Ethical and Sustainable Use of Plastic Value Chain and Gradual Phasing-out of Plastic Waste

Photo: Safai Saathis (waste pickers) sort materials at Swachhta Kendra facility in Patna, India. Credit: UNDP India

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About the Research Paper

This Research Paper is a part of our endeavour to improve accountability and inculcate professional excellence in the areas of environmental audit and sustainable development. We have initiated from 2022 an Occasional Research Paper Series featuring different emerging areas in environment and sustainable development-related discourse. This review paper on "**Ethical and Sustainable Use of Plastic Value Chain and Gradual Phasing-out of Plastic Waste**" forms a part of this Occasional Research Paper Series from the International Centre for Environment Audit and Sustainable Development (iCED), Jaipur, under the aegis of the Comptroller and Auditor General of India.

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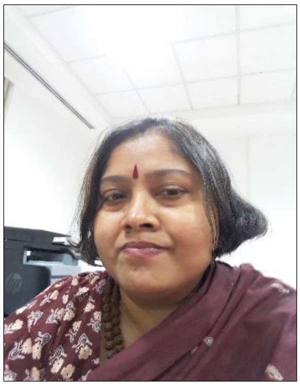
Foreword



Plastic is a commodity that has become a component of modern lifestyles when compared to glass or paper. Its production, use, and management can be more resource-intensive. Combined with the ease of processing, it has become a preferred option among the different recyclable materials. However, the ease of use and high preference for it have also burdened the earth's ecosystems with unsurmountable burdens of plastic pollution. Plastic pollution, in turn, has serious backward and forward linkages with the wider causes of Climate Change and global warming, threatening the very existence of the planet Earth.

Circular Economy seeks to promote a sustainable way of living, one in which resources are used more effectively and are retained in the economy for as long as feasible. Creating loops that feed resources back into the system for usage in similar or new components and products with the same or lower functionality helps to achieve the latter. Can the usage of plastics ever be sustainable? The key perhaps lies in the ethical usage of plastics and the minimisation of the ill effects of plastic usage through circularity processes. This involves the proper management of plastic waste.

Almost every piece of plastic beginning its journey from the petrochemical industries, traces itself back to a fossil fuel, and greenhouse gases are released from its extraction, processing, usage, and end-of-life at each point of the plastic lifecycle. Prolonged use, lesser use, and sustainable management and disposal techniques would hold the key to plastic-free terrestrial and aquatic ecosystems.

This is the context we need to keep in mind. International Centre for Environment Audit and Sustainable Development (iCED) as a global Centre of Excellence under the Comptroller and Auditor General of India for improving accountability and governance in the area of environment and sustainable development, has already done considerable work in the area of research on plastic waste. In fact, in the Asian Organisation of Supreme Audit Institutions (ASOSAI) journal of October 2022, our seminal contribution on behalf of SAI India was in the paper "**Auditing Plastic Waste – An Overview and Experience from SAI India-SAI India".** "**Ethical and Sustainable Use of Plastic Value Chain and Gradual Phasing-out of Plastic Waste**" is the latest addition to iCED's Occasional Research Paper series launched in May

2022. It highlights the role, discusses various barriers as well as challenges to the Plastic Value Chain and informs ways to improve the Circular Economy of plastics by introducing the element of ethicality and sustainability to its usage.

I would like to commend the author, Dr. Divya Singh, an erstwhile Research Associate for the initial work on the paper. I would also like to appreciate the efforts made by Dr. Nanda Dulal Das, Director (Training and Research). I would also like to thank Shri Mehul Grover, Director (Administration) and the entire research team at iCED viz. Shri Kamal Kumar Sahal, Sr. Consultant, Shri Jayant Sharma, Sr. Consultant, Shri Manoj Kumar, Asstt. Administrative Officer, Shri Vikas Dhir, Asstt. Administrative Officer, Dr. Mahesh Kumar Saini, Research Associate, Dr. Gulshan Sharma, Research Associate and Shri Akash Sharma, Research Associate, who have put in sincere efforts to cohere the earlier inputs into the structure and firmament of the present Occasional Research Paper.

26th October 2023 **(Sayantani Jafa)**

Jaipur Additional Deputy C&AG and Director General, iCED

Abbreviations

ABS	:	Acrylonitrile Butadiene Styrene
BFRs	:	Brominated Flame Retardants
BPA	:	Bisphenol A
CPCB	:	Central Pollution Control Board
ECI	:	Ethical Consumption Intention
EPR	:	Extended Producers’ Responsibility
GHG	:	Greenhouse Gas
HDPE	:	High-density Polyethylene
LCA	:	Lifecycle Assessment
LDPE	:	Low-density Polyethylene
MDD	:	Material Driven Design
MFA	:	Mass Flow Analysis
PBDE	:	Poly-Brominated Diphenyl Ethers
PET	:	Polyethylene Terephthalate
PFAS	:	Perfluoroalkyl and polyfluoroalkyl substances
POPs	:	Persistent Organic Pollutants
PP	:	Polypropylene
PS	:	Polystyrene
PVC	:	Polyvinyl Chloride
PWM	:	Plastic Waste Management
SUP	:	Single Use Plastics
TBS	:	Tracer-based-sorting
TCM	:	Technical Characterisation of the Material
TRA	:	The Theory of Reasoned Action
UT	:	Union Territory

Abstract

The global proliferation of plastics has given rise to an urgent environmental crisis characterised by widespread pollution, ecological harm, and ethical concerns. Plastic has become an essential part of our lives, but its production and use have also led to a number of environmental problems, including plastic pollution. The ethical and sustainable use of the plastic value chain and the gradual phasing-out of plastic waste are therefore becoming increasingly important. This abstract explores the critical imperative of transitioning towards an ethical and sustainable plastic value chain while progressively reducing plastic waste. Plastic, once hailed for its convenience, has now become emblematic of environmental degradation, posing serious threats to ecosystems and human health. The ethical dimension of this crisis extends to fair labour practices within the plastic industry and the well-being of communities affected by plastic pollution. To address these challenges, this abstract emphasises the need to re-evaluate our dependence on Single Use Plastics, promote eco-friendly alternatives, and implement robust recycling and waste management systems. Ethical considerations encompass ensuring equitable wages, safe working conditions, and corporate responsibility within the plastic industry. Moreover, consumer awareness and responsible consumption choices play a pivotal role in this transformation. Government regulations must incentivize ethical practices, restrict harmful plastic products, and encourage sustainable production and consumption patterns. International cooperation is paramount, as the plastic crisis transcends borders. Ultimately, the gradual phasing-out of plastic waste hinges on a collective commitment to embrace reusable, recyclable, and biodegradable materials, fostering a more sustainable and ethical future for our planet.

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Ethical and Sustainable Use of Plastic Value Chain and Gradual Phasing-out of Plastic Waste

Chapter I: Introduction

The production of plastic heavily relies on fossil fuels, thereby contributing to adverse environmental effects and Climate Change. Throughout the entire lifecycle of plastic products, Greenhouse gas (GHG) emissions are released at each stage, encompassing extraction, manufacturing, reusability, and disposal. The indiscriminate utilisation of plastic, coupled with improper disposal and inadequate waste management practices, significantly contributes to the predicament of plastic pollution. Both landfills and incineration processes discharge pollutants, amplifying greenhouse gas emissions. Given the long lifespan of plastics, the consequences of plastic pollution are expected to linger for decades, resulting in long-term environmental deterioration and harm to species and ecosystems. Plastic wreaks havoc on marine life, particularly in oceans and streams, by causing ingestion and entanglement, disrupting ecosystems and endangering diverse species.

Every year, there are 140 million tonnes of synthetic polymers, like polyethylene, polystyrene, polypropylene, polyvinyl chloride, Teflon, etc., used in making plastics worldwide are leading to generation of large quantum of waste products (Chi, 2022). In spite of the fact that plastic products help in quickly solving many challenges in packaging and transportation in the society, the harmful effects of the plastic waste on humans as well as on environment cannot be ignored. Nations around the world need to focus on cleaner production to manufacture eco-friendly plastic products in order to reduce the negative effects on the environment and human health. The price of eco-friendly plastic products is higher than traditional plastics. Besides, the usage of first generation feedstocks like corn grain and sugarcane and the need for extractive land use for production of bio-degradable plastics makes it an unattractive option at this point (Wellenreuther, Wolf, & Zander, 2022). It is crucial to understand consumers' consumption behaviour towards eco-friendly plastic products for sustainable development and cleaner production in the future (Chi, 2022).

Of all the plastic waste generated in 2019, the projected share of plastic waste that will be successfully recycled is expected to increase from 9 per cent in 2019 to 17 per cent in 2060. Meanwhile, incineration and landfilling are anticipated to account for approximately 20 per cent and 50 per cent of plastic waste, respectively. The proportion of plastic that escapes waste management systems, such as ending up in uncontrolled dumpsites, being burned in open pits, or leaking into soil or aquatic environments, is projected to decrease from 22 per cent to 15 per cent (OECD, 2022). If all plastic wastes worldwide were to be recycled, it could save enough energy to be equivalent to 3.5 billion barrels of oil each year, thereby significantly reducing our carbon footprint (Climate-KIC, 2021).

Even though plastic is extensively used in our daily lives, the current linear economy model of "create, use, and dispose of" poses substantial health hazards due to GHG emissions and pollution. In response to these challenges, the circular plastic economy is gaining momentum as a response, aiming to minimise waste by promoting reduction, reuse, and recycling of all plastic waste. For the circular economy to be effective, it is crucial to implement circular principles throughout the entire plastics supply chain (Figure 1).

Important steps of the Plastic Value Chain and associated environmental risks are:

- Extraction and transportation of fossil fuel: Emissions and land disturbances
- Production and manufacturing: Greenhouse gas emissions
- Post-use disposal: Recycling, landfilling, and incineration resulting in air, water, and land pollution.

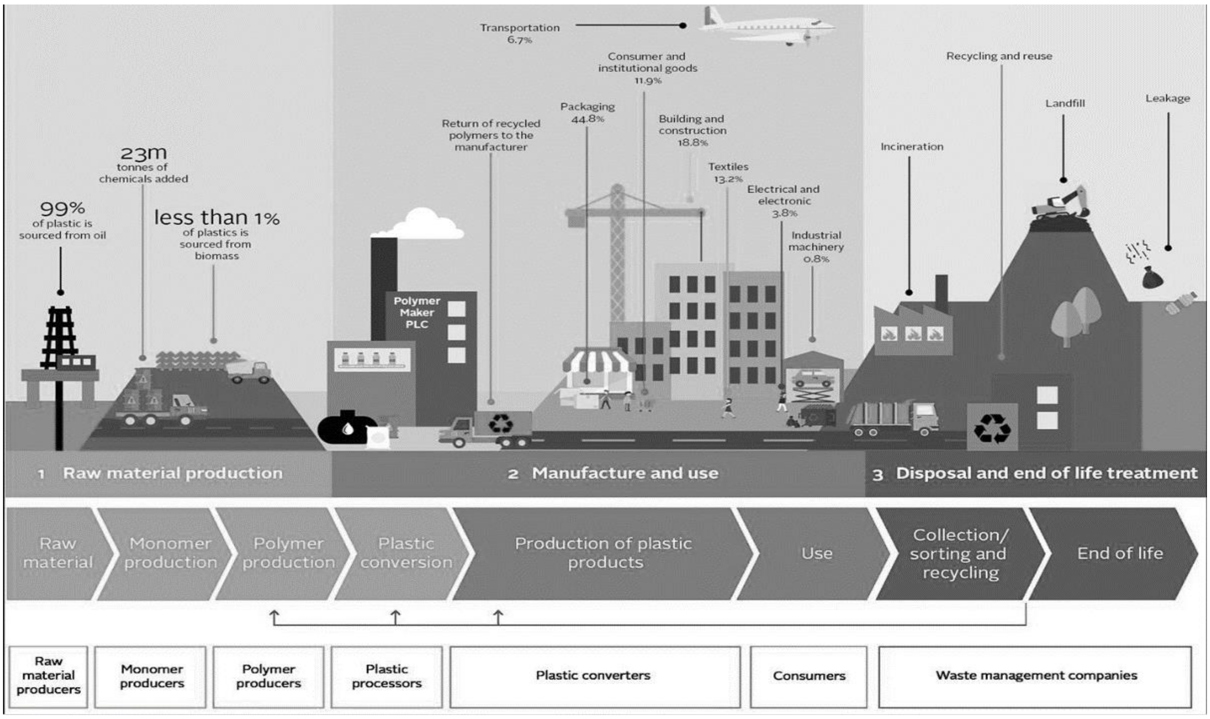

Figure 1: Overview of the global plastic supply chain. Source***:*** (UN PRI, 2019)

The principles of a Circular Economy revolve around designing out the concept of waste, restoring natural resources, and ensuring that products, materials, and molecules circulate efficiently within the economy at their highest value. The transition to a Circular Economy cannot be achieved solely by modifying the waste management system; it necessitates changes throughout the entire value chain, including design, production, and consumption phases. Consequently, there is a societal requirement to establish a knowledge base that supports this transition by thoroughly examining the entire plastics value chain (Johansen, 2022). This study aims to determine how plastic can be designed, manufactured, used, and recycled within the framework of a Circular Economy. Besides, it also highlights how ethical concerns for ensuring intra-generational and inter-generational sustainability can determine phasing-out of conventional plastics from the current value chain while adopting an environment-friendly and viable alternative.

Chapter II: Ethical Use of Plastic Value Chain

Human beings, plants, and animals have been surrounded by plastic and its products since their birth. The rapid proliferation of plastic in human lives has fostered the perception of its immense utility, overshadowing its potential harm to both individuals and the environment. The versatile, alluring look, longevity, lightweight, flexible, moisture-resistant, strong, relatively inexpensive, and easy accessibility of plastic items have elevated their popularity above that of glass, paper, clay, wood, and metals. In such a scenario, consumers striving to make environmentally conscious choices find themselves grappling with ethical dilemmas due to the limited alternatives available. Consequently, this situation can give rise to feelings of frustration and helplessness.

The Theory of Reasoned Action (TRA) states that a person's behaviour is determined by his/her intention (a function of his/her attitude and subjective norms) to perform the behaviour (Fishbein, M., & Ajzen, I., 1975). Fishbein and Ajzen (1975) highlighted that individual awareness, concern, and attitudes will contribute to responsible action. Personal concerns and beliefs (e.g., socio-political, cultural, and environmental aspects) also play a vital role in determining their behaviour, as highlighted by Ramdas and Mohammed (2014) (Chi, 2022).

While growing awareness of the problems generated from the improper management of plastic waste is there, the awareness has not yet been translated into sustainable consumption behaviour (Siltaloppi J. M., 2021). Therefore, encouraging demand for eco-friendly plastics requires critical knowledge about individual concerns, intentions, and attitudes, which motivates their consumption behaviour. Chi (2022) in his research has shown Ethical Consumption Intention (ECI) as individual intended behaviour or expected future behaviour. Ethical Consumption Behaviour deals with decision-making, purchases, or other consumption experiences which are affected by the ethical concerns of consumers. Further, individuals with positive environmental awareness are more likely to consume eco-friendly plastic products than individuals who are not much environmentally concerned (Chi, 2022).

Developing and adopting sustainable alternatives to plastic raises ethical considerations regarding the balance between economic growth and environmental preservation. Therefore, the responsibility for the use of plastic and its waste management is often shared among manufacturers, consumers, and governments. While banning of single-use, low-value plastics is important, enforcing the ban by financial incentives and disincentives are equally important. Urban and rural Government bodies need to be aware of proper management and reduction in disposal of plastic waste to minimise harm to the environment. Companies producing and using plastics have a large responsibility to minimise their environmental impact. This includes adopting sustainable practices during the production of plastics, investing in research for alternatives, and taking accountability for their products throughout their lifecycle. Extended Producers' Responsibility (EPR) principles are needed to be streamlined into the entire plastic value chain. Recycling industries and informal sector waste pickers also play vital roles in the management of plastics towards the post-usage value chains. Individual consumers may grapple with the balance between convenience and environmental impact in their daily choices, given their different socio-economic situations. The choices made by individuals, industries, and governments in the world have far-reaching consequences for ecosystems, communities, and future generations.

Chapter III: Driving Plastics into the Circular Economy: The Problematics of the Plastic Value Chain

By 2050, global plastic production is expected to be over 800 million tonnes per year and thus plastic will become one of the highest users of fossil fuels. As per the report, **"Circular Economy: A Powerful Force for Climate Mitigation"** the combined emissions from plastic production and embedded carbon would be as much as 287 billion tonnes by 2100, which equates to over a third of the entire carbon budget for a 2°C economy (Climate-KIC, 2021). Figure 1 shows a scheme of the global plastic supply chain. This supply chain mainly deals with a “Linear Economy” concept of Plastic Waste. The Linear Economy of plastics has led to never-seen-before consequences for the environment and Climate Change. In order to successfully transition to a low-carbon economy, it is necessary to address the emissions from the generation, management, and disposal of plastics. To achieve this, the current plastic value chain needs to be reshaped into a “Circular Economy” by using reusable alternatives, new materials, and more sustainable solutions.

Chapter IV: Plastic Lifecycle and Value Chains

The lifecycle of plastics begins with the extraction of fossil-fuels from the from the mines and oil rigs, which then passes through the refineries, petrochemical industries, band owners, businesses, consumers, recyclers, incinerators, and disposers (Siddharth Ghanshyam & Atin, 2022). While recyclable plastic products may find a second shelf-life as a comparatively lower grade recycled plastic, non-recyclable plastic materials end up either in sanitary landfills or in larger land and ocean ecosystems while getting washed away through water or carried away by wind from the open dumps. In this context, the next sections address the various stages of the plastic lifecycle and emphasise several view points on sustainability and circularity in plastics management.

4.1 Plastic Production

Plastic can either be ‘Synthetic’ or ‘Bio-based’. Synthetic plastics are derived from crude oil, natural gas, or coal, while Bio-based plastics come from renewable products such as carbohydrates, starch, vegetable fats and oils, bacteria, and other biological substances (Baheti, n.d.). Traditionally, the plastic production phase included melting and moulding of primary plastics to produce plastic polymers which were converted into different products.

4.2 Use of recycled plastic and other chemicals in Plastic Production

The production phase plays a very significant role in a Circular Economy by incorporating recycled plastic waste into the mixture during the plastic production phase (Roland Yawo Getor, 2020). A study conducted by Shia-Chung Chen et al. on Acrylonitrile Butadiene Styrene (ABS) showed a blend of varying proportions of ABS recycled resins (0–50 per cent) during the production phase resulted in no change in tensile strength, elongation at yield, and impact strength (Shia-Chung Chen, 2011). Fillers are widely used, especially nanocomposites, in the food packaging sector. The mechanical and thermal properties of plastics can be significantly improved using nano-based fillers. The antimicrobial and antioxidant properties of nano-fillers make them ideal packaging materials for the food industry (Nikolova, 2020). Figure 2 shows different types of nano-fillers used in polymer nanocomposites. Polyethylene and polypropylene additions to nano-fillers do not greatly affect the final recycled material as compared to conventional plastics (Sarfraz, 2020). Thus, a careful selection of the added organic filler is desired during the plastic production phase. The added fillers may or may not lead to recycled plastics, even with improvements in some key mechanical, thermal, and barrier properties.

Figure 2: Examples of various nanoscale filler morphologies used in polymer nanocomposites
Source: (Nikolova, 2020)

4.3 Design

The existing recycling chains are inadequately tailored to handle the end-of-life products in a manner that supports a Circular Economy. Furthermore, products are often poorly designed to integrate effectively into their intended recycling chains, leading to a lack of synergy between product designers and stakeholders in the recycling chain. This lack of synergy can be attributed to insufficient communication and the time gap between product design and end-of-life treatment (Martínez Leal J. P., 2021). Circularity in plastics can be achieved by including sustainable design solutions that prioritise responsibility for waste management at the end of a product's life. The designer’s mindset must include the entire life cycle and impact of a plastic product from resource extraction to end-of-life. Viewing the plastic product as a service can maximise its value throughout its entire lifecycle. This synergy between the product designers and recycling-chain stakeholders will significantly reduce GHG emissions, which are responsible for Climate Change and other environmental benefits like reducing the usage of fossil resources (Material Economics, 2018).

4.3.1 Plastics in packaging

More than 40 per cent of plastics are used for packaging purposes worldwide. Unfortunately, most of the packages are designed for single use, and a large amount of material ends up as waste and garbage in landfills. Some important types of plastic commonly used for packaging are (1) Polyethylene Terephthalate (PET), (2) High-density Polyethylene (HDPE), (3) Polyvinyl Chloride (PVC), (4) Low-density Polyethylene (LDPE), (5) Polypropylene (PP) and (6) Polystyrene (PS) (Cassie Damewood, 2019). Plastic packaging typically consists of a mixture of polymers and contains a whole range of components, which pose problems during recycling. The plastic is composed of raw polymer (base resin) plus fillers, plasticisers, and additives. The chemicals added at various stages of plastic production have a significant impact on plastic circularity. The following section tells about the various roles of these additives in plastic design and production.

4.3.2 Base Resins

The plastic-base resins are created through a cracking process by heating hydrocarbons at various ranges of temperatures. The goal of cracking is to break down large molecules into ethylene and propylene (obtained from the crude petroleum refining process). The monomer is then changed into polymers through the process of polymerisation. There are more than 30 different types of resins available, and out of them, six to seven types are used in plastic manufacturing as the base resin. The plastic-making companies are able to make plastics with a variety of properties by combining different chains and polymers. The different compositions allow the resins to be employed in a variety of applications. Soft drink bottles, for example, require polyethylene terephthalate. Thicker bottles, such as those used for prescriptions or milk, necessitate a greater density of polyethylene. In addition, heated items used in the food business may necessitate the usage of a specific polymer. The clear plastic wrap would be constructed of polyvinyl chloride and would be exceedingly thin (PSC, 2019). There are technical and financial barriers to the recycling of thinner plastics, and hence, not recycled.

4.3.3 Additives

Every plastic item contains additives that determine the properties of the material and influence the cost of production. Typical additives include (Figure 3) stabilisers, fillers, plasticisers, and colourants, as well as functional additives such as flame retardants and curing agents (Nordic Council of Ministers, 2017). There are different types of additives commonly used in plastics (British Plastic Federation). Some additives includes:

(1) Anti-Counterfeiting
(2) Antimicrobials/Bio-stabilisers
(3) Antioxidants
(4) Antistatic Agents
(5) Biodegradable Plasticisers
(6) Blowing Agents
(7) Colorants
(8) External Lubricants
(9) Fillers/Extenders
(10) Flame Retardants

(11) Fragrances
(12) Heat Stabilisers
(13) Impact Modifiers
(14) Internal Lubricants
(15) Light Stabilisers
(16) Pigments
(17) Plasticisers
(18) Process Aids
(19) Reinforcements
(20) Stabilisers

Recycling plastic improves resource efficiency. However, as per a study conducted by Leslie et al, banned brominated diphenyl ether flame retardants and other toxic flame retardants

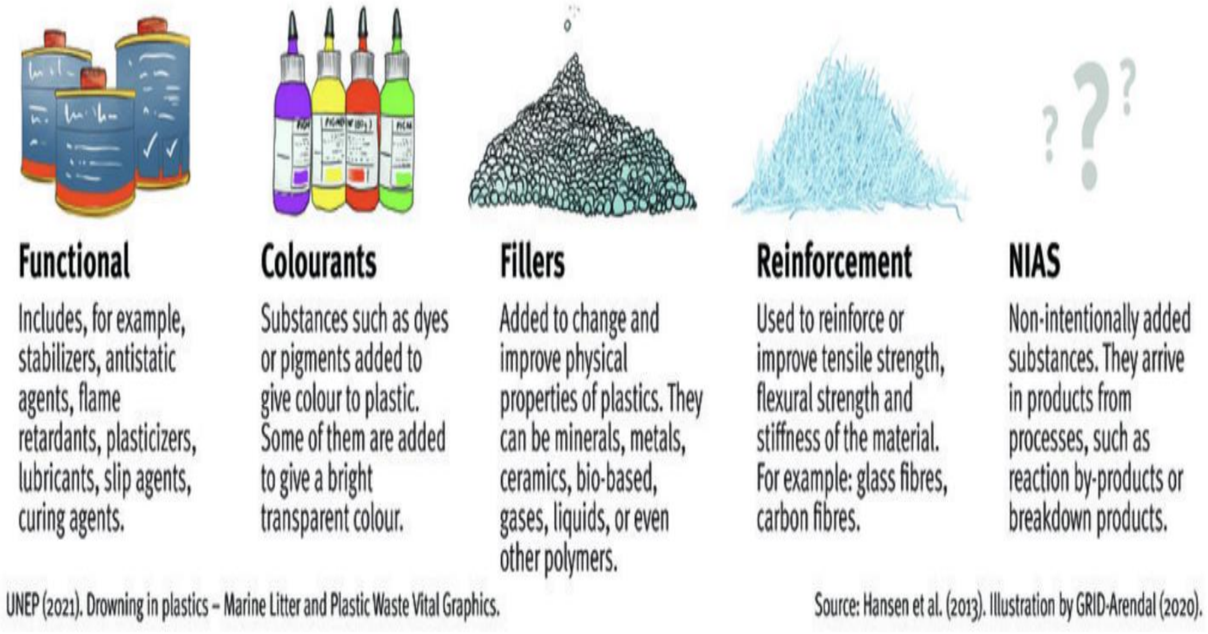

Figure 3: Different types of plastic additives *(GRID-Arendal A UNEP PARTNER, 2021)*

(commonly used as plastic additives) have been found at high concentrations in certain plastic materials destined for recycling markets (Leslie, 2016).

Stabilisers are used at all stages of the polymer life-cycle. They allow plastic items to be produced faster and with fewer defects, extend their useful lifespan, and facilitate their recycling. However, they also continue to stabilise waste plastic, causing it to remain in the environment for longer.

Plastic fillers are particles added to plastic products with a view to cutting production cost and improving some specific properties of the end products. As such, plastic fillers can enhance the tensile strength and toughness, boost the heat resistance and increase the quality of colour together with plastic's clarity.

Plasticisers are mainly liquid and non-volatile compounds and are incorporated into plastics to increase their flexibility, extensibility, and processability. They are also known to increase plastic’s thermoplasticity. Plasticisers are cheaper, most widely used additive and are commonly found in PVC (SpecialChem, n.d.).

Phthalates are most commonly plasticisers and used in around 90 per cent PVCs. The weak interaction between plasticisers and polymer resins leads to their gradual release into the environment. These plasticisers are among the most commonly encountered chemicals to which humans are exposed on a daily basis (Net, 2015). Phthalates have also been reported in tinned foods (1370 µg/g) and vegetables (500 µg/g) and several regulatory authorities have banned certain phthalates, particularly in toys (Wagner & Schlummer, 2020).

Colourants are essentially used for making products appealing and attractive. Additionally, they're also used for adding bulk and durability to different types of products. Following are some of the other uses of colourants: Colourants are utilised for establishing a product’s recognition or image.

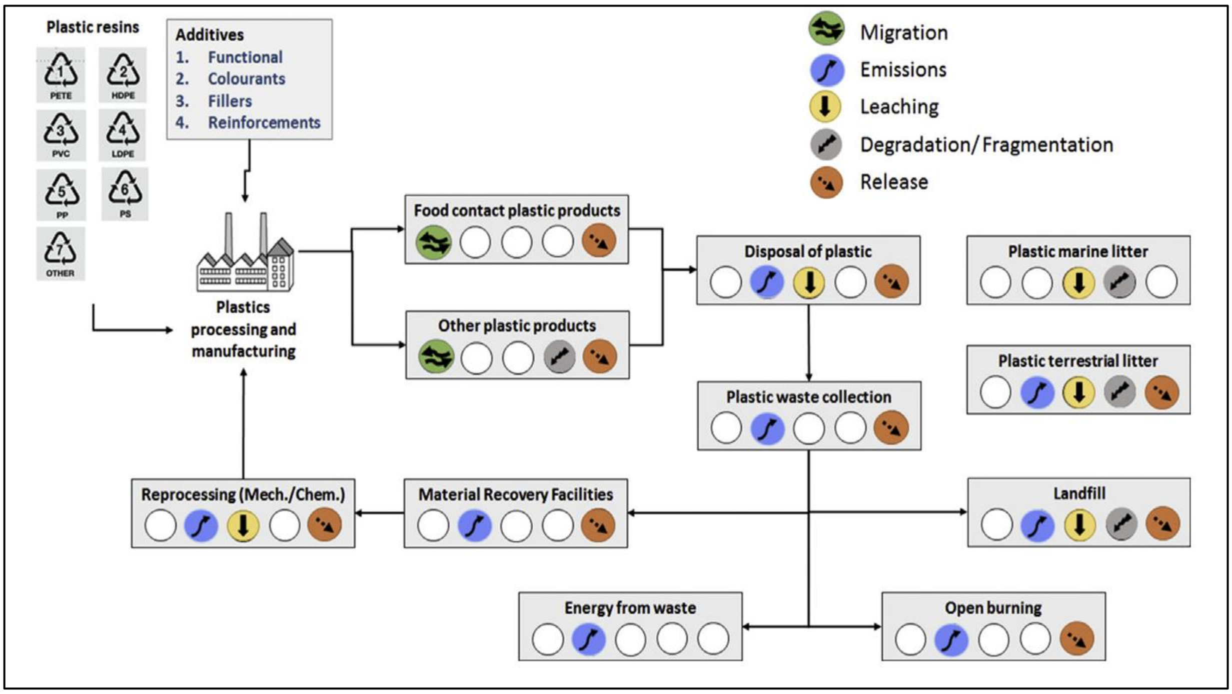

Figure 4: Different Routes of Release of Plastic Additives (Hahladakis, 2018)

Since 1999, the European Union has prohibited the use of some phthalates. Similarly, since 2008, the United States and Canada have prohibited the use of phthalates, especially in toys for children or other items that young children may put in their mouths (UN Environment BRS Conventions and IPEN, 2020). The recycling process increases phthalate plasticiser concentration with an increase in the number of cycles (Carlos, 2018). As per reports, phthalates are migrated to the external surface during thermal ageing resulting in higher environmental exposure (Ito, 2007). According to a study by Eales et al. (2022), there is currently a lack of available reviews on epidemiological human studies regarding the health effects of phthalates from recycled plastics. Furthermore, the concentration and potential effects of phthalates in recycled plastics may differ from those in virgin plastics. However, due to limited evidence and research, our understanding of these differences and their implications remains limited (J. Eales, 2022). Figure 4 shows various routes through which plastic additives like phthalates can migrate and get released from the use of plastic products.

4.4 Plastic: End-of-Life

End-of-Life is the final phase and an important aspect of the Circular Economy. This includes sorting and recycling of plastic waste and giving them back to the economy in the form of new products or services. As per Johansen et al., 2022, different stages in End-of-Life plastic management are:

1) Collection and sorting;
2) Recycling (mechanical, chemical, biological);
3) Lifecycle Assessment (LCA) and Mass Flow Analysis (MFA) (of the End-of-Life phase); and
4) Policy and regulation

One area of collection and sorting management is elaborated below:

4.4.1 Collection and Sorting

Once the plastic waste is collected, innovative and effective sorting methods may be adopted for efficient sorting of plastic waste, as depicted in Figure 5. The unique absorption bands found on each type of plastic can be used to identify the substance. Through the measurement

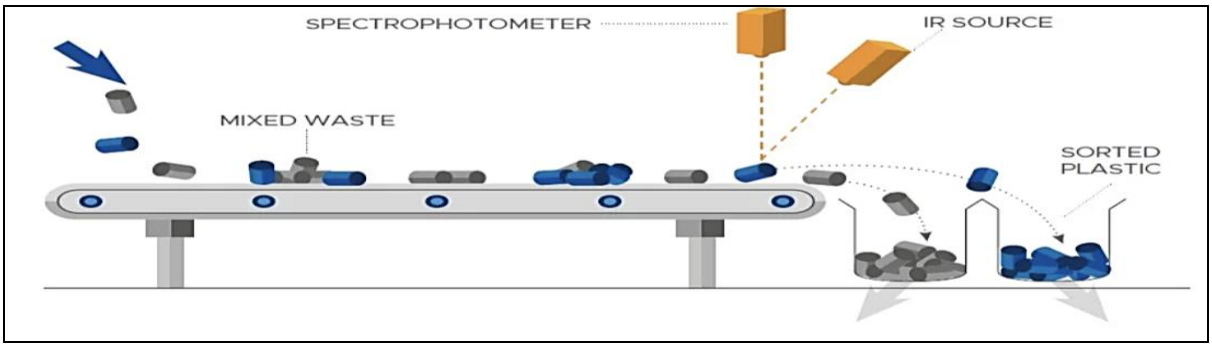

Figure 5: Sorting of Plastics using VIGO Detectors. Source: *(VIGO Photonics)*

of these distinctive absorption bands, VIGO's linear detector array can distinguish between all varieties of plastic (VIGO Photonics)[1].

Fluorescent tracers can be combined with image recognition to improve waste package identification and sorting. The new technology Tracer-Based-Sorting (TBS) can be viewed as being particularly effective and reliable among the other existing methods. This technique bases its sorting of plastic garbage on fluorescent tracer materials and a related detection

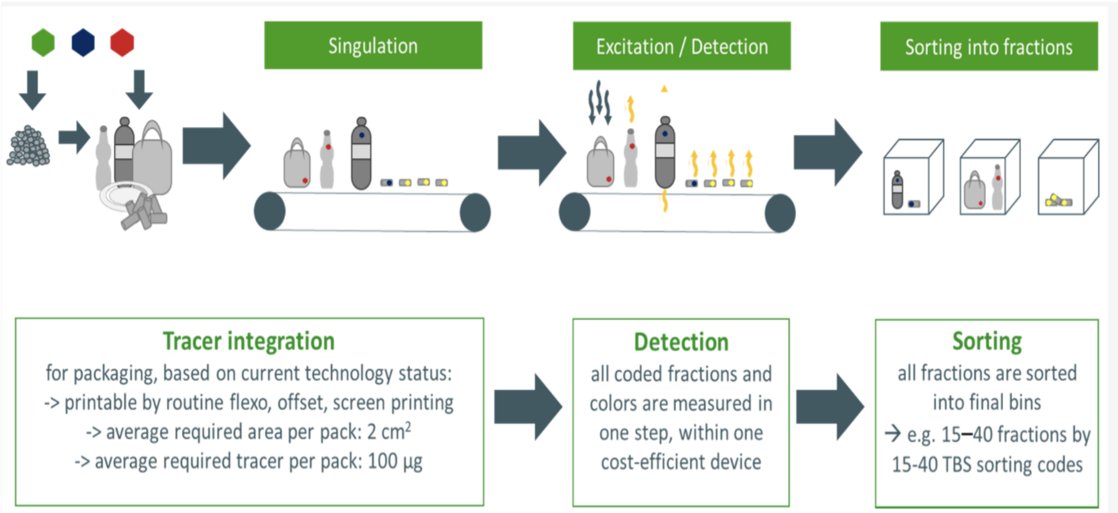

Figure 6: Functional Principle of Tracer-Based-Sorting (TBS) for Identification and Sorting of Plastic Packaging **(Gasde, 2020)**

Device (Gasde J, Plastics Recycling with Tracer-Based-Sorting: Challenges of a Potential Radical Technology, 2021). Figures 5 and 6 presents an example of sorting of plastic by using VIGO detectors and tracer-based sorting principles.

Chapter V: Plastic Circularity can be improved

5.1 Designing Plastic Re-circulation

Here, the idea is to implement circularity at each phase of the Plastic Value Chain. Chemicals, polymers and additives which create hindrances in plastic circularity should be completely removed from the value chain. For example, addition of red dye to PET bottles makes easily recyclable plastic much harder to process (Economist Impact, 2021).

In determining overall circularity, designing is essential (Figure 6). The "Circular Design" process consists of (1) research and development, and (2) business model development. A systemic shift towards a Circular Economy depends on circular design. Figure 7 shows an

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[1]*VIGO Photonics is a European manufacturer of semiconducting materials and instruments for photonic and microelectronic, specialised in MWIR and LWIR detectors and modules, produced with the use of internally developed technology* (Source: https://vigophotonics.com/).

example of “Design for circularity” for electronic and food industries. Business model innovation, product and service design, and supply chain management are some of the key areas for research in electrical and electronics industry. In food industries, knowledge about sources of contamination and chemicals of concerns will aid in plastic recycling in the food industry.

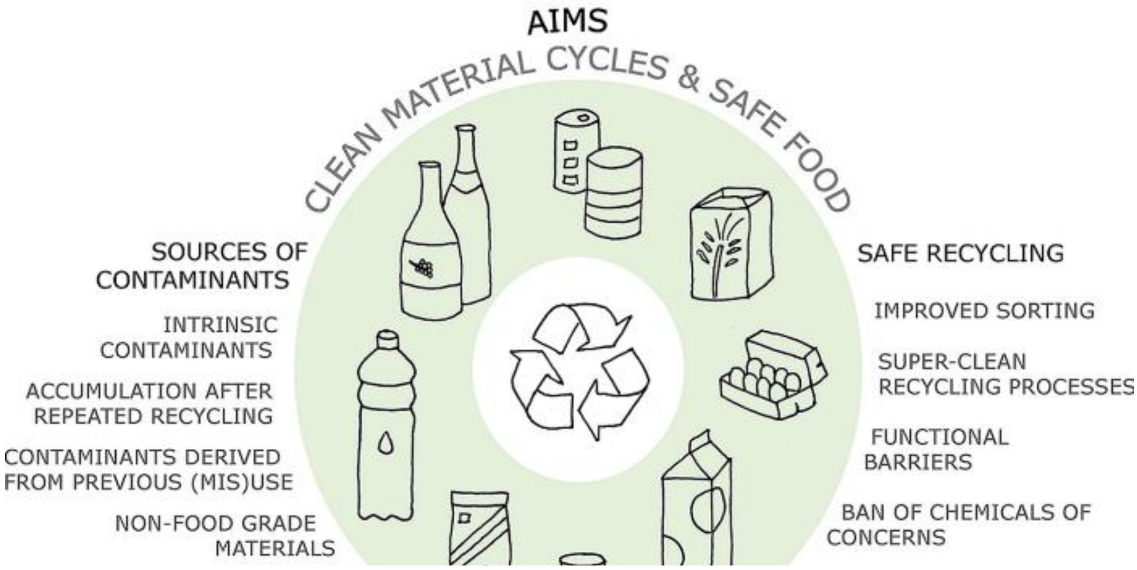

Figure 7: An example of “circular design” in Food industry. Source: *(Geueke, 2018)*

5.2 Removing Toxic Chemicals and Unwanted Materials from the Value Chain

When recycling is being considered, it is advisable to remove non-plastic elements such as metal inserts, screws, clips, labels, adhesives, and paints from assemblies, as their presence can make the recycling process more challenging. If any metals are present, the product must be deconstructed before the materials can be recycled (Kent, 2016).

The presence of harmful chemicals poses a significant barrier to plastic recycling and the successful transition to a Circular Economy. To ensure the proper and effective implementation of the Circular Economy, it is crucial to address additives used in plastic, particularly banned chemicals, in order to avoid risks to humans and the environment. A study conducted on waste plastic samples revealed significantly higher levels of phthalates. Furthermore, recycled household plastics showed higher levels of contamination and concentration compared to recycled industrial plastic and virgin plastic (K. Pivnenko, 2016).

Before putting plastic into circularity, it is crucial to conduct comprehensive investigations into potential health outcomes. Since the chemical composition of phthalates changes with successive recycle, the risk to human holds high level of uncertainty. Flame retardants known as Poly-Brominated Diphenyl Ethers (PBDE) are commonly employed in the production of a variety of commercial plastic products. The commercial PBDE mixtures are scheduled for global elimination and are listed in the Stockholm Convention on Persistent Organic Pollutants (POPs). Some of the recent examples of chemicals that are present as a result of recycling products are (IPEN, 2022):

- Bisphenol A (BPA) is commonly found in recycled plastic and baby bottles
- Brominated Flame Retardants (BFRs) in recycled plastic products
- Perfluoroalkyl and polyfluoroalkyl substances (PFAS), known as ‘forever chemicals’, in clothing

There is an urgent need to accelerate innovation of non-toxic and safer material options. Availability of safer, non-toxic alternatives and chemicals with similar structures can be utilised as replacements to avoid future mishaps (UN Environment BRS Conventions and IPEN, 2020).

5.3 Improving Information Availability

There is a need for publicly accessible information regarding the utilisation of chemicals in plastics, the chemical composition of final products, and the consequences of recycling processes on the presence of POPs and other toxic additives. The absence of data on chemical usage hampers exposure-based evaluations, thereby restricting our understanding of the long-term effects of these chemicals on both human health and the environment (UN Environment BRS Conventions and IPEN, 2020). A study by IPEN recommended that “restriction of all brominated flame retardants needs to be implemented immediately” (IPEN, 2022).

Polybrominated diphenyl ethers and hexabromocyclododecane treated products should be separated from the recycling stream.

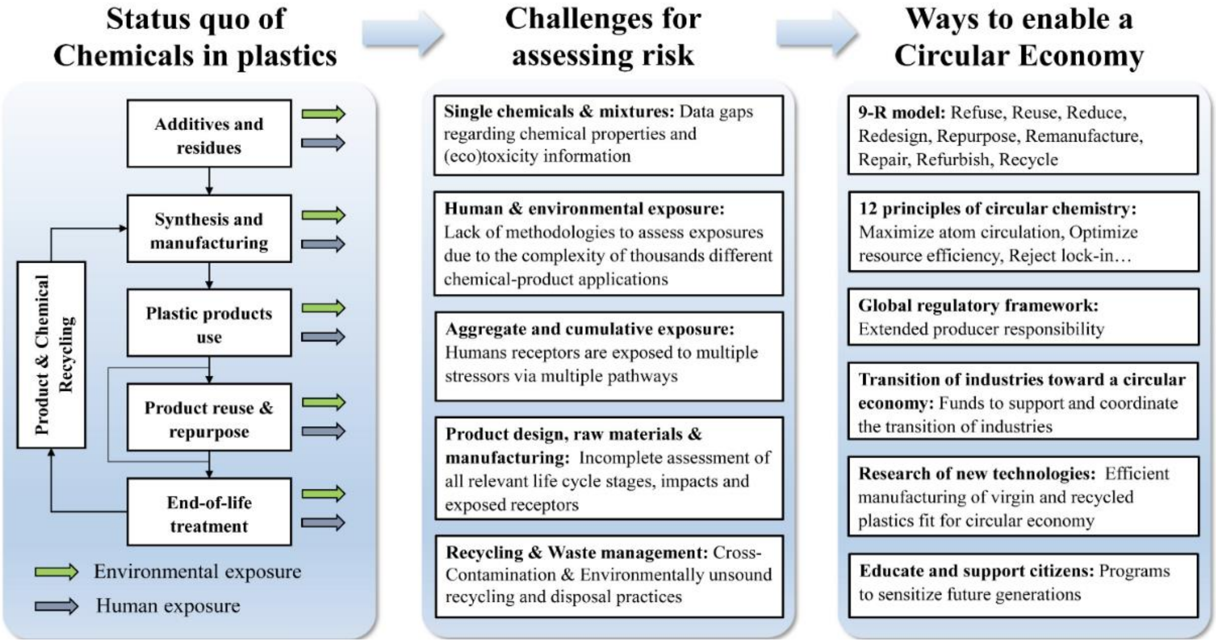

Figure 8: Overview of the Status of Chemicals in Plastics, Challenges and Gaps in Assessing Plastic-related Chemicals', and Ways Forward for enabling a Circular Economy for Chemicals in Plastic

Source: (Aurisano, 2021)

Figure 8 above shows the status of chemicals in plastics, main identified challenges and gaps in assessing plastic-related chemicals' impacts in a circularity context, and options and ways forward for enabling a Circular Economy for chemicals in plastics.

5.4 Design for Recycling

Design for recycling offers insight into the compatibility of different elements of packaging, such as caps, labels or adhesives, within given recycling streams. Design for recycling is an eco-design strategy that supports the industry to improve the overall recyclability of plastic products (RecyClass). (1) Eco-design is a systematic approach that enables the design of more environmentally friendly products (ecodesign-packaging.org, 2019). (2) Material Driven Design (MDD) approach aims to provide designers with technical datasheets and samples to better understand the given recycled plastic and explore its unique opportunities. This includes three steps to better understand the given recycled plastic and to explore its unique opportunities.

The Technical Characterisation of the Material (TCM) helps to understand the main properties of the material on technical grounds. Other questions about the material TCM includes identification of (a) the most convenient manufacturing process for material formation;

(b) other possible methods of material formation and behaviour of material to other processes; and (c) technical constraints and opportunities of the material (Karana, E., 2015).

As per Karana et al. (2015), some of the guiding questions for experimental characterisation are to understand the:

a) sensorial qualities of the material;
b) most and least pleasing qualities of the material as per end of user;
c) association of material with other material of similar aesthetics;
d) description of material as per people; and
e) how do people interact and behave with material.

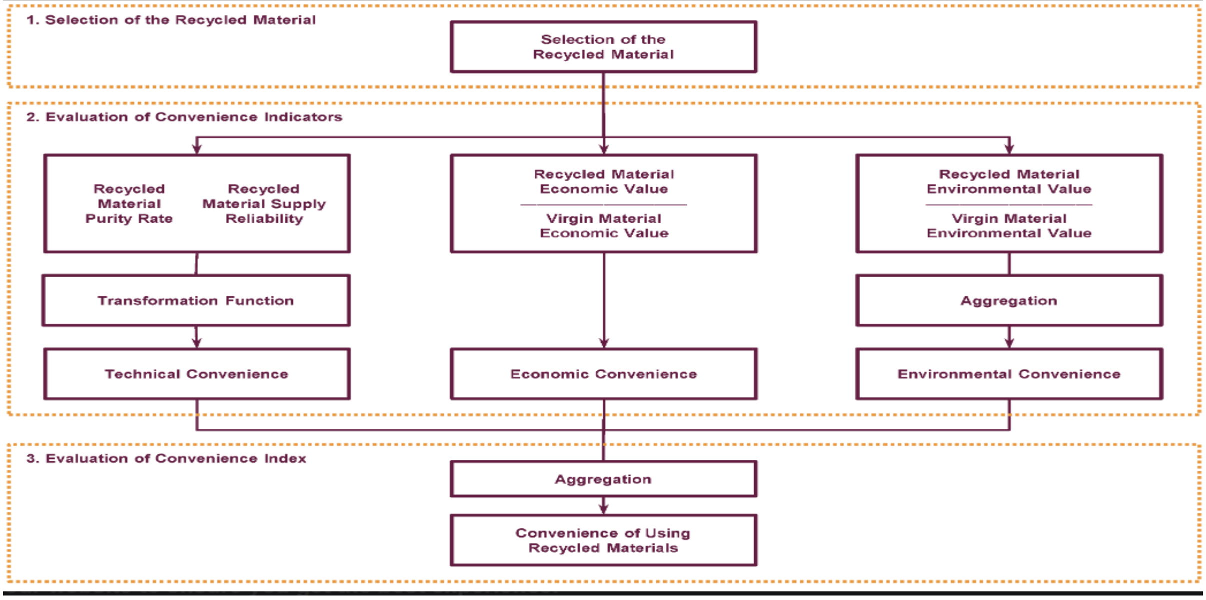

Figure 9: Schematic Representation of the Proposed Design-for-Recycling Approach by Martínez et al.
Source**:** *(Martínez Leal J. P., 2020)*

5.5 Connecting Plastic Design, Stakeholders and End-of-Life

The plastic products shall be designed keeping in mind the End-of-Life (EoL) and from EoL. Similarly, from the stakeholder side, the products shall be designed for EoL and from EoL. Figure 10 shows design and EoL exchanges from stakeholders' and designers' perspectives.

There are several approaches for EoL designs, as detailed below:

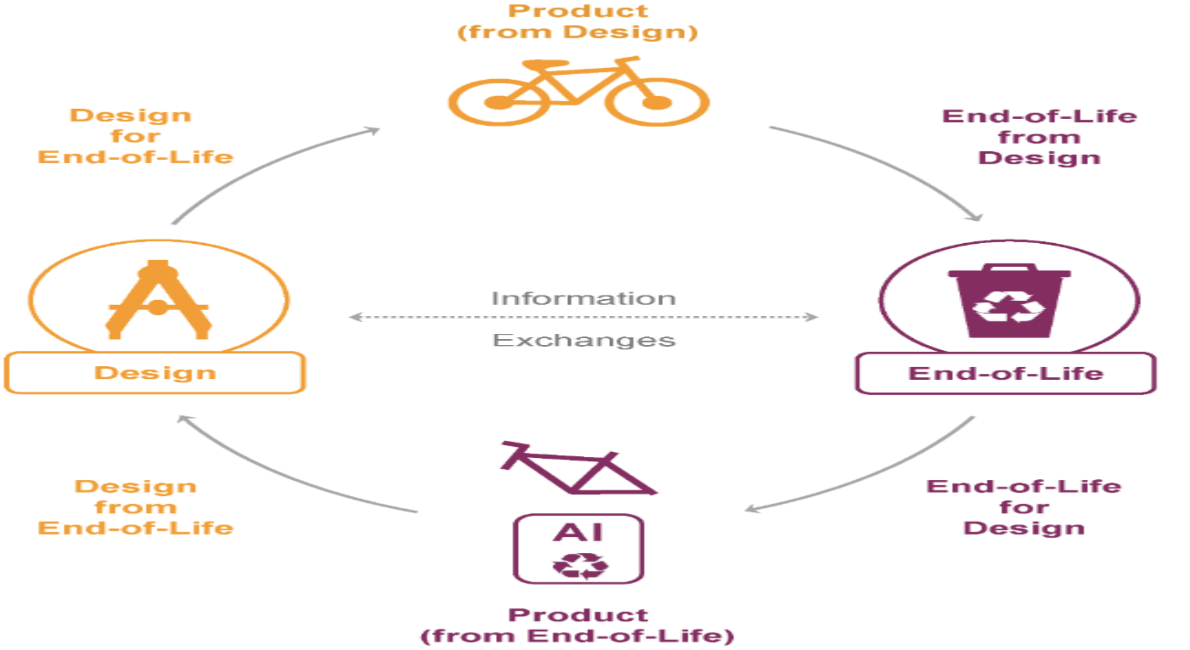

Figure 10: Design and End-of-Life Exchanges. Source***:*** *(Martínez Leal J. P., 2020)****.***

(a) Design for EoL is the most known and the most used. It aims:

(i) To improve the product so that it can be recovered in the best possible way when it becomes waste; and

(ii) To promote the elimination of residues that could not be recovered;

(b) EoL for design is concerned with the end-of-life treatment pathway that becomes a supplier of artefacts (i.e., product, module, part, or material from a recovery pathway), which must meet the designer's specifications.

Two major approaches from EoL, are detailed below:

(a) Design from EoL is concerned with the integration of artefacts from the end-of-life treatment chain into a new product (e.g., use of recycled materials instead of virgin ones, reuse of modules or parts extracted during disassembly, etc.).

(b) EoL from design aims to integrate the information accrued from the product design into the operating mode of the chain or its treatment processes to increase the functional, material, and energy recovery (Martínez Leal J. P., 2020)**.**

Chapter VI: Role of Consumers in Promotion of Sustainable Use of Plastics

It is crucial to consider the role of consumers in developing solutions for the entire plastic value chain. The current workflows of the value chain present a barrier because they often overlook additional phases, and changing customer behaviour can be challenging (Clark, 2020).

According to Ann Tracy, Colgate-Palmolive Sustainability Officer, consumers can hinder progress in addressing plastic waste. Despite customers' awareness of the problems associated with plastic waste, further research is necessary to determine the extent to which their purchasing decisions can make a difference and how much they are willing to pay for alternative packaging (Economist Impact, 2021).

For example, one of the significant challenges faced by the food industry, which is one of the most plastic-intensive sectors, is transitioning towards a Circular Economy that promotes sustainability and reduces plastic usage. A key challenge faced by Companies in this direction is determining whether sustainability considerations will influence consumers' purchasing decisions. To respond to this, a study was conducted by Pedro Núñez-Cacho et al. to identify the factors that influence consumers' sustainable purchase decisions in relation to the plastic and food industries. The study's findings revealed that several factors, such as age, sustainable behaviour, knowledge of the Circular Economy, and the perception of the usefulness of plastic, have an impact on consumers' purchase decisions. These factors play a role in shaping consumers' attitudes towards sustainable choices (Núñez-Cacho P, 2020).

Another study conducted by Søren Boesen et al. on plastic demand addressed the issue of how well-educated young consumers living in Denmark understand the environmental sustainability of five different types of packaging for liquid food (milk, beer, soft drinks, olive oil, and skinned tomatoes). This qualitative study, based on interviews, revealed that consumers have limited knowledge of sustainability-related ecolabels (Søren Boesen, 2019). Furthermore, a separate study examined consumers' mind-sets, behaviours, and influencing factors within circular consumption systems, identifying consumers' mind-sets as the starting point for engaging with circular offerings (Giovana M. Gomes, 2022). Understanding the complexity involved in consumers' decision-making processes and the potential conflicts in logic is essential, as it may result in tensions in purchasing decisions that can impact the transition towards a Circular Economy.

The American Chemistry Council (ACC), in conjunction with Trucost, in a comprehensive 2018 study on packaging alternatives to plastic found that alternatives to plastics had a greater environmental impact by nearly four times. These alternatives were costlier as well as exploitative in terms of material and energy recovery and ocean damage (Kiara Goodwine, 2019). Therefore, adoption of available costly alternatives has been very slow among the consumers.

Chapter VII: Gradual Phasing-out of Plastics

There have been projects around the world to gradually phase out plastics that are not recyclable or whose recycling is prohibitively expensive. Akenji and Bengtsson (2019) have identified several policy considerations which can be applied at different stages of the supply chain. These have been depicted in Table 1 below:

Table 1: Policy Tools across Plastic Supply Chain

Stages in supply chain	Important considerations
Resource (raw materials, recycled or reused plastics)	• Research and new innovations to identify alternative materials for plastic (Single Use Plastics) (R/F/T/V/I) • Standards/technology development to identify biodegradable plastic (R/T) • Ban use of hazardous additives from primary plastics (R/T) • Set strategy/targets to use plastic more as resource than energy (R/T)
Design/production	• Practice design-for-environment - easy to reuse, repair, recycle (T/F) • Avoid use of toxic chemicals in plastics (e.g. benzene and styrene in Styrofoam, and harmful additives in children's toys) (R/T) • Design/produce longer lasting products (T) • Improve energy efficiency and use of renewable energy sources • Ban microbeads in personal care products and cosmetics (R) • Minimise input of virgin material/resins (F/R/T) • Use EPR regulation to drive supply of materials and increase economies of scale, reduce costs and increase resilience (R) • Phase-out or ban (R) Single Use Plastics care products and cosmetics (R/V)
Trade (trade in raw materials, recyclables, etc.)	• Prioritise trade in, and use of recycled and recyclable plastics over virgin resources/resins (R/F/V) • Place disincentives (e.g. eco-tax) on difficult-to-manage and most unsustainable plastics (R/F) • Develop and share market information to allow actors to expand into new markets (R/F/V/I)
Retail	• Obligate manufactures to set up buy back systems for their products (e.g. deposit-refund schemes for plastic packaging) (R/F) • Reduced packaging (T/V) • Prioritise alternative (more sustainable) packaging material (T) • Consumer awareness and education on optimised plastics use (I)
Use (domestic and business)	• Charge waste producers for collection and disposal (pay-as-you-throw) (F)

	• Use of recycled and recyclable products (R/V) • Waste separation at source (R/V)
Reuse/repair	• Prioritise reduce/reuse before recycling based on waste hierarchy (R) • Identify local systems/mechanisms on reuse/repair and set incentives for their application (R/F/V/I) • Awareness raising/information sharing on repair/reuse opportunities (T/I)
Recycle	• Standardise effective waste collection systems (R) • Set limits and targets for recycling (R/T) • Reduce illegal waste trafficking (R) • Mobilise investment for developing countries to improve collection, sorting and processing systems (F) • Development of better and cost-effective technologies for recycling (T)
Disposal	• Zero plastic to landfills (R) • Enforcement to reduce illegal dumping and waste burning (R) • Down cycling to lower-grade construction materials and other products as an interim solution (T/V/I)

N.B.: R – Regulatory, legally binding rules; F – Financing/Economic incentives and disincentives; T – Technical; V – Voluntary agreements, non-binding and I – Information and education Source: (Akenji, 2019)

Single Use Plastic ban, which is a regulatory ban at the design/production stage as per the above table, has been, by far, the most widespread instrument in different parts of the world. While Bangladesh was the first country to ban Single Use Plastics in 2002, over 80 countries in the world now have imposed such bans (Planet Patrol, 2021). The Government of India, through notification of Plastic Waste Management Amendment Rules, 2021, banned 'manufacture, import, stocking, distribution, sale and use of identified Single Use Plastics items, which have low utility and high littering potential, all across the country from July 1, 2022' (MoEFCC, Government of India, 2022). This was implemented for elimination of light-weight plastic bags, buds with plastic sticks, plastic sticks for balloons, plastic flags, candy sticks, ice cream sticks, and polystyrene, plastic plates, glasses, cutlery, plastic stirrers, etc. Extended Producer Responsibility has been mandated by India on producers, importers, and brand owners for plastic packaging waste in 2016 (Ministry of External Affairs, Government of India, 2023).

The implementation of Single Use Plastic ban, however, lies with the respective State governments and respective State Pollution Control Boards. Therefore, it is not uniform, and the States can and do modify the stringency as they deem fit. The effectiveness of the ban will remain elusive in the absence of the availability of cheap alternatives to cater to the demand of these banned products, and effective public engagement and concerted action by end consumers (refusal to use) (Danda, 2022).

In order to enforce the ban through citizen action, the Central Pollution Control Board (CPCB) in India has launched an application on Single Use Plastics (SUP-CPCB) urging citizens to act as watchdogs and help authorities to take appropriate action against violators (Figure 11). With the help of the application, citizens can report SUP's being manufactured in the industry, used in restaurants, sold in shops, stored and distributed by suppliers. The application could be very effective in soliciting citizen action as no state machinery will be able to implement the ban completely to achieve its universal implementation on SUPs (Danda, 2022). However, the adoption and citizens' awareness in this regard have been very low.

Figure 11: SUP-CPCB application dashboard
Source: CPCB

Sitaloppi and Jahi have highlighted the barriers like limited production of sustainable plastics, lack of uses and demand for sustainable plastics and missing economic logic for recycling development as the three core conundrums and also suggested four methods of solution for addressing such conundrums (Siltaloppi J. M., 2021). Major barriers to adoption of sustainable plastics and three core conundrums are shown below in Table 2:

Table 2: Barriers to sustainable plastics development around three core conundrums

	Limited production of sustainable plastics	**Lack of uses and demand for sustainable plastics**	**Missing economic logic for recycling development**
Description	Introducing sustainable plastics to a large-volume production system under conditions of limited raw material availability and uncertain demand.	Matching the technically limited and uncertain supply of sustainable plastics with uncertain and difficult-to-mobilise customer demand.	Creating momentum for the development and growth of the recycling infrastructure with costly processing and low value of circulate.

Technological barriers	• Technology and production processes optimised for fossil feedstocks • Complexity of and limited capabilities in Life Cycle Assessments	• Inferior (or new) material properties of sustainable plastics • Manufacturing processes optimised for virgin, fossil-based materials	• Technology underdeveloped for sorting, mechanical processing and chemical recycling • Limited recyclability of certain waste streams (e.g., PVC, composites, multi-layer materials)
Operational/ supply chain barriers	• Lack of actors and production capacity • Raw material scarcity/low availability • Mass production logic incompatible with small volumes • New demands for transparency	• Limited availability of sustainable plastics (especially high-quality circular plastics) • Limited demand/current applications • Fragmented supply chain inhibits collaborative development	• Dispersion of consumer plastic waste • Lack of recycling capacity and infrastructure • New plastics incompatible with current recycling schemes
Market barriers	• Low and uncertain market demand • Higher price of bio-based plastics • Competition with fossil • High investment cost in new production capacity	• Higher cost of bio-based plastics • Adaptation cost in the manufacturing processes • Sustainable packaging is not a strong driver of consumer purchase decisions	• Cost of processing and logistics exceed market value for most circular plastics • Limited demand for lower quality circular plastics
Societal barriers	• Limited regulative and societal pressure for fossil-free solutions • Ambiguity in certification and standardisation • Environmental issues with increased use of bio-feedstocks	• Ambiguity or lack of regulation • Missing support for sustainable consumer choices (e.g., eco-labels)	• Uncertain global policies (e.g., import bans for plastic waste) • Lack of efficient supporting mechanism (e.g., taxation)

Source: (Siltaloppi J. M., 2021)

Given the above barriers, solutions like shifting focus to material solutions, shifting from firm-centric development to cross-tier collaboration, focusing on sustainability benefits, and infrastructure development have been highlighted as probable solutions. These solutions are highlighted in the Table 3 proposed below:

Table 3: Four Solution Mechanisms Against the Core Conundrums

Solution mechanism	Description	Conundrums addressed
From bulk materials to material solutions	New type of offering—Introduction of new sustainable plastics as easy-to-adopt solutions, based on • Applicability in current manufacturing processes • Consideration of sustainability and branding benefits	• C1: Limited production of sustainable plastics • C2: Lack of uses and demand for sustainable plastics
From firm-centric development to cross-tier collaboration	New actor roles—Adopting new roles to initiate collaboration across the value chain to develop and scale-up new material solutions through • Production coordination and support • Process and product design development	• C1: Limited production of sustainable plastics • C2: Lack of uses and demand for sustainable plastics
From price competition to competition on sustainability benefits	New market dynamic—Increase the use of sustainable plastics based on sustainability benefits, especially in the Fast Moving Consumer Goods (FMCG) vertical characterised by • Competitive market dynamic and benchmarking • Ability to leverage sustainable product categories	• C2: Lack of uses and demand for sustainable plastics
From isolated technologies to infrastructure development	New assets—Systematic development of recycling infrastructure for plastics through multi-actor collaboration. Requires • Financial incentives for collecting and sorting plastic waste • Integration of chemical recycling effectively into the recycling value chain	• C1: Limited production of sustainable plastics • C3: Missing economic logic for plastics recycling

Source: (Siltaloppi J. M., 2021)

Above solutions, along-with widespread consumer awareness, change in consumption behaviour, regulatory policy along-with financial incentives and disincentives, stricter enforcements would be the key to phasing out of plastics from India in particular, and the World in general. Following box highlights some of the good practices undertaken in different parts of India to mitigate the problem of plastic pollution.

Plastic Waste Management in India: Exemplary Practices and Initiatives

The Government of India has taken significant steps to address the challenges emanating from plastic waste. The Plastic Waste Management Rules of 2016, later amended as the Plastic Waste Management (Amendment) Rules in 2018 and in 2021, have been crucial in guiding waste management practices across various sectors. These rules encompass Waste Generators, Local Bodies, Gram Panchayats, Manufacturers, Importers, Producers, and Brand Owners, making them accountable for sustainable waste management (including plastic waste) practices.

Here are some exemplary practices and Initiatives adopted towards plastic waste management by local authorities across the country:

Operation Blue Mountain in Nilgiris, Tamil Nadu: The year 2001 witnessed a remarkable environmental campaign known as Operation Blue Mountain, spearheaded by Supriya Sahu, the District Collector of Nilgiris, Tamil Nadu. This endeavour was pivotal in curbing plastic usage in the district and alleviating the problem of clogged river sources and springs. Documented by the Planning Commission and the United Nations Development Programme (UNDP), this initiative exemplifies effective governance. The campaign ingeniously employed images of animals choked by plastic and vividly illustrated how plastics obstruct drains and infiltrate lakes and water bodies (Ministry of Housing and Urban Affairs, Government of India, 2019).

Sustainable Waste Management in Indore: India's rapidly expanding city of Indore has been recognised as a model for sustainable waste management practices. Due to an effective waste management system, Indore has been continuously rated as the cleanest city for the last six years (Swachh Survekshan , 2022). Indore Municipal Corporation (IMC) has previously established a Material Recovery Facility-II at the Devguradiya Trenching Ground to effectively manage and process significant volumes of dry waste. This facility engages licensed recyclers, commonly known as Kabadiwalas, to sort various dry waste fractions, such as plastics, rubber, leather, glass, metals, cloth, and more. Some of the shredded and purified plastic waste is supplied to the Madhya Pradesh Rural Road Development Authority for road construction. To enhance the ecological and financial benefits, plastic (specifically, High Modulus Polyethylene (HMPE) and LDPE) derived from petroleum is blended with coal tar, reducing the tar content by 15 per cent. This innovative mix enables the recycling and reuse of approximately 45,000 kilograms of plastic waste daily during the production of Plastic Cement Concrete (PCC) (Mohini Jadon, 2021)**.**

IMC's accomplishments also include the construction of India's first 300 MT Fully Automatic Material Recovery Facility-I at a cost of 30 crores, covering approximately 3 acres. Designed by the Turkish firm Disan, this state-of-the-art facility features an automatic sorting system that surpasses manual sorting in efficiently segregating various dry waste categories, including plastic, metal, textiles, paper, and other materials. Thanks to these advanced recycling facilities, over 95 per cent of the total plastic waste processed is recycled (Mohini Jadon, 2021).

Sikkim's Eco-Friendly Endeavours: A Pioneer in Sustainable Practices, Sikkim, celebrated for its pristine environment, has been at the forefront of sustainable practices. The state government had banned plastic water bottles in governmental meetings and programmes, as well as disposable cups, plates, spoons, containers and other foam products across the entire State. Another Himalayan State, Himachal Pradesh, has also adopted a similar approach, like Sikkim (Ministry of Housing and Urban Affairs, Government of India, 2019).

Innovative Solutions for Plastic Waste: The Ministry of Road Transport and Highways, Government of India has made it mandatory for road developers to use waste plastic along with bituminous mixes for road construction to overcome the problem of disposal of plastic waste in India’s urban centres. Addressing the challenge of plastic waste disposal in urban centres, the directive of the Ministry requires road developers to integrate waste plastic into bituminous mixes within city peripheries with over 5 lakh population. Each kilometre of road construction takes away a tonne of even unclean plastic, saving approximately INR 35,000–40,000 per kilometre through reduced bitumen use (Ministry of Housing and Urban Affairs, Government of India, 2019).

Bicholim's Model of Comprehensive Waste Management: Bicholim, a semi-urban town in Goa, distinguishes itself by championing material recovery from segregated waste. The Bicholim Municipal Corporation (BMC) diligently promoted waste segregation and waste recovery. Bicholim sets itself apart from other similar towns and cities of the country by ensuring material recovery from segregated waste. Bicholim leads by example by managing plastic waste through the entire waste management chain (Atin Biswas, 2021).

Kumbakonam's Ingenious Plastic Waste Reuse and Disposal: Kumbakonam, a temple-town and municipality in Tamil Nadu, showcases innovative methods to repurpose plastic waste. Kumbakonam has set an example for tier-2 cities of India by effectively managing both its legacy plastic waste (recovered from the Karikulam dumpsite) and new plastic waste generated due to the high influx of tourists. Decentralised waste management and source segregation; awareness campaigns among students, resident welfare associations, self-help groups, and other important stakeholders; integration of authorised waste pickers into the management system; processing of non-recyclable plastics; and use of plastic as a refuse-derived fuel for pet coke in cement factories have worked wonders for the city (Atin Biswas, 2021).

In conclusion, India's efforts to combat plastic waste reflect a diverse range of approaches, from legislative actions and awareness campaigns to innovative reuse strategies and collaborative partnerships. These practices underline the significance of concerted efforts at governmental, local bodies, community, and individual levels to address the plastic waste crisis effectively. Through these exemplary initiatives, India paves the way for a cleaner, more sustainable future.

Chapter VIII: Summary and Conclusion

This paper focuses on the role and different stages of the Plastic Value Chain from the perspective of circularity in plastic management with special focus on ethical aspects and sustainable use of plastics throughout the value chain. It provides a comprehensive review of the different components of the Plastic Value Chain and their contributions to plastic circularity. The study highlights challenges like technological and cost barriers, lack of information on post-consumer plastic use, design, production, and overall plastic utilisation as factors impeding the adoption of sustainable alternatives. Post-consumption plastic waste poses a significant obstacle to achieving plastic circularity due to its inherent diversity and heterogeneous quality. It comprises a wide range of plastic products made from different polymers and often contains trace amounts of foreign elements, such as additives and other contaminants. The caps, lids, and labels of plastic products often contain foreign substances and residues. Consequently, plastic contamination and the presence of various polymers and foreign materials diminish its overall value for recycling. Integrating circularity principles, along with ethical and sustainable business practices, innovations in product design and usage, and awareness generation are some of the accepted approaches to reduce the technical and economic challenges associated with the different stages in the plastic value chain.

Recycling small quantities of plastic may prove unprofitable and uneconomical due to low efficiency and high prices. A major complexity to achieving circularity lies in consumers' perceptions of the environmental damage caused by plastics. Creating awareness among consumers about the products they purchase can help overcome this obstacle.

Efforts should not only focus on ensuring effective carbon recycling but also on effective recycling of used polymers. Throughout the product lifecycle, there should be a commitment to reducing energy consumption and waste generation. Reuse should be prioritised based on the quality and purity of the waste, followed by mechanical recycling, depolymerisation to monomers, conversion to hydrocarbon feedstock, and as a last resort, energy recovery. Plastics often get contaminated by food and other substances, rendering the resins unsuitable for reuse. Furthermore, many items consist of multiple types of plastic and different layers that are challenging to separate, making recycling a labour-intensive and costly process. Enforcing the principles of Extended Producer’s Responsibility can go a long way to ensure the safe and sustainable use of plastics. Best practices highlighted from different cities in India need to be widely propagated in the country towards a gradual reduction and subsequent phasing-out of plastics from the value chain.

Chapter IX: Way Forward

In order to tackle plastic pollution, one of the approaches should be to discontinue the manufacture and use of identified Single Use Plastics instead of penalising the offender. The ban might be effective for small and micro enterprises, but large corporate entities may be able to bear the penalty for manufacture and use of SUPs and yet be profitable.

In accordance with the Plastic Waste Management Amendment Rules, 2021, a ban has been implemented on Single Use Plastic items that exhibit low utility and possess a high potential for littering. This prohibition came into effect on July 1, 2022 (Ministry of Environment, 2022).

Furthermore, it is important to note that the manufacture, import, stocking, distribution, sale, and use of plastic carry bags with a thickness of less than 75 microns was prohibited as of September 30, 2021. Additionally, plastic carry bags with a thickness less than one hundred and twenty microns had been prohibited since December 31, 2022 (Ministry of Environment, 2022). The Ministry of Environment, Forest and Climate Change, Government of India, in its fourth amendment to the Plastic Waste Management Rules, dated February 16, 2022, notified 'Guidelines on Extended Producer Responsibility for Plastic Packaging' in Schedule II of the Rules, according to which it is the responsibility of Producers, Importers and Brand-owners to ensure processing of their plastic packaging waste through recycling, re-use or end of life disposal (such as co-processing/Waste-to-energy/Plastic to-oil/road making/industrial-composting) (Ministry of Environment, 2022).

Environmental concern is an important element of consumers' behaviour towards eco-friendly plastic products. Based on this observation, manufacturers should address the benefits and deliver the positive messages of consuming eco-friendly plastic products by launching awareness programmes/branding campaigns in crowded places (i.e., parks, super markets, cities, etc.). Moreover, businesses and service providers also need to address the quality of their eco-friendly products than traditional plastics for protecting human health and the environment. Political concern is another important determinant of ethical consumption behaviour of eco-friendly plastic products. Governments especially at state levels and policymakers can help the manufacturers by creating an enabling atmosphere to produce eco-friendly plastic products (i.e., reducing tax on finished products, reducing tax on agricultural ingredients for making eco-friendly plastic products, making unutilised fallow land available for cultivation of crops which is to be used in development of alternatives). Policymakers may also consider imposing restrictions on the usage of disposable plastic products or replacing them with environmentally friendly products as well as strengthening inspection and supervision of the collection of domestic waste.

Further, the following measures have been undertaken by the Central government to enhance the enforcement of the Plastic Waste Management Rules, 2016 and to implement the ban on specified Single Use Plastic items:

Thirty-six States and Union Territories (UTs) have formed Special Task Forces led by their respective Chief Secretaries or Administrators to eradicate specified Single Use Plastic items and enhance plastic waste management. At the national level, a Task Force has been established to coordinate these efforts and ensure the effective implementation of the Plastic Waste Management Rules, 2016. This national Task Force has already convened three meetings. State and UT governments, along with relevant Central Ministries and Departments, have been urged to devise comprehensive action plans for eliminating Single Use Plastics in a timely manner.

Under Section 5 of the Environment (Protection) Act, 1986, directives have been issued:

- Plastic raw material manufacturers have been instructed to halt the supply of materials for the production of banned Single Use Plastic items.
- State Pollution Control Boards and Pollution Control Committees have been tasked with revoking or modifying permits granted to producers of banned Single Use Plastics.
- State Urban Development Departments are taking action to enforce the ban on Single Use Plastics. Additionally, customs authorities have been directed to prevent the import of prohibited Single Use Plastic items.

To effectively monitor the ban on identified Single Use Plastic items and the management of plastic waste, several online platforms have been implemented, including a National Dashboard for monitoring action plan implementation, a CPCB Monitoring Module for Compliance on the Elimination of Single Use Plastic, and a CPCB Grievance Redressal App (Ministry of Environment, 2022).

A month-long nationwide enforcement campaign was carried out from July 1 to July 31, 2022, to enforce the ban on specified Single Use Plastic items. Furthermore, States and Union Territories have been encouraged to conduct regular enforcement drives to ensure the ban's compliance (Ministry of Environment, 2022).

Adopting new rules and redefined societal feedback mechanisms to initiate and develop collaboration across plastic value chains for the development of new alternatives, have to be the priority to address the growing menace of plastics. Widespread consumer awareness, changes in consumption behaviour, along with regulatory and enforcement changes would hold the key to the future.

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