KEARNEY

Confederation of Indian Industry

Solving Plastic Waste:
Roadmap for a Sustainable Future

Contents

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Message

Plastics have become an integral part of our modern lives, revolutionizing industries and enhancing convenience. Their unparalleled versatility and functionality benefit a vast number of industries, not limited to agriculture, automobiles, packaging, healthcare, construction, and textiles. As we navigate the current climate of waste generation in India, it is integral to recognize the necessity and challenges of plastics. Their environmental impact must be structurally acknowledged and solved for in order to continue enjoying their cost-effectiveness.

In a growing economy such as India's, with its vast population, upward of 10 million metric tons of plastic waste are generated annually, necessitating immediate action for waste reduction and management. Our commitment to sustainability and circularity of plastics will shape the future of its consumption and growth in India. This whitepaper is a clarion call for decisive action, presenting a strategic framework to address the multifaceted challenges of plastic waste management in India. It outlines a series of practicable steps, tailored to India's unique context, that span the entire life cycle of plastics. These steps form a holistic action plan that underscores the imperative for collaborative efforts and the enactment of supportive government policies to effectuate a meaningful resolution to the plastic waste dilemma.

India could set a benchmark in sustainable practices. It is incumbent upon us to join forces in this endeavor, not only to safeguard our environment but also to establish a paradigm for the international community. This document serves as a comprehensive guide to augmenting the circularity of plastics.

(Deepak Mishra)

Foreword

As we navigate the complexities of modern life, plastics remain a cornerstone of industrial and consumer applications, showcasing unparalleled versatility and cost-effectiveness. Their benefits are indisputable, ranging from improving healthcare outcomes to enhancing transportation efficiency. However, this ubiquity has brought forth significant environmental, economic, and societal challenges that cannot be ignored.

In today's world, the challenge of plastic waste management has emerged as a critical issue impacting our environment, economies, and societies. This whitepaper, "Solving Plastic Waste: Roadmap for a Sustainable Future," addresses the urgent need for strategies to tackle the growing menace of plastic pollution. It also serves as a comprehensive guide to understanding the lifecycle of plastics and the critical steps required to transition toward a circular economy.

The journey towards a sustainable future is complex and challenging, but it is one we must embark upon with determination and collaboration. India has the potential to set a global benchmark in sustainable plastic waste management. By adopting the comprehensive strategies outlined in this document, we can lead the way toward a circular economy that balances the necessity of plastics with our environmental responsibilities.

Confederation of Indian Industry (CII) recognizes the pivotal role we must play in leading the transition towards sustainable practices and promoting a circular economy for plastics.

Virendra Gupta
Deputy Director General
Confederation of Indian Industry

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Foreword

While plastic waste and circularity is global problem, in India the problem is particularly pronounced. While many other materials have found their balance in circularity, the clock is ticking for plastic waste management and its circularity practices. The nation's economic and consumption growth is leading to a mounting plastic waste crisis, generating 10-12 million metric tons annually, much of which remains uncollected or poorly managed. Mismanaged collection leads to mixed plastics rendering them hard to recycle and then end in landfills.

Historically the circularity of materials have been left to marginal income groups to solve for their livelihood. The problem of plastic waste is much more complex and hence needs to be prioritized and addressed systematically with innovations, increased capital , talent and collaborative efforts between civic authorities, brand owners, processors , material and machinery producers al coming together .The society is the starting point for responsible segregation which in turn plastics contribute its benefits usage.

This paper presents a variety of steps that can be taken to address this issue. Recognizing India's unique challenges, it offers solutions across every phase of the plastic life cycle for a comprehensive action plan. More importantly, it also emphasizes the need for collaboration and supportive government regulations as critical for achieving a substantive solution to the plastic waste crisis.

Poised to become a major economic power, India has the potential to lead by example in sustainable development. It is important that we participate in this movement through collective action to not only protect our environment but also set a precedent for other nations.

Janardhan Ramanujalu

Chairman, CII Conference on Sustainability & Plastics

Vice President, RoA Region

SABIC IP India Pvt. Ltd.

Foreword

We find ourselves at a critical juncture in addressing one of the most pressing challenges of our era: the management of plastic waste. Integral to the convenience and innovation of modern life, plastics have also become emblematic of widespread environmental degradation and sustainability challenges worldwide. In India alone, more than 10 million to 12 million metric tons of plastic waste are generated each year, with a significant portion remaining unmanaged or misallocated. The diverse nature of plastic waste, composed of varying substrates and end applications, presents a formidable challenge to effective recycling efforts.

This whitepaper is a call to action—a comprehensive roadmap to enhance plastics circularity throughout their life cycle. From advocating "design for recycling" in product innovation to fostering robust waste collection and sorting mechanisms and advancing mechanical and chemical recycling technologies—each action item is crucial to forge a sustainable path forward. Stringent and effective enforcement of regulations, bolstering industry collaboration for sustainable solutions, and investments in innovative recycling technologies will be vital to pioneer a sustainable circular economy for plastics. We need to balance necessity with environmental stewardship, ensuring a cleaner, more resilient future for generations to come.

Sudeep Maheshwari
Partner
Kearney India

Executive Summary

Plastics are essential to modern life, offering unparalleled versatility and affordability across sectors. Their cost efficiency and exceptional strength-to-weight ratio make them indispensable in a wide variety of end applications from packaging to automotive and aerospace. However, the unchecked proliferation of plastic waste presents severe environmental, economic, and societal challenges.

India annually generates 10 million to 12 million metric tons of plastic waste, much of which remains unrecovered or mismanaged. Plastics represent a wide variety of materials and end applications. It is critical to prioritize efforts toward the right substrates and applications to realize the maximum impact and build momentum. For example, HDPE-based packaging and PET must be prioritized given their widespread use, short useful life, and well-established recycling infrastructure and technology. Similarly, PVC and PS can be taken at a later point given their longer life cycles, relatively less mature recycling technologies, and/or smaller volumes compared with other substrates.

Each step of the plastics value chain requires close examination to identify issues and drive potential solutions:

Upstream activities (plastic production, conversion and consumer use):

“Design for recycling” is key to enable recycling. Examples include switching to mono-material designs and reducing non-recyclable parts such as metallization, colored labels, and adhesives. Developing these solutions requires collaboration across value chain partners (plastic producers, machine manufacturers, converters, and brand owners) and significant innovations in product design and material properties.

Alternate materials such as biodegradable plastics and *bioplastics* offer another potential solution. However, challenges associated with product costs, functional limitations, and feedstock sustainability issues are likely to limit their scale and adoption over next decade or so.

Midstream activities (collection and sorting of plastics waste):

Waste segregation is a major obstacle in unlocking the true potential of recycling in tackling plastic waste. In India, waste is rarely separated into compost, recyclable, and toxic waste, which impedes recycling efforts. *Raising awareness* through tailored campaigns and community groups can encourage household-level waste separation. Success stories such as Chai pe Charcha in Rishikesh, highlight the impact of grassroots initiatives.

Incentivizing local communities to create a vibrant waste-collection t economy can help fill the gaps created by inefficiencies or the absence of municipalities and elevate the living standards of the informal sector involved in waste recovery.

Investments in Material Recovery Facilities (MRFs) need to be incentivized by enhancing the quality and quantity of feedstock, leveraging viable supply chain design and technology to avoid pilferage of high-quality plastic waste to enhance yields of MRFs. Further, derisking the return on investments in MRFs via contracting mechanisms, enforcement of Extended Producer Responsibility (EPR) etc. can go a long way.

Downstream activities (recycling of sorted waste and use of recyclates):

Large-scale deployment of mechanical recycling, the most mature recycling pathway, requires financial support and policy interventions to establish demand offtake and ensure project viability. In addition, the supply chain will be critical to ensure high-quality feedstock for optimal utilization. Further, development of chemical recycling technologies is crucial to alleviating the shortcomings of mechanical recycling. The focus needs to be on promoting R&D to develop this pathway. Finally, to inspire confidence and encourage the use of recycled plastics in sensitive industries, end-to-end traceability of plastics needs to be promoted.

Government regulations

The Plastic Waste Management Rules aim to regulate the country's plastic waste and have undergone multiple amendments to address gaps and adapt to evolving needs. Persistent challenges include inadequate policies, weak enforcement, and insufficient industry support. More needs to be done in areas such as stricter enforcement through local authorities, subsidies and investments toward ecofriendly materials, investment in expansion and advancement of recycling technologies, comprehensive data management and data-driven decision making, and catalyzing enhanced industry collaboration.

Stakeholders must collaborate extensively to tackle plastic waste effectively. Governments should run broad public awareness campaigns, empower the informal waste sector, and incentivize traceability technologies. Local municipalities should gradually enforce recycled content quotas and advocate for advanced recycling. Industries should design products for recyclability, reduce plastic use, expand refillable options, and forge strong partnerships for waste management. Investments in upcycling and sorting technologies, along with digitizing feedstock management, are crucial. These efforts can significantly enhance the recycling rates and promote a sustainable circular economy.

In this context, we argue for a comprehensive initiative to address the challenges of plastics. The government, private sector, and citizens must prioritize recycling, enhance plastics circularity, and foster public–private partnerships to balance necessity with environmental responsibility.

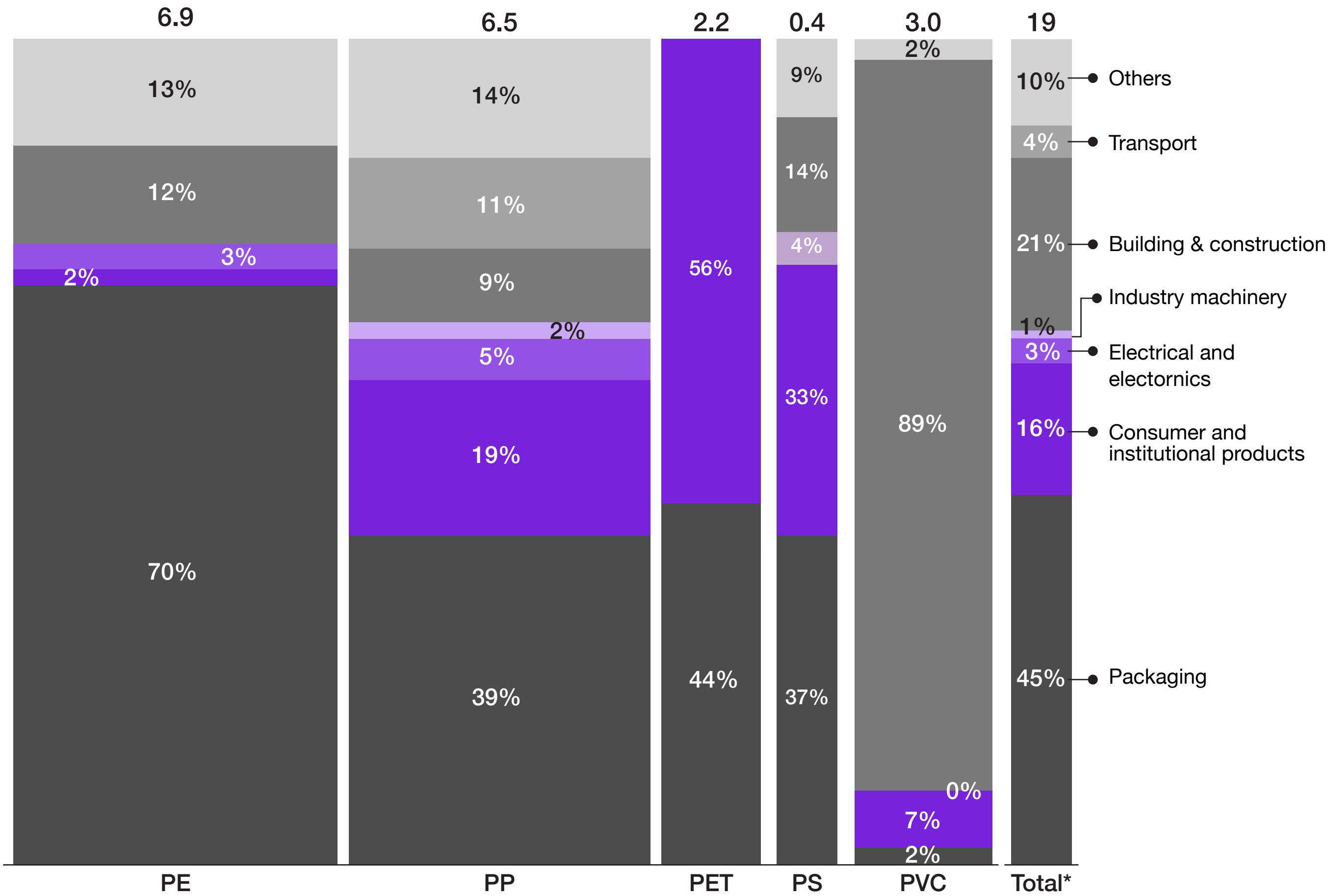
The Role of Plastics: Balancing Necessity and Impact

Plastics have become woven into the fabric of our lives. From the moment we wake up until we lay our heads down at night, we encounter plastics in myriad forms. Their versatility and affordability have fueled widespread use across numerous applications. In packaging, their lightweight design allows for efficient transportation and storage. Within electronics and appliances, plastics act as insulators, safeguarding delicate circuitry. For construction and infrastructure, they offer advantages such as durability, corrosion resistance, and cost-effectiveness. The healthcare industry leverages their sterile and non-reactive properties to prioritize patient safety.

Plastics have extended their reach beyond these sectors. They contribute to fuel efficiency in transportation by reducing vehicle weight. The fashion and textile industries utilize them for their ability to create stretchy, durable, and vibrantly colored fabrics. Even in environmental applications, plastic mulch in agriculture helps conserve water and suppress weeds. Ocean cleanup efforts often rely on plastic-based materials to collect marine debris.

In essence, plastics have become an essential part of our daily routines, offering a unique combination of versatility, affordability, and functionality.

Applications of plastics in India (in million metric tons) as of FY2023 has been shown below:



Note: *sum of PE, PP, PET, PS and PVC, which account for ~90% of India's demand.
Source: Plastindia foundation, Kearney

Compared with glass and metals, plastic offers significant cost advantages. Specifically, the production costs of plastic are approximately 20 to 30% lower than glass and over 30% lower than metals. New processing technologies are constantly refining plastic production. These advancements allow for shaping plastic products with less heat and in a shorter time, significantly reducing energy consumption. In comparison to glass production, which requires high temperatures for extended periods, plastics offer a more streamlined and energy-efficient manufacturing process.

A key strength of plastics lies in their exceptional balance of strength and weight, making them ideal for applications where weight is a major concern, such as in the aerospace and automotive industries. Their lightweight nature translates to better fuel efficiency and overall energy savings. This advantage positions plastics favorably compared with metals. Furthermore, plastics boast impressive durability. They can endure harsh environments and resist corrosion, making them well-suited for long-lasting performance in demanding fields such as marine applications and chemical processing.

While plastics offer numerous benefits, the world faces a growing problem with plastic waste. Every year, we generate an enormous amount, exceeding 350 million metric tons. Unless significant changes are made, this number is projected to triple by 2060, reaching a staggering one billion metric tons. India generates 10 million to 12 million MT of plastic waste every year—most of which either ends up in a landfill or leaks out to the environment, causing a significant environmental, societal, and economic impact.

Environmental Impact

Plastic packaging imposes hefty environmental and economic costs, estimated by the United Nations Environment Programme to be around USD 40 billion. With plastic usage continuing to grow under a business-as-usual scenario, these costs are expected to increase substantially. Every year, at least 8 million tons of plastic end up in the ocean globally, equating to one garbage truck's worth of plastic being dumped every minute. Without intervention, this rate could double by 2030 and quadruple by 2050. Research suggests that plastic packaging is a major contributor to this oceanic plastic pollution, leading to marine life disruption. Currently, over 150 million tons of plastic in the oceans, and projections indicate that by 2025, there will be one ton of plastic for every three tons of fish, potentially surpassing the weight of fish by 2050.

Economic Impact

The mismanagement of plastic waste is escalating the costs of responsible waste disposal. The financial strain of cleaning up plastic pollution, repairing damaged infrastructure, and addressing the health impacts is significant and growing. In India, landfills—similar to open dumps used worldwide—are the primary waste disposal method, with plastic waste constituting about 6% of landfill content. The country lacks an effective waste management system, leading to most plastic waste ending up in approximately 1,700 landfills nationwide. The average cost of managing this waste ranges from Rs. 500 to Rs. 1,500 per ton, across collection, transportation, and basic treatment before disposal. Additionally, the health impacts of plastic pollution, such as respiratory issues and cancer from open burning, contribute to rising healthcare costs and reduced productivity.

Societal Impact

Plastic waste presents significant societal health risks through multiple channels. Chemical additives in plastics, such as phthalates and Bisphenol A, can leach into the environment, causing endocrine disruption and developmental problems. Microplastics, formed from the breakdown of larger plastic items, can enter the food chain and pose potential long-term health risks. Toxic pollutants from burning plastic waste contribute to respiratory and cardiovascular diseases. Improper disposal creates physical hazards and breeding grounds for disease vectors, while contamination from plastic food packaging adds further health risks. Additionally, plastic pollution disrupts marine ecosystems and affects human food sources, underscoring the urgent need for improved waste management and reduced plastic use.

Prioritizing Recycling Efforts

It is irrefutable that the 10 million to 12 million metric tons of plastic waste generated in India annually will have adverse impacts. The problem is exacerbated by the diversity of these plastics, each with varying properties, segregation ability, recycling requirements, and useful life. Some plastics re-enter the system within months of production, while others take decades. Tackling all the different types of plastics simultaneously would be expensive, inefficient, and ineffective. Instead, a more targeted approach should focus on plastics that have short lifespans and represent larger volumes and whose recycling challenges have not been solved.

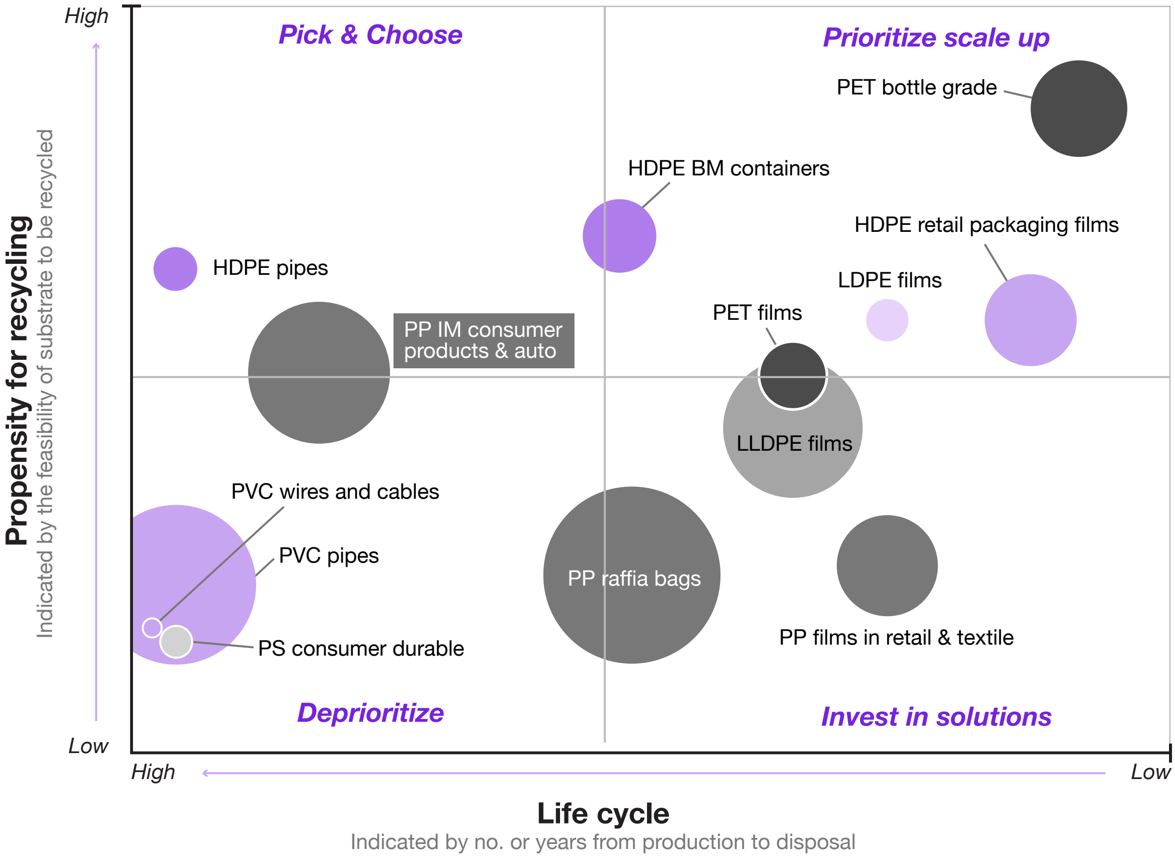
There are seven key plastic substrates widely used:

- **PVC** (3) Polyvinyl chloride
- **PET** (1) Polyethylene terephthalate
- **PS** (6) Polystyrene
- **PP** (5) Polypropylene
- **HDPE** (2) High-density polyethylene
- **LLDPE** (4) Linear low-density polyethylene
- **LDPE** (4) Low-density polyethylene

Scaling up sustainability solutions for HDPE and PET must be prioritized given that they account for large volumes and are relatively easy to recycle with well-established recycling infrastructure and technology. LLDPE and LDPE, used in films and bags, often face contamination issues and are designed as multi-material layers. They will require specialized collection programs and advanced recycling technologies to improve recycling rates. PP is one of the most popular plastic packaging materials, and most PP is disposed in landfills due to competition with cheaper virgin feedstock. Ensuring financial viability is imperative to promote recycling of PP, especially PP films in retail and textile and PP consumer durables. PVC and PS recycling can be deprioritized in short term to focus on other substrates with larger footprint and shorter useful lives.

Recycle Prioritization Matrix

Size of the bubble represents the demand of substrate (In MMTPA)



Source: Kearney

Details of each substrate and the issues faced in recycling are detailed below.

Ease of Recyclability

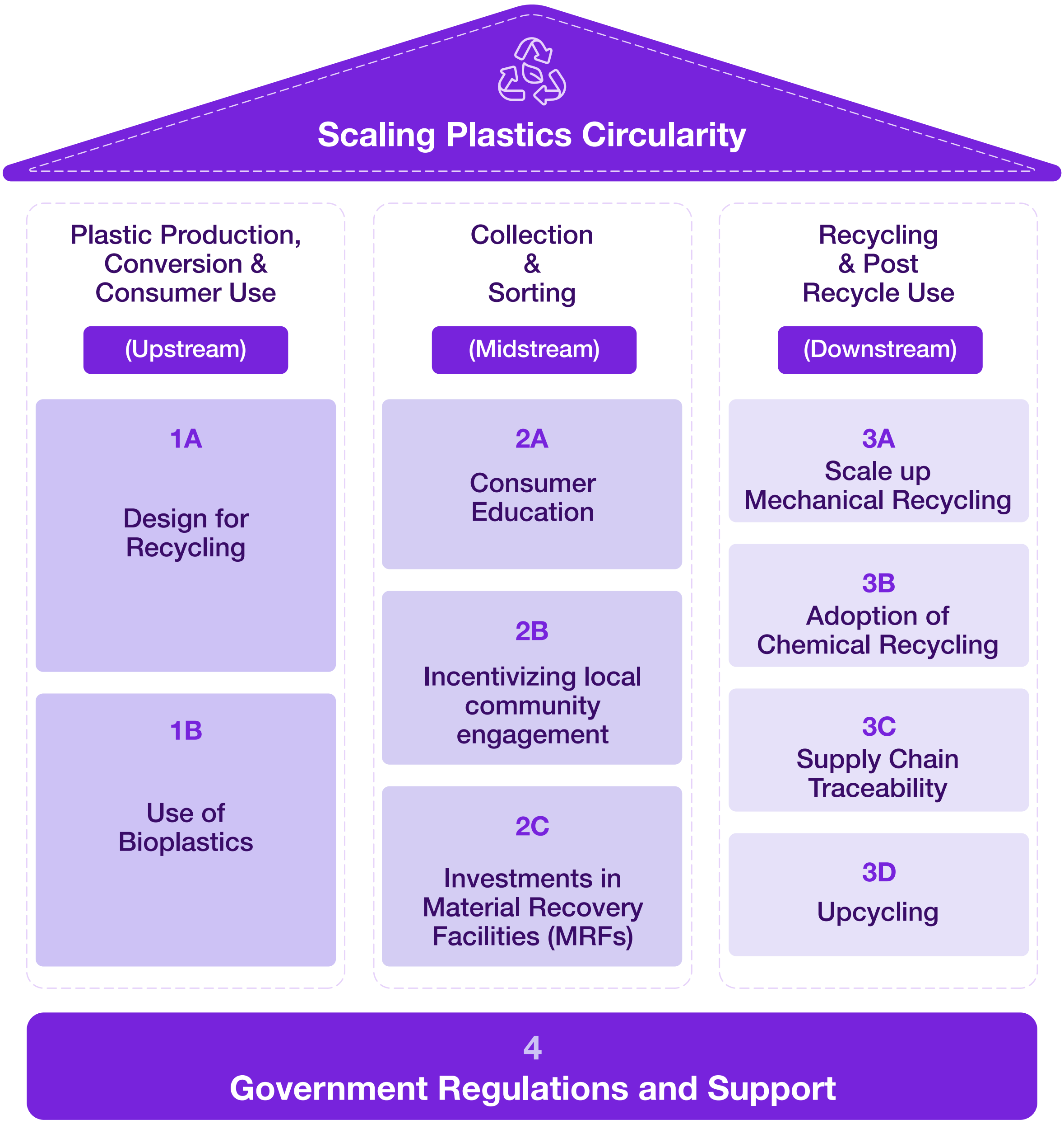
High	Moderate	Low

Substrate	Application	Approx annual demand (KTPA)	Typical life in years	Plastic product design and usage	Supply chain considerations	Recycling tech availability and adoption
HDPE	Retail packaging films	1,300	<1	Designed for recycling but contamination (especially oil) hinders recyclability	Infrastructure under development	Available with moderate adoption due to design issues
HDPE	Pipes	700	10 to 20	Highly recyclable but contamination and separation from construction debris a challenge	Low collection rates due to lack of dedicated collection system and scattered use	Mechanical recycling well-established
HDPE	Blow-molded (BM) containers	1,000	<2	Designed for recycling; labels and residual content cause contamination	Well-developed collection and recycling infrastructure	Defined pathways via mechanical recycling
LLDPE	Films (FMCG and retail)	1,900	1–2	Multi-layering and contamination is an issue	Lacks efficient collection system; sorting from mixed waste stream is also a challenge	Flexibility and mixed waste create difficulty toward mechanical recycling; chemical recycling is key
LDPE	Films (FMCG and retail)	600	<1	Designed for recycling as they are mostly mono material		
PVC	Pipes	2,200	15	Toxicity concerns due to additives such as plasticizers, stabilizers and pigments	Effective separation from construction debris is labor intensive and collection is challenging due to fragmented use	Limited recycling using mechanical route
PVC	Wire and cables	300	20			
PET	Films in FMCG	900	~1	Multi-layering and contamination is issue	Lacks efficient collection system; sorting from mixed waste streams is also a challenge	Mechanical recycling is available but not scaled
PET	PET bottle grade	1,300	<1	Designed for recycling, and widely accepted in recycling systems	Robust collection systems are in place, especially for bottle-grade PET	Mechanical recycling offers the lowest cost and lowest emission pathway

Substrate	Application	Approx annual demand (KTPA)	Typical life in years	Plastic product design and usage	Supply chain considerations	Recycling tech availability and adoption
PP	Raffia bags	2,400	<2	Multi-layering, re-enforcements such as zippers, stitching threads and contamination hinder recyclability	Fragmented use makes collection challenging	Degradation in quality during recycling and availability of cheaper virgin PP renders recycling unviable
PP	Injection molded (IM) consumer products and auto	2,000	5–10	Products not designed with disassembly and recycling in mind.	Disposed through informal recycling sectors, despite auto sector being organized	Mechanical recycling facilities are available, but the capacity is limited
PP	Films in retail and textiles	1,400	~1	Not designed for recycling, majorly due to contamination and multi-layering	Efficient collection and cleaning systems are not available	Mechanical recycling for clean films is available; chemical recycling is being explored for contaminated/ mixed waste
PS	Consumer durables	300	15+	Often not designed for recycling, usually combined with other materials	Collection systems for durable goods are underdeveloped	Limited commercial scale for chemical and mechanical recycling

Scaling Plastics Circularity

Scaling of plastics circularity requires robust solutions across the entire plastics value chain, from upstream (plastic production, conversion, and consumer use) to midstream (collection and segregation of plastic waste) and downstream (recycling and the use of recycled plastics). Regulatory support is a key enabler to catalyze this value chain



1A. Design for Recycling

Today's plastic products must meet various functional requirements, such as protecting the product, ensuring long shelf life, and maintaining low weight. The preference for multi-layer and mixed polymer materials has increased due to their ability to meet these needs. Currently, 15 to 25% of all flexible packaging is multi-layered, which is difficult to recycle. The rising importance of sustainability and recycling is pressuring manufacturers and brands to ensure products are recyclable without compromising functionality or cost.

To ensure products are recyclable, two important principles must be incorporated in the design philosophy of the product. First, product designs must be simple; there must be no ambiguity in how it needs to be recycled. Second, designs must be free of unnecessary elements such as contaminants, nonessential colorants, and non-recyclable elements.

These design interventions are vital for achieving circularity in plastic production and consumption. Incorporating these principles during the design phase will also reduce downstream recycling challenges often caused by non-standard plastic waste composition and multi-layer components. Thus, manufacturers have a significant responsibility to design their products for recyclability. Broadly, design initiatives for recyclability fall under three themes:

Reuse

Design products with longevity in mind to minimize the frequency of purchase and disposal.

Reduce

Avoid using colorants, non-recyclable parts, including stickers, when possible. Standardizing packaging production facilitates easier separation and collection.

Recycle

Prefer mono-material plastic products. Increase the use of recycled plastic over virgin stock to grow the recycled plastic market. Design plastic products to aid separation and recycling for both consumers and waste handlers.

These Design for Recycling (DfR) initiatives are already being spearheaded by industry leaders, with the means to invest and experiment with overhauling existing manufacturing technologies and processes. For example, Tetra Pak, known for sustainable and innovative packaging solutions, adopts DfR guidelines for beverage cartons to optimize recycling, aiming to combine best-in-class packaging practices without compromising product shelf life. Their inclusion of a paper-based barrier in milk cartons has resulted in over 90% recycled content and a nine-month shelf life.

There are several such examples scattered across various plastic end uses. However, widespread adoption remains a challenge due to feasibility, cost, functionality, and other issues. Such changes often require overhauling of existing materials and conversion processes across polymer producers, machine manufacturers, converters, and brands. Large-scale implementations and scale up will require close collaboration across these stakeholders to achieve breakthroughs. Policy and regulations can help catalyze these collaborations via enabling incentives or stringent mandates.

1B. Use of Bioplastics

Ecofriendly alternatives to fossil-based plastics include bioplastics derived from renewable biomass and biodegradable plastics that can be decomposed by living organisms. The rise of these alternatives stems from a growing commitment to sustainable materials that match the functionality of traditional plastics but with a significantly lower environmental footprint.

However, both of these alternatives suffer from high production costs, functional limitations, concerns around competition with food supply, and accurate accounting of end-to-end life cycle environmental impact considering land use changes, deforestation, and biodiversity loss. Further, bioplastics derived from renewable biomass require recycling infrastructure like fossil-based plastics while large-scale use of biodegradable plastics would require significant investments in composting facilities.

Given these challenges, these alternatives are unlikely to significantly reduce plastic waste over the next decade. However, they can still be part of overall solution. To effectively ramp up the production and use of bioplastics, several strategic steps need to be taken:

Investment in R&D

Invest in research and development to bring down the cost curve, develop synthesis routes from Agri residues instead of food crops and improve the performance and durability.

Regulatory Support

Provide tax breaks, subsidies, and other incentives to encourage the production and use of bioplastics.

Market Creation

Use government policies such as green premium, demand mandates to create a stable demand for bioplastics and spread consumer awareness.

2A. Consumer Education to Enhance Segregation

Effective recycling technology and processes are crucial for mitigating plastics' environmental impact. However, the lack of waste segregation hampers recycling from the start, as unsegregated waste makes separating recyclables very challenging. This mixed waste often ends up in landfills or is incinerated, harming the environment. Ideally, households should segregate waste into compost, recyclable, and toxic bins. In India, achieving this is challenging, and even basic segregation into dry and wet waste could significantly reduce the problem. Despite being mandated by law in several states, lax enforcement means household waste is rarely segregated.

India's unique challenges require solutions tailored to its vastness and variability in plastic waste generation. Raising awareness about the adverse impacts of waste is crucial to encourage household-level separation.

Tailored Awareness Campaigns

To make a significant impact, awareness campaigns must be tailored to different demographics. For instance, television ads, radio features, and posters in local kirana stores featuring celebrities discussing waste management could be highly effective. Similarly, videos on OTT platforms or sports channels highlighting the plight of communities affected by waste could resonate with audience.

Community education

Community groups also play a pivotal role. Consider the success of Chai pe Charcha, driven by the Alliance to End Plastic Waste, in Rishikesh, where NGO-driven tea gatherings led to 85% of households separating their waste. These small informal meetings, mainly attended by women, have been incredibly effective. Similar initiatives could be spearheaded by resident welfare associations in urban areas.

Supply side intervention

Enforcing waste separation by collecting different types of waste on different days and imposing penalties for non-compliance could be considered. This method has seen success in Panaji, Goa, where a stringent system has made a significant impact. Effective implementation of these solutions hinges on strong collaboration with local municipalities to influence the communities they serve. Municipalities must ensure consistent, timely, and tailored waste collection schedules that meet the diverse needs of residents. Visible efforts to maintain separate waste streams are crucial for building trust in recycling outcomes and encouraging widespread participation.

Community involvement, enforcing waste separation by collecting different types of waste on designated days, and penalties can drive consumer compliance.

2B. Incentivizing Local Community Engagement

In most geographies, the responsibility for waste collection stays with local government, executed through municipalities or equivalent bodies. At this crucial juncture of the value chain, a robust local community engagement becomes critical.

The involvement of local communities in waste collection drives plays a pivotal role. Apart from enhancing consumer education for plastic circularity, imparting full ownership of the collection to local communities along with creation of jobs that pay respectable wages can be major steps in gaining the support of individual consumers for plastic circularity. One of the flagship projects of Alliance to End Plastic Waste, Project STOP Jembrana has involved more than 1.6 lakhs of residents in collection and recycling of more than 18,000 tons of plastic waste preventing more than 2,000 tons of plastic waste from leaking into the environment. In the project, local communities have full ownership of managing the waste collection system while having a justified reward scheme from the local municipality and government.

Ensuring minimum wages and incentives for local communities can help create a willing army of segregators, collectors, and transporters. Such communities, supervised through local government bodies, can go a long way in closing the gap in waste collection especially in suburban and rural areas.

Project STOP Jembrana has involved more than 1.6 lakhs of residents in collecting and recycling more than 18,000 tons of plastic waste, preventing more than 2,000 tons from leaking into the ocean by empowering local communities.

2C. Investments in Material Recovery Facilities

Material Recovery Facilities (MRFs) play a pivotal role in segregating different types of plastic from other collected waste. The quality and quantity of feedstock largely determine the efficacy and economic feasibility of these facilities. Improving access to high-quality waste requires basic segregation at the consumers' end, preventing leakage of high-value plastics during collection and transportation and well-defined catchment areas. Large-scale investments in setting up new MRFs require a careful economic assessment, especially given fluctuating bale prices and demand. The economic viability of such investments can be uncertain at times. Several initiatives can go a long way in improving economic viability of MRFs as detailed below:

Utilizing technology to prevent high-grade waste leakage in the supply chain has been effective in certain regions through partnerships with government bodies. Additionally, establishing an optimized collection and MRF network at city and district levels is essential for setting up scaled facilities. Examples such as NEPRA-managed facilities in Indore and Ahmedabad demonstrate successful use of geo-fencing to prevent illegal pilferage, defined catchment areas supported by collaboration with private players and cooperatives such as Amul, Reliance, various hospitals and municipalities such as Indore and Ahmedabad, along with thousands of individual waste pickers. Although the investment required for these initiatives is feasible, achieving them necessitates significant societal change along with participation and political willpower at the local level.

Within the walls of MRFs, **implementation of mechanized equipment and digital tools** such as robotics, optical pneumatic sorting, and optimal designing such as separate assembly lines for sorting waste sub-types can improve sorting yields.

Driving economic viability: Potential collaborations with industries involving **long-term purchase contracts, stable bale prices through minimum guaranteed prices,** and joint investments to improve sorting capabilities can help address viability challenges. Therefore, the role of industrial producers of plastic waste and consumers of recycled materials, such as consumer packaged goods companies, becomes pivotal. Further, investments in expanding sorting capabilities from rigid to flexible plastics, reimagining sorting lines, and deploying digital tools would be beneficial.

Improving access to high-quality waste requires basic segregation at the consumers' end, preventing leakage of high-value plastics during collection and transportation and well-defined catchment areas.

3A. Scaling up of Mechanical Recycling

Mechanical recycling is the most adopted approach and accounts for the highest-by-volume recycled plastics. It is a mature technology with low complexity. By 2030, mechanically recycled plastics could scale to 12 to 14% of the plastics used globally.

The economics of mechanical recycling can be challenging due to fluctuating prices of virgin and recycled materials as well as high initial investment costs in recycling infrastructure. Insufficient or outdated recycling infrastructure that rely on labor-intensive methods like manual sorting and outdated shredder, extruder and other equipment render these facilities incapable of handling large volumes and variety of plastic waste effectively. Further, limited demand for recycled plastics hinders the scaling of mechanical recycling operations.

Multiple steps are required to ensure large-scale deployment of mechanical recycling facilities. These include:

Financial incentives and subsidies for recycling infrastructure investments including expansion and modernization of recycling facilities with state-of-the-art equipment and processes, supporting stable pricing mechanisms for recycled materials, and encouraging collaboration between recyclers and manufacturers to create and promote robust demand for recycled plastics.

Promoting the use of recycled plastics through government procurement policies, eco-labeling initiatives. Government procurement policies can mandate or incentivize the purchase of products containing recycled plastics, while eco-labeling initiatives can help consumers identify and choose environmentally friendly products, thereby boosting the market for recycled materials.

Partnerships across the value chain with an aim to bring together private players with complimentary capabilities to create robust demand, drive operational efficiencies and necessary supply chain setups in order to reduce financial risks and enhance project viability. These initiatives partnerships could involve entities such as polymer manufacturers, CPG players, collection agencies, and recyclers. Partnership between SABIC and Pashupati Group is one such example with former focusing on the marketing and sales of recycled products leveraging its wide network, access to large scale customers and a fast-growing portfolio of circular polymers while the latter brings in expertise of recycling technology producing high quality recyclates.

3B. Adoption of Chemical Recycling

Currently, mechanically recycling is the technology of choice due to maturity. But it has several challenges, such as the inability to recycle mixed plastics, applicability to select plastic types only, structural degradation impacting material properties, and other scaling issues.

Chemical recycling offers potential solutions to overcome the limitations of mechanical recycling by diversifying the types of plastics that can be recycled and allowing for tailored molecular weight distributions. This process is seen as superior due to its promise of addressing the plastic waste problem on a large scale. However, implementing chemical recycling faces challenges such as limited technology maturity, high operating costs (approximately three times higher than mechanical recycling), expensive solvents, contamination risks, and the complexity of a resource-intensive process with significant emissions. Currently, chemical recycling is in a nascent stage, with pilot projects yet to achieve commercial viability; economic feasibility is primarily viable at large scales, emphasizing the critical need for scalability in advancing chemical recycling technologies.

Achieving the potential of chemical recycling requires unlocking technological advancements, developing infrastructure, and forging strategic partnerships. Petrochemical companies and technology start-ups are investing in advanced recycling technologies, such as converting plastics into pyrolysis oil for circular polymers and others. Select examples include Dow's partnership with Mura to build a 60 KTPA advanced recycling facility by 2030 and ExxonMobil's plan to establish a 30 KTPA chemical recycling capacity in Baytown. SABIC and Plastic Energy are in the final stages of construction of world’s first commercial unit in Geleen, Netherlands. This plant can process 20,000 tons of plastic waste per annum. More such investments are needed to propel chemical recycling forward.

R&D investments and commercial deployment can be supported through green premiums and other incentives to foster market development in the medium term. Establishing a reliable plastic feedstock supply necessitates expanding infrastructure and enhancing sorting capabilities, beginning with robust waste collection programs, and digitalizing feedstock management. Significant global investments are crucial for accelerating maturity in this ecosystem. Coordinating across all stakeholders in the value chain is essential to develop the market, sustain green premiums, scale technologies, and attract investment.

3C. Supply Chain Traceability

As the trend shifts from using virgin plastics to recycled plastics, the quality of these materials becomes a significant concern. Recycled plastics, especially mechanically recycled ones, possess different material properties compared to virgin plastics, depending on the recycling process, plastic type, and level of contamination. With the aim to use recycled plastics in industries such as food and beverage packaging, automotive parts, and construction, these materials will need to meet stringent quality standards—a necessity that has brought plastics traceability to the forefront.

To inspire confidence and encourage the use of recycled plastics in sensitive industries (such as food and pharma) and products, companies need to inform customers about the plastic's history. Gathering and storing data on the plastic's origin, type, recycling methods, and environmental impact can provide transparency. This information can be made accessible through a QR code on products, allowing consumers to scan and view the recycling history. The data can be stored securely on a cloud or blockchain network. For example, the German automobile giant Porsche uses QR codes and blockchain technology to let consumers access information on the origin of some of its parts. Independent audits, centralized data platforms, and periodic inspections can ensure accurate and honest reporting.

3D. Upcycling: Improving Recycling Outcomes

After recycling, the quality of the plastic often comes into question. Recycled plastics have different properties than their virgin counterparts, typically exhibiting reduced mechanical properties, lower melting points, and higher impurities. A growing area of interest is upcycling, aiming at improved recyclate properties suitable for application in various industries. However, upcycled recyclates often lose to virgin polymers on cost, deterring widespread adoption.

Solutions to enable upcycling include the following:

Green Premium

Given the consumer trend shifting toward sustainability, there is a growing market for goods produced with recycled materials and a potential solution could be to charge a "green premium" for products that use such recyclates. Such premiums can incentivize further investments in research and development, which are crucial to innovate cost-effective upcycling technologies and eventually bring down costs.

Subsidies or financial incentives

Monetary support to companies that adopt these technologies can further drive down costs and promote wider adoption.

Policy frameworks and strong regulatory support

Mandatory recycling quotas, extended producer responsibility, and potentially a carbon tax could drive economic feasibility.

SABIC, a chemicals manufacturer, chemically upcycles consumer-discarded PET (primarily single-use water bottles) into higher-value PBT materials with enhanced properties and suitability for more-durable applications offering a smaller cradle-to-gate environmental footprint than virgin resins.

4. Government Interventions and Regulatory Support

The Indian government has a crucial role in tackling plastic waste through various initiatives and policies aimed at promoting sustainable waste management practices. Some of the key measures include the implementation of the Plastic Waste Management Rules (2011), which mandate the segregation, collection, and recycling of plastic waste. The government has also introduced EPR guidelines, requiring manufacturers and brand owners to take responsibility for the life cycle of their plastic products. Additionally, the Swachh Bharat Abhiyan (Clean India Mission) emphasizes reducing plastic waste and improving sanitation across the country. The government supports technological innovations and infrastructure development for efficient waste management and recycling processes.

However, the 2011 rules did not address several crucial issues, such as producer responsibility, plastic waste tracking, and industrial plastic waste management, which were aimed to be addressed through subsequent amendments between 2016 and 2024.

Despite the best intentions and multiple amendments to regulations, several factors have hindered the success of plastic waste management due to multiple issues with design and implementation. The policy design needs to be more pragmatic. For instance, recycling rate target for rigid plastic at 50% in 2025 and 80% by 2028 lack reasonable backing. Such targets need to be more realistic, backed by case studies and India's current plastic scenario and capabilities as only 45% of the plastics produced are used in packaging (which is the focus for recycling) and the remaining are used in appliances, cars, etc. with a longer product life cycle and no systematic supply chain for recycling. Further, policies need to address the high costs associated with setting up and operating recycling facilities, leading to a lack of adequate recycling and waste management facilities.

Challenges with implementation have a far-reaching impact on the realization of the intended benefits. Policies would benefit from better enforcement that needs to be driven at local levels but suffer from centralization across central and state levels. Further, insufficient monitoring and tracking of plastic waste management practices result in inadequate data to drive improvements. A lack of comprehensive national database, as envisaged in policy framing, poses a challenge for accelerating plastics circularity. Establishing such a database would enhance transparency and enable better enforcement of regulations.

Lack of industry support is another key impediment toward large-scale deployment. Several plastic recyclers have not registered on the centralized portal, hindering the government from getting a complete view on the plastic waste movement. Similarly, not all producers, importers, and brand owners (PIBOs) have registered on the respective pollution control boards, making it difficult to track their EPR compliance and enforce penalties. Large corporations have been purchasing recycling credits to comply with their EPR mandates. These credits represent a certain amount of waste collected and recycled by third parties on behalf of the companies. By buying these credits, companies can meet their EPR obligations without directly increasing their own recycling efforts and potentially limited incremental recycling.

Continued efforts are needed to achieve a circular economy for plastics and reduce plastic pollution. To effectively manage plastic waste in India, a multipronged approach is necessary:

Enhance EPR compliance

Enforce stringent EPR guidelines to ensure manufacturers and brand owners actively participate in the collection and recycling of plastic waste. Local government authorities may be empowered to provide incentives and enforce penalties for non-compliance.

Invest in the expansion and advancement of recycling technologies

Support through monetary incentives research and development in mechanical and chemical recycling technologies to improve efficiency and output quality. Support development and modernization of recycling facilities across the country, ensuring adequate coverage in both urban and rural areas.

Subsidize ecofriendly materials

Encourage manufacturers to redesign products using less plastic, opting for sustainable materials when possible. Offer subsidies or tax breaks for businesses using biodegradable or recyclable materials.

Boost public awareness and education

Launch widespread educational campaigns to raise awareness about the importance of plastic waste segregation, reduction, and recycling including school programs to integrate waste management and recycling education into school curricula to instill sustainable practices from a young age.

Enhance public infrastructure

Develop infrastructure for efficient waste collection, sorting, and processing, including the use of digital tools for better waste management.

Facilitate industry collaboration

Foster partnerships between the government, private sector, and non-governmental organizations to develop and implement effective waste management solutions.

Implement data-driven decision-making

Initiate a comprehensive data collection exercise with maintenance of databases along with real-time data on waste collection and movement in the nation. Implement robust monitoring and evaluation systems to track progress, identify challenges, and make data-driven decisions for continuous improvement.

Establish industry standards

Establish industry standards for recycled plastic content in products to create a stable market for recycled materials.

Action Agenda for Stakeholders

Catalyzing plastic circularity would require all stakeholders—the government, industry players, and society to collaborate and create a united force to shape the future.

Government

The government has taken policy steps toward achieving plastics circularity. However, as this paper illustrates, there is still much to be done to anchor India's plastics circularity efforts with an ambitious vision for a zero-plastic-waste economy. This includes setting pragmatic targets and roadmaps, creating a regulatory framework with incentives to drive change, innovation in demand creation, advancement of nascent and mature recycling technologies, driving awareness in society, and fostering a collaborative process for stakeholder engagement.

Industry

Industry participants must set ambitious waste reduction and recycling targets while monitoring and reporting progress. Investments in research and innovation across the value chain—from design to chemical recycling to traceability—are essential. Collaboration with the government and other private sector entities to drive regulatory change, ensure compliance, and create a market for recycled plastics should be top priorities.

Civic Society

Civic society plays a pivotal role in plastic waste reduction by raising awareness, advocating for sustainable practices, and holding stakeholders accountable. Community-led initiatives can promote waste segregation and recycling at the grassroots level. Individuals and communities would need to increase self and collective awareness about the environmental impact of plastic waste and the importance of responsible consumption. Civil society organizations need to collaborate with local governments and businesses to implement effective waste management systems and policies.

Conclusion

Plastics, indispensable for their versatility and economic benefits, also pose significant global challenges through unchecked waste proliferation, impacting the environment, economies, and public health. The staggering annual cost of $40 billion from plastic packaging alone underscores the urgency for robust waste management solutions.

The challenge needs to be addressed across the entire plastics value chain as discussed in this paper. Regulatory interventions are essential to drive the transformation across industry stakeholders and civic societies to create an enabling ecosystem. Progress on recycling demands collective action across industries and regions, emphasizing collaboration throughout the plastic life cycle.

The transition toward zero plastic waste would require large scale investments in R&D for recycling technologies, innovation in product designs, incentivization of recycling infrastructure, and data-led tight execution at a grassroots level. Government will need to play a pivotal role by strengthening policies to enhance producer responsibility, improve waste tracking, spread awareness, incentivize infrastructure, and catalyze market for recyclates.

While plastics remain indispensable, their management requires immediate and concerted efforts. The onus is on us to commit to innovative solutions, stringent regulations, and collaborative partnerships to achieve a sustainable circular economy.

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Confederation of Indian Industry

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