

# Skill Gap Study on Plastic Waste Management

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Submitted to



**Skill Council for Green Jobs**

Prepared by



**Indian Pollution Control Association**

## **Executive Summary**

This report is a result of primary data collected from waste collectors, scrap dealers, MRF operators, workers, recyclers, desk research and more than twenty years of experience and knowledge of Indian Pollution Control Association (IPCA) in the field of waste management. IPCA is the pioneer organization in preparing & executing Extended Producer Responsibility (EPR) action plan for plastic waste management in India. It is the member of expert and core committees constituted by MoEF&CC, CPCB, Government of NCT of Delhi, Government of Jammu and Kashmir, Govt. of Uttarakhand, and registered as Producer Responsible Organization with Chandigarh Pollution Control Committee for plastic waste management.

The report presents an overview of the plastic waste management sector. About 3.4 million metric tonnes of waste is estimated to be generated in India in the year 2019-20. Projections from an independent data research organization state that the figures are going to increase to 31.4 million tonnes by 2031 and 55 million tonnes by 2041 (Statista, 2022). These estimates are alarming and highlight the need for taking proactive measure in the field of plastic waste management. The Government of India has rightly recognised the importance of scientific management of plastic wastes through legislations and regulations during past few years and giving importance to this issue in its flagship missions, evaluating the implementation of policies and performance of municipalities. Industries have also started seeing plastic waste management as an opportunity to reduce their environment footprint and reduce its cost in their supply chain. Public awareness has increased and efforts to bring behavioural change essential for effective management of plastic waste have gained momentum.

These initiatives have helped in tackling the issue, however, there are still many gaps that hinder sustainable management of plastic waste. These gaps at the level of stakeholders, systems, market, etc are described in details in the report. Along with this, key recommendations to bridge these gaps have also been presented. It is hoped that recommendations will help in improving the collection, treatment, and supply

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chain of plastic waste generated by the country. At the same time, it will help the waste collectors, waste dealers and other stakeholders in earning a better living.

The later part of the report explains the spectrum of business opportunities that are offered by the plastic waste management sector in its various applications in the form of occupational mapping. It is believed that currently the sector provides direct employment to around 1 crore people, and 10 times more indirectly (Plastindia Foundation, 2022). The opportunities are going to increase manifold in the years to come, considering the increasing growth rate in the generation of plastic waste.

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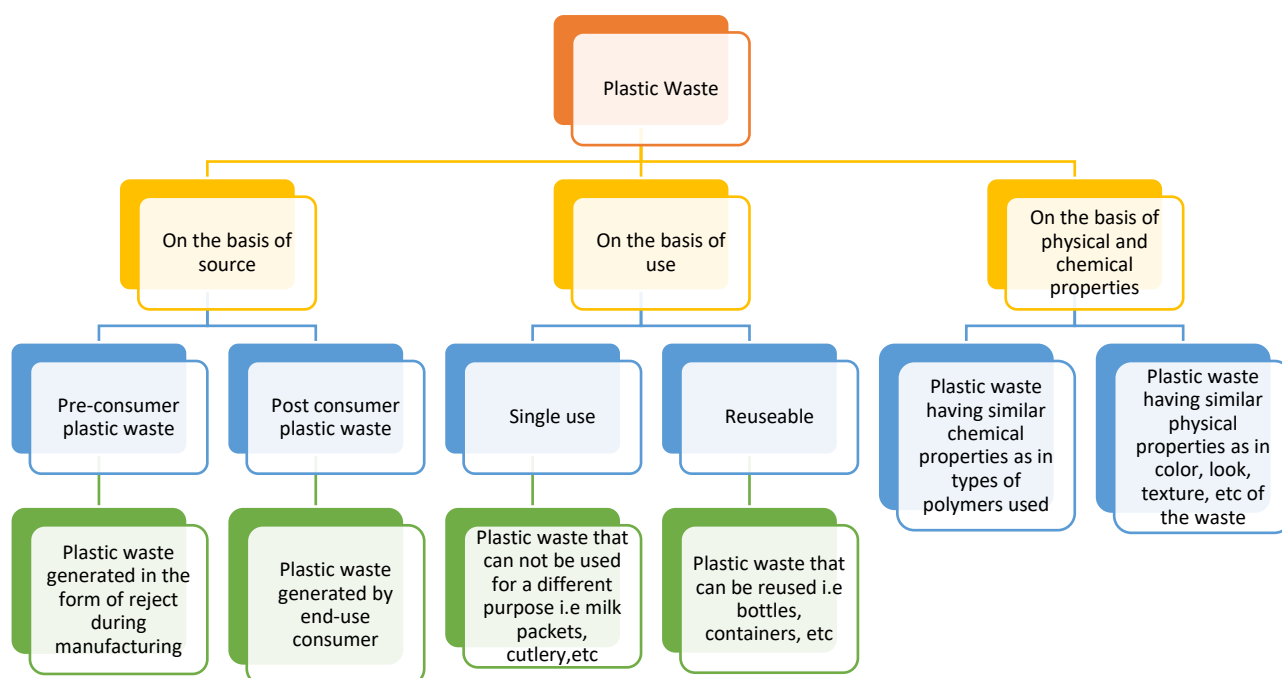
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# 1. Introduction

## 1.1 Introduction to plastic waste

As per Plastic Waste Management Rules, 2016 as amended several times, plastic waste means any plastic discarded after use or after their intended use is over. Plastic waste can be categorised into different ways:

Figure 1 Categorization of Plastic Waste



One of the widely used categorisation of plastic is on the basis of polymer used in its making. In this way, plastic and its waste can be divided into 7 categories:

Table 1 Categories of Plastic/ Plastic Waste

S. No	Category of plastic	Products
1	Polyethylene Terephthalate (PET)	Water and Beverages Bottles, toiletries container/bottle, face shield, sweet and biscuit tray, food and water jars
2	High Density Polyethylene (HDPE)	Various containers, dispensing bottles, wash bottles, tiffin box, toys

3	Poly Vinyl Chloride (PVC)	Pipes, hoses, sheets, wire cables insulation, window profile fencing, lawn chairs, labels
4	Low Density Polyethylene. (LDPE)	Milk pouches, plastic carry bags, plastic films sheets, wrapping sheet
5	Polypropylene (PP)	Disposable cups, bottle caps, straws, auto parts, industrial fibres, cutlery
6	Polystyrene Resins (PS)	Disposable cups glasses, plates, spoon, trays, CD covers, cassette boxes, foams
7	Multi-materials like Acrylonitrile butadiene styrene, poly-phenylene oxide, poly-carbonate, Poly-butylene terephthal	Thermoset plastic, multilayer and laminates, nylon SMC, FRP, DC, melamine plates, helmets, shoe soles.

Currently, the manufacturer and producers of plastic packaging/products use blending of polymers and compounding. This means there is sometimes more than one polymer of the above categories in the products. During the survey conducted with waste collectors, it was found that there are more than 300 variety of plastic waste (i.e *kali guddi*, crystal, polybag, HM, white water bottle, milk pouch, MLP, *dabba* etc) which are being segregated by the waste workers and scrap dealers on the basis of color, texture, thickness, contamination, quality, compounding, virgin, recycled, compostable, biodegradable, layers, and use of product that is packaged in the plastic.



*Image 1 Plastic waste- Milk pouch, Green PET, Crystal (from left to right)*



*Image 2 Plastic Waste- White PET, Kali Guddi, Dabba (from left to right)*

Plastic waste generated at different sources can be summarised as below:

*Table 2 Source and Generators of Plastic Waste*

Source of plastic waste generation	Typical waste generators	Type of waste generated
Plastic and plastic packaging industries	Industries, manufacturing unit, packaging companies, etc	Mostly segregated plastic
Residential area	Residential colonies, societies, authorised and unauthorised dwellings, buildings, etc	Bottles, jars, plastic wrappers, milk packets, carry bags. plastic packaging, toys, bucket, mug, cutlery etc
Commercial areas	Markets, shopping complexes, malls, etc	Plastic packaging, carry bags, plastic wrappers, bottles, etc
Institutional areas	Educational institutions, government offices, corporate offices, etc	Plastic packaging, plastic wrappers, bottles, cutlery, etc
Religious places	Visitors, priests, vendors, etc	Plastic packaging, plastic wrappers, cutlery, etc

## 1.2 Status of plastic waste generation in India

It is estimated that in the year 2019-20, India generated more than **34 lakh tonnes of plastic waste** (Annual Report on Implementation of PWM Rules, 2016, CPCB). This roughly means that 9300 TPD of plastic waste is generated, as per data collected from 35 SPCB/PCC of India. The same report estimated the annual per capita generation of plastic waste to about 2.5 kgs.

The estimated amount of plastic waste generated by states of India in the fiscal year 2019-20 is mentioned in Table 3

Table 3 Estimated plastic waste generation in Indian states (2019-20)

S. No	SBCB/ PCC	Estimated Plastic Waste generation per annum (in tonnes)	S. No	SBCB/ PCC	Estimated Plastic Waste generation per annum (in tonnes)
1	Andhra Pradesh	46222	18	Lakshadweep	46
2	Andaman & Nicobar Island	387	19	Madhya Pradesh	121079
3	Arunachal Pradesh	2721	20	Maharashtra	443724
4	Assam	24971	21	Manipur	8293
5	Bihar	41365	22	Meghalaya	5043
6	Chandigarh	6746	23	Mizoram	7909
7	Chhattisgarh	32850	24	Nagaland	565
8	Daman	1948	25	Odisha	45339.4
9	Delhi	230525	26	Punjab	92890
10	Goa	26068	27	Pondicherry	11753
11	Gujarat	408201	28	Rajasthan	51966
12	Haryana	147734	29	Sikkim	69
13	Himachal Pradesh	13683	30	Tamil Nadu	431472
14	Jammu & Kashmir	74826.33	31	Telangana	233655
15	Jharkhand	43332	32	Tripura	32
16	Kerala	131400	33	Uttarakhand	25203
17	Karnataka	296380	34	Uttar Pradesh	161148
			35	West Bengal	300236

\*Source: Annual Report on Implementation of PWM Rules, 2019-20, CPCB

The above table clearly states that Maharashtra is the largest generator of plastic waste in the country followed by Tamil Nadu and Gujarat. States like Tripura, Sikkim and Lakshadweep generate negligible plastic waste.



## **2. Plastic Waste Management**

### **2.1 Plastic Waste Management**

Plastic waste management is the process through which different categories of plastic waste are collected from their source, undergoes various levels of segregation, transported to treatment facilities, treated using different technologies to produce recycled plastic granules and products, low density oil, energy, used as alternate source of energy.

### **2.2 Plastic Waste Management (2<sup>nd</sup> Amendment) Rules, 2022**

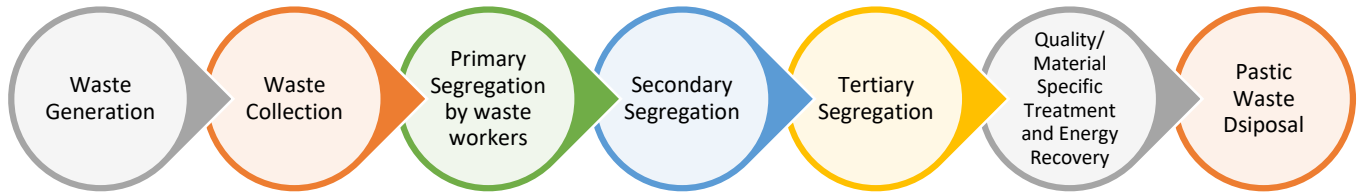
Plastic Waste Management (2<sup>nd</sup> Amendment) Rules, 2022 were notified by Ministry of Environment, Forest and Climate Change on 6<sup>th</sup> July 2022. The rules reflect a paradigm shift to regard waste as a wealth and resource for circular economy. It aims for a more efficient regulatory framework for the management of plastic waste generated in the country. At the same time, it will give thrust to plastic waste minimization, source segregation, recycling, involving waste pickers, recyclers and waste processors in the collection of the plastic waste fraction either from households or any other source of its generation or intermediate material recovery facility, and adopt polluters pay principle for the sustainability of the waste management system

The rules apply to every waste generator, local body, Gram Panchayat, brand owners, Importers, and producers (PIBOs). The rules have clearly defined the roles and responsibilities of stakeholders involved in the management of plastic waste.

These rules encourage the recycling, alternate use and energy recovery of plastic waste vis-a-vis waste to energy, waste to oil and cement kilns, gasification and for road construction. The rules also introduced the concept of Extended Producers' Responsibility (EPR) for PIBOs and fixes their responsibility to develop collect back system for the equivalent quantity of plastic packaging waste introduced by them/ their products into the Indian market.

## 2.3 Process mapping of plastic waste management

Figure 2 Process of Plastic Waste Management



**Waste generation:** Plastic waste is generated from various activities. At the pre-consumer level, it is generated as a reject or discarded material that comes out of pre-production or production activities. For instance, scraps of plastic material left while making bottle caps. The source of generation of this type of plastic waste is fixed and it is easy to estimate the waste that is generated by an industry/ manufacturing unit. At the post-consumer level, plastic waste is generated by the consumer of different products after consuming main ingredient of the product as a non-consumable part at various sources. The waste is generated along with other kinds of dry, wet and domestic hazardous waste.

**Waste collection:** The plastic waste generated at different sources is collected either by municipality, waste collectors, and waste management agencies. At the pre-consumer level, plastic waste is a source of revenue for the waste generator and it is sold either to the scrap dealer or recycler. Because the quality and quantity of pre-consumer plastic waste is good. Whereas, there is a challenge to collect post-consumer plastic waste because of many reasons such as

- Mixed with other waste like organic waste, domestic hazardous waste and inert
- Littered on open area
- Inconsistent and Poor quality
- Less quantity per household or consumer per day
- High logistic cost

At the post-consumption level, plastic waste is mostly disposed with other kind of waste and is mostly collected in mixed form.

Primary segregation of plastic waste: The first level of segregation happens at the level of waste collectors. As stated above, they collect mixed waste from different sources. Out of the total waste collected, they segregate different kinds of waste i.e paper, plastic, glass, rubber, metal, and organic (wet) etc.

Secondary segregation of plastic waste: This level of segregation is usually done at the level of scrap dealers at their godowns or sometimes at the Material Recovery Facility (MRF). Here, sorting is done for different types and grades of plastic and other waste commodities. For example, bottles, containers, packaging, etc are segregated from each other.

Tertiary segregation of plastic waste: In this level of segregation, value is added to the plastic waste as per the requirement of the recyclers/ co-processing facilities. This is usually done by aggregators or at MRF facilities and plastic waste is further segregated and packed in more compact form like bale to reduce the cost of storage and transportation. The plastic waste is segregated on the basis of color, size, shape, and improve the quality by removing the contamination of moisture, inert and any other unwanted material.

Plastic waste treatment and Energy recovery: Plastic waste segregated as per quality and specific of the industry is received for treatment and energy recovery. The plastic waste can be treated/used in the following ways:

- Recycling, where plastic waste is converted into another product such as plastic granules, chips, flakes, yarn, fibre, compressed board, remoulding etc.
- Pyrolysis, where treatment of plastic waste helps in generating fuel oil
- Road construction, where plastic waste is added to bitumen to make roads
- Co processing in cement kilns, where plastic waste is used as an alternate source of energy
- Incineration, where plastic waste is used for energy recovery

Plastic waste disposal: This is the stage where plastic waste is disposed in landfills. Although, all kinds of plastic waste is recyclable or treatable, some of the plastic waste still lands on the landfill. This happens due to the following reasons:

- The plastic waste is mixed with other types of waste that is difficult to segregate/ Due to this reason, the waste collectors do not segregate the plastic and it goes to the landfill
- There are plastic items, which are very light in weight and small in size e.g. toffee wrapper, carry bag, straw, medicine packaging etc. which is difficult to segregate from the mixed waste and such waste reaches to dump yard along with other disposable waste.
- Consumer do not dispose plastic waste in a dustbin and usually dispose at open area like road side, park, water bodies, railway track and it is very difficult to collect littered plastic waste because of high logistic cost involved. As a result, either plastic waste remains littered for many years or reached to dump yard along with road sweep.
- Recycling facilities require specific material for their facilities. However, there are times when the specific type of plastic is mixed with other kinds of plastic waste that is useless for that particular recycler. As a practice, this unwanted plastic is disposed of in landfills by that recycler. The plastic waste that cannot be treated is disposed in landfills across the country.

Disposal of plastic waste at landfills and water bodies is a major cause of concern and there is a need to reduce the amount of plastic waste that ends up in the landfill and water bodies.

## 2.4 Existing gaps in management of plastic waste

The plastic waste management sector has made progress over the years, however, there is still a long way to go to achieve its full potential. There are many reasons that come in the way of sustainable plastic waste management in the country. These gaps identified with the help of primary research with waste collectors, recyclers and on the basis of IPCA's experience in the sector are described in details below:

- Lack of sense of responsibility: In a country like India, people are still struggling for basic amenities. Their first priority is food, shelter and clothing. The thought of environment and its deteriorating condition comes much later. People think protecting environment is not his/ her responsibility.

Environmental protection is considered as a responsibility of the municipality/ government. Specifically for plastic waste, people use and dispose it irresponsibly. This lack of sense of responsibility is the major challenge for efficient management of plastic waste.

- *Lack of awareness:* The awareness level of people with regards to plastic waste and its impact on the environment, human beings, animals, etc is very low. The use and importance of plastic waste in circular economy is also not known to the people. They lack the understanding of how a simple change in their habits can make a lot of difference.
- *Collection of unsegregated waste:* Due to lack of awareness and sensitization, the practice of source segregation is not practiced by many and there is mixing of plastic waste with other kinds of waste. Or even worst, most of the waste generators engage in littering plastic. This makes collection of plastic waste difficult. Similarly, most of the waste collection agencies/ municipalities do not have any additional provisions for the collection of plastic waste.  
Unsegregated waste affects the productivity of the recyclers. High rate of contamination in the plastic waste increases the cost of operation since additional activities are to be undertaken for further segregating it. It also increases the logistic cost since material useless to the recycler is transported to the recyclers. Unsegregated plastic waste also leads to low yields and results in low rate of recycling.
- *Recyclability of plastic:* The infrastructure for recycling/ treatment of plastic waste is not available at all places. This leads to geographical variations in recycling. A plastic waste material that is in high demand at one region may not have any demand in another. For instance, PET bottles have a huge demand in the recycling industry in Delhi/ NCR and one would not see PET bottles littered on streets/open areas. However, this particular plastic waste material does not have any demand in Ladakh and Kashmir since there is no infrastructure in Ladakh or its neighbouring region to recycle PET bottles. The logistic cost of transporting this waste to nearest available recycling facility will also be higher than the value of recycled product. Hence, PET bottles are not collected by

waste collectors since they do not fetch them any value. Similarly, recycling facility to process other types of plastic may be available at some place while missing in another. This creates a problem in recycling all types of plastic.

- *Lack of involvement of organised industries in recycling:* Plastic waste management is largely dominated by the informal sector. There is hardly any involvement of big industries in the recycling of plastic, except for recycling of PET bottles. Wherever big/ organised industries are involved, it leads to adoption of ethical practices, fair rates of waste, and standardised procedures. This benefits all the stakeholders involved in the process. In the absence of such involvement, market is regulated by informal players and leads to inequitable distribution of profit. This impacts the income of aggregators, waste dealers, scrap dealer and ultimately waste collectors, who are at the last end of supply chain of plastic waste.
- *Absence of sustainable supply chain of plastic waste:* For many types of plastic waste item, there is still lack of sustainable supply chain. There are limited facilities that recycle/ use this material and hence, there is not enough demand. For instance, the management of Multi-layered Packaging (MLP) waste is totally dependent on policy mandate. As per Plastic Waste Management (Amendment) Rules, 2022, PIBOs are mandated to collect back the plastic waste that they have introduced in the market. They are responsible for the end-of-life disposal of these waste plastic products/ packaging. In case this clause is deleted from the policy, this particular waste material will not be collected and will remain littered, like it used to before introduction of EPR in 2016.  
On the other hand, in case of PET recycling, the industry is well established and the demand comes from the recyclers for waste PET material. This demand is met by intermediaries who ensure that PET waste is collected and traded. Thus, the supply chain for PET waste material is sustainable. It will continue to function even if waste management rules do not state that plastic waste has to be collected. This kind of sustainable supply chain is lacking for many kinds of plastic waste.

- *Lack of recycling facilities*: Considering the amount of plastic waste generated in the country, there are limited recycling units in India. It is estimated that 70% of the plastic consumption is in packaging and plastic packaging converts in waste in a short span of time. These packaging waste mostly comprises MLP. However, the facilities that recycle MLP waste are limited in number.
- *Lack of quality/ specific plastic waste for recycling*: Every recycling facility deals in certain type and grade of plastic. The machinery/ equipment used in the facility is often specific to a certain type/ grade of plastic. It is found that the material supplied to the recycling units are often of poor/low quality or has impurities in terms of other types of plastic/ dirt. This leads to loss of revenue for the waste dealer/ aggregators/ traders since recyclers receive material which is of no use to them.
- *Lack of certified trained workforce*: Training on plastic waste management is lacking at all levels of stakeholders. Information regarding types of plastic, recyclability of categories of plastic waste, market prices, buyers, market, scientific treatment/ disposal, etc is often found missing. The sector is operating with very less trained professional and more informal workers. Informal sector does not adhere to compliances, rules and regulation. It also does not generally follow a human resource policy. Unskilled manpower is recruited at low cost. They are given direct exposure to technology considering that they will get trained automatically to save cost. However, lack of certified trained manpower with limited knowledge of machine/ equipment leads to many kinds of damages that in turn increases the expenses of the recyclers.
- *Lack of ethical practices*: Since the sector is majorly dominated by informal workers, practices adopted in the supply chain management of plastic waste are sometimes unethical. The sector still works without bills, with unauthorised dealers/ facilities and unscientific treatment mechanisms, and mostly do not follow environmental compliances.
- *Absence of BIS standards for recycled plastic products*: The market for recycled products is still in its nascent stages. Like other items, there are

currently no BIS standards for the recycled plastic products. This hampers the sale of products to bulk customers such as government department and agencies.

## 2.5 Recommendations on bridging the gaps

Based on the stakeholder consultations and recommendations of the experts, following recommendations are presented for bridging the gap in the management of plastic waste in India. These recommendations can become action points for making the system sustainable.

- *Awareness and Education*: The improvement in the attitude of waste generators will be possible when they are sensitised about the criticality of plastic waste for the environment. Workshops, training sessions, campaigns, etc should be organised in schools, colleges, RWAs, market associations, so that stakeholders of all age groups and occupations can be educated. Sense of responsibility should also be instilled in people so that consider waste as their responsibility.
- *Enabling environment*: The educative measures will only be successful when they are clubbed with enabling environment. If the training is given on segregating plastic waste, initiatives on collection of plastic waste separately should be taken. This could be done through a plastic waste collection drive by the municipality once a week or by waste collection and management agencies. With the introduction of EPR, a lot of brands and industries are joining hands with the local bodies and waste management agencies to set up infrastructure for the collection and transportation of the plastic waste. These initiatives should multiply across the country.
- *Capacity building*: Capacity building can be done at the level of a) waste collectors b) waste dealers/ aggregators c) recyclers
  - a) Waste collectors: In the primary research study conducted with waste collectors, the following gaps were identified:



- most of them were not aware about all the categories and grades of plastic waste. They only knew about the plastic categories that were bought by the waste dealers. Hence, their understanding of the diversity of market of plastic waste was limited
- most of them were not aware about the market price of different categories of plastic waste.
- most of them have identified dealers and they do not explore new dealers for selling the waste

These gaps can be filled by building the capacity of waste collectors. SCGJ should organise training on types/ grades of plastic waste, prices of plastic waste, information regarding available waste dealers for different categories of plastic waste in their region. This in turn would not only increase the collection rates of plastic waste, but will also improve the livelihood of waste collectors.

- b) Waste dealers/ aggregators: It was analysed during the discussion with waste collectors and dealers that waste dealers/ aggregators are themselves not sensitized about the market of plastic waste. Their knowledge on expanding applications of plastic waste is limited. It is recommended that training on the same, along with market linkage, and information regarding recyclers/treatment plants/ units of other applications should be provided to them. Waste dealers / aggregators should also be trained on the taxation, packaging, storage and safety of their work place.
- c) Recyclers/ other units: Recyclers and co-processors also require support for efficient management of plastic waste.
- SCGJ should organise training on updated technology for the recyclers/ other units.
  - SCGJ should organize training on the compliance, occupational health hazards, and machine and stock maintenance for the recyclers and its workers
  - SCGJ mentors should also certify workers already working in the plants
  - SCGJ should facilitate recycler in developing the BIS specification for their end products

- Infrastructure development:
  - It was found that most of waste collectors did not have space for segregating the waste. This leads to them selling unsegregated waste to the waste dealer at a lower price as compared to the price they could get after segregating different kinds of waste. Therefore, there should be efforts to build ward wise MRF and if possible, its integration with EPR to support Circular Economy.
  - Waste collectors should be trained to operate and manage these MRFs. Waste collectors should be encouraged to become MRF entrepreneurs
  - Tier I cities should have dedicated plastic recycling industrial area, where start up and existing industries may set up plastic recycling industries with multiple recycling technologies as most compliance and organized sector.
- Research and Innovation: There is a greater need for research institutions to find innovative and sustainable solutions to manage plastic waste.
  - Research efforts should focus on the uniform design of plastic packaging with uniform compounding.
  - Research efforts should focus on the maximum yield from recycling or co-processing.
  - Research efforts should focus on the value addition of low grade and low commercial value plastic waste. develop technologies or system to increase the collection and treatment of such plastic waste.
- Sustainable supply chain: An efficient plastic waste management system would mean collection of all kinds of plastic, transportation of segregated plastic waste, treatment/ energy recover/ recycling of collected plastic waste and finally sale of end products. This can be done through
  - All the recommendations presented above
  - Creation of value- added chain for recycled products
  - Establishment of quality control mechanism
  - Development of BIS specification for recycled products
  - Development of market/ use for other end products

An action plan to implement these recommendations will help in maximizing the collection of plastic waste, increase the livelihood of waste collectors, will make them self-reliant, and streamline a sustainable supply chain of plastic waste.

### 3. Business Potential in Plastic Waste Management sector

According to a report on PWM released by Ministry of Housing and Urban Affairs, India has an **annual per capita plastic consumption of 11 kg**. This figure is expected to reach to 16-20 kg by 2025 (CSE,2019). As the consumption increase, the rate of plastic waste generation will also increase since 70% of plastics packaging products are converted into plastic waste in a short span (SBM, 2019). The annual plastic waste generation is also estimated to increase to 31.4 million tonnes by 2031 and 55 million tonnes by 2041 (Statista, 2022).

At the same time, it is estimated that only 60% of the plastic waste generated by our country is recycled (TERI, 2018). The remaining plastic waste is either left uncollected or is littered (SBM, 2019).

The above facts and figures provide a visual of the expanding scope of plastic waste management in India. The extent of scope can be understood in the following ways:

- The increasing rate of plastic waste generation implies that more raw material will be available for plastic waste recycling/ treatment industries
- The opportunity to bring collection and recycling figures close to 100% as against 60% in current scenario. This again would multiply the amount of raw material available for treatment and use in circular economy
- As India progresses, research and innovation will help in developing sustainable solutions and technologies to manage waste

In line with the above, the plastic waste management sector has a potential to contribute socially, environmentally and economically in India's growth. It is estimated that proper management of plastic waste can create 14 lakh jobs and could potentially represent a 2 billion economy (Circular Economy Symposium, FICCI, 2018). A study estimates that MRFs will help to generate employment of 40 Lakh person-days during construction of MRFs and ~80 Lakh person-days in perpetuity for operations & maintenance of these facilities (MoHUA, 2021).

Table 4 presents the current scenario of plastic waste management and the scenario that can be achieved after implementing circular economy principle in 2025.

*Table 4 Current and projected scenario of management of plastic waste*

Year	Waste Generation (TPD)	Recovery, %	Qty Recovered, TPD	Value, Rupees Per MT	Value Recovered Daily, In Crore
2021 (Current)	21,750	60%	13,050	6,000	7.83
2025 (after implementation of Circular Economy Principle)	30,750	80%	24,600	10,000	24.60

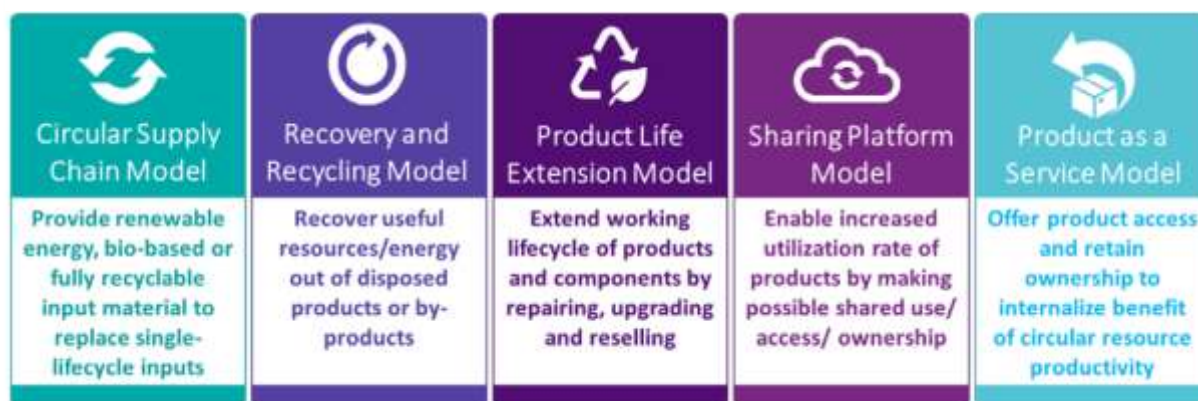
Source: Circular Economy in Municipal Solid and Liquid Waste, MoHUA, 2021

It can be analysed that efficient management of plastic waste can lead to increase the recovered value of plastic waste as well as can help in generating employment opportunities.

### 3.1 Business Models in Plastic Waste Management

Plastic waste management is a growing business arena and the following models can be adopted by budding entrepreneurs or waste management companies entering in the field.

*Figure 3 Business models in Plastic Waste Management*



Source: Circular Economy in Municipal Solid and Liquid Waste, MoHUA (2021)

### 3.2 Applications of Plastic Waste

With the increase in the generation of plastic waste, improvement in technologies and innovation in research, the applications in which plastic waste can be used have grown immensely. An inclination towards plastic waste management can be clearly seen in the policy makers, government departments, researchers, entrepreneurs, non-governmental organizations, and corporates, etc over the last decade. Due to this reason, it has been made possible to reuse, recycle and repurpose plastic waste and utilize it as a resource.

The introduction of Extended Producers Responsibility (EPR) for plastic waste in Plastic Waste Management Rules, 2016 had paved the way for increase in the collection and treatment of plastic waste. As per the rules, the Producers, Importer and Brand Owners (PIBOs) are responsible to oblige EPR for environmentally sound management of their products until the end of its life. This means the PIBOs are responsible to develop and execute the collection back mechanism for the equivalent quantity of plastic waste packaging waste introduced directly or through sale of their products into the Indian market.

This has led to availability of plastic waste for various applications. Some of the major applications of plastic waste are presented below:

- *Plastic waste recycling*: Plastic recycling has been practiced in India for many years. However, the categories of plastic recycled and the end products have increased over the years with the advent of research and innovation in technology. Today, it is possible to recycle almost all the categories of plastic waste (HDPE, PP, PET, LDPE, PVC, etc), provided they are received by the recycler in a segregated manner. There are technologies even to recycle multi-layered plastic that was earlier difficult to recycle.

The following types of end products can be developed through recycling of plastic waste:

- Plastic granules that can be used for various purposes
- Merchandise such as t-shirts, caps, stoles, shoes, etc

- Décor items such as lamps, show pieces, photo frames, wall hangings, etc
- Outdoor items such as swings, plant pots, dustbins, etc
- Furniture items such as chairs, tables, desks, benches, etc
- Tableware such as coasters, pen holders, visiting card holders, etc
- Roof sheets, walls, etc

Category wise products developed from plastic waste is mentioned in Table 5

*Table 5 Products Developed from Recycled Plastic*

S. No	Category of plastic	Recycled products
1	Polyethylene Terephthalate (PET)	Mineral/ Drinking Water Bottles, Cosmetic Bottles
2	High Density Polyethylene (HDPE)	Tubes, sewer pipes, pallets, boxes, buckets, toys, bottles for detergents, construction, cable insulation, packaging of food products etc.
3	Poly Vinyl Chloride (PVC)	Sewer Pipes, Window frames, Construction, Flooring, Wallpaper, Bottles, Car Interiors, Medical products, Planks, etc.
4	Low Density Polyethylene. (LDPE)	Flexible packaging, bin liners, carrier bags, tubes, agricultural mulch film, agricultural sheet, construction film, cling-film, heavy duty sacks, etc.
5	Polypropylene (PP)	Pipes, pallets, boxes, furniture, car parts, pots of yoghurt, buckets, butter, margarine, fibres, milk crates, etc.
6	Polystyrene Resins (PS)	Clothes Hangers, Park Benches, Flower Pots, Toys, Spoons, Cutlery, Picture Frames, Seeding containers, etc.
7	Multi-materials like Acrylonitrile butadiene styrene, poly-phenylene oxide, poly-carbonate, Poly-butylene terephthal	CDs, Pallets, Floors, Roofs, Furniture, Sheeting, Benches, Shoe soles, etc.

With the rising environmental consciousness among people, the demand of recycled plastic material is increasing day by day. Some of the opportunities that can be explored in this application are mentioned below:

- Collection of plastic waste from residential, commercial, institutional, industrial sectors
  - Setting up segregation units for sorting plastic waste
  - Manufacturing machines and equipment for bailing, sorting, shredding plastic waste, recycling units, etc
  - Providing transportation services to transport plastic waste to recycling plants
  - Providing consultancy services to different plastic waste management entities
  - Trading plastic waste in different supply chains
  - Designing recycling products
  - Selling the end products manufactured in the recycling unit
  - Providing services of security, electrician, labour, etc at the recycling facility
- 
- Upcycling of plastic waste: Here, plastic waste is used to design creative products that serve different purpose, usually decorative in nature. For instance, PET bottles are upcycled as flower beds or wall décor items. A lot of designers, architects, and people with creativity are opting to build their career in upcycling. Due to their unique style and eco-friendly tag, these products have started attracting demand.

People interested in being involved in this application have the following opportunities:

- Collecting plastic waste
- Segregation of specific kind of plastic waste
- Trading specific plastic waste to the upcyclers
- Designing of products
- Making the products



- Painting the products to make them look attractive
  - Training others to make the products
  - Selling the products
  - Designing online forum for these products
  - Writing about the products
- Co-processing in cement kilns: Co-processing refers to the use of waste material in industrial processes as alternative fuels or raw material (AFR) to recover energy and material from them. Use of plastic waste in cement kilns as AFRs utilizes the material and energy value present in the waste and replaces the fossil raw materials and fossil fuels that are conventionally used in the kiln. Plastic waste is cleanly burnt while its leftovers are used as ashes in the cement itself. As per Rule '5(b)' of Plastic Waste Management Rules, 2016, there are guidelines for the co-processing of plastic waste in cement kilns.

Following are the potential business opportunities that can be explored in this application:

- Collection of plastic waste from residential, commercial, institutional, industrial sectors
  - Setting up segregation units for sorting plastic waste
  - Manufacturing machines and equipment for bailing, sorting, shredding plastic waste, co-processing, etc
  - Setting up a plastic shredding plant for preparing material to be used by cement kilns
  - Providing transportation services to transport plastic waste to cement kilns
  - Providing consultancy services to different plastic waste management entities
- Road Construction: The technique to using plastic waste in road construction is a very recent development. The biggest drawback of plastic that it does not decompose was used as its strength in developing this application. The process does not require any new machinery. For every kg of stone, 50 gm of bitumen is used and 1/10<sup>th</sup> of it is plastic waste. This reduces the use of bitumen.

Plastic waste increases the aggregate impact value and improves the quality of roads. The roads constructed using this technology are said to require lesser maintenance.

The business potentials in this application are similar to that of cement kilns:

- Collection of plastic waste from residential, commercial, institutional, industrial sectors
  - Setting up segregation units for sorting plastic waste
  - Manufacturing machines and equipment for bailing, sorting, shredding plastic waste, etc
  - Setting up a plastic shredding plant for preparing material to be used for construction of roads
  - Supplying shredded plastic waste of specified parameters to the road construction authorities
- *Pyrolysis*: Pyrolysis is a process in which plastic waste is used to generate fuel oil. Unsegregated plastic waste that can't be recycled is used in the process. It helps in deriving alternative fuel from waste. The technology is yet to popularise and is currently adopted by a few companies only.

Pyrolysis presents the following opportunities:

- Trading of unsegregated plastic waste
  - Transportation of plastic waste
  - Consulting services for various stakeholders involved in the process
  - Marketing and selling of end product
- *Waste to Energy*: Plastic waste works as an excellent material for waste to energy plants due to its high calorific value. It is recommended that unsegregated plastic that cannot be recycled should be used in this application. In India, there are very few functional waste-to-energy plants and they help in generating alternative energy from waste.

The following opportunities can be explored in this application:

- Collection of plastic waste
  - Transportation of plastic waste
  - Trading of plastic waste to waste to energy plants
  - Setting up waste to energy plants
- Other innovative initiatives:
    - *Eco bricks:* An Eco-brick is a reusable building block comprising a plastic bottle filled with solid non-biodegradable waste to a set density. Eco-bricks are durable and never crumbles, making them ideal construction materials. They are used to create furniture, walls and even houses in developing countries.
    - *Plastic waste for 3D printing:* An innovative application of plastic waste has been the use of plastic waste in 3D printing. Plastic filaments and HDPE waste are converted into flakes which are then melted and extruded into HDPE filaments which are then used in the process of 3D printing, an additive manufacturing technique in which one can create, or print, objects layer by layer using raw material powder or filament as feedstock.
    - *Plastic waste for pavements:* Plastone is a material prepared using waste plastics available in the solid waste of the particular area which can be segregated and used as binder with the stone aggregate. This prefabricated Plastone can be used in the construction of structure of the Toilet Blocks (Individual Household Latrines) and is an effective substitute for bricks and cement blocks. This process can also be done in situ and no external industry is involved.

These applications are expected to expand as the plastic waste generation will increase in the near future. As can be seen from this chapter, this sector provides opportunities to both skilled and unskilled workers.

## 4. Occupational Mapping

### 4.1 Overview of jobs in plastic waste management

Plastic waste management offers a gamut of career opportunities to people belonging to varied educational background and experiences. The job roles can be divided into following 6 categories:

- Administration
- Logistics
- Operations
- Communication and Branding
- Sales and Marketing
- Research and Development

The overview of job titles and responsibilities is mentioned in the Table 6.

*Table 6 Job Titles and Responsibilities in Plastic Waste Management*

S. No	Category	Key activities	Key job roles
1	Administration	To provide administrative support in various operations of plastic waste management business. For example, managing people, internal and external communication, providing information technology support, etc.	Managing Director General Manager, Admin / HR DGM, Admin / HR Manager, HR/ Admin Executive, Admin / HR General Manager, EPR Manager, Compliance Executive, Compliance Manager, Sustainability Executive, Sustainability Manager, IT Executive, IT Manager, Communication Executive, Communication

2	Logistics	Waste Collection and segregation: collection of mixed waste from residential, commercial, industrial or other sources and segregating plastic waste out of it.	General Manager, Supply Chain Management DGM, Supply Chain Management Manager, Supply Chain Management Executive, Supply Chain Management DGM, EPR Manager, EPR Executive, EPR Waste Dealers Waste Aggregators Waste Collectors Waste Segregators Head, MRF Manager, MRF Supervisor, MRF Machine Operator, MRF
		Waste Transportation: Transporting plastic waste for processing/ treatment, arranging bills for transportation and maintenance of vehicle	Manager, Logistics Executive, Logistics Driver Mechanic
3	Operations	Waste Trading: buying and selling of plastic waste	Head, MRF Manager, MRF Manager, Accounts Waste collectors Waste dealers Waste aggregators Head, Procurement Officer, Procurement
		Treatment/ co-processing: recycling, co-processing, pyrolysis, upcycling, road construction, etc	Head, Recycling Unit Manager, Recycling Unit Recycling Technician, Recycling Unit Head, Co-processing/ Pyrolysis/ WTE plant

			Manager, Co-processing/ Pyrolysis/ WTE plant Executive, Co-processing/ Pyrolysis/ WTE plant Manager, Environment Health and Safety Welder Electrician Labour Civil Engineer Designer
		Product development: responsibility of ensuring innovation, quality and variety in products developed with plastic waste	Head, Product Development Manager, Product Development Executive, Product Development Designer Manager, Quality Control Supervisor, Quality Control
		Accounts: responsibility of managing the finances of the entity	Head, Accounts Manager, Accounts Accountant, Accounts
		Web developers: developing websites, and other online forums	Manager, Web Design Designer, Web Design
		Education and awareness: implementing projects on education and awareness of different stakeholders	Manager, Education Executive, Education, Manager, Community Outreach Executive, Community Outreach Manager, CSR Executive, CSR Trainers Designer Content Developer Head, Printing and Publication Print technician, Printing and Publication

			Print Operator, Printing and Publication
		Security Services	Supervisor, Security, MRF/ Recycling Unit/ Co-processing unit/ Pyrolysis plant Security Guard, MRF/ Recycling Unit/ Co-processing unit/ Pyrolysis plant Caretaker, MRF/ Recycling Unit/ Co-processing unit/ Pyrolysis plant
		Other services	Office Assistants Maintenance Supervisor Sweepers Peons
4	Communications and branding	Communication about the organization/ unit and developing its brand	Manager, Communication Content Developer, Communication Manager, Social Media Content Developer, Social Media Manager, Print Media Coordinator, Print Media Manager, Business Development Executive, Business Development Manager, Public Relation Executive, Public Relation
5	Sales and Marketing	Marketing and sales of products: responsibility of marketing about the products and services and selling them	General Manager, Marketing and Sales Manager, Marketing and Sales Executive, Marketing and Sales
6	Research and Development	Developing new technologies/ solutions for management of plastic waste	Scientist Researcher Lab technician Lab Assistant Typist Data entry operator Supervisor, Quality Control
7	Legal and compliance		Head, Legal Department Associate, Legal Department

			Analyst, Compliance and Legal (Patent)
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## 4.2 List of job roles

The various job roles that either are present in the plastic waste management sector or are expected to be generated in future are mentioned below. These job roles have been categorised as general or critical on the basis of their importance in the sector. The job roles highlighted in green are identified for preparation of qualification packs by the Skill Council for Green Jobs.

*Table 7 List of Job Roles in Plastic Waste Management*

S. No	Title	Specific/ General
1	Managing Director	General
2	General Manager, Admin / HR	General
3	DGM, Admin / HR	General
4	Manager, HR/ Admin	General
5	Executive, Admin / HR	General
6	General Manager, EPR	General
7	Manager, Compliance	Critical
8	Executive, Compliance	Critical
9	Manager, IT	General
10	Executive, IT	General
11	Manager, Sustainability	General
12	Executive, Sustainability	General
13	Manager, Communication	General
14	Executive, Communication	General
15	General Manager, Supply Chain Management	Critical
16	DGM, Supply Chain Management	Critical
17	Manager, Supply Chain Management	Critical
18	Executive, Supply Chain Management	Critical
19	DGM, EPR	General



20	Manager, EPR	General
21	Executive, EPR	General
22	Waste Dealers	Critical
23	Waste Aggregators	Critical
24	Waste Collectors	Critical
25	Waste Segregators	Critical
26	Entrepreneur, MRF	Critical
27	Head, MRF	General
28	Manager, MRF	General
29	Machine Operator, MRF	Critical
30	Head, Procurement	Critical
31	Officer, Procurement	Critical
32	Manager, Logistics	General
33	Executive, Logistics	General
34	Driver	General
35	Mechanic	General
36	Head, Recycling Unit	General
37	Manager, Recycling Unit	General
38	Recycling Technician, Recycling Unit	Critical
39	Head, Co-processing/ pyrolysis/ WTE plant	General
40	Manager, Co-processing/ pyrolysis/ WTE plant	General
41	Executive, Co-processing/ pyrolysis/ WTE plant	General
42	Manager, EHS	Critical
43	Welder	General
44	Electrician	General
45	Labour	General
46	Civil Engineer	General
47	Designer	General
48	Head, Product Development	General
49	Manager, Product Development	General
50	Executive, Product Development	General
51	Executive, Education,	General
52	Manager, Quality Control	Critical

53	Supervisor, Quality Control	Critical
54	General Manager, Accounts	General
55	Head, Accounts	General
56	Manager, Accounts	General
57	Accountant, Accounts	General
58	Executive, Accounts	General
59	Manager, Web Design	General
60	Executive, Web Design	General
61	Manager, Education	General
62	Manager, Community Outreach	General
63	Executive, Community Outreach	General
64	Manager, CSR	General
65	Executive, CSR	General
66	Trainers	General
67	Consultant, Turnkey project	Critical
68	Content Developer	General
69	Printer	General
70	Supervisor, Security	General
71	Security Guard	General
72	Caretaker	General
73	Office Assistants	General
74	Maintenance Supervisor	General
75	Sweepers	General
76	Peons	General
77	Manager, Communication	General
78	Content Developer, Communication	General
79	Manager, Social Media	General
80	Content Developer, Social Media	General
81	Manager, Print Media	General
82	Coordinator, Print Media	General
83	Manager, Business Development	General
84	Executive, Business Development	General
85	General Manager, Marketing and Sales	General

86	Manager, Marketing and Sales	General
87	Executive, Marketing and Sales	General
88	Scientist	Critical
89	Patent Consultant	Critical
90	Researcher	Critical
91	Lab technician	General
92	Lab Assistant	General
93	Typist	General
94	Manager, HSE	Critical
95	Executive, HSE	Critical
96	Store Keeper	General
97	Head, Legal Department	Critical
98	Associate, Legal Department	Critical
99	Analyst, Compliance and Legal (Patent)	Critical
100	Manager, Public Relation	General
101	Executive, Public Relation	General
102	Head, Printing and Publication	General
103	Print technician, Printing and Publication	General
104	Print Operator, Printing and Publication	General

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