
	Chemicals	07	
	E-waste management and disposal	17	
	EPR	01	
	Education/Employment/Health	02	
	Legal/regulation/patents	01	
Total			92

Source: UNEMG (2017: 34–39). Compiled by the author.

- **UN Collaborative Efforts**
- **Types of Initiatives**
  - The types of initiatives undertaken by the UN are:
  - (i) one for standardisation;
  - (ii) two for policies;
  - (iii) three for programmes;
  - (iv) six for working groups and workshops;
  - (v) seven each for glossaries and compilations, and trainings and learnings;
  - (vi) 11 for partnerships;
  - (vii) 13 for networks and consortiums;
  - (viii) quantitative assessments;

- (ix) 23 are studies and reports related;
- (x) 28 for projects; and
- (xii) 30 for preparing manuals and guidelines

- Statistics on collaborations: UN-public, UN-private, UN-only
- Total 139 collaborations and partnerships by UN provide an idea of various aspects of e-waste management and need for addressing requirements on different counts.
- The characteristics of existing collaborations for e-waste management are:
- 68 (49%) collaborations are UN and public;
- 50 (36%) collaborations are UN and private;
- and 21 (15%) collaborations are UN-only.

V. **Indian scenario: e-waste generation, collection and recycling**

- India collected and recycled 30 kt (0.030 Mt) in 2019 , which is less than 0.036 Mt of its e-waste in 2016–2017
- . This reveals that the e-waste generation in India is almost 60% higher in three years, as against its recycling capacity.
- **E-Waste Management in India**
    - Informal sector handling e-waste -including collection, transportation, dismantling, recycling, and selling of secondary/recovered materials in the market.
    - Inefficient technologies and environmental pollution-E-waste in India is majorly processed using inefficient technologies, inadequate infrastructures, and improper and unhealthy eco-system
    - Regulatory challenges and non-compliance
    - (Despite being highly effective in collecting WEEE, its recycling techniques yield low extraction rates and result in large scale environmental pollution, which negatively affects the physical wellbeing of thousands of people (GIZ 2017: 4). In 2017, over 200 manufacturers of electronic goods, including some e-giants, were served notices by the Central Pollution Control Board (CPCB) for not complying with e-waste procurement norms (Henam 2018)

Historical, domestic e-waste in India: generation and composition

- Historical Data:
    - E-waste generation trends (2005-2019)

- Major sources of e-waste

- Future Projections:
  - Expected rise in e-waste by 2020 and beyond

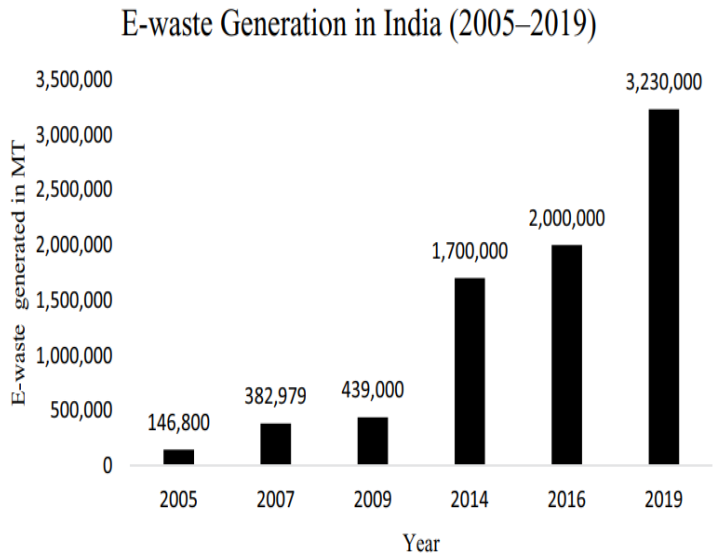


FIGURE 1.5 E-waste generation in India (2005–2019)

Essentials of e-waste cohesive management thinking in India

- India has largely focused on a regulatory framework, employing EPR as management and enforcement strategy for various aspects of e-waste management along with increasing thrust on RE and CE.
- Under the existing legal framework, i.e. the E-waste Management Rules, 2016 (henceforth 'Rules, 2016') and E-waste Management (Amendment) Rules, 2018 (henceforth 'Amended Rules, 2018'), effective implementation of EPR occupies centre stage.
- The producers or the producer responsibility organisation (PRO) is expected to establish collection channel, segregation, safe transportation and ensure recycling of e-waste
- Strategic Approaches for E-Waste Management in India
  - Integration of Make in India, Digital India, Clean India (Swachh Bharat)
  - Material Flow Analysis (MFA) for cohesive management
  - The MFA for e-waste management works as a tool for comprehensive understanding on why, how, where, and what of e-

waste (the flow of matter – compounds, chemical elements, materials, or commodities) at different levels / with a certain categorisation (e.g. national-level assessment, regional-level assessment, product-level assessment, element-level assessment). The MFA helps in what supports a material balancing, conservation flow that brings in multiple axes – e-waste generation estimation, material flow and stock estimation, potential material recovery, socio-technical structure of WEEE management, economic sustainability of e-waste management system, product substitution effects due to technology transition, product and element characterisation, etc.

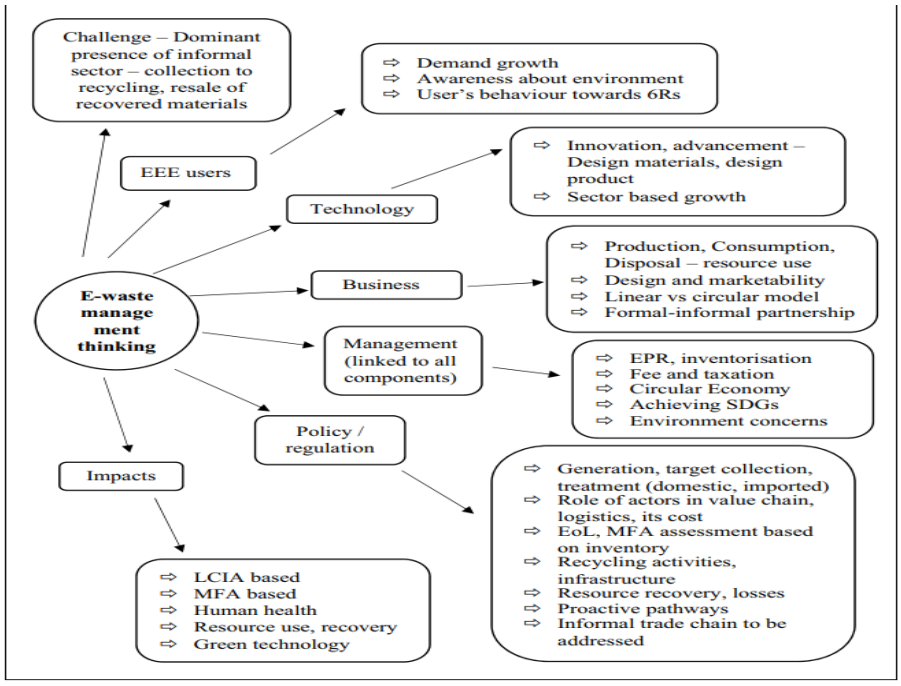


FIGURE 1.6 Essentials of cohesive e–waste management thinking in India

Informal e-waste trade chain in India

- This is the first layer in this sequence of e-waste disposal and collection.
- EEE manufacturers and users (consumers, bulk consumers) are the generators of domestic e-waste; the inflow of imported e-waste is observed, though legally banned.
- The individual consumers are disposing e-waste – either give away for reuse to individuals and institutions or sell it to the kabaadiwala.
- The bulk consumers either auctioned off, sold to scrap dealers, or given away to PROs.
- The manufacturers dispose of e-scrap to scrap dealers, and the imported e-waste is directly entering the trade by dealing with scrap dealers

- The second level – e-waste collection introduces three actors –
- first level of kabaadiwala, scrap dealer/scrap trader/ government agency (MSTC) that trades in metal scrap/PRO, and scrap dealer/scrap trader who may or may not refurbish the e-waste.
- In the third layer of dealing with e-waste, mainly the local kabaadiwala sell the e-scrap to city level waste aggregators. Before the e-waste steps to large-scale aggregators
- in the fourth layer, most e-waste is reported to be sorted, dismantled and/or cannibalised.
- The last layer is of large-scale waste aggregators who may be informal recyclers; if not, they sell off e-waste to the formal and informal recycler
- The e-scrap dealer/trader sells e-waste to the formal/informal recyclers while the PROs pass on the e-waste to the formal/authorised recyclers for legal compliance.
- In this layer, leakage of e-waste is reported, and thus, the e-waste (sorted, dismantled, cannibalised) come back to the market for resale.
- The last layer is of sale of secondary material in the market for reuse/in the supply chain (Figure 1.7)

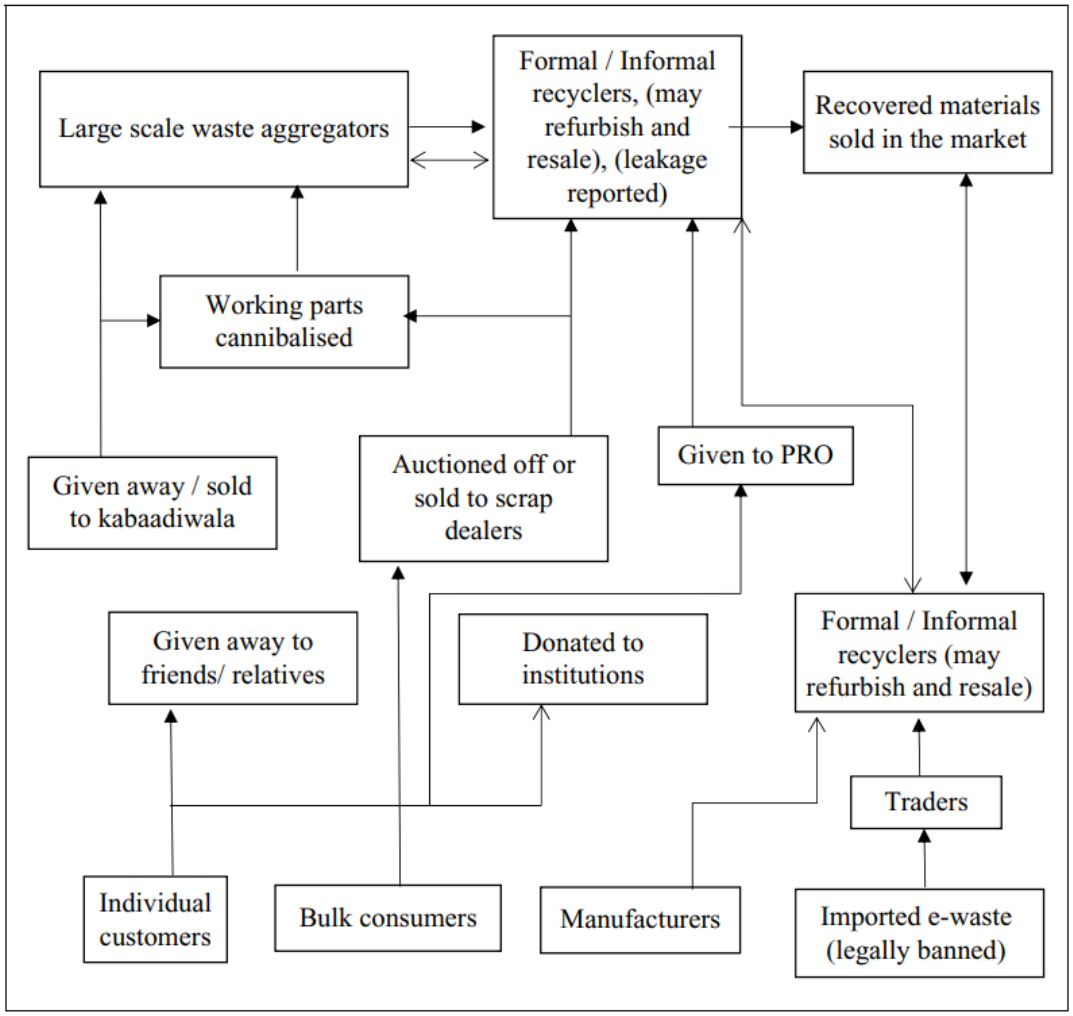


FIGURE 1.7 E-waste flow and recycling scenario in India

- **E-Waste Flow Diagram:** Flowchart of E-Waste Disposal and Collection
- **Levels of E-Waste Flow:**
  - **Generation:** Consumers and manufacturers
  - **Collection:** Kabaadiwala, scrap dealers, PROs
  - **Aggregation:** Local aggregators, city-level aggregators
  - **Recycling:** Formal and informal recyclers
- **E-Waste Flow - Detailed Breakdown**
- **Generation:**
  - **Consumers:** Dispose through reuse, sell to kabaadiwala
  - **Bulk Consumers:** Auction, sell to scrap dealers, or give to PROs
  - **Manufacturers:** Dispose of e-scrap to scrap dealers

    - **Imported E-Waste:** Enters trade via scrap dealers
- **Collection Actors:**
    - **Kabaadiwala:** Local collectors
    - **Scrap Dealers/Traders/PROs:** Intermediate collection points
- **Aggregation:**
    - **Local Aggregators:** Sort, dismantle, cannibalize
    - **Large-Scale Aggregators:** Formal/informal recyclers
- **Recycling Processes:**
    - **Formal Recyclers:** Compliant with regulations
    - **Informal Recyclers:** Risky practices
- **Market Impact:**
    - **Secondary Material Sales:** Reuse and resale
    - **Challenges:** Leakage, informal sector practices

Opportunities and challenges of e-waste management in India

Opportunities in E-Waste Management

- Economic Value of e-waste: $62.5 billion annually
- Material Recovered globally: High-value metals like gold, silver, platinum,tin,cobalt,antimony,copper (extracting gold from e-was--one ton of ore has an extractable reserve of about 1.4 grams of gold while a ton of mobile phone PCBs can produce about 1.5 kg.)
- Environmental Benefits: Reduced CO2 emissions, lower global warming
- Economic Benefits: Extended product life, job creation

Challenges in E-Waste Management

- **Environmental and Health Risks:**
    - **Improper Disposal:** Landfill, burning, illegal trade - threat it creates to the environment, sustainable development, economy, human health and surrounding ecosystems.
- **Operational Challenges:**
    - **Logistics and Costs:** Collection and transportation
    - **Technology:** Viability and advancements in recycling
    - **Informal Sector Issues:** Low income, risky practices
- **Regulatory Issues:**

- **Compliance and Enforcement:** EPR implementation
- **Data Collection:** Accurate e-waste statistics

Strategic Actions and Solutions

- **Partnerships:** Formal-informal sector collaborations
- **Awareness:** Educating users and producers
- **Data Management:** Reliable databases and enforcement
- **Innovation:** Technology advancements in recycling

MODULE 1 -QUESTION BANK

1. Define Ewaste
2. E-waste management thinking across the globe.
3. Explain life cycle,of e product.
4. Importance of electrical and electronic equipment in a nation's development, and e-waste as toxic companion of digital era
5. Explain 6R framework for E-waste management
6. What is the Impact of Undocumented E-Waste Flows and suggestion from GEM.
7. Internationally, three sets of legislation/regulatory frameworks exist mainly for management of e-waste

8. The definition of e-waste that has been agreed by StEP is and Three terms are explained as part of the definition in StEP White Paper.

9. described important observations about transboundary movements of e-waste
10. Explain E-waste flow and data on transboundary movements
11. Explain (i) EU) legislations applicable to EU countries; (ii) multilateral environmental agreements; and (iii) SAICM
12. Explain l
13. ink between RoHS, WEEE and REACH
14. explain UN initiatives for e-waste management
15. what are the types of initiatives undertaken by the UN e-waste management
16. explain SDG
17. explain Indian scenario: e-waste generation, collection and recycling
18. explain essentials of e-waste cohesive management thinking in India with neat diagram.
19. Explain Informal e-waste trade chain in India with neat diagram.
20. Explain Opportunities and challenges of e-waste management in Indi