सत्यमेव जयते
नीति आयोग
National Institution for Transforming India

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Department of Electronics and IT
Ministry of Communications & Information Technology
Government of India

Strategy for Secondary Materials Management for promoting Resource Efficiency (RE) and Circular Economy (CE) in Electrical and Electronic Equipment Sector

Draft for Comments

Foreword and Acknowledgement

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Executive Summary

Urban Mining and secondary materials management has gained prominence from public policy thinkers and business alike. There is tremendous scope for enhancing resource efficiency with the move towards recycling and circular economy and this makes economic sense for entrepreneurs considering the resource potential in end of life electrical and electronic products. Precious metals, steel, aluminum, copper and plastics make these products lucrative both from the potential of source of secondary metals as well as livelihood for millions in the country. India, at present, isranked as the 5th highest generator of e-waste with year on year growth rates of about 30 percent.

The resource efficiency strategy for secondary materials from end of life products also fits into multiple missions which have been initiated by the Government of India. These are Make in India, Digital India, Skill India and Swacch Bharat (Clean India). The missions are aimed at not only achieving key social and economic goals but also aim to enhance the quality of environment by reducing GHG emissions, specifically from waste which reaches the landfills and from reduction in use of virgin materials. Digital India mission, which is a key socio-economic empowerment initiative, rests on the availability of electronic products as a communication medium with the end user. Hence, its success predominantly rests on the penetration of electronics and communications products across the nook and corner of the country.
EEE products have a lifecycle where end of life disposal is critical not only because they are hazardous in nature and affect human health and environment but also because they are a source of secondary materials which can easily be channelized back into the production process. This can lead to livelihood generation and growth.
In India, such end of life materials have been predominantly handled by the informal sector. They have an immense network of collectors and aggregators across the country. Materials are dismantled and then sent across to selected hubs for recycling. A case in point is PCBs from different parts of the country finding their way through informal channels to Moradabad where dismantling and recycling of PCBs takes place across thousands of households in the city and its vicinity. This informal recycling has led to destruction of the environment and caused health hazards for its residents.

On the other hand, C-MET and CIPET, which are research arms of the Ministry of Electronics and Information Technology and Ministry of Chemicals and Fertilizers respectively, have done pioneering work in developing technology for recycling of metals and plastics respectively. The laboratory models have been scaled up for industrial use and have been shared with entrepreneurs who have applied for the same. These technologies help to enhance efficiency of recycling and are environment friendly thereby mitigating health hazards.

It is important, therefore, to design policy frameworks which allow for proliferation of these indigenous technologies in the informal sector. This will lead to the formalization of the informal sector and lead to mitigation of health and environmental impacts. Furthermore, it will enhance resource security which is key to success of missions like Make in India. Livelihood security for the informal sector through formalization can lead to access to services under the Digital India mission.

Policy makers need to ensure that key steps to achieving the desired results follow a strategic path which integrates all stakeholders concerned, including consumers, producers, collectors, aggregators, dismantlers, recyclers, both in the formal and informal sector. Specific strategies for stakeholders can include creating awareness on hazards associated with unsafe disposal of end of life products, it's secondary resource potential, dissemination of technology for upgradation of the informal sector, proper implementation of EPR for producers, monitoring and evaluation by state agencies and capacity building of key stakeholders for successful implementation of the e-waste management rules, 2016.

This strategy paper explores the key dynamics which exist with value actors and material flows and identifies the intervention areas with stakeholders. It then explores technology intervention with the informal sector to enhance resource efficiency, resource security and circular economy which can directly influence success of specific missions of the Government of India. The action agenda outlines the key responsibilities of identified stakeholders to enhance resource efficiency and circular economy in the electronics sector.

Preamble

Rising consumption and production have led to overstressed use of available resources on the planet. This has caused serious environmental, social and economic impact such as rising inequalities within the country and among different nations.

Resource efficiency and circular economy can be the answers to possible conflicts which can arise from socio-economic, socio-political and politico-economic inter-relationships which is caused due to scarcity of resources. Keeping this essence in mind, it is important to understand how manufacturing can be made sustainable by adopting policies and strategies which promote circular economy and resource efficiency such that growing demand of electrical and electronic equipment (EEE) products can be met. This will also aid in the flagship government programme of Digital India which aims to move towards a digitisation of processes and services which will enable it to reach the entire population across the length and breadth of this vast country.

This strategy paper identifies the strategies that can be adapted in India for the end-of-life management of EEE products in order to address key challenges of resource availability for production, loss of precious resources, pollution and environmental degradation resulting from crude handling of e-waste, enhanced livelihood opportunities, safe and non-hazardous workplace environment.

The world is becoming a closer place through the use of the internet. Globally, almost half of the population is now connected over the internet and is online[1] (Baldé et al, 2017)). Reduction in communication time has enhanced productivity but has also led to increase of material use for EEE production over this time period. Emerging economies with a low Purchasing Power Parity have the fastest growth of EEE equipment. In terms of absolute rates of consumption, materials like refrigerators, washing machines and flat TV panels have shown the maximum growth (ibid). Furthermore, fall in service prices have made the use of mobile phones much cheaper than before.

Key challenges which exist for manufacturing are development of skills and inclusion of the informal workers into the formal chain which will allow to address resource security concerns. Furthermore, it is important to note that the work of the informal sector leads to serious health and environmental hazards. This endangers livelihood security and has socio-economic consequences. It is therefore important to foster adoption of technology which will not only mitigate negative impacts of e-waste recycling but also enhance resource recovery leading to higher incomes, availability for resources for manufacturing and mitigate the environmental and health impacts of hazardous substances.

Resource efficiency and Circular economy are at the heart of the solutions which can provide the necessary fillip to key Government of India missions and ensure the next wave of growth in the country.

[1] Baldé et al, 2017

Background

NITI Aayog with the EU Delegation to India released a Resource Efficiency (RE) strategy for India in November, 2017. The objective of the strategy paper is to address resource security issues by enhancing resource productivity and strengthening secondary raw materials utilization. The RE strategy proposes a comprehensive action plan to initiate an enabling framework for its implementation. Priority sectors/ issues like Construction and Demolition Wastes, Electronic Waste, Steel Recycling and Aluminium recycling have been identified by NITI Aayog to address RE and CE approaches in abiotic materials.

Outline of Strategy

The strategy for enhancing recovery and utilisation of secondary materials for production of EEE takes forward the work of developing a comprehensive action plan of promoting Resource Efficiency in India and towards transformation to a Circular Economy. The approaches mentioned here addresses material use trends, history and evolution of the end-of-life management of EEE, status and practices of secondary raw materials recovery from WEEE, recycling capacities, practices in the informal sector, indigenous technologies and challenge along with challenges and opportunities. The strategy will also supports the implementation of existing E-waste Management Rules, 2016 and MeitY's awareness generation programme on e-waste. In particular, it will explore how e-waste management can be linked to key government programs, including Make in India (focus on usage of secondary raw materials, technology development and upgradation), Swachh Bharat (focus on economic instruments for collection, reuse and recycling) as well as Digital India (focus on awareness raising, transparency and eco-innovation in the ICT sector). Thus it envisions the transformation of India's increasing EEE production in India and pathways towards a Resource Efficient and a Close loop economy to address need for critical materials.

1. Material Use Trends

1.1 Growth in Material Use Over the Years

One of the largest users of raw materials today are EEE manufacturers. With rising consumerism, affordability and steep growth of digital products such as mobile phones and laptops, obsolescence of these is a critical problem facing the world. The sweeping digital revolution across the world has added more than 1.5 billion mobile phones units in 2017[2]. Mobile phones manufacturing alone accounts for 225,000 tons of material usage, if we consider an average weight of 150 grams per unit.

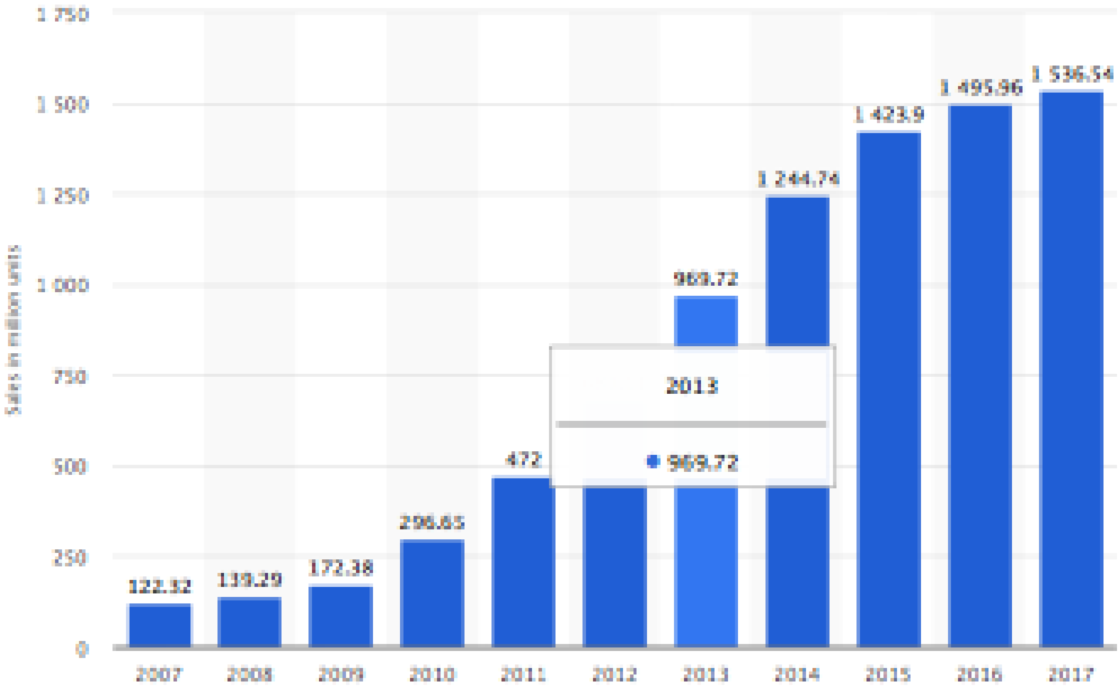

Fig. 1.1: Consumption of mobile phones over the last 10 years (Source: www.statista.com)

By 2020, the demand of electronic products in India is expected to reach nearly $400 billion with an CAGR of 41% during 2016-2020. Domestic production is expected to grow at CAGR of 27% to reach $104 billion given the Government of India (GOI) push towards manufacturing through its Make in India Initiative and Digital India missions. The growth rate has nearly tripled from 2010-2016 period when CAGR was at 9.6%. In 2016, India was the fifth largest producer of e-waste in the world after the United States, China, Japan and Germany, and according to the Global E-waste Monitor 2017 estimates, it generated nearly 2 million metric tons of e-waste in 2016. With a multitude of electronics which have now become a part of daily life, the consumption of metals and materials like plastics has seen a boom. The resource use per capita shows a significant difference in developed and developing countries. The quantum of waste generated follows a similar pattern as well.

[2] www.statista.com

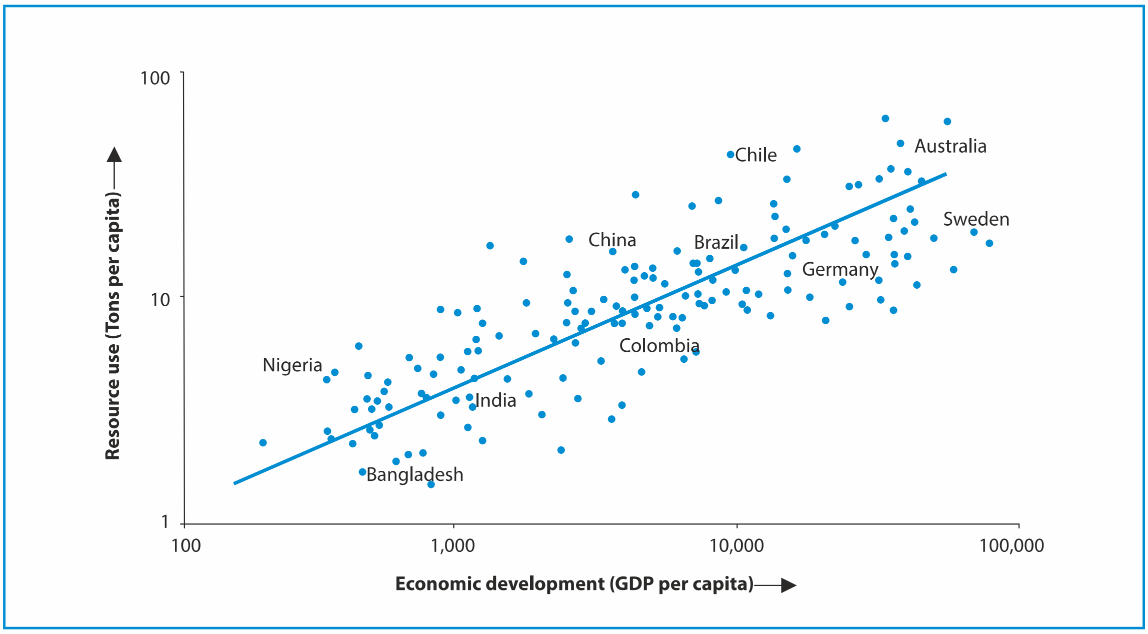

Fig 1.2: The Link between Economic Development and resource use (FICCI Circular economy report, GDP per capita figures in US dollar)

The figure above clearly indicates the positive co-relation between growth per capita and resource use across different countries in the world. Higher per capita GDP leads to consumption of more resources thereby indicating a positive impact on consumption from enhanced income.

1.2 Implications and the Role of Resource Efficiency

There are implications for developing economies when it comes to charting out their specific growth paths. Finite resources are depleting by each passing year and the earth has crossed the threshold where it can replete these resources. In 2018, August the 1st was Earth overshoot day[3] which signifies that within 7 months of the entire year, mankind consumed resources which the earth would have taken at least 12 months to replenish. This also signifies the excess carbon which is being generated through increased consumption which the earth cannot absorb.

It is imperative that resource efficiency is adopted within business models such that material extracted can be put to multiple use through recycling after it has been disposed at end of life. Urban mining in the electronics sector provides a scope for ensuring that different kinds of materials, especially metals, can be brought into the circular chain, thereby enhancing multiple uses than the typical linear consumption models which have been followed in developed economies.

1.3 Material Use Trends in India

India has been a consumption-based economy with limited capacities for manufacturing. This is evident in the trade imbalance where imports to India far outweigh the exports from India[4]. A key reason for the same is the lack of resources like Oil, Gold, rare earths, etc which are the drivers for electronics manufacturing. Moving towards circular economy and resource efficiency provides an opportunity whereby urban mining can help access the

[3] https://www.overshootday.org

[4] http://www.dgciskol.gov.in/data_information.aspx, Directorate General of Commercial Intelligence and Statistics

required resources by recovery through recycling to provide a fillip to the EEE manufacturing sector.

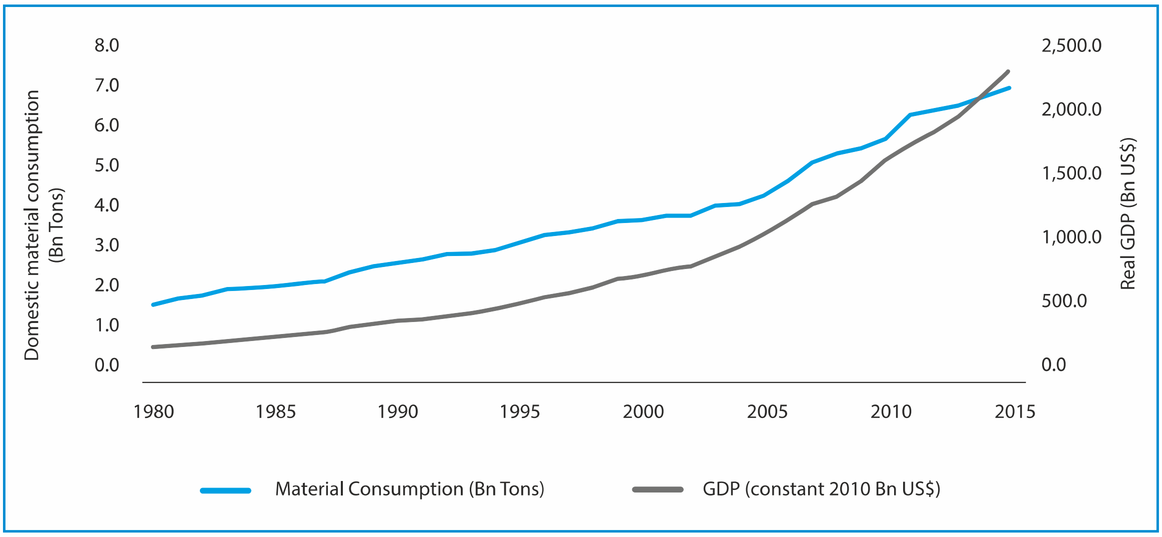

Fig 1.3: Rising material use and economic development in India (FICCI Circular Economy Report)

As indicated earlier in Fig 1.2, India follows a similar path as other countries in terms of direct relation between growth and consumption of resources.

1.4 Resource Use in the Global and Indian EEE industry

Material use per capita over the last few decades has increased in the Asia-Pacific and Latin American countries which can be attributed to growth rates witnessed in many developing countries in these regions.

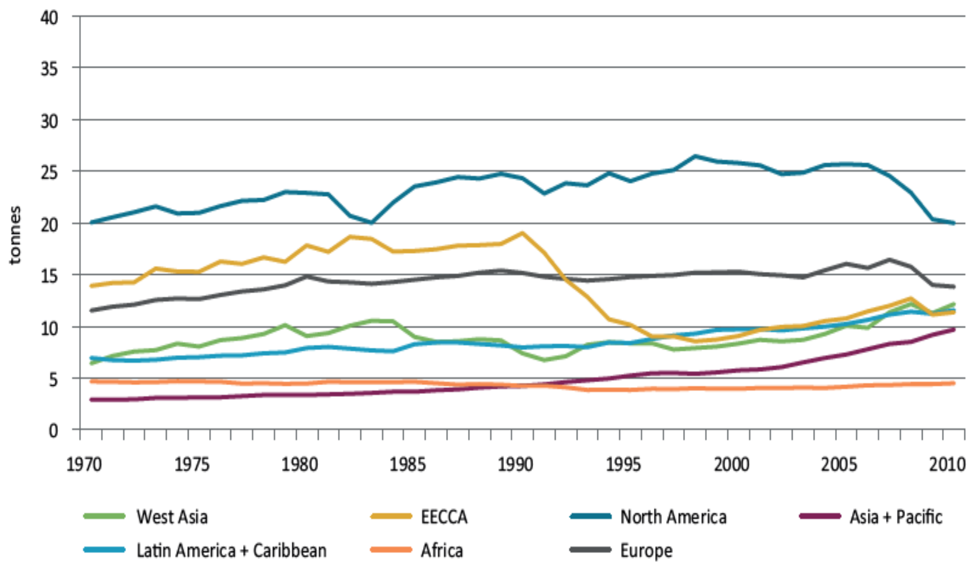

Fig 1.4: Material use per capita across regions over the last 40 years (Source: UNEP)

Global material use increased from 35 billion tonnes in 1980 to more than 67.8 billion tonnes in 2009[5]. Out of the 67.8 billion tonnes of global material use, India's share was about 7.1 percent or close to 4.83 billion tonnes. With rising population and the high growth rates which India has been witnessing henceforth, this is likely to triple by 2030.

Increase in demand for metals in the last 40 years has been to an extent of 87 percent. The drivers for this demand have been the building infrastructure sector, automotive and electronics, primarily the consumer white goods sector[6]. According to the Global e-waste monitor, the estimated value of raw materials which can be mined from e-waste stood at 55 billion euros of which mobile phones alone was to the extent of 9.5 billion euros. The table below shows the quantum and potential value of raw materials which can be extracted from e-waste in the year 2016[7].

Material	kilotons (kt)	Million €
Fe	16,283	3,582
Cu	2,164	9,524
Al	2,472	3,585
Ag	1.6	884
Au	0.5	18,840
Pd	0.2	3,369
Plastics	12,230	15,043

Table 1.1: Potential value of raw materials in e-waste in 2016

Metal stocks are however depleting are not able to keep pace with fast emerging economies. Lifestyle changes have pushed metal demand to levels where large economies have now started adopting circular economy laws which will facilitate circular economy, raising resources utilization rate, protecting and improving environment and realizing sustained development[8]. Fig 1.5 captures the metals and its impact on everyday lives of people.

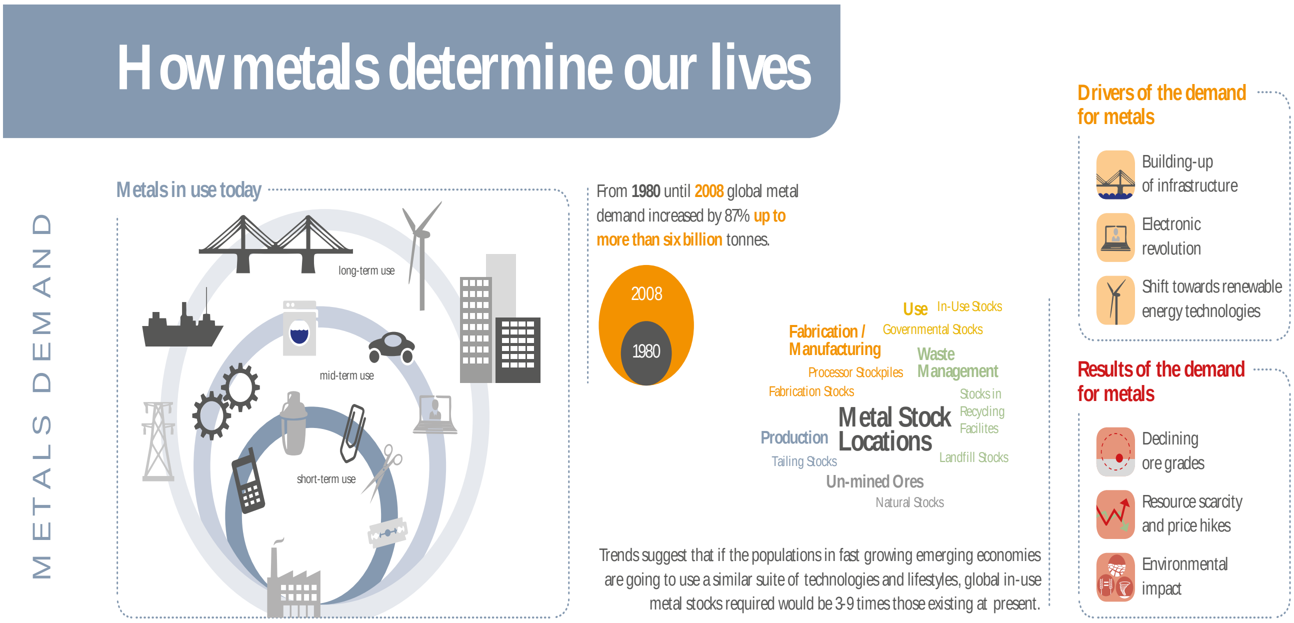

Fig 1.5: Metals and their impact

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[5] India's Future Needs for Resources: Dimensions, Challenges and Possible Solutions November 2013, IGEP, GIZ
[6] https://www.pwc.in/assets/pdfs/industries/search_article_020112.pdf
[7] The Global e-waste Monitor, 2017, Baldé, et.al
[8] http://www.fdi.gov.cn/1800000121_39_597_0_7.html

This consumption led growth has had it upsides and downsides. While this growth rate have added jobs and led to the technological advances which has resulted in improved quality of life across the world, it has also added the problem of end of life materials which has huge ecological implications. The material life cycle has been linear for a long period of time which meant that resources which could otherwise be channelised back into the production process, have been lost and the pressure has been felt on earth for mining more ore to meet metal demand.
This has led to loss in biodiversity since land has been taken over for mining as well as landfill creation where end of life products have been dumped uninhibitedly leading to water, soil and air pollution. This has caused health hazards and impacted human life adversely. While growth rates have increased incomes, this has come at the cost of environment and human health.
Enhancing efficiency in resource use will lead to mitigation of these adverse impacts. Urban mining will also help in meeting metal demand from recycling reducing the pressure on mining for ore. This will mean reducing carbon footprint and make growth more sustainable.

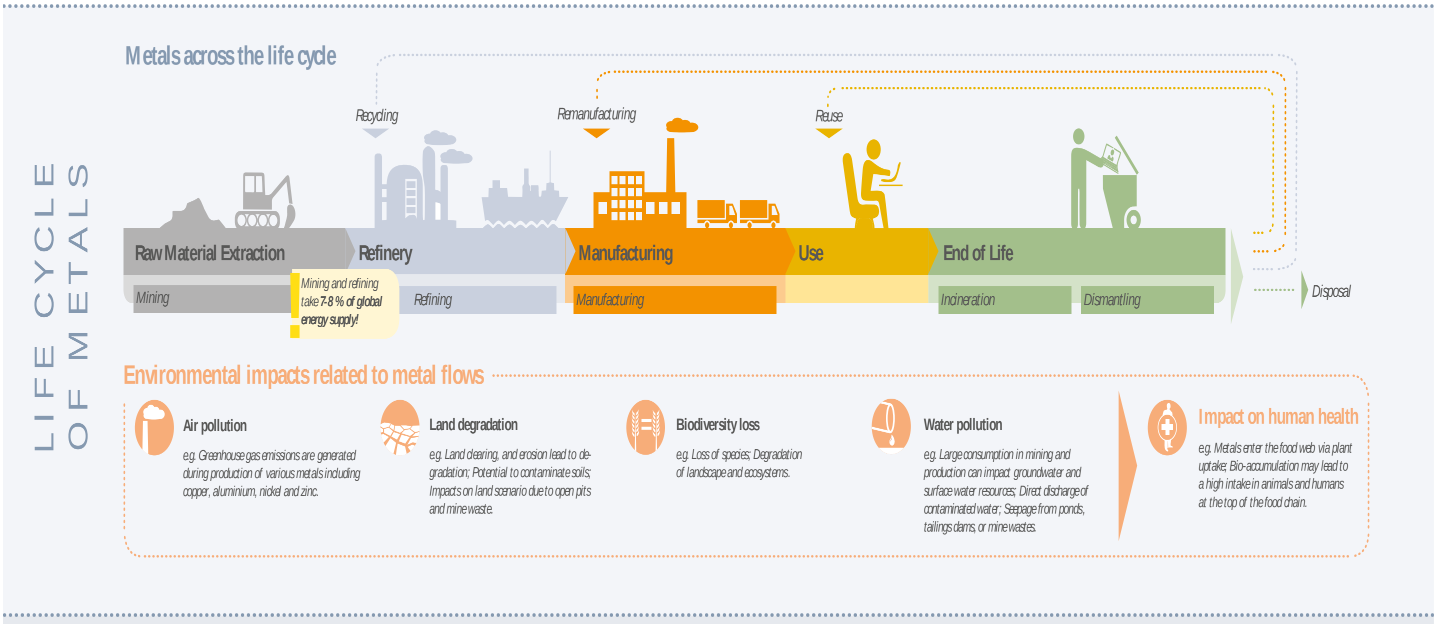

Fig 1.6: Lifecycle of metals

Households in urban areas have multiple IT and consumer electronics equipment today in order to make their lives more comfortable. While these equipment are not disposed as frequently, the frequency of disposal for smartphones is the highest. This is due to the fact that EEE hardware is rendered obsolete due to fast technological innovations including high speed networks, the need for increased data-storage and software upgrades. Overall these are the key drivers for increased quantum of end of life products being generated. Per capita generation is expected to reach 6.8 kg per inhabitant in 2021 from 5.8 kg per inhabitant in 2014. This translated to a total of about 52.2 million metric tonnes by 2021 from 44.7 million metric tonnes in 2016[9].

[9] The Global e-waste Monitor, 2017, Baldé, et.al

1.5 Changing Perspectives/ use of EEE in Automobiles, Construction, Manufacturing and other Allied Sector

The productivity of human beings has increased manifold from being able to communicate using electronic devices to mechanisation of daily chores like washing clothes. Industries have adopted electronics to enhance safety in work processes which had risks involved for humans. Automobiles have become safer due to the enhanced use of electronics.

In the evolving landscape of the engineering and construction sector, electronics is playing a major role. Advanced software, construction-focussed hardware and analytical capabilities are ensuring state of the art improvements in enhancing productivity of materials as well as workers on a real time basis. Safety monitoring on site using electronic equipment has led to faster tracking and reporting of safety incidents. Quality control has increased the efficiency and accuracy of implementation of projects reducing costs and increasing productivity[10].

Box 1.1

How Universal Power Adapters and Chargers Reduce E-waste

One million tons of external power supplies are manufactured each year. This highlights the importance of efforts to reduce the number of such power supplies, and to make them more sustainable. In this regard, environmentally friendly standards for power adapters by the International Telecommunication Union (ITU) are an important step towards reducing greenhouse gas emissions, increasing energy efficiency, and reducing the amount of e-waste generation. In one of its latest eco-standards, ITU identifies specific principles for the eco-design of laptop chargers to reduce power consumptions, and to make them compatible with more devices. This will help increase a charger's lifetime and reduce the amount of e-waste resulting from their disposal.

Source: ITU 2012 and ITU 2016b

Resource efficiency considerations are now been advocated in the design of products (eg, Fairfone) which are used in these industries. This will lead to reduction in environment footprint of producers. Regions like to EU have drafted laws which aim to enhance resource efficiency and circular economy through not only better product design but also enabling product and material recycling.

A few of these regulations include the Restriction of Hazardous Substances Directive (RoHS), the Basel Convention, and the Waste Electrical and Electronic Equipment Directive (WEEE) which are enabling frameworks for resource efficiency and circular economy.

1.6 Resource Efficiency and Economic impact

Resource efficiency in the EEE sector has the potential for significant economic impact. Electronics manufacturing requires complex materials and is resource dependent. In order to ensure that the production process does not suffer due to raw material flow, producers have to be on the continuous lookout for sources which they can depend on. Urban mining provides that opportunity to producers which can ensure that they can access materials at a far lower cost and on a continuous basis.

The major direct impacts of the growth economy model on Organizations can be summed up as shown in the diagram below

[10] https://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/the-new-age-of-engineering-and-construction-technology

Increasing costs	Revenue Reduction	Intangibility of Assets
• Companies whose growth is tightly tied to scarce resources will find themselves at a competitive disadvantage due to rising and volatile prices	• Supply uncertainties and changing consumer preferences could prevent companies from generating revenues and maintaining market share.	• A company's environmental footprint and resource dependence could erode brand value as consumers shun companies with unsustainable business practices.

Fig. 1.7: Challenges for organizations in the Growth economy scenario

Shrinking rate of supply of resources have the potential to disrupt current production processes which can cause chaos in economic systems across the world. Organisations face challenges from growing consumer awareness on forced obsolescence of products from regular upgradation of software which does not work with existing hardware. It is important that holistic consideration on product design, easy reparability and collection mechanisms work hand in hand to enhance resource efficiency which ultimately work to the benefit of the producers.

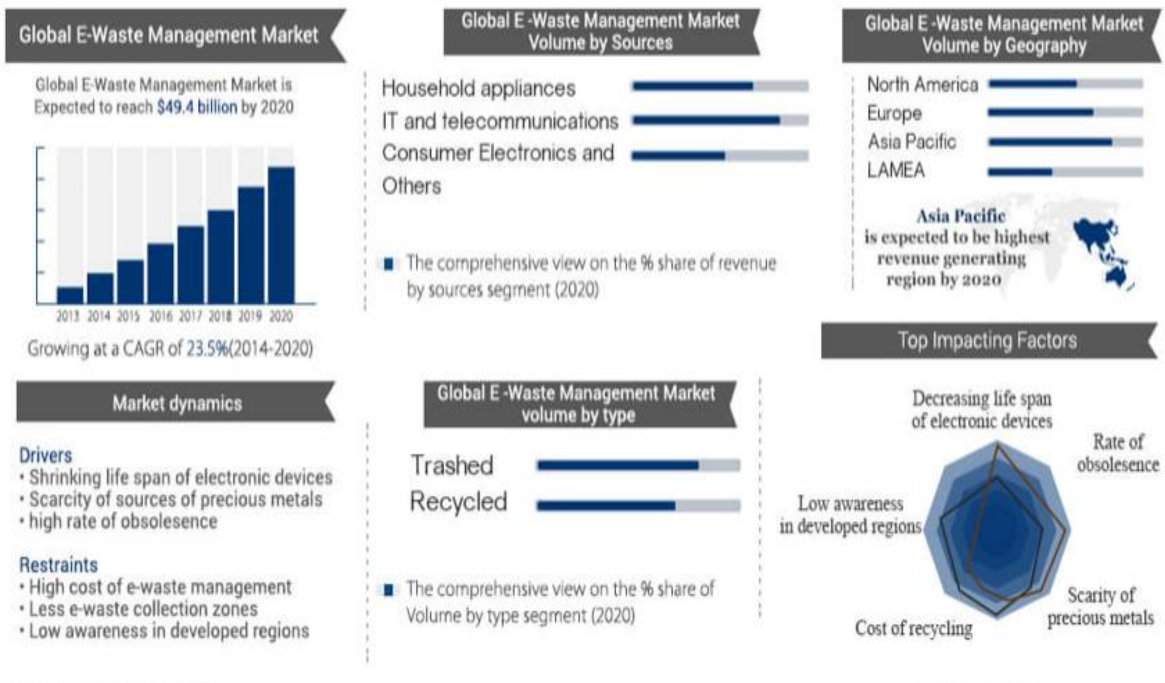

Fig 1.8: Global e-waste market Source: https://www.alliedmarketresearch.com/e-waste-management-market

The movement towards a circular and resource efficient design than the traditional linear model of produce, use and dispose has the scope of business savings for businesses. The FICCI Circular Economy Report, 2017 clearly outlines that the business opportunity for extracting gold from e-waste is to the tune of $0.7 - $1 billion. Furthermore, 1 ton of ore has an extractable reserve of about 1.4 gms of gold while a ton of mobile phone PCBs can produce about 1.5 kgs. As stated above, according to the Global e-waste monitor, the estimated value of raw materials which can be mined from e-waste stood at 55 billion euros of which mobile phones alone was to the extent of 9.5 billion euros. The table below shows the quantum and potential value of raw materials which can be extracted from e-waste in the year 2016[11].

Extended Producers Responsibility in the e-waste management rules, 2016 in India is a step towards making India resource secure by promoting proper disposal of e-waste and its collection which can ensure that secondary materials can flow back into the production stream.

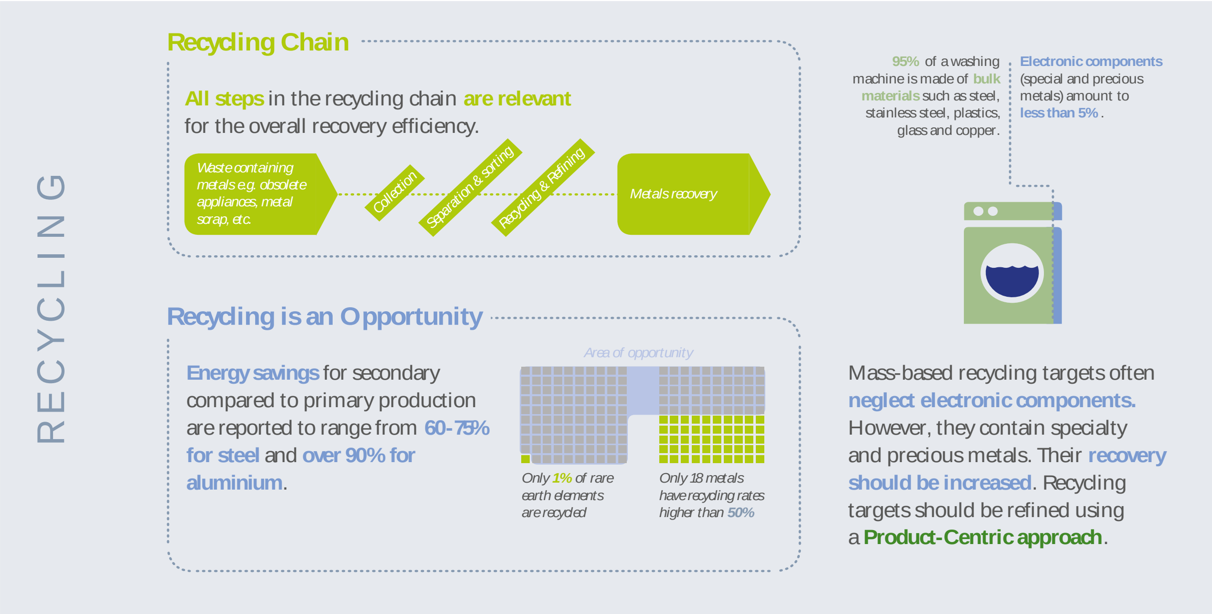

Fig 1.9: The opportunity in recycling

The benefits of recycling can be seen both from a sustainability and climate change perspective. Sustainability can be enhanced by using secondary materials after recycling of end of life products and energy efficiency of these operations which have a positive impact on climate change by using lesser energy than would have been used in extraction of the metal from its ore.

[11] The Global e-waste Monitor, 2017, Baldé, et.al

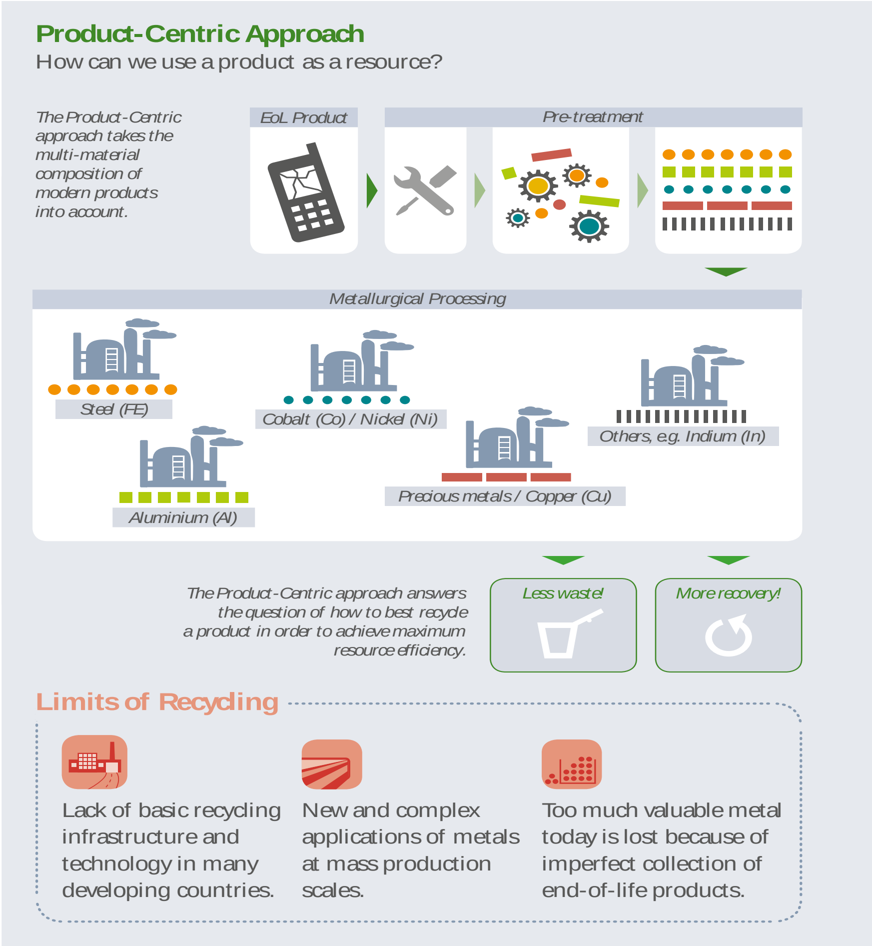

Fig 1.10: Using product as a resource

Having a product centric approach to recycling allows for specialised technology which can be used to extract metals and other materials from the specific waste product. Furthermore, design of products can enhance recoverability and recyclability of materials from products thereby leading to resource efficiency and aiding circular economy.

In order to ensure that India moves towards resource efficiency, it is pertinent that the recycling opportunity be grabbed. Recycling leads to not only recovery of materials and metals from waste which can be channelised into the production process but also ensures energy savings while recovering from secondary materials than production of metals from primary sources like ore[12]. Furthermore, it is important to ensure that a design centric approach is followed so that dismantling and recycling for recovery of materials is made easier. This will not only reduce recovery costs but also enhance demand for secondary raw materials but pushing down their prices.

[12] https://www.recupel.be/en/why-recycle/7-reasons-why-urban-mining-is-overtaking-classical-mining/

2 History and Evolution of E-Waste Management

The earliest steps towards e-waste management came about in 1976 with the Resource Conservation and Recovery Act in the United States. While it became illegal to dump e-waste in the United States, it was the Basel Convention in 1989 which made ensured that laws and policies were adopted which would ensure safe disposal of e-waste anywhere in the world. This provided the platform for the recycling industry to prosper in a number of countries which has provided for resource recovery and mitigation of serious environmental hazards.

Switzerland became the first country in 1991 to introduce a recycling system for refrigerators. Other items were gradually added to the system and by 2005 there was an established system for take back which was institutionalised by setting up of Producers Responsibility organisations (PROs).

The EU implemented, in 2006, the WEEE Directive which aimed to set-up a system for product take back which would increase efficiency and move towards Circular Economy[13]. The RoHS directives also allowed for the reducing the use of hazardous substances which would make recycling safer for many of the end of life equipment.

In the US, in 2004, the state of California introduced a waste recycling fee to cover the cost of recycling of monitors and televisions. The amount was adjusted to match the real cost of recycling later. Till date 18 such states have drafted rules for e-waste management.

In Asia, many countries have drafted e-waste rules. India and China, which are among the largest producers of e-waste have implemented EPR within the ambit of the legislation. In India, targets have been given to producers, which keep increasing over a period of time, to collect end of life electronic and electrical products. The e-waste management rules, 2016, are a step in that direction in India which has led to PROs being set-up to manage targets for producers.

2.1 E-waste Management: Policy Frameworks

E-waste management is governed through policy instruments which can have multiple elements. Specific elements can be stated as:

- Enforcement
- Monitoring and Evaluation
- Capacity building and awareness
- Storage, disposal and treatment
- Resource mobilisation
- Institutional mechanism and implementation
- Waste minimisation
- Environmental considerations
- Socio-economic considerations

Most of these elements[14] form part of the framework which is the basis for e-waste management principles in a country. However, many of the core principles are guided by the Basel Convention (1989) where trade in e-waste is regulated. The Basel Convention started to address e-waste issues since 2002 which include, among others, environmentally sound management; prevention of illegal traffic to developing countries and; building capacity around the globe to better manage e-waste. The Mobile Phone Partnership Initiative (MPPI) was adopted by the sixth meeting of the Conference of the Parties to the Basel Convention[15].

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[13] http://closeweee.eu/weee-management-and-circular-economy/

[14] https://www.researchgate.net/publication/271564472_Electronic_and_electrical_waste_management_in_Sri_Lanka_Suggestions_for_national_policy_enhancements/figures?lo=1

[15] http://www.basel.int/Implementation/Ewaste/Overview/tabid/4063/Default.aspx

The Nairobi Declaration on the Environmentally Sound Management of Electrical and Electronic Waste and decision IX/6 adopted by the ninth meeting of the Conference of the Parties (COP9) gave a mandate to the Secretariat to implement a work plan for the environmentally sound management of e-waste.
E-waste management frameworks have evolved in regions like the EU where WEEE directives like 2012/19/EU introduce schemes and targets for collection, recycling and recovery of all types of electrical goods and appliances and 2002/95/EC which restricts the use of substances in electrical and electronic equipment because of their hazardous properties. Furthermore, the CloseWEEE project[16] looks at aligning these directives in a manner which will help recover valuable materials which can be then fed into the production process thus trying to establish the principles of resource efficiency and circular economy.

2.2 Trends and Differentiators in E-waste Rules and Frameworks across Regions

An analysis of the environmental legislation of the different countries indicate the following trends and differentiators in e-waste frameworks which have led to the design of policy for regulation purposes.

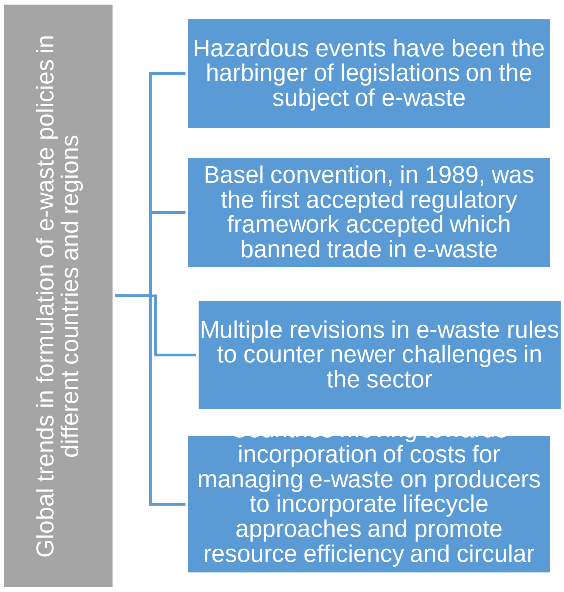

Fig 2.1: Global trends leading to formulation of e-waste management frameworks and policies

E-waste policy frameworks over the years have been encompassing of global trends which are seen in the Basel convention and WEEE Directive. Fixing producer responsibility through EPR has been one of the keynotes of the WEEE Directive in order to ensure that costs for managing waste can be covered from producers who are responsible for putting the product in the market.

[16] http://closeweee.eu/weee-management-and-circular-economy/

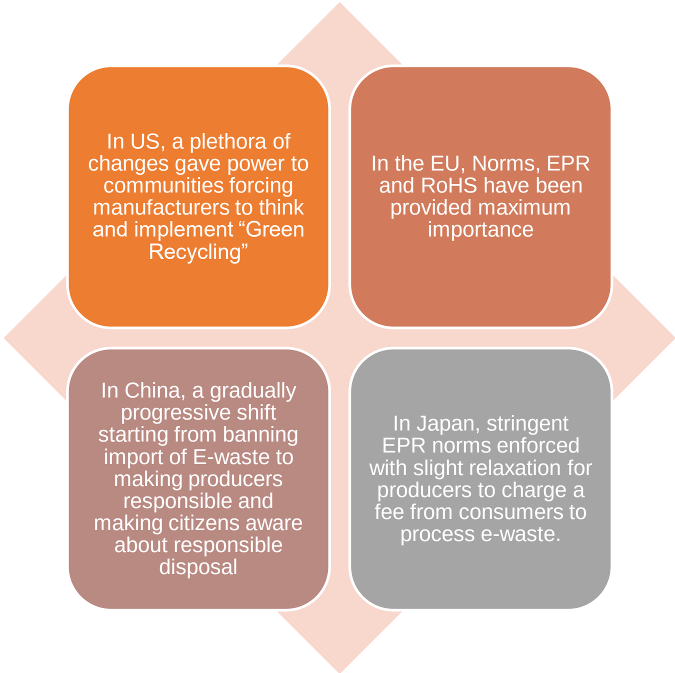

Fig 2.2: Key differentiators in e-waste management frameworks and policies

2.3 E-waste Management Policy in India

E-waste management frameworks in India have developed over the years from different rules on the subject of waste. These include the Hazardous Waste Management and Handling Rules, 2003, which featured some important schedules defined how hazardous materials should be disposed which found applicability for e-waste since it was comprised of those metals and materials. Schedule 3 of the Hazardous Waste management and handling rules, 2003 specifically mentioned that 'Electrical and electronic scraps as a hazardous waste are covered under Sl.No. A 1180 in List A and Sl.No. B 1110 in List B. Sl.No. A 1180 is hazardous under the rules'[17].

The supersession of the hazardous Waste management and handling rules 2003, in the year 2008 was an endeavour to frame appropriate legislation in line with the Basel Convention for which India was a signatory. E-waste was specifically included in the waste and any person who wanted to process or recycle the same had to register with the Central Pollution Control Board. Considering the growing concern specifically in e-waste, the Government supported several initiatives on the assessment of the subject and came up with guidelines around the Environmentally Sound management of e-waste in 2008 which led to the advent of the e-waste management and handling rules, 2011. In order to ensure that the framework could be made more robust in light of the increasing challenge of this fast growing waste stream, the rules were revised to the present day e-waste management rules, 2016. Extended Producers Responsibility (EPR) was made a cornerstone of the rules.

The table number 2.1 below summarises the definition and the applicability of the rules thereby giving an account of the stakeholders which are impacted by the same.

Year of Notification	Title of the Rule	Definition of E Waste	Applicability
2003	The Hazardous Wastes (Management and Handling) Amendment Rules	The 2003 definition provided here is similar to that of Basel Convention. E-waste only briefly included in the rules with no detail description.	Not defined
2008	Guidelines for Environmentally Sound Management	It classified the E-waste according to its various components and compositions and mainly emphasises on the management and	Producer and End of line player in the supply chain

[17] https://rajyasabha.nic.in/rsnew/publication_electronic/E-Waste_in_india.pdf

	of E Waste	treatment practices of E-waste. The guideline incorporated concepts such as “Extended Producer Responsibility”.	
2011	The e-waste (Management and Handling) Rules	According to this regulation, ‘electrical and electronic equipment’ means equipment which is dependent on electric currents or electro-magnetic fields to be fully functional and ‘e-waste’ means waste electrical and electronic equipment, whole or in part or rejects from their manufacturing and repair process, which are intended to be discarded. These rules are meant to be applied to everyone in the supply chain as depicted in the next column.	Producer, consumer or bulk consumer, collection centre, dismantler and recycler
2016	E-Waste (Management) Rules, 2016	Same as above	Expanded to manufacturer, dealer, refurbisher and Producer Responsibility Organization (PRO)

Table 2.1: Progressive account of the e-waste rules in India

- Some key observations with respect to the framework for e-waste management rules in India could be summarised as
  - The producers role has been clearly articulated under the Extended Producers Responsibility whereas a target has been fixed for each year for collection of the quantum of e-waste produced in the country
  - The bulk consumers of e-waste have been mandated to ensure that they dispose the e-waste in an environmentally sound manner to a recycler and maintain records of the same to be produced as and when requested by the respective SPCB or PCC
  - The refurbishers have to register themselves with the SPCB or PCC in order to carry on with their livelihood of repair of electronic and electrical items so that any waste generated is disposed of in an environmentally sound manner to the recycler of dismantler of e-waste
  - Producers can set-up Producers Responsibility Organisation (PRO) which can manage collection and safe disposal of e-waste as per the targets stated in the e-waste management rules, 2016
  - Provisions of legislations were not sacrosanct and hence the same has been revised a few times to make it more robust and fool-proof.

2.4 Challenges

The current challenges to the e-waste management in India can be summed up as illustrated in the diagram below

Addressing these challenges can lead to integration of stakeholders in implementation of the rules. This will need to happen not only for stakeholder which have been mentioned in the rules but also at an inter-ministerial level at the Government in order to ensure that there is enough knowledge which is created and tested at the ground level which can ensure technical implementation of the rules.

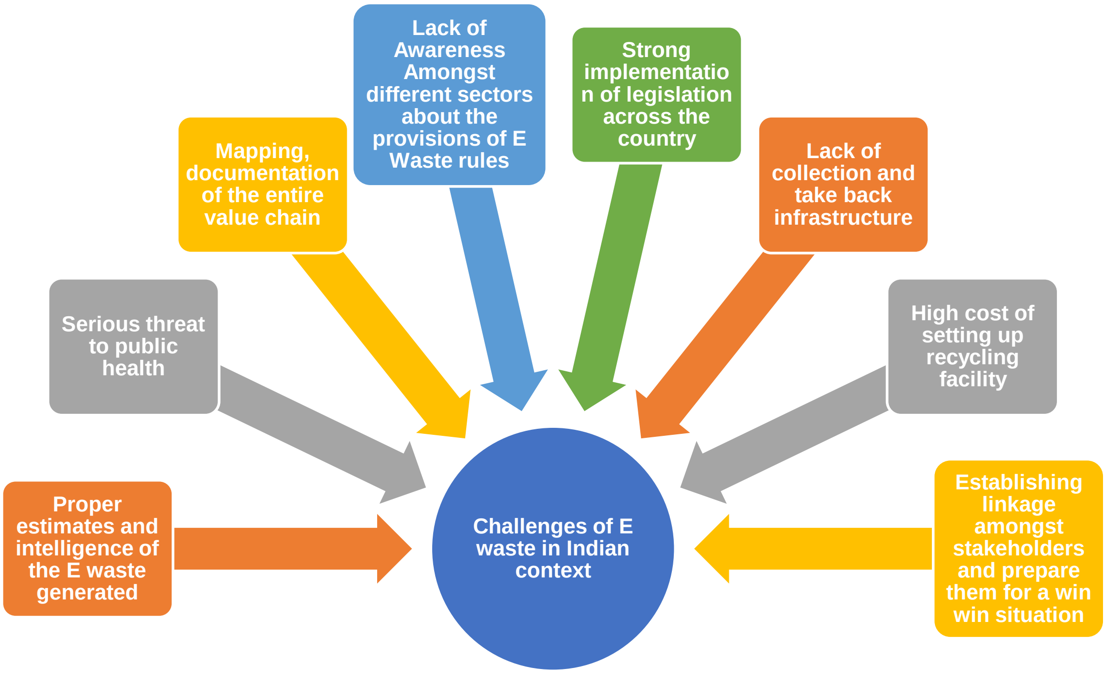

Fig. 2.3: Challenges of e-waste management in the Indian context

A case in point could be a key role that can be played by the Ministry of Electronics and Information Technology in provision of indigenous technology for recycling which can lead to effective implementation of the rules. This will likely aid the different Government of India missions which have interlinkages and spur growth. Furthermore, it will not only allow stricter compliance but also lead to raise awareness levels when it comes to disposal of e-waste by consumers. The resultant impact will lead to movement of waste from the informal to the formal sector making it lucrative to set-up recycling units in the country. This is likely to ensure sustainable practices which will lead to mitigating environmental and health hazards associated with improper recycling of e-waste.

2.4 Opportunities

E-waste management rules, 2016, present an opportunity for not only meeting several goals under different missions as initiated by the Government of India but also ensuring that resource efficiency and circular economy can be built at the heart of approaches when it comes to sustainable production and consumption. This will allow for producers to think about design of products which would be circular in nature, allow for better disposal practices from consumers and also ensure that recycling through best available technologies is promoted which will allow for generation of employment and opening new vistas for growth.
The size of this opportunity can be summed in a table as follows:
The global quantity of e-waste in 2016 is mainly comprised of Small Equipment (16.8 Mt), Large Equipment (9.1 Mt), Temperature Exchange Equipment (7.6 Mt), and Screens (6.6 Mt). Lamps and Small IT represent a smaller share of the global quantity of e-waste generated in 2016, 0.7 Mt and 3.9 Mt respectively.
A comparative scenario of the different continents are presented in the table below:

Continents	Indicators				
	Population in region (millions)	WG (kg/inh)	Indication WG (Mt)	Documented to be collected and recycled (Mt)	Collection Rate (in region)
Africa	1,174	1.9	2.2	0.004	0%

Americas	977	11.6	11.3	1.9	17%
Asia	4,364	4.2	18.2	2.7	15%
Europe	738	16.6	12.3	4.3	35%
Oceania	39	17.3	0.7	0.04	6%

Table 2.2: Opportunity for recycling in e-waste
Source: www.statista.com

In 2016, most of the e-waste was generated in Asia; around 18.2 Mt, or 4.2 kg per inhabitant. Approximately 2.7 Mt were documented to be collected and recycled. The difference of e-waste generated in developed versus developing countries is quite large. The richest country in the world in 2016 generated an average of 19.6 kg/inhabitant, whereas the poorest generated only 0.6 kg/inhabitant.

3. Congruence of e-waste strategy with Government Priorities

The 3 important missions of the Government of India which look forward to putting India to a growth path driven by manufacturing in essence work closely with each other and are interdependent. The Swacch Bharat Mission looks into extracting resources from waste which can be fed into the production cycle. The production cycle falls under the Make in India mission which looks into reusing the resources generated. The Digital India mission is likely the largest consumer of the Make in India which will enhance consumption leading to perpetual growth.

The congruence of these missions leads to the development of a circular economy where resource use is optimized, a production stream is created which is likely to never run out of resources and would be self-fulfilling and resources are generated through urban mining. Resource efficiency is key at the heart of the missions which looks at the next generation transformation of the country. Furthermore, this model leads to the attainment of the Sustainable Development Goals including SDGs 6,8,9,10,11,12 and 13. This ensures that social, economic and environmental concerns are addressed in congruence with these missions thus enabling sustainable development. The missions go a long way to also meet India's commitment towards the Paris Agreement.

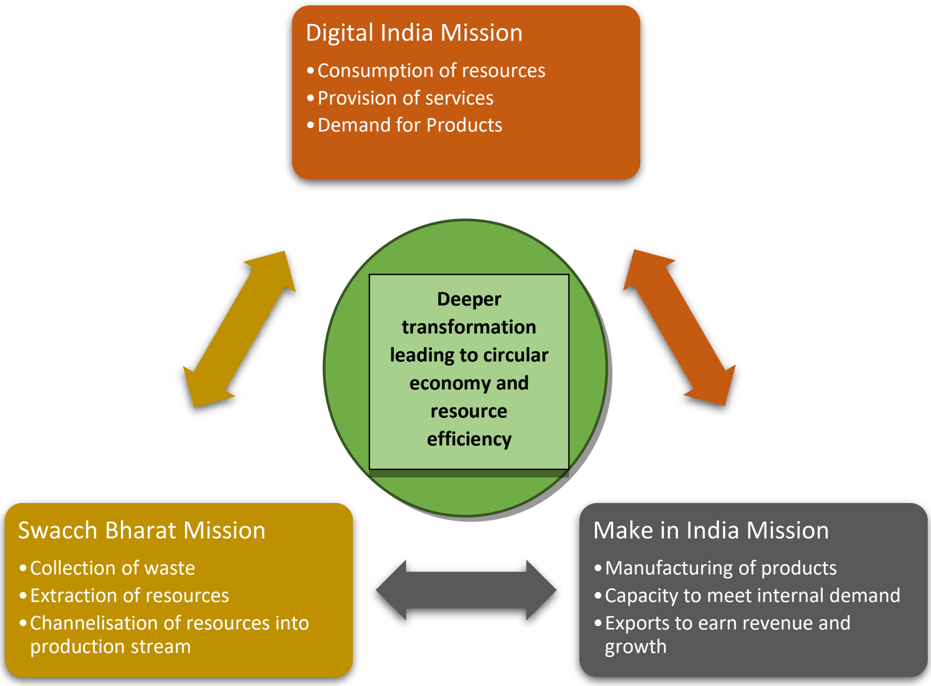

Fig 3.1: Transformation to a resource efficient economy: The role of GoI missions

Opening up of the Indian economy in the early part of the 90s lead to enhanced consumption which has been driving growth. However, this also increases India's dependence on other countries and continuously increases trade imbalance. Countries like China enjoy absolute advantage when it comes to access to natural resources either through local availability or through investments in countries in Africa which have high quantum of availability of resources required in the production process. China is the leader in mining gold, zinc, lead, molybdenum, iron ore, coal, tin, tungsten, rare earths, graphite, vanadium, antimony and phosphate, and holds second place in mine production of copper, silver, cobalt, bauxite/alumina and manganese[18].

[18] www.mining.com/china-burning-natural-resources/

China has been enjoying positive trade balance with most large nations across the world owing to their economic prowess built around manufacturing which contributes to more than 40 percent of GDP[19]. India wishes to move towards this scenario which will ensure that it becomes less dependent on imports, enhances livelihoods through better job opportunities, drives consumption through a self-manufacturing revolution and moves India towards a different growth path which will be more sustainable owing to lesser impact of external shocks.
In order to achieve these goals, the first step which needs to be ensured is access to resources which will aid in the production process. India has a vast variety of resources but most of these are either difficult to extract or are insufficient to meet the requirements of high-end industries like electronics and others as compared to China stated above.
India can turn to waste to foster security of resources required for the production process. Being a huge consumer of resources has also led to enhanced generation of waste. India needs to invest in processes and technology which can recover resources from the waste that is generated in the consumption process so that they can be channelized back into the production process. This will reduce the dependence on imports, enhance resource security for production, lead to development of skilled jobs and a better work force, higher GDP and an economy which will be resilient to external economic and trade shocks.

Appliances	Average weight(kg)	Iron(Fe) % weight	Non-Fe % metal weight	Glass % weight	Plastic % weight	Electronic component % weight	Others % weight
Refrigerators and freezers	48	64.4	6	1.4	13		15.1
Washing machine	40 to 47	59.8	4.6	2.6	1.5		31.5
PC	29.6	53.3	8.4	15	23.3	17.3	0.7
TV sets	36.2	5.3	5.4	62	22.9	0.9	3.5
Cellular phones	0.08 to 0.1	8	20	10.6	59.6		1.8

Table 3.1: Constituents of e-waste

Source: UNEP E-waste Assessment manual Vol I (1) Data compiled from waste from electrical and electronic equipment (WEEE)

As part of a secondary materials strategy, it is important to look at how recovery of resources can lead to security of resources which can propel different missions of the Government of India. Access to secondary materials provides opportunities to several industries to be set-up in India. This will not only ensure a clean India, but will also aid Make in India, Skill India and Digital India because India will have the relevant technology and materials which will aid growth to the next level.

3.1 Make in India – Towards Resource Security

The Make in India mission of the Government of India was launched on the 25th of September, 2014, with the purpose of getting manufacturers to produce their products in the country and hence increase investments. This mission has a direct impact in enhancing GDP of the country, thereby adding to growth and also creation of jobs and livelihoods for the ever-increasing educated class.
The mission covers 25 sectors across manufacturing and services which have to the potential to add jobs as well as grow at a very fast pace owing to internal demand. It is a big opportunity for investors to set up their business (manufacturing, textiles, automobiles, production, retail, chemicals, IT, ports, pharmaceuticals, hospitality, tourism, wellness, railways, leather, etc) in any field in the country. This attractive plan has resourceful proposals for the foreign companies to set up manufacturing powerhouses in India.

[19] www.statista.com

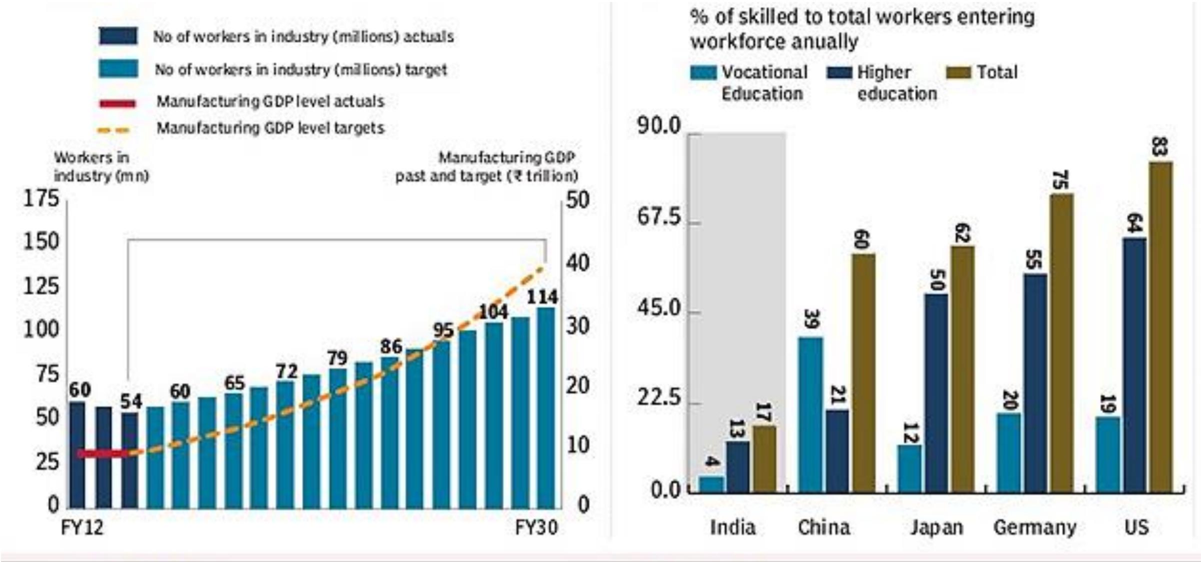

Fig 3.2 : Workforce in Manufacturing

Source: https://www.financialexpress.com/opinion/data-drive-global-lessons-for-indias-manufacturing/13782/

After the launch, India received investment commitments worth ₹16.40 lakh crore (US$240 billion) and investment inquiries worth ₹1.5 lakh crore (US$22 billion) between September 2014 to February 2016. This resulted in India emerging as the preferred destination globally in 2015 for foreign direct investment (FDI), surpassing the USA and China, with US$60.1 billion. Several states have launched their own Make in India initiatives, such as “Vibrant Gujarat”, "Happening Haryana" and "Magnetic Maharashtra".

While India has resources which are required for large infrastructure support sectors like Steel and Aluminium, it lacks materials which are required for production of electronics and their components. In this age of fast paced connectivity, electronics plays a key role and India aims at ensuring that companies which have been leaders in this sector come and set-up in India as well.

The policy makers have realised that the disadvantage of not having access to raw materials can be turned into an advantage through the consumption route which we have followed over the last 25 years. In terms of the quantum of secondary materials that can be accessed, it can provide a major boost to manufacturing in India and hence act as a boon for the Make in India Mission.

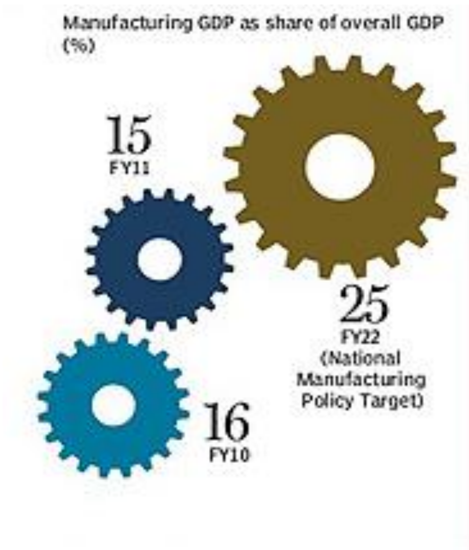

Fig. 3.3: Manufacturing GDP as share of overall GDP

3.2 Swacch Bharat: Waste management, Tackling Pollution and Occupational Hazards esp. in Semi-formal/Informal sector

The Government of India led by the Hon'ble Prime Minister Shri Narendra Modi, launched the Swacch Bharat Mission on the 2nd of October, 2014. The programme aims at ensuring proper waste management as well as enhancing infrastructure around sanitation in the country and making it open defecation free by 2nd October 2019.

The informal sector has been handling a variety of material ranging from plastics, paper to electrical, electronics as well as end of life vehicles. In some cases, even radioactive and hazardous material has found its way into the informal sector due to lack of monitoring and compliance which has caused serious hazards including loss of life.

Many civil society organisations have come forward by integrating the informal sector in order to ensure that living conditions can improve and proper disposal methods for waste are followed. Outreach and advocacy with disposers of waste has been ongoing by building capacities and running awareness programmes indicating hazards of improper disposal to human health and environment.

A look at some of the waste rules indicate that the municipalities have now been asked to integrate the informal sector so that proper collection of waste can take place. The Solid waste rules, 2016 as well as the plastics waste management rules, 2016 are testimony to this fact that the informal sector has been recognised as a key player which can play an important role in the implementation of these rules. However, the e-waste management rules, 2016, do not recognise the informal sector, whereas data shows that more than 95 percent of the e-waste is handled by the semi-formal and informal sector in the country.

In order to enhance the effectiveness of the Swacch Bharat Mission, there is a need to adopt Best Available Technologies which will help to enhance material recovery and secondary resource utilisation in the country. This recovery of resources within the boundaries will ensure that such resource as required in the production process will now no more required to be imported which will reduce the cost of production for manufacturing companies. This is likely to provide fillip to the Make in India mission of the Government of India leading to creation of livelihoods, skills and overall, enhanced growth.

3.3 Digital India: Holistic vision of Digital India whereby the waste generated as a result of digitalisation is proactively managed

The Digital India Mission was launched by the Hon'ble Prime Minister on the 1st of July 2015. The mission was aimed at enhancing digital infrastructure which can be used to provide services to citizens, enhancing e-governance to ensure transparency in the functioning of the government and provision of services and empowerment of citizens through digital availability of data and services.

Fig. 3.4 Digital India – Vision

Under the Digital India mission there is a huge demand for electronics infrastructure which has been set-up for provisioning of services. Furthermore, the government has also ensured research support for development of indigenous technologies for management of waste that will be emanated once these devices reach end of life. The technologies will support recovery of resources which can then be channelised back into the production stream.

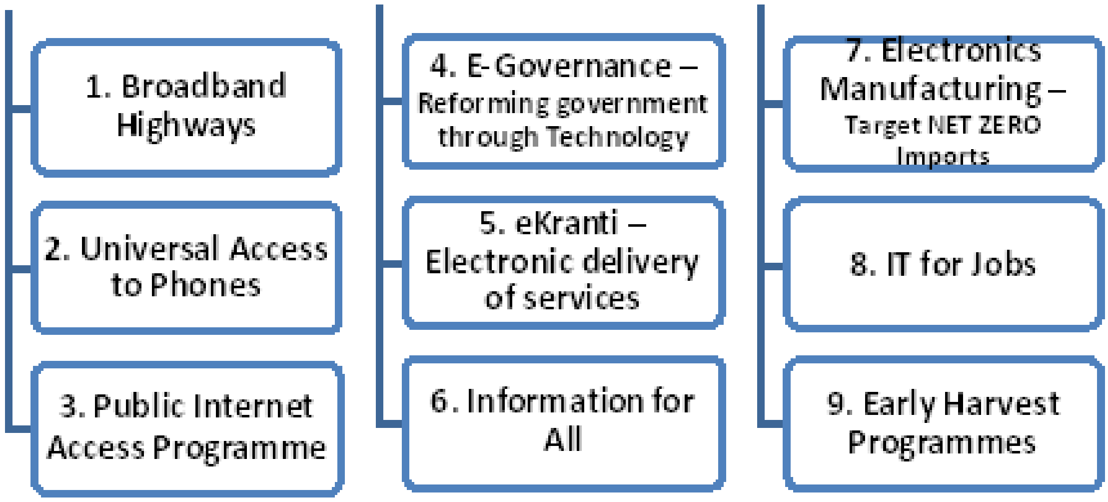

Fig. 3.5: Nine Pillars of Digital India Mission

The Digital India Mission has also launched an awareness programme on the environmental hazards of electronic waste. The awareness programme has been implemented in a city each in 30 identified states and union territories so far. In future, cities in remaining States/UTs would be covered. This is likely to result in change in attitude towards disposal of e-waste into the semi-formal or informal sector to the formal chain which will result in its environmentally sound recycling.

The Digital India mission also aims to work on Best Available Technologies and conduct research for development of technologies which are best suited for the Indian conditions. This will not only provide a fillip to the Skill India Mission, but will also aid the Make in India and the Swacch Bharat Mission in the country.

4 Components of the Secondary Materials Strategy

Development of a strategy to enhance secondary material availability in India requires the identification of stakeholders and ensure engagement between them. Engagement among stakeholders can be developed after understanding key asks and how they can be provided. As an example, disposers in India value waste which is why there is a price attached to the same. In case producers have to meet their EPR targets, they have to purchase waste. In order to ensure that such expenditure does not impact the bottom line, it would be pertinent to ensure that resources for the same can be generated from within the system such that environment friendly recycling can take place.

4.1 Culture of Circularity: Capitalising on the Traditional Values of Reuse, Repair and Refurbishment in the Indian society and Economy

India has traditionally been a society which has produce limited quantum of waste. Being more agri dependent, most of the wet waste produced was channelised back as a resource in the form of manure. The culture of reuse and repair lead to the creation of jobs and ensured elongation of life of materials and resources. Demand for such services on a sustainable level lead to creation of jobs which were passed along through generations and can be visualised in an entrenched caste system formulated on the kind of occupation one was involved in.

The economic rationale for the same seems to have come about from an early realisation of the dependence of mankind of nature and the finite quantum of resources that are at its disposal. This led to the development of various jobs focussed on repair and reuse of materials and hence sustainable livelihoods. The growth boom in the early 90s lead to a spurt in consumption and a move towards linear modes of living whereby materials began to be produced, used and then disposed. Rapid urbanisation and growth allowed the issue of burgeoning quantum of waste to be pushed to the backburner for a long period of time until recently when in the last 20 years sustainability has become a major question in pursuit of growth worldwide.

In the post reform period of the 1990s, opening up of the economy led to liberalisation in industrial regulations, which resulted in increase of the informal sector[20]. However, in other areas like vehicle repair, electronics repair, etc, livelihoods saw a spurt due to the positive effects of liberalisation[21]. With a growing middle class which has been driven by consumption and demand for these products, livelihoods in these areas helped people economically. However, over the years, these activities have been pushed to the end of the value chain by big businesses which have not been able to adopt circularity in their production process as they become increasingly connected with global markets and supply chains[22].

The economies of scale have predominantly taken over the narrative around resource use leaving principles of circularity and resource efficiency in the background. However, over the last few years, research and advocacy around bring-back principles of circularity have mainstreamed the subject and businesses have started to look at creating impact through adoption of resource efficiency and circular economy in their production processes. Legal frameworks around the subject also ensures that businesses are more compliant through use of tools like Extended Producer Responsibility.

In India, presently the culture of circularity has been driven to the fences because the activity is seen at the end of the value chain and hence not very attractive from a social point of view. The informal sector has thrived on this being the only source of livelihood which requires zero investment but can ensure economic sustainability in urban spaces. However,

[20] Unni and Rani 2003; Chandrashekar and Ghosh 2002

[21] https://cept.ac.in/UserFiles/File/CUE/Working%20Papers/Revised%20New/08CUEWP8_Livelihoods%20for%20the%20Urban%20Poor%20A%20Case%20Study%20of%20UMEED%20Programme%20in%20Ahmedabad.pdf

[22] Livelihoods for the Urban Poor, C N Ray, 2010

this carries with itself a socio-economic and ecological impact. In most cases the law does not recognise their presence in the work that they do for the cities and are thus pushed to the fringes.

4.2 Informal Sector: Upgradation of Skills of Informal Sector through Provisions for Utilisation of Indigenous Technology and Capacity Development

The informal sector in India is the backbone of recycling and resource recovery, thereby contributing towards development of a circular economy. However, owing to lack of economic prowess and access to technology, the ways and means employed are often archaic in nature leading to low yield of resources and creation of waste. Most of the times, the methods employed have added risks to human health and environment. The problem is further accentuated with lack of capacity development for this sector which leads to lower levels of resource efficiency from the work that is done around recycling of waste.

Collection and segregation are the key tasks which the informal sector performs for materials which have reached end of life and are at the end of the value chain. The material which cannot be used any further or has reached the end of the value chain where worthy resources cannot be extracted are then disposed of at a landfill site, which is very close to where the informal sector settles and carries on with its livelihood.

It is widely seen and researched that access to material for the informal sector is much easier because of the widespread network that has been created. Over the years, connections between informal actors in different cities has been established which is well documented in several studies as well[23]. An informal actor in Moradabad who is recycling printed circuit boards has access to an informal aggregator in the outskirts of Kolkata who is involved till dismantling of the CPU and then send the PCB to the actor in Moradabad. Similar cases are observed in End of Life Vehicles as well where a reused engine demand for a truck required in Kolkata can be fulfilled by an informal recycler in Chennai[24].

These value chains which have been created over time has also allowed the informal actor to develop their specialisation. As an example, printed circuit board recycling and extraction of precious metals using archaic means is practiced to a large extent in Moradabad. Actors in the value chain across different cities do not recycle and are happy to send it to Moradabad either due to lack of knowledge or are paid well which allows them to make sound economic gains by just dismantling the waste product. **This makes it easier to target the provision of indigenous technology to the informal sector since there is a geographical concentration of such actors which need to be provided with a specific technology.** Not only does this ensure monitoring which will drive other informal actors towards formality but also ensure that compliance requirements will lead to greater access to resources in the formal markets for producers.

4.3 Challenges with the Informal Sector in India

The informal actors have very limited knowledge on the path they need to pursue towards formality because they are either illiterate and are scared of the paper work involved, or they have a perception that the work that they do and the material that they access is mostly perceived of as stolen from somewhere.

Formalisation of the informal sector requires 2 key aspects which needs to be delved into:

- Research to understand the key asks of the informal sector which can lead them on the path towards formalisation
- Capacity building of the informal sector which will ensure that they understand the advantages of being formal and help others in the informal sector to formalise by becoming brand ambassadors for transition from being informal to formal in the value chain

[23] Urban Informal Sector: Concepts, Indian Evidence and Policy Implications: Meera Mehta, Economic and Political Weekly, 1985

[24] Analysis of End of Life Vehicles in India: Bharati Chaturvedi, et.al.

There has been a distinct recognition on the work that is done by the informal sector towards bringing down GHG emissions by governments and multilateral agencies[25]. However, the challenges which remain are manifold as well. There is a severe crisis as far as human health is concerned. In most cases work on e-waste metal extraction and end of life vehicles requires chemical processes which are not performed in closed environment and have the potential to causes serious ecological damage.

4.4 Integration of the Informal Sector: Moving towards Formalisation

Key asks of the informal sector varies across demographies but common elements which have been identified are the following:

- Access to land where they are able to engage in their livelihood which will not lead to any damage to nature
- Access to infrastructure which will allow them to engage in their livelihood in ways and means which will comply with the law
- Access to finance so that they are able to invest in infrastructure and work within the legal framework

These key asks can be fulfilled by integrating the informal sector through capacity building. As a case, the Ministry of Electronics and Information Technology has initiated an awareness programme on the environmental hazards of electronic waste. As part of the programme, workshops have been conducted in the informal sector including in Moradabad, which is the hub of informal PCB recycling in India. Benefits of formalisation have been discussed and interaction channels have been opened up with experts in the area. This has allowed to disseminate information on formalisation and stakeholders have come forth with their requests and actions agenda as a first step. Hand-holding these stakeholders through a formal process will allow to build confidence which will help the move towards formalisation.

The informal sector recycles material at an efficiency rate of between 20 to 30 percent. Provision of technology to these informal actors who are willing to formalise will allow benefits in the socio-economic and environmental space.

Social benefits to the informal sector can accrue from formalised livelihoods in e-waste recycling by use of technology. Proper registration of their units allows them to reach out to disposers of e-waste both individuals and bulk consumers. The recognition also helps in the upliftment of social status from being at the lowest rung in the value chain for e-waste to authorised and formal recyclers pursuing their livelihoods to add value to materials and being resource efficient.

Capacity building of the informal sector on the use of technology can allow them to upgrade themselves to the formal chain. This has direct benefits of resource efficiency and circular economy allowing for more materials to flow back into the production chain. Furthermore, formalisation allows for materials to remain in the value chain which can be used for manufacturing and thus create resource security. Overall a win-win situation for the informal sector as well as the country as a whole.

4.5 Technological Development: Assessment of Technical and Technological Solutions Available in India and Globally

The Ministry of Electronics and Information Technology has developed indigenous technology at C-MET and Central Institute of Plastics Engineering & Technology (CIPET) for recovery of precious metals and plastics from e-waste respectively. After laboratory scale experiments, these technologies have now been upscaled to industry level use. The C-MET technology for recycling of Printed Circuit Boards from electronic items like mobile phone, laptops, computers and television can recycle at the rate of 100 kg per day (~1,200 tonnes

[25] Greenhouse Gas Emissions from the Informal Sector in India: Murali Ramakrishnan Ananthakumar Roshna N.

per annum of e-waste) and the CIPET technology for plastics from e-waste can recycle at the rate of 1 metric tonne per hour (3,600 metrics tonnes per annum).
The process for recycling of PCBs from these technologies can be summarised as below:
The key steps involved in C-MET process technology are:

- Manual dismantling: Motherboards are basically large PCB's that have multiple components added on the main board. These components are mostly joined with PCB by Soldering, only a few steel casings are joined by screws. These screws cannot be removed by depopulation system due to high melting point. The screws have to be removed manually to separate steel casings which interrupts the shredding process while shredding.
- Depopulation: The multiple components which are connected to PCB are joined with soldering technique. To weaken the strength of the solder material PCB is heated above the solder melting point. But due to high surface tension the solder cannot be removed easily and solidifies with components rapidly, if we increase the temperature the PCB itself catches fire due to high calorific value of PCB. C-MET has indigenously designed a technique and optimized the parameters which can separate the solder from the components without igniting the PCB. Solder elimination before smelting can increase the purity of copper from 60 % to 90%
- Shredding: To ease the feed for further process decreasing the size of PCB is necessary for efficiency and economical purpose (Size reduction to 40 to 50mm pieces)
- Calcination/pyrolysis: Removal of organic and toxic gases with adequate gas cleaning system is necessary as for processing as well as environmental concerns. C-MET has indigenously designed, developed and optimized the parameters to calcine the organic content of PCB and treat the toxic gases evolved during calcination process and release into atmosphere as per CPCB guidelines.
- Smelting: Removal of inorganic fillers and obtaining black copper. C-MET has optimized the parameters and flux ratios to enrich the precious metals concentrations in black-copper, and remove the gangue material through slag.
- Remelting/anode preparation: Preparation of anode for electrolysis, Anode has to be free from Sn, Pb and other impurities to eliminate the contamination of electrolyte which decrease the deposition rate. C-MET has adapted the standard procedure with indigenously developed furnace to eliminate impurities.
- Electro-refining: The process has been adapted from existing technology to obtain pure copper. The obtained anode copper is kept as anode keeping SS plate as cathode immersed in electrolyte ($CuSO_4$) in a PP electrolytic cell. The electro-deposition of copper takes place from anode to cathode and obtained 99.99% pure copper where the precious metals are concentrated in anode slime.
  Note: It is observed that Tin elimination is crucial to decrease the turbidity of electrolyte which decreases the deposition rate, so it is necessary to remove tin in initial stages.
- Anode mud processing: Separation and purification of Au, Ag and Pd are extracted through hydrometallurgical process by selective leaching and precipitation method. These methods are adopted from standard procedures and optimized the parameters to required conditions.

The key steps in the CIPET technology for recycling of plastics:
1. Description about the process

Magnetic separation: Magnetic separation is one of the most reliable ways to remove unwanted ferrous metals from grinded Plastics waste obtained from e-waste.
Electrostatic Technique: In electrostatic separation technologies, electric force acting on charged or polarized bodies is used for the separation of granular materials. Electrostatic separation by means of corona charging or eddy current could apply to separate metal/non-

metal mixtures. Furthermore, a technique that makes use of the eddy currents is also employed to separate plastic particles from a metal/plastic mixture

Density separation: Mostly plastics density varies from 0.9-1.8 gm/cm3, wherein metals are found to be much higher than plastics. Thus, density separation is shown to a fundamental tool for separation of plastics and other ingredients.

Sink and Float Separation: Sink–float separation techniques are a well-known method for separation of mixed plastics. In this method various mixtures of plastics with different densities could be separated by sink–float separator.

Air Table Technique: The air table is a compact device with simple geometry capable of effectively treating plastics of different densities. The air-table uses air and vibration to separate the heavier plastics that moves up the table from the lighter material that stratifies on top and slides down the table.

Froth Flotation: Froth flotation process is envisaged as a promising technique for fine fractions of electronic waste. Based on the differences in hydrophobicity between non-metals and metals, plastic fractions could be separated from metals.

Air Classification: The principle of separation is based on the fact that the particles suspended in a flowing gas, usually air move towards different points under the influence of different forces so that they can be separated from one another. The dispersed solid particles are separated based on their difference in size and density. Heavy particles, having terminal settling velocity larger than the velocity of air move downwards against the air stream, while the light particles whose terminal settling velocity is smaller than the velocity of air rise along with the air stream to the top of the column.

Elemental Analysis method: The elemental analysis is used to identify the presence and concentration of various metals plastics in E-waste. Following methods are used for elemental analysis:

- Fourier-transform infrared spectroscopy (FTIR)
- Differential scanning calorimeter (DSC)
- Thermogravimetric analysis (TGA)
- Melt flow index tester (MFI)

2. Separation of 100kg of plastics by utilizing the above process may take 1-2days depending upon the plant capacity.
3. The entire 100kg of grinded E-waste shall be used for separation, whereas elemental analysis can be carried out by using few grams of materials from each segments.
4. The cost of the above inputs to process 100 kg batch depends on the plant capacity.
5. The recovery of materials from 100kg of batch is as follows:

- Plastics: 30-35kg
- Metals: 45-50kg
- Glass, ceramics and others: 10-15

6. The total cost of material that is covered considering that the 100 kg batch consisted of mixed plastics from WEEE items.

- Plastics: Rs. 65-75/kg
- Metals: Rs. 15-150/kg (depending upon various metals)
- Glass, ceramics and others: Rs. 5-10/kg

These indigenously developed technologies provide solutions for recycling of complex materials which otherwise had to be exported to countries where state of the art technologies have been developed and large-scale investments made to source and recycle materials from different parts of the world. One such facility which recycles precious metals from e-waste is Umicore in Belgium which is one of the largest such facilities in the world today.

4.6 Adoption of Technology: Aggregation and Benchmarking

In India, the informal sector plays a key role as far as resource recovery is concerned. However, the resources are extracted using technology which is hazardous to the environment as well as to human health. Fostering adoption of such technologies as stated above can create a disruption in the way e-waste is managed in India today and can create co-benefits to many different stakeholders concerned.

It is however, important that access to such technology is made available to the informal sector at prices where a potential demand can be created. This will lead to formalisation and cause materials to flow back into the formal chain. Furthermore, enhanced resource efficiency through a technologically proven process will create resource security for the country leading to greater accomplishments across different missions instituted by the Government of India.

Aggregation of demand for such technologies is likely to bring down the price of the same as well, which will benefit the institution who has developed the technology as well as the buyer of the technology. This can create the platform for large scale proliferation which will enable access to material in the formal value chain. A disruption of this scale can alter the way e-waste is recycled in the country and can provide fillip to Make in India and Swacch Bharat Missions.

It is however, important to be able to benchmark these technologies to already existing ones including those in the informal sector. This will not only provide a scope to visualise the benefits but also provide an estimate on the economies which are provided by each of these technologies.

Parameters	Indigenous technologies developed by MeitY	Umicore	Informal Sector
Materials recovered from e-waste	Gold, Silver, Platinum and Palladium, Plastics of different varieties	17 metals including Gold, Silver, Platinum and Palladium	Gold, Silver, Platinum, Palladium and Lead
Efficiency of recovery of materials	Between 80% to 97%	Above 95%	20%-30%
Input costs involved	Rs 25,000 per 100 kg	Includes Ore which increase input costs as higher amount of energy is required	Rs 7,000 for a 100 kg batch
Logistics cost	Depends on where the facility comes up	Export costs include shipping from India	Delhi to Moradabad in a truck is about Rs 10 per kg
Capital costs involved[26]	Rs 25 crores to start the facility for precious metals and plastics recycling	More than Euro 2 billion invested already	In-house facility
Operational costs	Rs 7-10 lakhs per month	Not Available	Rs 15,000 to Rs 25,000 per month
Profit margins	~50% to 80%	Not Available	~15% to 25%

Table 4.1: Comparative of recycling processes of C-MET, Umicore and Informal sector

Benchmarking of the technologies which are in use in the informal sector as well as the best available technologies show the huge gap which exist when it comes to recycling complex materials embedded in e-waste. Furthermore, when it comes to recycling of precious metals the efficiency of recycling and extraction of metals in the informal sector lags behind from the other 2 options that are available.

[26] The basic input for the cost of the material and other essential utility required were provided by MeitY and arrived at by GIZ, which is tentative.

A look at the comparative parameters achievable under indigenous technologies and Umicore shows that considering the costs involved, the difference in extraction rates of materials can be more than offset by using indigenous technologies. Proliferation of this technology can lead to more material being recycled in the country. There are several direct and indirect impacts of the same as well which are listed below:

- Fostering use of the technology in India will lead to opportunities in the recycling sector and its development. This will allow for creation of livelihoods in the country
- Technology availability with the informal sector will allow them to retain their livelihoods as well as bring in knowledge and rich experience, especially in the domain of dismantling
- Formalisation of the informal sector will lead to mitigation of health and environmental hazards of improper e-waste recycling
- Resource security of materials will allow for proliferation of the manufacturing sector of electronics in the country, thus providing a fillip to the Make in India mission
- Development of skilled jobs in the recycling industry will provide a fillip to the Skill India Mission
- Safe e-waste disposal in an environmentally friendly manner will provide a fillip to the Swacch Bharat Mission

This will also leave a positive impact on the Sustainable Development Goals and help India meet its targets for reducing emissions under the Paris Agreement.

Presently, India has a policy whereby, material fractions for which technology is not available in the country are exported. Many recyclers who have been operating under the ambit of the e-waste management rules, 2016, have not developed such technologies, either due to lack of resources or due to lack of materials because of the intense competition with the informal sector. Now, with the availability of indigenous technology as well as a strong EPR regime, both of these issues have been countered by the Government.

4.7 Extended Producers Responsibility and its role in proliferation of best available technologies

Recyclers can now access more material because producers are channelizing the same to them to meet their EPR obligations. This allows them to now operate at full capacity and also invest in technology which will help them to recycle all fractions of e-waste in the country.

In the present scenario, the entire chain marked inside the box (Fig 4.1), operates in the informal domain. Policy interventions, through which technology is made available, will have the benefit of formalising the informal sector and enhance resource security. Strengthening EPR compliance will enhance access to secondary materials which will make economic sense for the recycler to then recycle the material rather than sell it in the informal sector or export the same. This intervention will create an enabling mechanism for proliferation of recycling industry in the country with benefits of access to resources on one hand and creation of jobs on the other.

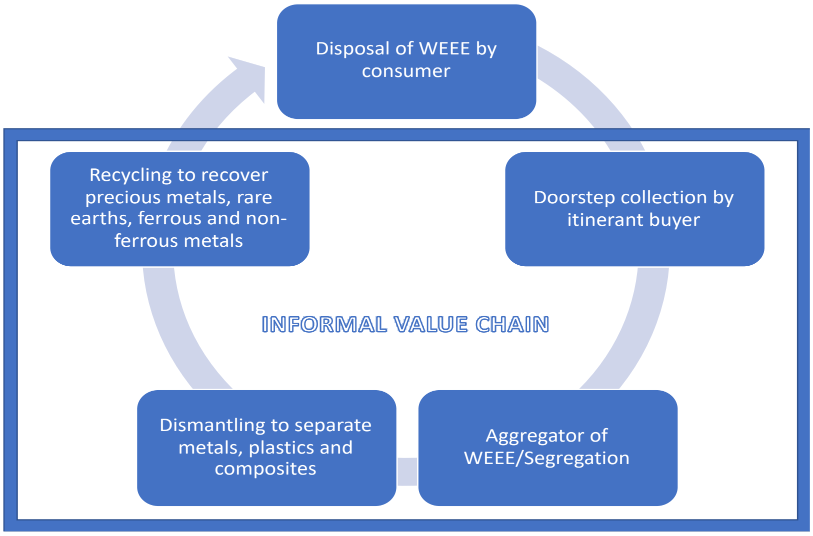

Fig. 4.1: Impediments to formal recycling in India

The blurb above indicates the issues which plague the formal recycling of e-waste in India. The informal value chain has access to resources which increase the acquisition cost for the formal recyclers, thus making recycling in an environmentally sound manner a costly proposition

Acquisition cost of WEEE + Recycling cost of WEEE >
Value of materials recovered from WEEE in the formal recycling sector
This is a key dis-incentive for recycling in the formal sector

Recycling of e-waste is a capital-intensive business because it involves technology which has to be either developed indigenously or purchased from abroad. In order for the operations of e-waste recycling to be profitable to cover the costs of capital involve, it is pertinent that the e-waste is available at prices which are affordable to run these operations. However, the channel of informal actors in the collection of e-waste from consumers to recyclers can lead to higher costs which act as a disincentive for the recycler because the acquisition cost of e-waste is far higher than expected and not enough to cover costs despite the value of materials which can be extracted from the same.

The e-waste management and handling rules, 2012, had introduced the concept of extended producer responsibility. This makes the producers responsible for the complete life cycle, which in other words would mean that they are responsible even after the product has reached end of life in order to ensure that it is disposed of in an environmentally sound manner. However, not much progress was made in this area since there were no specific guidelines which would describe the kind of compliance that would have to be met on behalf of the producer as well as the penal provisions thereof. The e-waste management rules, 2016, changed the paradigm completely with introduction of targets as part of extended producers' responsibility (EPR).

In order to develop an ecosystem that would ensure a higher quantum of e-waste flows into formal recycling, the Government introduced targets which would progressively increase year on year. While on paper, it is an increase of 10 percentage point each year, overall considering the rate of growth of the sector, it is a geometric progression which targets will increase over time. The highest achievement rate has been defined at 70 percent over a 7 year period. Producers have been provided with multiple options on how these targets can be achieved. These are instruments which allow for set-up of Producers Responsibility Organisations (PROs) or even economic instruments like Advance Recycling Fee (ARF) and Deposit Refund Scheme (DRS) which incentivise the user to dispose of their e-waste in the formal channel.

The introduction of compliance has forced the producers to look for ways and means in order to meet targets under the EPR regime. In most cases, larger producers have tied up with not one but multiple PROs and have distributed their targets to hedge risks. In most of the cases, these PROs recognise that the material is available in the informal sector and are hence looking at ways and means to develop stakeholder engagement in order to have access to the e-waste collected by informal sector. Presently, the areas of conflict are purely economic in nature since producers consider a payment to access e-waste to meet compliance a burden which impacts their bottom-lines. However, penal provisions which are stated in the rules, have ensured that they have allocated budgets to PROs to work on collecting the amounts required to meet targets as specified in the EPR plans.

5 Action Plan

Successful envisioning of a strategy will require engagement and integration of multiple stakeholders in the value chain. It is important that these stakeholders are identified and their key asks studied to ensure that they can be incorporated in the strategy. E-waste management in India is presently guided by complex dynamics where producers have been tasked with ensuring collection of end-of-life material and the informal sector has been handling the same through its network for the last few decades. In this scenario, it is therefore important that action agendas be identified along-with the implementing agencies who will ensure time bound implementation of strategies with identified stakeholders.

The informal sector has been at the heart of recycling of WEEE in India for the last two decades. Basic knowledge of Chemistry is put into practice including acid baths and heat treatment to extract precious metals. Not only does this affect the environment but is also hazardous for the health of humans residing in the ecosystem. Development of recycling technology for mitigating the hazardous effects of environment and human health is as important as its development for new electronics products.

5.1 Informal Sector Integration in the E-Waste Management Ecosystem to Strengthen Implementation of EPR regime

Going forward, the integration of the informal sector would be the key to ensure that collection costs can be brought down to sustainable levels. The informal sector, through its network of aggregators, dismantlers, recyclers has been able to develop an ecosystem which has been able to sustain multiple actors across different geographies in the country. These actors have also been able to develop competitive advantages for themselves in terms of specific areas of expertise which they cater to when it comes to handling different material flows for end of life electronics.[27] It is important to recognise these material flows and value chains which will then allow for development of key strategies which would allow for integration of the informal sector in a formal value chain.

The graphic below gives an account of the material flow and value chains in end of life electronics. The green boxes represent formal actors in the value chain while the grey ones are the informal actors. Grey lines represent material which flows in the informal chain, the green ones represent material which flows back into the formal chain. The key players that are in the informal chain can be recognised as follows:

- Informal or grey markets where refurbished/repaired goods are sold
- Itinerant buyers who purchase e-waste from households
- Small scrap shops in localities who are aggregators of different types of e-waste
- Large aggregators who are primarily in localities which have historically managed scrap who deal with specific types of e-waste
- Dismantlers, who extract materials without the use of any chemical process using manual techniques
- Recyclers, who primarily are found in clusters an extract precious metals from e-waste through chemical treatment
- Informal producers, who purchase materials either from the informal recyclers or from the formal markets and manufacture products which are not certified for safety and health

[27] OECD: (https://www.oecd.org/environment/waste/Session_2-Part_1-EPR-Role-of-Informal-Sector-Sandip_Chatterjee.pdf

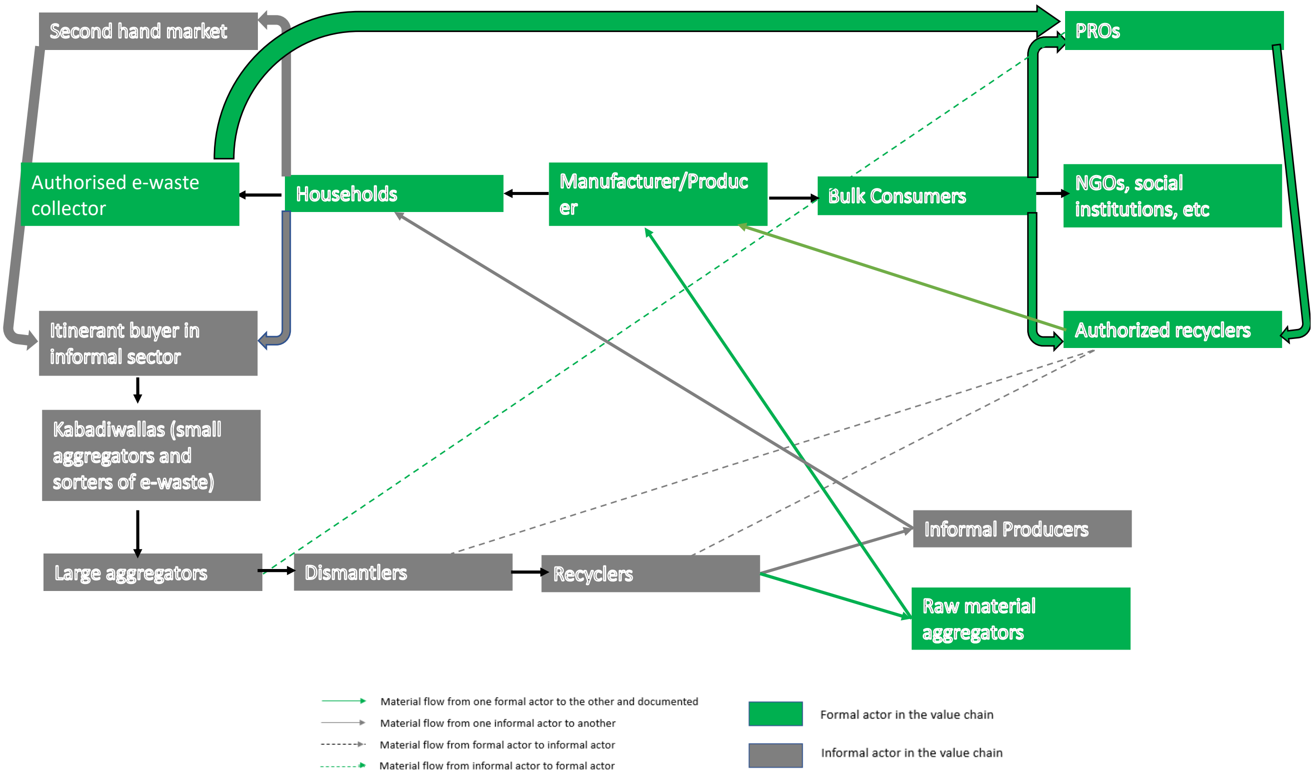

Fig. 5.1: Current material flows and value chain in WEEE in India

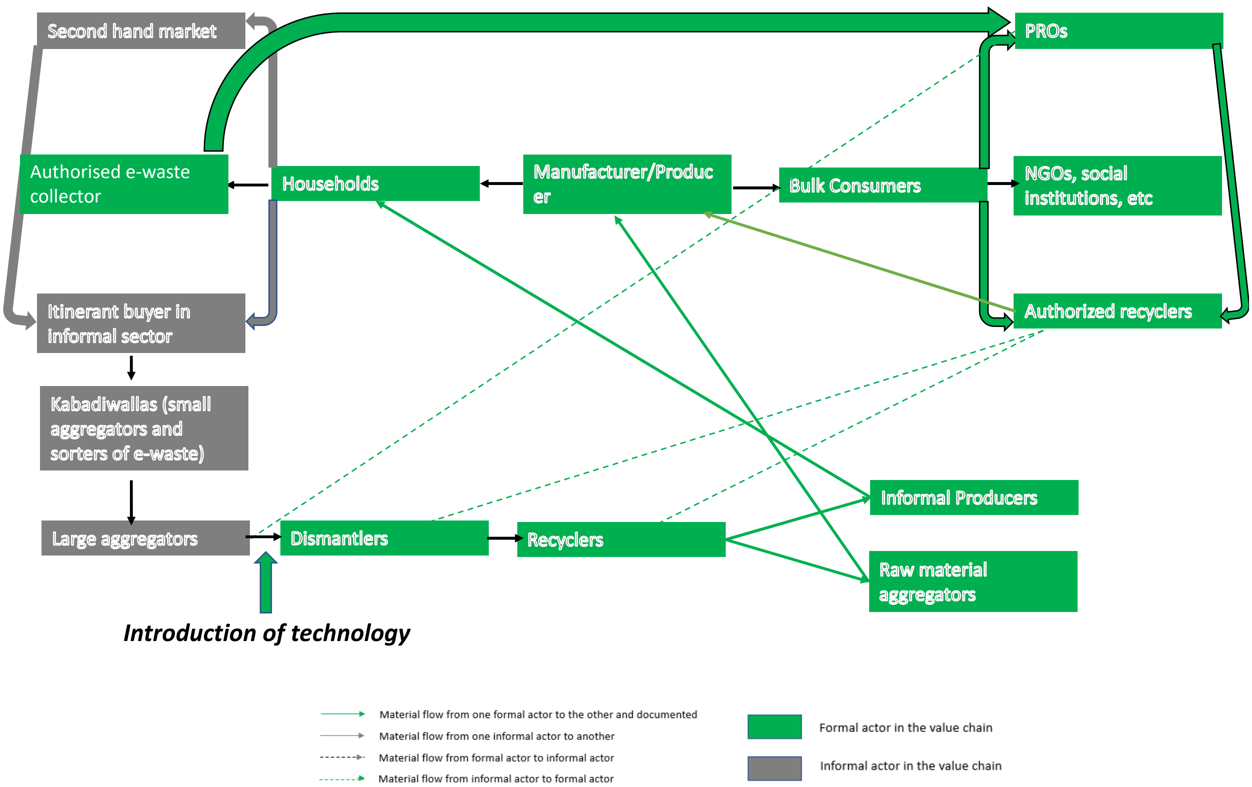

Fig. 5.2: Proposed material flows and value chain upon introduction of Technology

As mentioned earlier, land, infrastructure and finance are the key asks of those informal actors in the value chain who are engaged in activities which are related to dismantling and recycling. From a resource efficiency perspective, it makes sense to design interventions which are targeted at these actors because of the following reasons:

1. The work done by these actors is not conducive to human health and environment. Hence it is important to introduce an intervention which will lead to better working conditions for workers as well as less pollution of the environment which impacts clusters where they operate
2. The methods employed by these actors are no resource efficient which reduce the amount of metal which is extracted from e-waste. A technology intervention in this area is likely to improve efficiency in the recycling process and lead to economic gains for the informal actors as well as the economy as a whole
3. Clusters where these informal actors work are usually quite polluted which exposes them to serious health risks. These can be mitigated if the work is done in an environment which is away from residential civilization to ensure that children are not exposed to these health and environmental hazards. Furthermore, facilities can be developed to take care of environmental impacts of recycling and dismantling e-waste and provision of personal protective equipment which will allow for mitigating health risks to workers as well

The likely chain in the material flow will enhance missions like Make in India, provide skilled livelihoods to informal actors thereby enhancing the efficacy of the Skill India Mission and also reduce the environmental impact of improper e-waste recycling thereby positively impacting the Swacch Bharat Mission.

5.2 Industrial Clusters – Twin Approaches

Integration of the informal sector can be done in 2 possible ways. Since end of life electronics falls in the category which is environmentally polluting, it is important that the work be done in industrial clusters such that effluents can be properly managed and environmental risks can be mitigated. Furthermore, a monitoring mechanism in such clusters helps to mitigate human health risks as well. It is however, important to understand the kind of interventions which are available and the risks and rewards attached to these approaches.

The 2 possible ways to therefore set-up these industrial clusters are

- Co-locating the e-waste management industrial cluster in a manufacturing cluster
- Locating e-waste management cluster in hubs where the informal actors have been working

It is important to understand the benefits and drawbacks of these 2 approaches from a social and economic perspective.

Co-locating E-Waste Management Industrial Cluster with Manufacturing Clusters

The Ministry of Electronics and Information Technology has come up with a scheme for development of Electronic Manufacturing Clusters (EMCs) in the country. As part of the Make in India Mission, the Government seeks to ramp up production capabilities of electronics in the country to become self-sufficient and also export to the world.

India, however, has to face considerable challenges as far as electronics production is concerned in the country. Electronics production is a complex process which requires skilled personnel as well as high end technology to produce state of the art products. Furthermore, production of electronics is a resource intensive process requiring multiple metals and different grades of plastics. India faces multiple challenges as far as access to these materials is concerned. While India has a rich supply of iron and aluminium, it has to import copper, nickel, cobalt and many other rare earths which are intrinsic to the production of an electronic product. It is therefore, important to look at other avenues for meet this demand for materials from a resource security perspective. Green fencing across various electronics producing countries has dried up trade of such materials to miniscule levels in effect leading to barriers to production of electronic products in countries like India.

Despite these challenges, India has huge potential from the consumption of electronics. India presently boasts of being the second largest user of mobile phones in the world. Use of electronics and electrical items has boomed in the last 20 years with the country witnessing significant growth levels. Moving from a linear to a circular economy model will allow India to use secondary materials in the production process enabling the growth of electronics manufacturing in the country. This helps to establish circular loops which enhances resource efficiency and reduces the carbon footprint of production. It also enables to meet the sustainable development goals and contributes to meeting targets under the Paris Agreement.

However, considering that India is a large country, movement of end of life electronics can be a serious challenge. This will also impact the cost of material reaching the recycling facility, thereby, denting the advantage of low-cost availability of secondary materials. It is therefore, important, to understand the different stages of the recycling process to enhance efficiency of extraction of materials and ensure their movement into the production process.

Locating E-waste Management Industrial Cluster in the Informal E-waste Management Hubs

The informal sector in India represents the capacity which exists for recycling of different kinds of end of life material streams. The skilled and unskilled labour force has been at the fringes of urban centres for the last 20 years. Clusters that a which are of note in the context of e-waste recycling are Shastri park, Seelampur, Mustafabad in Delhi and Moradabad in UP. Out of all the material collected, the most valuable for the informal sector is the PCB. In 2010, two motherboards, usually weighing up to one kg cost Rs 230. A profit of 10 percent could be made by selling the extracted metals. Open burning and acid stripping are two common methods used for PCB recycling for removal of chips, condensers and capacitors. Integrated circuit chips and components are sold for reuse. The defunct parts are burnt for extracting metals from solder and copper. Acid stripping method is used for extracting gold and platinum. At present, there exists many informal sector hubs where such dismantling, processing and recovery is undertaken. One such hubs in in Moradabad, also called the brass city, where according to 2015 estimates about half the EEE circuit boards end up.

Across the country, however, multiple actors are engaged in activities through the value as described above.

Locating e-waste management clusters in these hubs has the potential to upgrade these livelihoods in the informal sector. This will also lead to formalisation of these actors and ensure that working conditions are improved and environmental impacts of improper e-waste management are mitigated. Direct impacts will also allow for sustained livelihoods for these actors and has tremendous health benefits.

Industrial clusters in informal e-waste recycling hubs can take the form of eco-parks where co-working spaces can be provided to the informal sector. This will allow them to carry in with the livelihood of collection and dismantling. However, for all chemical processes involved in recycling, technology made available at the eco-park will be used. In order to ensure, that the eco-park by itself is sustainable, a small recycling fee can be imposed dependent on the material being recycled. As can be seen in the table in benchmarking technologies, the efficient recovery of material in the technology proposed will allow to cover the costs and still give higher profits to the informal sector.

5.3 Capacity Building Programmes Including Awareness Programmes for all Stakeholders and Actors

Waste disposal habits and mechanisms in India are very different from many of the developed countries in the OECD. Waste in India has always been considered as a resource which there has been an economic consideration attached to the same over the decades. This has been accentuated by a demand process which has been created by the informal

sector, which due to poverty and lack of economic opportunities has adopted waste collection and management as its primary livelihood.
The Ministry of Electronics and Information Technology has, considering the high stakes involved, launched an awareness initiative in 2015. The initiative titled 'Awareness Programme on Environmental Hazards of Electronic Waste' seeks to enhance outreach and advocacy around the environmental and health hazards of improper disposal of e-waste in the country.
This is a multi-stakeholder programme which has been envisaged to go on for 5 years. The awareness programme has been implemented in a city each in 30 identified states so far. In future, cities in remaining States/UTs would be covered. The different stakeholders in the programme where outreach and advocacy efforts are being targeted are:

1. Schools
2. Colleges
3. RWAs
4. Bulk Consumers
5. Dealers
6. Refurbishers
7. Informal Sector
8. Manufacturers

The Ministry has been implementing the programme through industry associations, viz. MAIT, CEAMA, NASSCOM, PHDCCI, etc.
Government is one of the largest consumer in the electronics and IT equipment space. The National Institute of Electronics and Information Technology has been tasked by the ministry to create awareness among different classes of government officials in order to ensure that e-waste is handled properly so that government departments implement the e-waste rules and dispose of their electronic waste through formal channels.

Under the programme, till December 2018, in around 600 Workshops and activities organised in various cities, more than 3.00 lakhs participants from School, colleges, RWA, manufacturer, informal operators etc. and 6000 government officials have so far participated. The mass awareness amongst youth of the country has also been created through cinema and more thatn 20 crore audience has been covered in nearly 3000 cinema halls. The details of the programme and its outreach can be viewed on the dedicated website of the awareness programme, www.greene.gov.in. The programme in phase II has seen industry come forward to contribute to the programme in creating awareness which is also part of their compliance requirement under extended producer responsibility as stated in the e-waste management rules, 2016.

The programme has been designed to ensure that it is sustainable as well as leads to direct action which allows for e-waste to move into the formal chain for its environmentally sound disposal. Activities, workshops, coupled with collection drives allow for safe disposal of e-waste by stakeholders. Furthermore, trainers across cities are being equipped with skills to engage with different stakeholders in order to ensure that activities and workshops can be conducted to build capacities and create outreach on ways and means for safe disposal of e-waste. These trainers can be adopted by producers, PROs, SPCBs as resources which can create awareness on e-waste disposal at a miniscule cost in the future.

Positive effects of awareness programme can be seen with different stakeholders. School teachers and students have led the efforts in conducting activities and workshops to enhance the outreach and build further capacities in this area. Details of the same can be accessed from (see:www.greene.gov.in). The producers which have been mandated as a part of compliance to undertake awareness of stakeholders have come forward to join the programme in the second phase in huge numbers through their PROs. Individual producers have also expressed interest in joining the programme to enhance awareness on safe e-waste disposal. This will lead to higher outreach where close of a million people will be impacted through this awareness and capacity building effort.

The informal actors have also realised the importance of managing e-waste in a proper manner through this advocacy effort. Many in informal hubs like Moradabad have expressed their positive intentions towards formalising so that they do not work in conditions which are not good for health and environment. Many have given signed affidavits suggesting that they will not use methods which are not environment friendly and will not employ children and pregnant women in such processes.

Capacity building in the next stage should be looked upon as an industry led process rather than a government led one. Since awareness building is a compliance under the rules, it is important that the government use such programmes to develop institutions which can lead these efforts and innovate as well to ensure that large scale impact can be created. These institutions can be funded through different sources including the public and the private sector. For stakeholders, who need to create awareness as part of compliance, a separate body can be set-up which can manage funds meant for awareness and capacity building. The institutions who would like to work in this area can apply for grants which will allow the body to evaluate such proposals and choose the best possible one. This will also allow for replication of best possible efforts since the learnings from different programmes would be evaluated by this body and chosen as best practices.

5.4 Standardisation and Research & Development (R&D)

India has developed guidelines and standards for new product development in the electronics sector. Any producer who wishes to introduce a product in the market has to register with BIS under the Compulsory Registration Scheme (CRS)[28]. Declaration and testing of materials that are used in the products need to conform to Indian standards and only then the standard mark of the BIS is allowed to be used and product can be introduced in the market.

Similarly, there is a need to ensure that a RE scheme is devised which encompasses the use of secondary materials in products to ensure that they are resource efficient and producers put circular economy principles into practice in the production process. The scheme should also address the development of R&D infrastructure in the country which provides cost effective recycling technologies for WEEE and also considers the rapid technological and material composition changes in the EEE. Although India is not majorly manufacturing products and components in the country so the application of Eco-Design or Design for Environment principles is difficult to accomplish through initiatives in India. Usually the components used for assembling the final products are compliant with the national and international regulations or standards. Thus to enhance RE, the scheme can focus on strengthening R&D advancements to create a platform for applied research in this direction.

The use of secondary materials can be guided through a standardisation of technologies which are being used for extraction of the material during the recycling process. This will ensure voluntary certification by recyclers as the demand for secondary materials increases and will also provide a fillip to the precious metal recycling sector in India, thereby promoting the Make in India mission.

It will encourage reuse and as well as refurbishment, if standards for use of secondary materials are specified. GHG emissions will reduce as well since lesser materials will move into landfills and will be recycled for industry owing to demand of secondary materials. Reuse and refurbishment will also benefit the consumer economically by reducing the obsolescence rate of products and the generation ot WEEE.

[28] http://meity.gov.in/esdm/standards (Compulsory Registration Scheme)

A step wise approach to standardisation at different stage of the product cycle will ensure a move towards resource efficiency and circular economy:

- Estimating quantity of virgin materials which can be replaced by secondary materials through proper recycling technologies
- Standards for use of secondary materials in the production process
- Testing and certification by authorised labs of BIS
- Collection and recycling infrastructure in a participative approach
    - Involve municipalities for the collection of e-waste through integration of the informal sector
    - Proliferate the use of technology in informal recyclers and dismantlers through outreach, advocacy and capacity building
    - Integrate informal sector recyclers in infrastructure developed by the states for Electronic Manufacturing Centres (EMCs) or Eco Industrial Parks
    - Develop schemes for providing financial and technology support to the informal sector so that they can formalise
- Create market place for secondary materials so that resource security issues can be addressed and the potential of Make in India mission is achieved

At each of the steps mentioned above, it is important to understand the principles which will ensure that an ecosystem can be created where stakeholders can maximise benefits, both economically and ecologically. It is therefore, important, that product standards, material use standards, recycling standards, disposal, collection and handling standards of end of life materials are specified so that a level playing field is created across all stakeholders.

5.5 Recommendations and Action Agenda

In order to move forward, it is therefore important that an action plan be framed up by recognising the key challenges which exist in enhancing resource efficiency in the e-waste sector. The key challenges which come to light are:

- Estimating the quantum of e-waste generated in the country which can help understand the scale of the problem to estimate infrastructure required to solve the same
- Gaps in Research & Development for technology development on recycling and to address rapid technological advancement in EEE
- Outreach and advocacy with all stakeholders to ensure that the environment and health hazards are communicated so that disposal mechanisms can be formalised
- Mapping of value chains which will enable to understand stakeholders and draw specific action plans towards formalisation
- Capacity building of monitoring and implementation agencies at the state level so that the rules are enforced across stakeholders
- Infrastructure for e-waste recycling in the country which can disrupt movement of e-waste in the informal sector or push them to formalisation
- Product design guidelines which can help make products and materials easier to dismantle and recycle thereby enhancing resource efficiency
- Standards for recycling which will enable to ensure that best in class technologies are used to mitigate the environmental and health impacts of unsafe recycling, as in the informal sector

The table below tries to map out these details further with respect to key stakeholders who could be involved in addressing these issues and the action agenda for each of these agencies. Inter-ministerial coordination will ensure that resource efficiency and circular economy can be implemented in the EEE sector because this is not just a monitoring problem. It is as much a technical issue as is a waste issue which requires handling by specific experts and stakeholders such that it can be addressed.

Table 5.1: Challenges, recommendation, Action agenda and responsibilities of key stakeholders in enabling resource efficiency in e-waste

S.no	Challenge	Source / Affected Stakeholder Group	Recommendation	Action Agenda	Implementation agency	Timelines for implementing agencies
1.	Framing resource efficiency ecosystem for secondary materials	All Stakeholders	To initiate a Resource Efficiency and Circular Economy Scheme	To drive overall goal of achieving RE and CE through capacity building, Formalisation of Informal Sector, Outreach and Advocacy, R&D for new technologies for recycling of EEE, Technology upgradation & proliferation with the action agenda mentioned below	MeitY with support from NITI Aayog	January 2019 – February 2020
2.	Integrating Municipalities to support collection of e-waste	Municipalities, informal sector, producers	Incorporating local bodies to set up collection infrastructure and integrating the informal sector for collection	Municipalities and informal sector to be included in E-waste Rules to enable setting up of collection infrastructure especially in Smart Cities	MoEFCC with MoHUA	January 2019 - March 2019
3.	Estimating secondary resource potential of e-waste for the manufacturing sector	Producers, Manufacturers, Informal sector, Recyclers	Feasibility study for assessing secondary resource potential for electronics manufacturing	Applying statistical tools and methods to arrive at data for secondary resources available from e-waste which can be extracted and used in production of electric and electronic items.	MeitY with support from EU-REI	March 2019 – December 2019
4.	Creation of outreach and advocacy on health and environmental challenges of e-waste	All stakeholders in the value chain	Awareness campaign in progress for all stakeholders including, schools, colleges, RWAs, Bulk Consumers, Dealers, refurbishers, Producers, informal sector and Government employees.	Supporting the MeitY initiated awareness programme by multiple agencies. Institutionalisation of awareness as a mechanism for capacity building across states by ensuring that the awareness programmes are funded by producers as part of their EPR compliance.	MeitY is leading	Under progress till March 2020
5.	Skilling of different stakeholders on handling e-waste and associated hazards	E Waste Handlers, Dismantlers, Refurbishers, General population	Capacity building of informal and formal actors in safe handling and disposal of e-waste and associates	Development of MOOCs for SWAYAM platform	MeitY and MHRD with content to be vetted by EU-REI	January 2019 till March 2020

6.	Formal recycling infrastructure in the country for extraction of secondary materials for e-waste	MeitY, Informal sector, Producers	Business models which can lead to proliferation of technology adoption with the informal sector so that they are able to formalise and retain livelihoods	Feasibility study which will help to understand the kind of business models which are adopted by C-MET and the changes as required in the same so that technology proliferation can take place. Understanding the key asks of the informal sector and development of a business model and business plan for C-MET	MeitY in partnership with MoEFCC	January 2019 – March 2022
7.	Standards for use of secondary materials in products	Producers, recyclers, informal sector	Policies and guidelines for adopting designs which are eco-friendly, and best available technologies and processes which will reduce decontamination in the dismantling and recycling process. Enhancing use of secondary resource thus enabling lower use of virgin metal extracted from ore.	Development and adoption of guidelines for use of secondary materials	MeitY and BIS with support from EU-REI	January 2019 – March 2020
8.	Enhancement of resource efficiency through refurbished and repaired products	Consumers and Producers	Standardisation for refurbished and repaired products	Research Study for evaluating policies and standards for repaired and refurbished products	MeitY and BIS	January 2019 – October 2019

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