CII-ITC Centre of Excellence
for Sustainable Development

Confederation of Indian Industry
125 Years: 1895-2020

A CIRCULAR PLASTICS ECONOMY STRATEGY FOR INDIA

Lead Authors
Shourjomay Chattopadhyay and Dr Nandini Kumar
CII-ITC Centre of Excellence for Sustainable Development

Other Contributors
Varuna Chauhan, Divya Aggarwal and Jayshree Singh
CII-ITC Centre of Excellence for Sustainable Development

Acknowledgment
We would like to thank Mr George C Varughese for conducting the workshop series and initial drafts, and Mr Sachin Joshi, for his expert review and guidance.

CONTENTS

List of Figures

List of Tables

List of Abbreviations

CE	-	Circular Economy
CII	-	Confederation of Indian Industry
CPCB	-	Central Pollution Control Board
CSIR	-	Council of Scientific and Industrial Research
EOL	-	End-of-life
EPR	-	Extended Producer Responsibility
EOU	-	Export Oriented Unit
EU	-	European Union
FRP	-	Fibre-Reinforced Plastic
HDPE	-	High-Density Polyethylene
Kg	-	Kilogram
LDPE	-	Low-density polyethylene
MLP	-	Multi Layer Plastic
MoEFCC	-	Ministry of Environment, Forest and Climate Change
MSW	-	Municipal Solid Waste
NCL	-	National Chemical Laboratory
PET	-	Poly ethylene terephthalate
PHA	-	Polyhydroxyalkanoate
PLA	-	Polylactic acid
PP	-	Polypropylene
PS	-	Polystyrene
PVC	-	Polyvinyl chloride
R&D	-	Research and Development
RE	-	Resource Efficiency
SEZ	-	Special Economic Zone
SMC	-	Sheet Moulding Compound
SPCB	-	State Pollution Control Boards
TPD	-	Tonnes per day
ULB	-	Urban Local Body
UNEP	-	United Nations Environment Programme
WWF	-	World Wide Fund for Nature

FOREWORD

The management of plastics and plastic waste, has become a huge challenge for India and, indeed, the entire world. Though there are a large number of interventions being seen across the country, a discernible impact is not visible. Overall, a cohesive picture with respect to management of plastics is missing.

To help understand the different parts of the picture and put together a high-level strategy, the Confederation of Indian Industry (CII) conducted a series of workshops across the country in late 2019. Extensive discussions with a variety of stakeholders (including business, government, civil society organizations, recyclers) during these workshops shed light on aspects of plastic waste management, such as solutions and recycling technology available.

It is imperative for India to leapfrog ahead in a search for solutions both, upstream and downstream of the user, simultaneously; this would help slow down the inflow of plastic while increasing the efficiency of management strategies downstream. Such measures supported by appropriate policies would facilitate the transition to a circular economy for plastics in India. The report draws up four strategies for bringing this about.

Recognizing the complexity and magnitude of the social, economic, technological and environmental dimensions of plastic waste management, in 2018, the Confederation of Indian Industry (CII), United Nations Environment Programme (UNEP) and WWF India, joined hands to form the Un-plastic Collective (UPC). With a vision to reduce the externalities of plastic, UPC aims to provide a platform for all stakeholders to work towards better management of plastics.

CII is grateful to all stakeholders for their participation in the workshops, and for the rich discussions which have led to this report. Uptake and adoption of the strategies described in this report will help manage plastic-use and waste generation more efficiently while retaining its value as a material, in India.

Chandrajit Banerjee

Director General

Confederation of Indian Industry

EXECUTIVE SUMMARY

The benefits of plastic resins are well-recognized and indisputable, but their persistence in all kinds of ecosystems and urban areas the world over, has left all countries grappling with the problem of managing plastic waste.

Recent studies suggest that since 1950 when plastics, as we know them today, first came into common use, only 9% of plastic used has been adequately recycled, with close to half having ended up in landfills or dumped in the environment.[1] It is thought that every year, around 8 million metric tonnes of plastic waste ends up in the oceans, mostly brought in by the world's rivers. Plastic packaging and some other items of single use make up the largest share in the waste stream.

Many countries have implemented legislations or bans in an attempt to control pollution by plastics: India is one such country, with large amounts of waste accumulating in landfills owing to inefficient collection. Although policy initiatives exist, their loose implementation is a matter of concern.

Uncollected plastic waste represents untapped economic value and a recognition of this has led to countries such as the European Union adopting circular economy practices along the entire value chain. Circular economy practices, while not new, can be aided and enhanced in the current times by using digital and information technologies, new business models and better designed materials.

In India, waste segregation, a prerequisite for improved post-use strategies is imperfectly and inconsistently practiced. India can leap-frog to a plastic strategy that is based on a circular economy, and not limited to waste management; the lesson can be learned from the experience of advanced countries where a well-developed and implemented collecting, sorting (for recycling) waste management system over the last three or four decades did not succeed in addressing the plastic menace.

In leap-frogging to a circular economy for plastics, where strategies to reduce-reuse begin to be applied high up in the value chain, India will benefit by (1) decreased quantities of waste throughout the value chain and especially at end-of-life (by 'turning off the tap'), and, (2) unlocking the economic value of disposed plastic material. Gains will result from avoiding the cost of externalities due to environmental impacts; landfill siting and maintenance costs; the costs of scaling up collection, sorting, processing/recycling of ever-increasing quantities of waste. It will be possible to better manage plastics relatively quickly.

The four strategies below, proposed by the CII-ITC Centre of Excellence for Sustainable Development are based on the notion that municipal solid waste is the crucial link between portions of the product life cycle upstream and downstream of the consumer, whether that consumer is industry or in the domestic sector: plastics end up in the municipal waste stream.

1. Frame a comprehensive policy for circularity of plastics, holistically addressing the entire value chain. This policy should include among other things, setting of standards to standardize composition of packaging material and amount of recycled content in plastics, avenues for research into new types of plastics (those not dependent on fossil fuel feedstock), setting of time-bound targets and ways to incentivize new technologies.
2. Availability of sound, viable and scalable technologies for the Indian context forms the backbone for management both downstream and upstream of the consumer. Downstream, technology for waste collection, sorting, and cleaning for recycling plastics should be identified. Upstream, there is a need to develop technological solutions for chemical recycling (upcycling: conversion of polymers to monomers) and design for tomorrow's polymers, incorporating features such as simplicity, standardization, recoverability, disassembly or reassembly, or degradation at the appropriate time, place, and rate and to the appropriate end products.[2]
3. Consistent, focused messaging to the consumer, whose role in a circular economy for plastics is important at several points where choice can be exercised, is needed. The messages are, to buy responsibly (avoiding use of unnecessary plastics), and, at the end-of-life stage, be responsible and practice segregating waste at household level.
4. Strict enforcement of law with penalties/incentives for consumers, and authorities made accountable. The successful working of municipalities and the Municipal Solid Waste (MSW) management system plays a key role in the overall circular economy strategy for plastics because plastics products/packaging end up as MSW. Therefore, ensuring that segregation takes place at the household level is the key to a successful circular economy-based strategy for plastics.

INTRODUCTION

The benefits of the material plastic are aplenty. The production of plastics since the 1950s when they were first invented, has grown exponentially. However, it is evident that the capacity to manage waste generated due to the prolific use of plastics has been limited: only 21% (9% recycled and 12% incinerated) of the plastics ever produced have been managed.[1] About 10 million tonnes of synthetic polymer material enters the ocean each year.

Most familiar plastic products are made from chemicals derived from non-renewable crude oil: several of these chemicals are hazardous and may be released during the production, use and disposal of the plastic product.[3] Some of these compounds are added during the manufacture of different types of plastics, while others adsorb contaminants such as pesticides from their surroundings (seawater, for example) after they are discarded, especially in the form of microplastics. Experimental data have also shown a transfer of contaminants from plastic to organisms.[4] Thus the eventual degradation of plastics into smaller and smaller fragments is of concern for more than one reason.

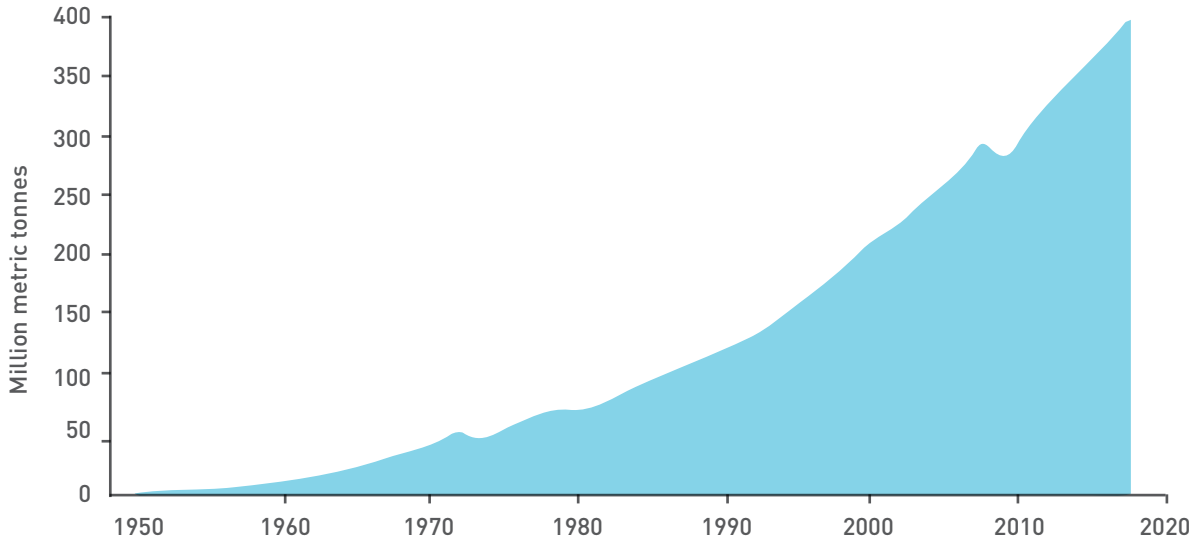


Figure 1: Annual global polymer resin and fibre production in million metric tonnes from 1950 to 2015[5]

Plastic production has risen by an average of 9% per year since 1950, a higher rate of sustained growth than in any other industry. About 350 million metric tonnes are produced globally today and low recycling rates have led to a buildup of plastic waste in the environment, some of which will persist for hundreds of years.

Historically, plastics were mostly produced in Europe and the United States, but current trends are different, with China now the leading producer. It was responsible for 28% of global production in 2015; the rest of Asia, including Japan, produces 21%: together nearly half the global production in 2015 came from Asia.[6] In India, the plastics industry has grown at a Compounded Annual Growth Rate (CAGR) of about 8%, with polyethylene (43%) and polypropylene (24%) being the resins associated with the largest demand. Plastics are consumed in the automobile and agricultural sectors, and in packaging and electronic appliances. India imports plastics to meet domestic demand; nearly 37% of polymer consumption is met through imports.[7] Major imports are of PE, PVC and engineering plastics from Saudi Arabia, Qatar, UAE, Korea, USA, Singapore, Thailand, Germany, Spain and Malaysia. A few plastic materials are exported to international markets in China, Egypt, UAE, Turkey, Vietnam, and Indonesia.

In terms of management of waste plastic via recycling, although technologies and adoption have improved over the years, recycling rates remain overall, low. The method used to manage plastics depends on the type of plastic in question.

Globally, about 15% of plastic waste is recycled, a slightly greater percentage is incinerated, and the rest is discarded. Polyester fibres are typically not included in the discussion, thus excluding an important source of waste.[2]

Studies suggest that about 50% of the plastic intended for recycling worldwide is traded overseas; the percentage for California, in the United States, as an example is higher still, at about 60%. With

the banning of waste imports by China in 2018 (from January 1), many recycling equations have been upended. Cities in the United States that earned revenue from their recycling programmes now have to pay for the disposal of material instead. At the beginning of 2017, a bale of low-grade mixed plastics could fetch $20 per tonne in California, but a year later it cost $10 to dispose of it.[8] Plastic waste meant for recycling is now reaching countries in south and southeast Asia which do not have the infrastructure for efficient waste management.

India's recycling rates are about 60% for all plastics (originating from industry and urban waste), and reported to be 90% for PET. However, recycling is not systematized, infrastructure not available at the scale needed, segregation is not practiced, and most of the recycling, is downcycling. Regulation does exist but weak implementation and enforcement have led to a situation where plastic litter is widespread in rural and urban areas; in the latter, flooding during the monsoons has been attributed to drains and sewers choked by ill-managed plastic waste (workshop discussions).

A significant deterrent in the effort to promote recycling is the price of virgin plastic (often of a higher quality than the pellets available after recycling). A dealer in plastic waste might spend $150 to buy a tonne of plastic scrap from a US recycler: once shipped abroad, sold to a processor, turned into pellets and then again shipped to a manufacturer, the seller might ask as much as $800 per tonne. Yet the cost of similar virgin plastic, which is often higher quality, is just $900 to $1,000 a tonne.[9]

At present, the world recycling market is one without rules or regulation. The 2019 Basel Convention is a beginning in this direction, with an international agreement to control transboundary movements of hazardous wastes and their disposal. The agreement also recognizes plastics as a hazardous material, the trade of which needs to be regulated.

In much of the developed world of Western Europe and USA, the adoption of segregation and recycling has been fairly good. However, in the European Union (EU), despite high rates of segregation and collection, waste has been exported because of a lack of sufficient recycling capacity (the EU exported 1,50,000 tonnes of plastic waste a month in 2019).

The prospect of increased incineration and landfilling of plastic waste within the EU, after China banned imports and EU's signing of the Basel Convention, led to the fast-tracking of steps to better manage EU's plastics and plastic waste.

The European strategy for Plastics in the Circular Economy of 2018, and new and more ambitious targets for plastic recycling included in the Waste Directives of 2018, are measures intended to enable more environmentally and economically sustainable plastic waste management in the EU. The Single Use Plastics Directive, which bans and restricts the use of various types of single-use plastics - knives, forks and straws, for example, from 2021 onwards, marks the beginning of a transition towards making plastics more circular.[10]

Uncollected plastic waste represents untapped economic value. Circular economy practices, while not new, can be aided and enhanced in the current times by using digital and information technologies, new business models and better designed materials. Transitioning to circularity is the only comprehensive approach to managing plastics in an economic, social and ecological system.

In India, waste segregation, a prerequisite for improved post-use strategies is imperfectly and inconsistently practiced. India can leap-frog to a plastic strategy that is based on a circular economy, and not limited to waste management; the lesson can be learned from the experience of advanced countries where a well-developed and implemented collecting, sorting (for recycling) waste management system over the last three or four decades did not succeed in tackling plastic waste.

In leap-frogging to a circular economy for plastics, where strategies to reduce-reuse begin to be applied high up in the value chain, India will benefit by (1) decreased quantities of waste throughout the value chain and especially at end-of-life (by 'turning off the tap'), and, (2) unlocking the economic value of disposed plastic material.

For India, adoption of circular economy principles will help avoid the cost of externalities due to environmental impacts; landfill siting and maintenance costs; the costs of scaling up collection, sorting, processing/recycling of ever-increasing quantities of waste at all administrative levels.

In terms of supporting requirements, the strict enforcement of penalties for non-segregated waste; high levels of accountability; consistent public awareness; identification and development of viable technologies, for the reduce-reuse-recycle triad, would be essential. Alongside, research into new materials, substitutes for plastic, and less polluting plastics would need to be stepped up.

Policies must specify targets for different aspects of the 3Rs, even at a sectoral level, and define how financial support can be made available, through instruments such as subsidies, incentives. The entire system must work effectively, not just the portions of the value chain or geographic location driven by motivated individuals.

For India, adoption of circular economy principles will help avoid the cost of externalities due to environmental impacts; landfill siting and maintenance costs; the costs of scaling up collection, sorting, processing/recycling of ever-increasing quantities of waste at all administrative levels.

THE PLASTICS CONTEXT: GLOBAL AND INDIAN

Despite their useful, desirable properties and presence in the lives of virtually all people on earth, plastics present a significant challenge in the waste stream, that is, after use. Plastics are used extensively as packaging material and in industrial, medical, agricultural, scientific and domestic applications, providing substitutes for traditional resources such as cotton, wood, metal, cement/concrete.

Internationally, issues around plastic waste and management have increasingly captured the attention of the public, government and businesses. Since plastics were first mass produced about 70 years ago, their production rate has risen twenty-fold and is expected to double over the next two decades, from the present rate.[11] Globally, 8.3 billion tonnes of virgin plastic have been produced to date. Estimates suggest that every year, between 4.8 and 12.7 million tonnes of mismanaged land-based plastic waste enters the oceans.[12] Unfortunately, the economic value of 95% of packaging material is lost soon after its first use.[11]

The scale and magnitude of the problem

Global

It is estimated that 2,500 million tonnes of plastics, or 30% of all plastics ever produced, are currently in use.[12] Between 1950 and 2015, cumulative waste generation of primary and secondary (recycled) plastics waste amounted to 6,300 million tonnes. Of this, approximately 800 million tonnes (12%) of plastics have been incinerated and 600 million tonnes (9%) have been recycled, only 10% of which have been recycled more than once. Around 4,900 million tonnes, 60% of all plastics ever produced, were discarded and are accumulating in landfills or in the natural environment. The rest has been incinerated or has not been accounted for.

Annual global plastic production has increased from 2 to 380 million tonnes since 1950 and is projected to double by 2035 and almost quadruple by 2050: this growth will be driven largely by the middle class in China and India.[13]

How much plastic is there?

Figure 2: Total global plastics production till date

More than three-fifth of the total plastics production and consumption are in China, the EU and USA (refer to Figure 3).[5] In the EU, Norway and Switzerland, the total demand for plastic in 2017, amounted to about 51 million tonnes, divided among the packaging sector (39.7 %), the building and construction sector (19.8 %), the automotive sector (10.1 %), the electrical and electronics sector (6.2 %), the households, leisure and sports sector (4.1 %), the agriculture sector (3.4 %) and other sectors (16.7 %).[14]

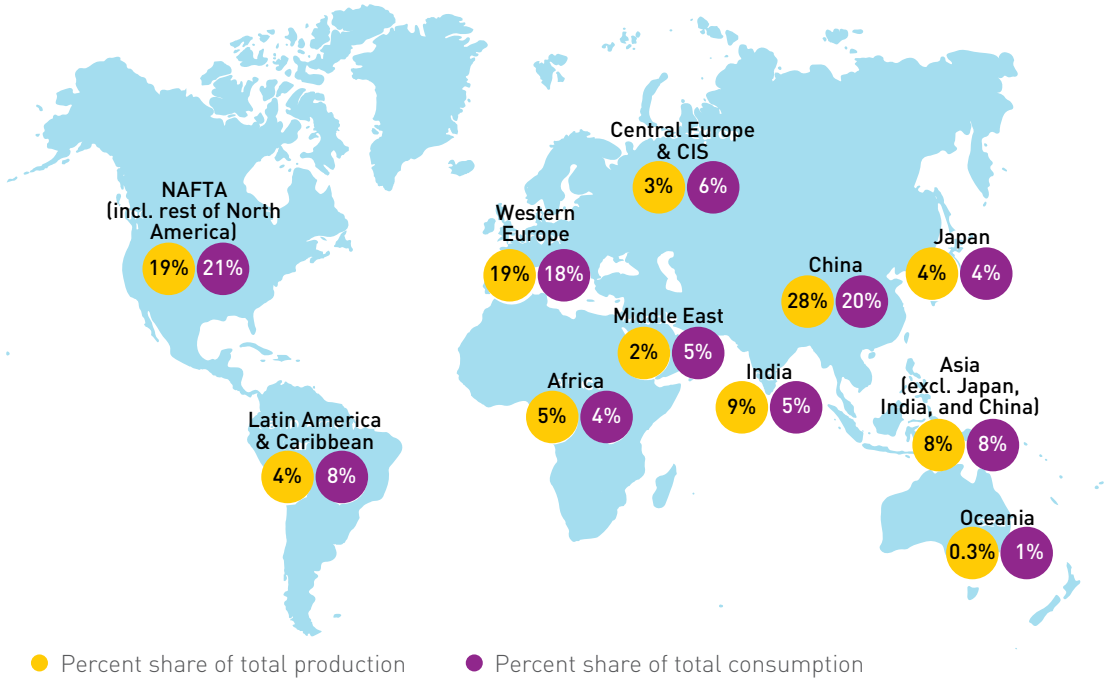


Figure 3: Share of total plastics production and consumption for the different world regions[5]

Indian

The production of plastic in India increased from 1,591 million metric tonnes in 2014-15 to 1,719 million metric tonnes in 2017-18.[15] While there is a paucity of reliable data on plastic consumption in India, there are some studies such as the one carried out by the Central Pollution Control Board (CPCB) in 2015 titled, Assessment and characterization of plastic waste generation in 60 Indian cities. The report estimated that in 2010-11, 3,501 tonnes of plastic waste were generated each day[16]; plastics constitute less than 10% of the MSW in major Indian cities.[17] According to a September 2017 report by CPCB that extrapolated the data from the 2015 report for the entire country, India generates around 25,940 tonnes of plastic waste a day (9.4 million tonnes per annum).[18] Majority of the waste is generated in five metropolitan cities: Delhi (690 TPD), Chennai (429 TPD), Kolkata (425 TPD), Mumbai (408 TPD) and Hyderabad (200 TPD).

How much plastic does India consume annually?

India consumes **16.5 MT** of plastics annually

Out of this **43%** is used for packaging and is single-use in nature

Figure 4: Scale of plastic-use in India[19]

Of the plastic waste generated each day, 94% is composed of thermoplastics such as PET (polyethylene terephthalate) and PVC, (polyvinyl chloride), both of which are recyclable.[18] The remainder, about 6%, is made up of the thermoset class of plastics and other classes such as sheet moulding compound (SMC), fibre-reinforced plastic (FRP) and multi-layer thermocol, none of which can be recycled, reset or reshaped.

India's urban population is approximately 377 million, spread across 7,935 towns in 640 districts.[20] It is in these (approximately 8,000) urban settlements where the consumption of plastic is high and hence the subsequent problem of mis-management of plastics is typically visible. Within these 8,000 settlements, there are 53 urban agglomerations that have a population greater than one million.[21]

Status of recycling

Global

Recycling as a strategy to manage plastic waste is under-practiced: rates of recycling vary with country and depend on regulation. Countries such as the EU and Japan have regulations in place to encourage recycling. Despite this, recycling rates in the EU are still significantly under 50% indicating a large potential for recycling particularly, packaging.

Awareness of the challenge of managing plastic waste has grown fairly recently which is why the EU still lacks capacity to reuse, recycle and recover all of its plastic waste, finding it more economical to export that waste. The European Union is said to be the world's biggest exporter of plastic waste, while the U.S. is the largest single-country source.[22]

In early 2019, the EU exported around 1,50,000 tonnes of plastic waste per month. This figure was about twice as high in 2015 and 2016 - up to 3,00,000 tonnes monthly - when exports went to China and Hong Kong primarily. Import restrictions in these countries are the reason for the decrease and shift in exports of plastic waste to other countries in Asia (see Figure 5).[10]

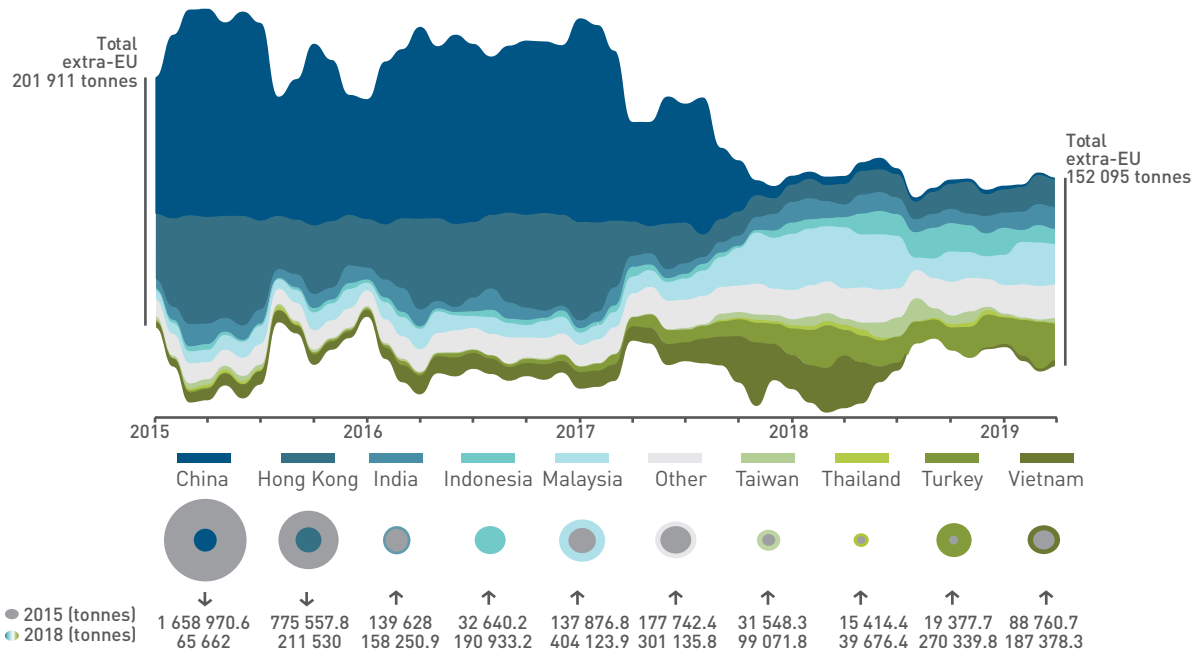


Figure 5: Extra-EU-28 plastic waste trade by receiving country

Plastic recycling rates vary significantly across different countries, waste streams and polymer types. Recycling rates for polyethylene terephthalate (PET) and high-density polyethylene (HDPE) commonly exceed 10%, while those for polystyrene (PS) and polypropylene (PP) are closer to zero. Recycling rates in the European Union average 30%, and are thought to be considerably higher in some EU Member States. In the United States, of the plastic component of MSW, 8% of plastics were recycled in 2017, while about 16% of plastic went into energy recovery; 19% of plastics were landfilled.[23] Recycling rates in other high-income countries are typically in the order of 10% (refer to Figure 6). Recycling rates in low-to-middle-income countries are largely unknown, but may be significant in situations where there is a well-established and effective informal sector. Data indicates that plastics recycling rates may be approaching 20% - 40% in some developing-country cities.[24]

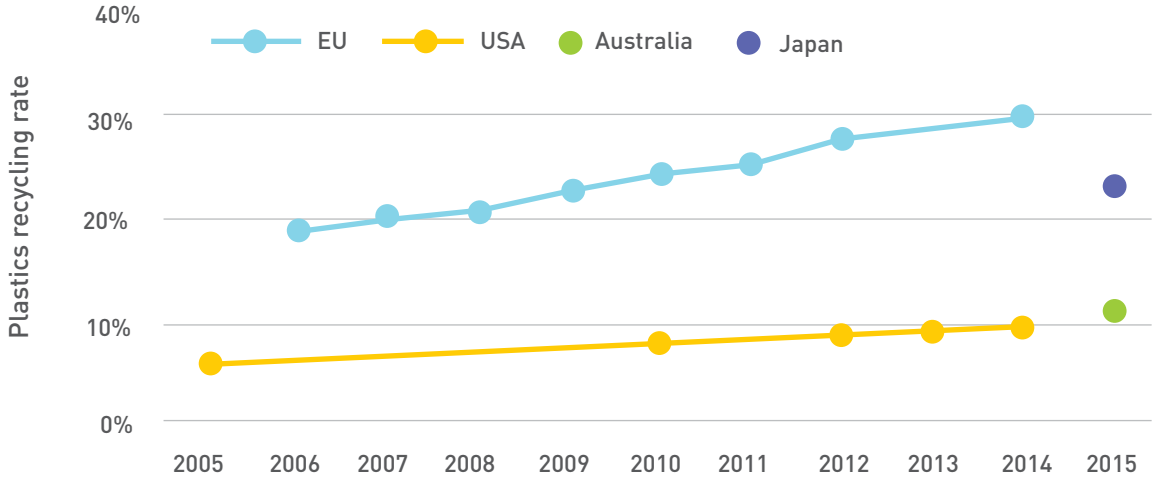


Figure 6: Recycling rates in selected high-income countries[24]

Indian

Little segregation is carried out at the individual household level in India: the recycling system operates through an informal chain of workers, from ragpickers who segregate, to dealers who sell the plastic to recyclers.

It is reported that the collection and recycling rate of plastics in India is 60%, (reported from both "industry and urban waste streams")[25] and that 80% of that plastic is recyclable (LDPE, PET, PVC, HDPE, PP, PS). The recycling rate for PET resin (which makes up 10% of the plastic in MSW) is estimated to be 90%: 65% is recycled at registered facilities, 15% in the unorganized sector and 10% is reused at homes, states a yearlong study by scientists from Council of Scientific and Industrial Research (CSIR) and National Chemical Laboratory (NCL). The rest ends up in landfills. The recycling rate for PET in Japan is 72.1%, 48.3% in Europe and 31% in the US.[26] However, most plastic is downcycled into products such as apparel, luggage, shoes, mats.[27]

The per capita consumption of plastic in India is 11 kg.[19] By contrast the corresponding figures for the average consumption, globally, in China, and United States of America are 2.5, 3.5 and 10 times higher respectively. Even though the per capita consumption is small compared to the global average, India's population (and its future growth) make the issue of management of plastic important to tackle. While the recycling rates of plastics in India are higher than the global average, the quantum of plastics reaching end-of-life is enormous. Also, the quality of recycling of the share that is managed is poor, that is, products are downcycled to lower-grade applications.

At present the government of India has no new scheme or fund allocation for recycling of plastic although local bodies are encouraged to use plastic waste for road construction, co-process in cement kilns and convert it into liquid oil.[15]

Regulations on plastic

Global

The number of new national regulations on plastic bags and Styrofoam has grown over the years, especially since 2014 (see Figure 7). This increase is partially due to a European Union (EU) directive in the same time frame which encouraged member states to set reduction targets or adopt economic instruments to achieve a sustained reduction of 'lightweight' carrier bags.[28]

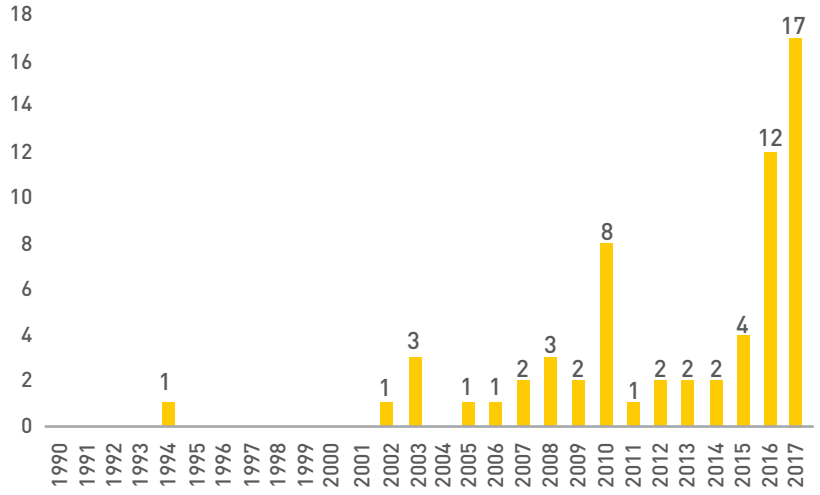


Figure 7: Estimated number of new regulations on single-use plastics entering into force at the national level worldwide

The Basel Convention, which is an international agreement to control transboundary movements of hazardous wastes and their disposal also recognizes plastics as a hazardous material, the trade of which needs to be regulated. With the amendment to the Basel Convention in 2019, to include plastics in a legally binding framework, all exporting countries such as the European Union and the United States, Canada and Australia, which had been exporting plastic waste are now required to obtain consent from the less wealthy countries (Vietnam, Malaysia, India, Indonesia, for example) receiving hazardous unrecyclable, mixed or contaminated plastic waste for recycling. The amendment is therefore expected to have a beneficial effect on humans and the environment in the country of import.[29]

The EU has taken steps to better manage its plastics and plastic waste. These include the European strategy for plastics in the circular economy and new and more ambitious targets for plastic recycling included in the waste directives of 2018. The Single Use Plastic Directive, which bans and restricts the use of various types of single-use plastics - e.g. knives, forks and straws - from 2021 onwards, marks the beginning of a transition towards making plastics more circular.[30] Jurisdictions across the United States have instituted bans and fees on various types of plastics, such as bags, carryout containers, polystyrene (Styrofoam), and straws. States have also enacted restrictions preventing future plastic bans. The United States is one of the only developed countries without Extended Producer Responsibility (EPR) bills addressing packaging.

Germany enacted a 'producer pays' law in 1991, and manufacturers have to collect, sort, and recycle packaging after consumers finish with it; similar laws were expanded to the whole European Union in 1994.

China, Japan and South Korea have national 'top down' strategies for enabling the circular economy. In 2008, China approved its circular economy promotion law to 'reduce, reuse and recycle' municipal waste and industrial by-products. The government has invested billions of RMB in demonstration projects and tax incentives.[31] In 2018, The Korea Ministry of Environment developed the 'Comprehensive Measures for Plastic Waste Recycling Management' to reduce plastic waste generation by 50% by 2030, and increase the recycling and recovery rate to 70% by 2030. In Japan, 'Resource circulation strategy for plastics' was developed to reduce the use of single-use plastics, and promote the development and use of substitutes for petroleum-based plastics in 2018.[32] Dozens of other countries, including Brazil, Estonia, Japan, Turkey, and South Africa now have EPR laws for packaging.[33]

Indian

In 2000, waste management rules were framed for municipal solid waste and in 2011, for plastics. In 2019, the Government of India (GoI) banned the import of solid plastic waste into the country, including in Special Economic Zones (SEZ) and by Export Oriented Units (EOU).[34]

The regulatory framework to manage plastic waste is well developed. It is governed by the Plastic Waste Management (Amendment) Rules, 2018, notified by the Ministry of Environment, Forest and Climate Change (MoEFCC). State-level bodies, the State Pollution Control Boards, either implement the Central rules as such or make changes to the Central rules and then implement those in a state. At the last level, Urban Local Bodies (ULBs) are the implementers.

The Rules emphasize banning plastics below 50 microns, phasing out use of multilayered packaging and introducing EPR for producers, importers and brand owners to ensure environmentally sound management of plastic products until the end of their lives. While rules and regulations are well framed, their poor enforcement and implementation is very often caused by:

- Overlap of jurisdiction: The plethora of formal institutions and informal stakeholders leads to overlapping jurisdictions, varying responsibilities and varying levels of on-ground success in management of wastes. The implementation of the EPR as part of the Plastic Waste Management Rules is a case in point where companies are trapped in a web of mismatched directives, including those related to jurisdiction of the CPCB, SPCBs, and local municipalities.
- Lack of institutional capacity: Grossly inadequate institutional capacity, both to implement and monitor at the last mile, especially among ULBs municipalities, gram panchayats, affects implementation. Last-mile capacity of State Pollution Control Boards (SPCBs) in terms of technical staff, skills and capacity, infrastructure/facilities and finances affect the enforcement.

The recently-framed draft National Resource Efficiency Policy (2019) lays out the basic contours for Resource Efficiency (RE) in the plastics packaging sector in India.[35] This policy, which can be leveraged to strengthen the Waste Management Rules, aims to establish the following targets in this regard:

- 100% recycling and reuse rate for PET plastic by 2025;
- 100% recycling of PET plastic and 75% recycling and reuse rate of other plastic packaging materials by 2030;
- Ban on disposal of recyclable waste (plastics, metals, glass, paper, cardboard and biodegradable waste) to landfills by 2025.

A CIRCULAR ECONOMY FOR PLASTICS IN INDIA

Like many other materials, the flow of plastics is largely linear. Data from 2013 suggests that globally, an estimated 72% of plastics packaging is not recovered at all: 40% is landfilled, and 32% leaks out of the collection system - that is, either it is not collected at all, or it is collected but then illegally dumped or mismanaged (Refer to Figure 8).[11] The data suggests the significant opportunity to increase circularity for plastics.

In the current Indian context, and as described in the preceding chapters, management of plastic waste centers on end-of-pipe management focusing on recycling.

Waste is not collected and segregated at source, on any meaningful scale, and overall compliance with waste management rules is loose. Recycling, as a means to manage the large quantities of waste generated cannot be the sole prescription in the absence of infrastructure/technology for collection, sorting, recycling commensurate with the scale of the challenge.

Overall, a circular approach will reduce plastic waste of a low value and high environmental impact, while improving the quality of plastic waste. Slowing the rate of inflow of plastics while simultaneously improving end-of-life management will help get a grip on the quantities of waste accumulated.

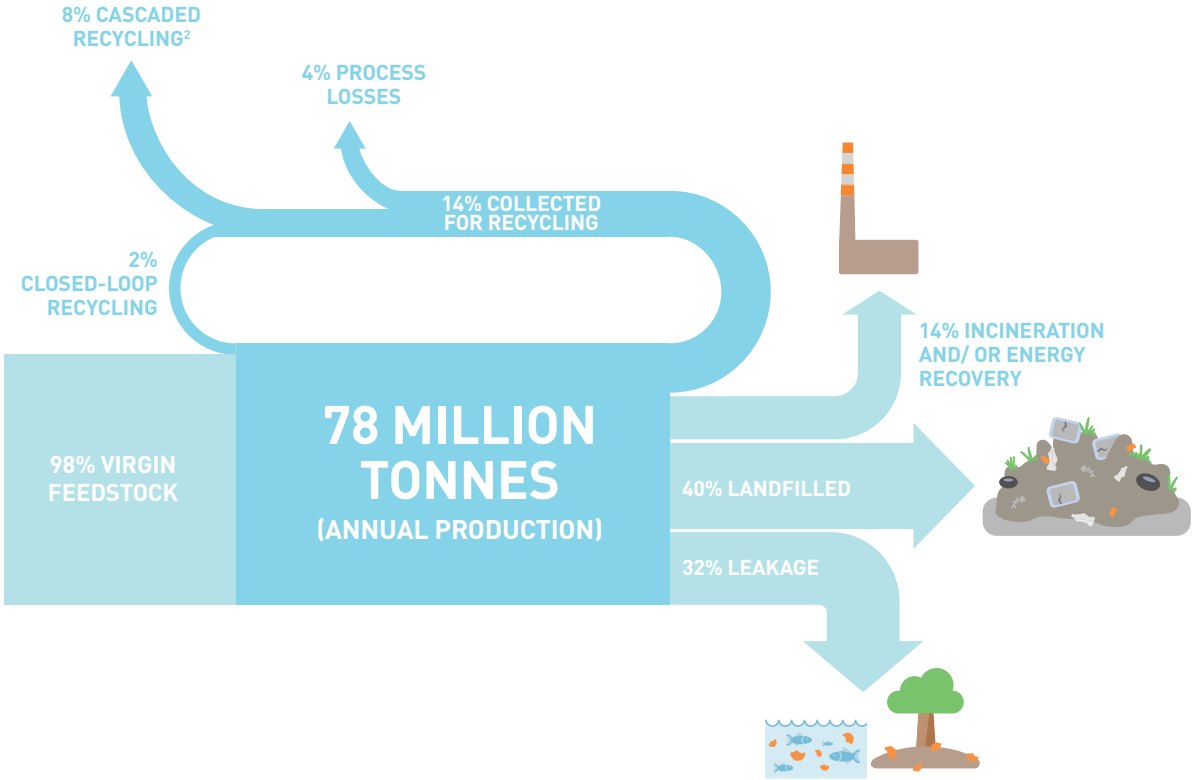


Figure 8: Global flow of plastics packaging in 2013[11]

Circular economy solutions

For plastics, circular solutions include: producing plastics from alternative non-fossil fuel feedstocks; using plastic wastes as a resource; redesigning plastic manufacturing processes and products to enhance longevity, reusability and waste prevention; collaboration between businesses and consumers to encourage recycling and increase the value of plastic products; encouraging sustainable business models which promote plastic products as services, and encourage sharing and leasing; developing robust information platforms to aid circular solutions; and adopting fiscal and regulatory measures to support the circular economy.

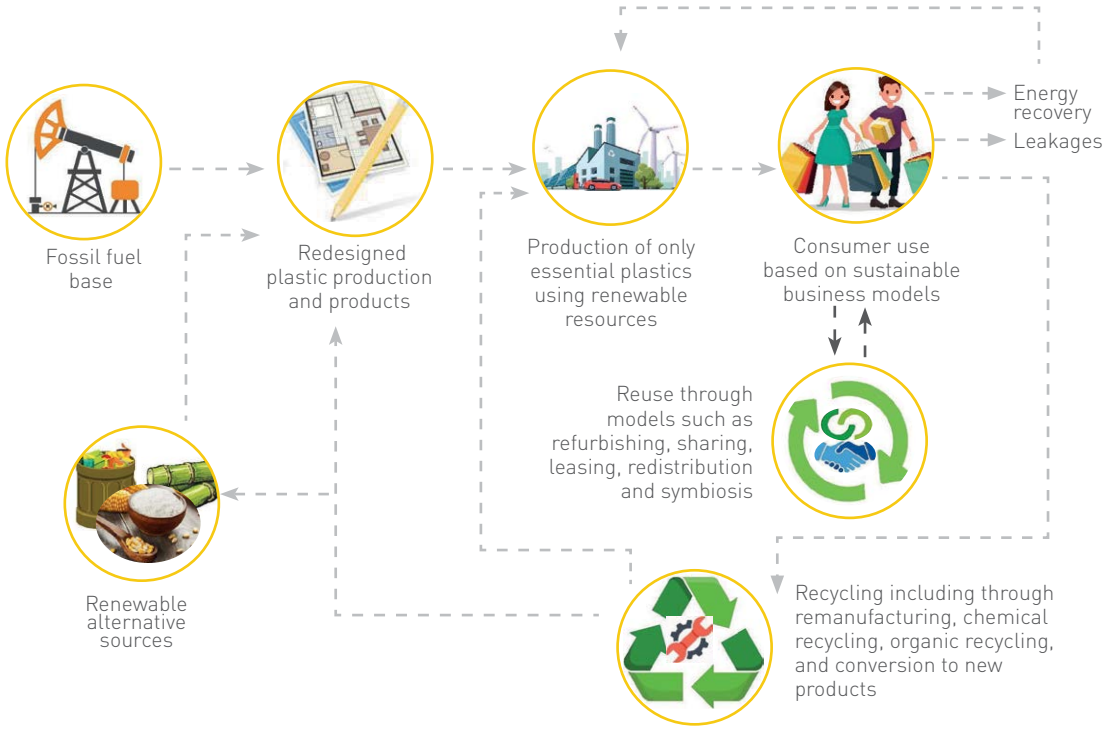


Figure 9: Outline of a circular economy for plastics[6]

The basic waste management 3Rs hierarchy can be applied to plastics to manage waste: in order of preference these are

i. Reduce: reducing the consumption of plastic to a minimum;

ii. Reuse: keeping plastic in use for as long as possible

iii. Recycle: putting the plastic material back in the production cycle.

With these in place, manufacturing will depend less and less on virgin resources and move to a situation where remanufacture, refurbishment and repair will dominate; this will necessitate involvement of people with a range of skills and abilities. The ways in which this can be achieved in a circular economy are:

- **Design for the future**
- **Plastic waste as a resource**
- **Alternative feedstock**
- **Increase collaboration**
- **Robust information platforms**
- **Rethink business models**
- **Policy instruments**

Design for the future

At the design stage, there is a need to examine all ways to

i. reduce the consumption of plastics per product without affecting the quality of application.

ii. eliminate the need for plastics in certain cases based on its application.

iii. support reuse of the product.

Redesigning would encompass approaches such as cleaner production, ease of separation, segregation, sorting, repair, recycling (especially upcycling). The incorporation of toxic substances, unnecessary dyes, packaging and so on, needs to be minimized or eliminated at the very beginning, during product or process/delivery design. Refillable beverage bottles, bulk delivery of personal care products are some examples of redesigning/rethinking product delivery.

Focusing even further, designing tomorrow's polymers, for at least one of the following characteristics: simplicity, standardization, recoverability, upgrading, disassembly or reassembly, efficient collection and separation, or degradation at the appropriate time, place, and rate and to the appropriate end products is required. For some products such as shoes, designing for degradability is particularly relevant because normal use makes dissipation into the environment unavoidable.[2]

Use waste as resource

Recycling can be chemical or mechanical (with biological processes also being developed) depending on the type of plastic; in general, improvements in the quality, uptake and economics of recycling should be complemented by efforts upstream (in terms of design) and downstream in terms of collection, sorting and reprocessing. Recycling provides a way to reduce the demand for virgin material upstream which can dramatically reduce greenhouse gas emissions, with five barrels of oil saved for every metric tonne of plastic recycled.[37]

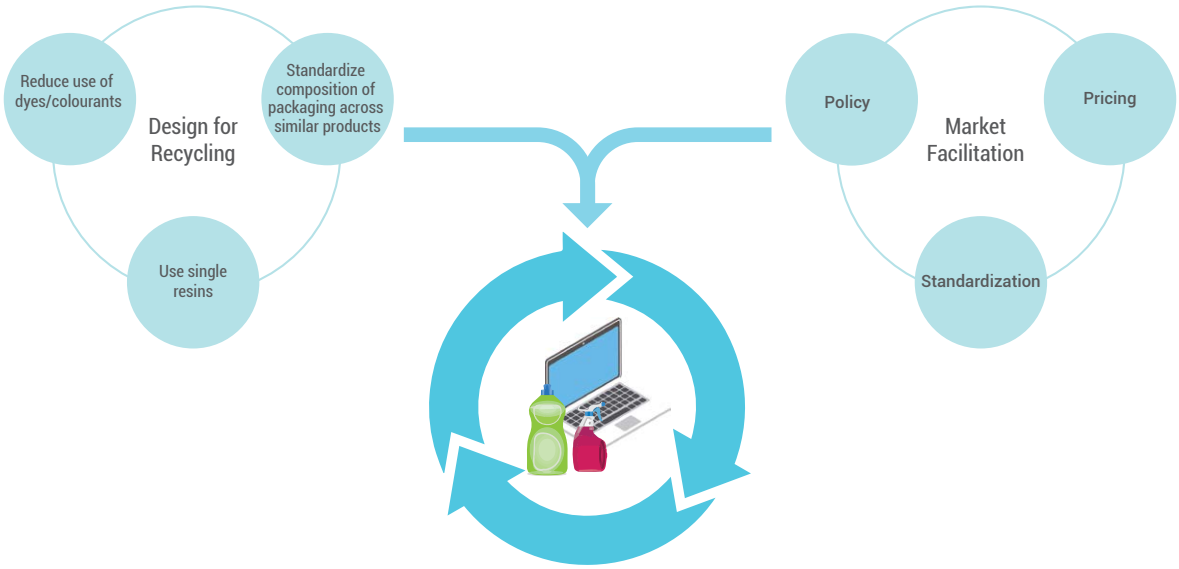


Figure 10: Factors facilitating the recycling of plastic products

Most recycling in India is downcycling: upcycling is the preferred management strategy, but rarely practiced, with the generic term 'recycling' being used to refer to all kinds of material recovery/processing (definitions in footnote 1).

Some of the technical challenges to be addressed upstream and associated with recycling include the multitude of combinations of resin in use, especially for packaging, by different businesses. This high degree of customization is a hindrance to collection, separation and reuse of material. Other challenges are, contamination of recyclable polymers with dyes, flame retardants, additives, and so on. These, together result in a dominance of downcycling into products of lower value, rather than upcycling. Efforts must focus therefore on maintaining the purity of the plastic stream: its cleaning, separation from non-plastic materials, and sorting according to polymer-type. Technology for separation is available and can be based on optical, density, and electrostatic properties.[2]

Remanufacturing of polymers into new value products is prevalent in India as elsewhere and examples include bricks and composites, in road construction, for furniture, clothes and footwear. Where recycling is not possible, conversion of polymers to liquid fuels can be examined. As a last resort, plastic can be burnt in cement kilns or in energy recovery units, via incineration.

Research into alternative feedstocks

The raw material for making plastics is derived from fossil feedstocks, therefore greenhouse gas emissions are associated with their manufacture, as well as end-of-life stages, if burnt.

Alternative feedstocks, including those based on biomass (sustainability impacts on land and water use, biodiversity, indirect greenhouse gas emissions and competition with food production are concerns) are part of the larger bioeconomy concept. Bioplastics include plastics whose constituents are derived from biofeedstock, as

A report from the Energy Transitions Commission (2018),[38] describes 'downcycling' or mechanical recycling: "Most of the recycling volumes are currently treated via mechanical recycling which entails cleaning, re-melting and repurposing plastic products which have reached end of current life, with each polymer type retaining its polymer structure through the recycling process. Mechanical recycling can only be applied to thermoplastics and not to thermosets. Mixed waste flows of several different plastic types, the use of multiple additives such as colorants, stabilizers and fire retardants, and the contamination of plastic packaging by the substances enclosed, make it often difficult to achieve 'closed-loop' recycling (in which plastic materials can be re-used in their original form; e.g. old PET bottles becoming new high-quality PET bottles). Much recycling instead entails 'open-loop' down-cycling, with, for instance PET bottles turned into polyester fibres for clothes or carpets, or multiple clear plastics ending life as black flowerpots, which cannot be recycled further."

In 'upcycling' or chemical recycling, end-of-use plastics can be broken down into smaller constituent molecules (monomers or lighter hydrocarbons) from which it is possible to produce either fuel or any of the different plastic monomers and then polymers. This can be achieved by a number of different thermal, catalytic or other routes, with different routes being suitable for the production of either fuel or new polymers.'

Chemical recycling is applicable to both kinds of plastic, thermosets and thermoplastics, and is useful even if the waste received is contaminated or contains different kinds of polymers. Despite its versatility, high costs are likely to limit its universal application.

well as plastics made from polylactic acid (PLA) or polyhydroxyalkanoate (PHA) are an alternative that can be explored to reduce dependence on fossil fuels. Products and packaging can be designed to incorporate bioplastics.

Other feedstocks include greenhouse gas such as CO_2 and methane, bio-based sources such as oils, starch, and cellulose, as well as naturally occurring biopolymers, sewage sludge and food products.[39] Some plastics can be produced using benign and biodegradable materials. Eco-friendly alternative flame retardants have been developed which could eliminate the use of some hazardous chemicals in plastics manufacture.[6]

Increase collaboration

Partnerships between plastics industry and converters, brand owners, waste-management companies and government can help identify the infrastructure necessary to solve the plastic-waste crisis. The concepts of industrial symbiosis (using by-products from one industry as a raw material for another) can be explored for reusing plastic pallets, for example. Models promoting resource exchange between households in urban areas and industry can

help reduce plastic waste. There is a need to promote industry-research-academic collaborations especially ones that would support cross-disciplinary work and exploring synergies among mechanical, chemical, and biologic recycling methods.

Use robust information platforms

For all aspects of a circular economy there is a need to reimagine the role of information platforms and digital technology. Waste exchanges via digital platforms can make it economical for users to search for what they need, and create lower recovery and transportation costs for those generating and collecting the waste.

Digital applications can, for instance, facilitate handing over empty plastic bottles at recycling centers and help bring about changes in people's behaviour (such as by guiding waste-sorting). Technology-based processes can help track the quality and volume of material to leverage existing informal infrastructure in building an efficient waste collection and management system.

Rethink business models

Circular business models need to create societal and ecological value, not just financial value. For example, web-based platforms for sharing allow the full use of capacity and availability of a product. Thinking of a product as a service, removes the necessity of buying, owning and maintaining a product, yet provides access to the service it offers. This can encourage the sharing and leasing of plastic products which could decrease the volume of manufactured goods.

Frame policy instruments

Finally, there is a need to frame policies and standards including incentives and regulatory measures to discourage the unsustainable production and use of plastics. Regulators need to help create favorable frameworks for the recycling industry to flourish, encouraging eco-design, separated collection and the inclusion of recycled plastic in products.

Indian examples of Circular Economy principles in use for plastics

In Table 1 below, examples of the actions described above have been listed; these were captured in the workshop series, and are indicative of adoption of circular economy principles in practice already.

Table 1: Indian examples of circular economy in practice

CE Principle	Description	Examples
Design for the Future	Redesign is an important element of a circular economy for plastics. Plastic products need to be designed in a manner that • Reduces the consumption of plastics per product without affecting the quality of application • Eliminates the need for plastics in certain cases based on its application • Supports product reuse	• E-commerce major Amazon is expanding its 'packaging-free shipment' programme, an India-first initiative, to nine cities. The programme, under which orders are shipped in their original packaging without any secondary or additional packaging, will also be available in Delhi, Mumbai, Ahmedabad, Nagpur, Bengaluru, Gurgaon, Noida, Chennai and Hyderabad by 2020. This is one of the many sustainability initiatives to help achieve Shipment Zero, through which Amazon's intends to make all shipments net zero carbon, with 50% of all shipments net zero by 2030.[40] • Starbucks has designed, developed and manufactured a lid that does not require straw. It has also made a commitment to eliminate straws globally.[41] • Marriott International has declared it will phase out miniature bottles of shampoo, conditioner and bath gel in favour of larger, pump-topped bottles at its 7,000 properties worldwide by December 2020. These pump-top bottles will be refilled and reused.[42] • Tata Chemicals innovated a multi-layered-packaging material to make laminate with one polymer (PE) instead of PE-PET. This assists in making the packaging material easily recyclable after use.[43] • Adani Wilmer, for its Fortune brand of edible oil, transitioned to PE-based laminate for all pouches.[44] • As part of its long-term sustainability initiatives, Flipkart is to replace poly pouches with recycled paper bags and bubble wrap with carton waste shredded material.[45]

CE Principle	Description	Examples
Use waste as resource	Recycle is a material-level strategy involving the use of machines and technology. Most of the conversations around recycling in India are focussed on downcycling.	• A pre-requisite for better recycling is proper segregation and collection of waste from households. This has been successfully practiced at municipality level in Ambikapur (Chhattisgarh)[46], Pune (Maharashtra)[47] and Muzaffarpur (in Bihar) [48] for example. • Reliance Industries champions the largest single agency-driven collection and recycling initiative for PET bottles in the country. Through local partners they collect PET bottles and convert them into fibre which replaces virgin material used to make polyester textiles. The collection effort is undertaken through 150 collection centres across India.[49]
Alternative Feedstock	In the long term, to reduce upstream impacts of plastics production (due to crude oil extraction, refining and production) there is a need to move virgin plastics production away from fossil fuel-based feedstock to renewable feedstock.	In 2016, Nestlé co-founded the NaturALL Bottle Alliance to scale up a next generation of bio-sourced PET, using biomass feedstocks that do not divert resources or land from food production, such as previously used cardboard and wood pulp.[50]
Increase collaboration	Collaboration between stakeholders is essential to arrive at feasible and scalable solutions.	The Hyderabad-based company Banyan Nation focuses on high-value recycling to make car bumpers (for Tata Motors) and shampoo bottles (for Loreal).[51] It uses mobile, cloud and Internet of Things to integrate thousands of informal sector last-mile collectors into its supply chain to recover post-consumer as well as post-industrial plastic waste. It has developed a data intelligence platform to facilitate collecting recyclable plastic, and a cleaning technology that ensures the input for recycling is of good quality.[52] Such interventions if supported by proper policy and standards can go a long way in enhancing its uptake across sectors (automobile and cosmetics in this case).
Robust information platforms	To increase data, knowledge and accountability	Kabadiwalla Connect aims to integrate informal actors into the formal waste management system by using ICT and IoT-based technology.[53]
Policy instruments	To encourage the transition to a circular economy	The recently-framed draft National Resource Efficiency Policy (2019) lays out the basic contours for RE in the plastics packaging sector in India

THE CIRCULAR PLASTICS STRATEGY

Supporting mechanisms for achieving a Circular Economy for plastics

The challenge of plastics management confronting policymakers, the private sector, municipal authorities and other stakeholders is huge; however, a large opportunity exists alongside. The opportunity lies in the potential for transitioning to a circular economy for plastics, recovering the usable resources (energy and materials) in discarded products to close loops, and extending the useful life of products, materials and components. This principle when supported by enabling business models and use of digital technology, for example, captures the leakages in the take-make-dispose value chain and forms the basis of a circular economy.

Overall, action should be steered along the entire value chain beginning with design and working up all the way to post-use and end-of-life aspects.

Figure 11: Elements of a product's life cycle

India needs to adopt Circular Economy principles, simultaneously, across the value chain of plastics: municipal solid waste is the vital link between portions of the value chain upstream and downstream of the plastic user.

For a difference to be apparent, each part of the waste management system has to work: leadership shown by a few motivated individuals in some parts of the chain is not likely to bring about the sea change needed.

Applying controls upstream of the user, will reduce the rate of entry of waste as also the quantum of waste to be managed, downstream of the user. Investments are needed to reduce the consumption of plastics and manage waste in a manner that avoids loss of material quality: attaching an economic value to each step of the product's life will ensure stemming of leakages.

The following strategies recommended by the CII-ITC Centre of Excellence for Sustainable Development will support a circular economy for plastics.

Table 2: The circular plastics strategy: a summary

Strategy I	Develop a comprehensive CE policy for plastics that includes: • Setting standards • Research on new types of plastic • Setting time-bound targets • Incentives and subsidies for identified technologies
Strategy II	• Identify viable and scalable technologies for better sorting, recycling. • Foster collaborations among brand owners, academia, converters, recyclers.
Strategy III	Provide consistent messaging on • Reducing the use of unnecessary plastics • Segregating at source
Strategy IV	Strictly implement laws and enforce penalties.

Strategy I: A comprehensive circular economy policy for plastics

As a first step it is important to estimate/assess demand for infrastructure at different parts of the value chain by projecting quantities and types (resin) of waste generated by users/municipalities. There is need to frame a comprehensive policy for circularity of plastics, holistically addressing the entire value chain. Such a policy for plastics should cover:

1. *Setting of standards/standardization*
   a. *for composition of packaging material:* systematically arrive at and agree upon polymer combinations to be used in packaging for packaging applications via consultations involving Ministry of Environment, Forest and Climate Change, manufacturers and brand owners. Uniformity in the composition of packaging will facilitate recycling.
   b. *for recycled content:* as recycled plastic content is introduced into products, standards to certify their quality and application via credible labelling is required.
2. *Research into new plastics:* develop easily decomposable polymers from bio-feedstock using renewable sources of energy to minimize the externalities of plastic at both stages: manufacture and end-of-life. Both, the private and public sectors should invest in R&D for alternatives; encourage industry-academia collaborations.
3. *Setting national, state-level, ULB-level, time-bound targets:* based on reliable metrics for quantities and composition, targets should be trackable using, perhaps, digital means. Some targets are also proposed in the draft National Resource Efficiency Policy with regards to plastics used for packaging.[35] However, overall targets should concern:
   a. *Segregation at source:* set targets for
      - Level of segregation, that is, percentage of households practicing segregation at source in city/town
      - Number of cities/towns practicing segregation at source
   b. *Recycled material content for selected applications:* for items incorporating, or able to incorporate recycled plastics, set firm, time-bound targets mandating minimum recycled content.
   c. *Sector-wise reductions:* to enhance upstream action by businesses directed at reducing plastic consumption.
   d. *Attach accountability:* to ensure that changes occur over the entire system and are not driven only by motivated individuals.
4. *Incentives and subsidies for identified technology (refer to Strategy II for types of technology to be identified):* access to finance for setting up infrastructure appears to be problematic in some cases: the cost of like-to-like recycling technology (say bottle-to-bottle) is high, pointing to the need for innovative gap financing as a way to make it viable. Some strategies in this regard are:
   a. Reduced lending rates for machinery
   b. Reduced import duty for selected technology

Strategy II: Viable and scalable technology

The availability of sound, viable and scalable technology for the Indian context forms the backbone of management downstream of the user; technology for waste collection, sorting, and cleaning for recycling plastics should be identified. Upstream, there is a need to develop technological solutions for chemical recycling and design for tomorrow's polymers, incorporating features such as simplicity, standardization, recoverability, upgrading, disassembly or reassembly, efficient collection and separation, or degradation at the appropriate time, place, and rate and to the appropriate end products. In this regard, India needs to:

1. *Identify technology*
   a. *for better sorting:* according to polymer type. Plastic-plastic separation is critical and can require several steps in a precise sequence. Optical, density, and electrostatic sorters are available to separate plastics; spectroscopic technologies are available in combination with sensitive detectors, image analysis, machine learning, and robotic technologies. Many advanced techniques can rapidly detect and sort plastics moving along a conveyer belt accurately.[2]
   b. *to recycle better (preferably upcycle):* most recycling in India is focused on downcycling, into products of low value. Technologies for upcycling to be encouraged so as to reduce the consumption of virgin plastics. Where mechanical recycling is applicable, ensure pure waste (plastic) streams.
   c. *to increase accountability:* use of IoT-based sensors to enhance tracking of waste through the value chain. Better tracking will increase transparency and accountability of stakeholders.
2. *Foster collaborations to improve feasibility and viability of technology:* partnerships with convertors, brand owners, waste management companies on the one hand, and academia, universities, public-private organizations focusing on innovations and scaling up ideas.

Strategy III: Consistent messaging

The consumer's role in a circular economy for plastics is important at several points where choice can be exercised. Beginning with buying responsibly, for example, products with minimum packaging, choosing reusable and durable products and refusing plastic bags, the consumer can reduce the use of plastic and generation of plastic waste. Maintenance and repair of products, giving them away when no longer used/needed, are all ways to reduce plastic footprint. At the final end-of-life stage consumers must be responsible for sorting/segregating their waste at household level.

Public awareness campaigns should be sustained and sharply focused on two key messages:

1. *Reduce or avoid the use of unnecessary plastics (or single-use plastic items) by exercising choice in simple ways such as* carrying a bag when shopping. These will reduce the entry of plastics into the waste stream by turning off the 'tap'.
2. *Segregate waste at source:* the success of the entire MSW system hinges on segregation of waste at source. A strong message to consumers (supported by appropriate infrastructure for recycling) can bring about a change.

Strategy IV: Strict implementation of laws and enforcement of penalties

The successful working of municipalities and the municipal solid waste management (MSW) system plays a key role in the overall circular economy strategy for plastics because plastic products/ packaging after disposal enter MSW. Thus, ensuring that segregation takes place at household level is important for the success of the CE strategy for plastics.

While the mandate for segregation at source already exists, poor enforcement of the mandate and low accountability in municipalities is a concern. Two strategies to enhance segregation are:

1. *Financial penalty (households and commercial establishments) for non-compliance:* a penalty per instance of non-compliance. This strategy been implemented in Ambikapur,[54] Pune [55] and Leh.[56]
2. *Non-financial penalty to users (households and commercial establishments) for non-compliance:* not collecting waste from households where waste is not segregated. This measure has been successfully implemented in pockets of Noida, for example, where waste collectors have the authority to leave behind unsegregated waste at the doorstep. A similar practice can be adopted by Resident's Welfare Associations. There are instances of the name-and-shame strategy being used to enforce segregation that have been successful in metropolitan cities.

The policy and institutional framework for waste management moving ultimately to a circular economy needs a comprehensive review. In the shorter term, clarity is required on waste management rules, the compliance requirements, and jurisdictions of the involved regulatory agencies. However, in the longer term, policy and regulatory framework need to be revamped to enable, rather than police the system, and to catalyze the transition to a circular economy.

When all methods of management fail, plastic can be burnt in cement kilns where the high temperature ensures complete combustion of the material into harmless products. As a substitute for fossil fuels, burning plastic is advantageous for the cement industry as well as for the municipal authorities trying to manage waste. If an existing facility is used, finances can be freed to invest on research and development for alternative plastic waste processing technologies: however, burning is the least preferred of all management solutions, as it destroys all the embodied value of the burnt material and is associated with environmental impacts of its own if not properly regulated.

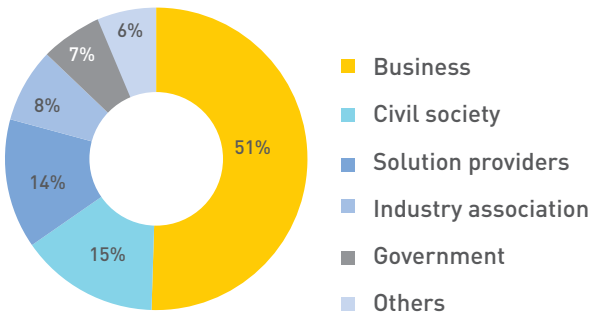
The obligation lies in segregation of waste at source and the opportunity lies in moving up the value chain to prevent externalities further down.

ANNEX I: OVERVIEW OF STAKEHOLDERS CONSULTED

This report is the output of a consultative process; four consultations/workshops were held in Delhi, Mumbai, Hyderabad and Guwahati by the CII-ITC CESD. About 100 stakeholders participated in these consultations, more or less equally divided among the four cities. These workshops helped gather information and opinions on developing an India-specific approach with respect to plastic use and management with a focus on viable solutions and enabling mechanisms.

Roughly half the participants were from the private sector representing automobile, e-commerce, petrochemicals, packaging, FMCG companies. The rest represented government, civil society, industry associations, academia and solution-providers.

Stakeholders consulted



Sectors represented by business stakeholders

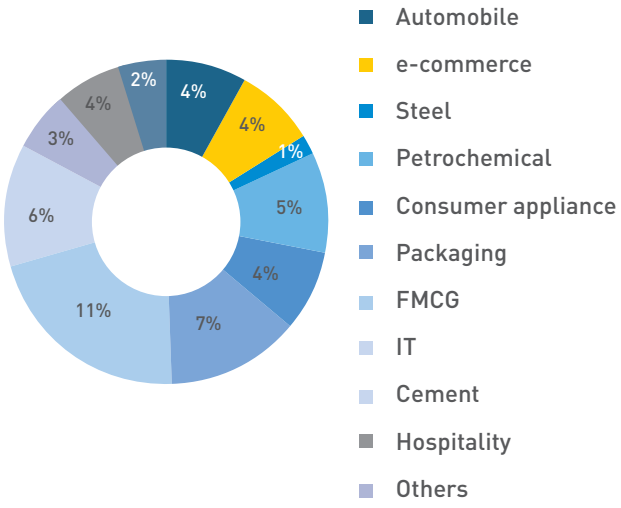


Figure 12: Description of stakeholders at workshops

ANNEX II: TYPES OF PLASTIC

Table 3: Types of plastics and their uses[57]

Polymer Family	Examples	Uses
Thermoplastics	Acrylonitrile butadiene styrene (ABS)	▷ Injection moulding applications
	Polycarbonate (PC)	▷ Shatterproof windows, lightweight eyeglass lenses
	Polyethylene (PE)	▷ Packaging such as bags, films, geomembranes, containers including bottles
	Polyethylene terephthalate (PET)	▷ Packaging foods and beverages
	Polyvinyl chloride (PVC)	▷ Building and construction, healthcare, electronics, automobile
	Polymethyl methacrylate (PMMA)	▷ Substitute for glass in products such as shatterproof windows, skylights, illuminated signs, and aircraft canopies
	Polypropylene (PP)	▷ Crates, bottles, pots, food packaging
	Polystyrene (PS)	▷ Rigid foodservice containers, CD cases, appliances housings, envelope windows, food service products, building materials
	Expanded Polystyrene (EPS)	▷ Fish boxes, packaging for electrical consumer goods, insulation panels for buildings
Thermosets	Epoxide (EP)	▷ Used in many fibre reinforced plastics such as glass-reinforced plastic and graphite-reinforced plastic; casting; electronics encapsulation; construction; protective coatings; adhesives; sealing and joining
	Phenol-formaldehyde (PF)	▷ Moulded products including billiard balls, laboratory countertops, coatings and adhesives
	Polyurethane (PUR)	▷ Insulating foams, mattresses, coatings, adhesives, car parts, pint rollers, shoe soles, flooring, synthetic fibres
	Poly tetrafluoroethylene (PTFE)	▷ Wiring in aerospace and computer applications, industrial applications such as plain bearings, gears, slide plates, seals, gaskets, bushings
	Unsaturated polyester resins (UP)	▷ Fiberglass systems: sheet moulding compounds and bulk moulding compounds; filament winding; wet lay-up lamination; repair compounds and protective coatings

References

1 Geyer R., Jambeck J.R. and Law K.L. (2017). Production, Use, and Fate of all Plastics ever Made, Science Advances, July 19, 2017.

2 NASEM (2019). National Academies of Sciences, Engineering, and Medicine. Closing the Loop on the Plastics Dilemma: Proceedings of a Workshop in Brief. Washington, DC: The National Academies Press. Available at https://doi.org/10.17226/25647

3 Lithner D., Larsson A. and Dave G. (2011). Environmental and health hazard ranking and assessment of plastic polymers based on chemical composition. Science of the Total Environment, Volume 409, Issue 18. Available at https://doi.org/10.1016/j.scitotenv.2011.04.038

4 Teuten E.L., Saquing J.M., Knappe D.R.U., Barlaz M.A., Jonsson S., Björn A., Rowland S.J., Thompson R.C., Galloway T.S., Yamashita R., Ochi D., Watanuki Y., Moore C., Viet P.H., Tana T.S., Prudente M., Boonyatumanond R., Zakaria M.P., Akkhavong K., Ogata Y., Hirai H., Iwasa S., Mizukawa K., Hagino Y., Imamura A., Saha M. and Takada H. (2009). Transport and release of chemicals from plastics to the environment and to wildlife. Phil. Trans. R. Soc. B3642027

5 UNEP (2018). Mapping of Global Plastics Value Chain and Plastics Losses to the Environment (with a particular focus on marine environment). Available at http://wedocs.unep.org/bitstream/handle/20.500.11822/26745/mapping_plastics.pdf

6 Barra et al. (2018). Plastics and the circular economy. Scientific and Technical Advisory Panel to the Global Environment Facility. Washington DC.

7 CII analysis based on Ministry of Commerce data. Available at https://commerce-app.gov.in/meidb/

8 Hook L. and Reed J. (2018). Why the world's recycling system stopped working. Financial Times, October 25, 2018. Available at https://www.ft.com/content/360e2524-d71a-11e8-a854-33d6f82e62f8

9 McCormick E. (2019). Where does your plastic go? The Guardian, June 17, 2019. Available at https://www.theguardian.com/us-news/2019/jun/17/recycled-plastic-america-global-crisis

10 EEA (2019). The plastic waste trade in the circular economy. Available at https://www.eea.europa.eu/themes/waste/resource-efficiency/the-plastic-waste-trade-in

11 World Economic Forum, Ellen MacArthur Foundation and McKinsey & Company (2016). The New Plastics Economy: Rethinking the future of plastic. Available at https://www.ellenmacarthurfoundation.org/assets/downloads/The-New-Plastics-Economy- Rethinking-the-Future-of-Plastics.pdf

12 Jambeck, J.R., Geyer R., Wilcox C., Siegler T.R., Perryman M., Andrady A., Narayan R. and Law K.L. (2015). Plastic waste inputs from land into the ocean, Science, 347, 768-771.

13 d'Ambrières, W. (2019) Plastics recycling worldwide: current overview and desirable changes. Field Actions Science Reports [Online], Special Issue 19. Available at http://journals.openedition.org/factsreports/5102

14 PlasticsEurope and Messe Düsseldorf (2019). Plastics – The Facts 2019: An analysis of European plastics production, demand and waste data

15 Kaur B. (2019). 40% plastic waste littered on India's streets: Javadekar in Lok Sabha. Down to Earth, November 22, 2019. Available at https://www.downtoearth.org.in/news/waste/40-plastic-waste-littered-on- india-s-streets-javadekar-in-lok-sabha-67887

16 CPCB (2015). Assessment & Quantification of Plastics Waste Generation in Major Cities. Available at http://www.indiaenvironmentportal.org.in/files/file/Assessment%20and%20Quantification%20of%2 0Plastics%20 Waste.pdf

17 Envis (2016). Newsletter published by the Indian Centre for Plastics in the Environment, Vol 17 (3), July – Sep 2016. Available at http://icpe.in/News_letter.htm

18 Venkatesh S. and Kukreti I. (2018). India's plastic consumption increases at over 10 per cent year-on-year. Down to Earth, June 08, 2018. Available at https://www.downtoearth.org.in/news/waste/breaching-the-threshold-60748

19 TERI (n.d.). Factsheet on plastic waste in India. Available at https://www.teriin.org/sites/default/files/files/factsheet.pdf

20 Census of India (2011). Provisional Population Totals: Rural-Urban Distribution. Available at http://censusindia.gov.in/2011-prov-results/paper2/data_files/india/paper2_1.pdf

21 PIB (2011). India Stats: Million plus cities in India as per Census 2011. PIB, October 31, 2011. Available at http://pibmumbai.gov.in/scripts/detail.asp?releaseId=E2011IS3

22 BBC (2019). Why some countries are shipping back plastic waste. BBC, June 02, 2019. Available at https://www.bbc.com/news/world-48444874

23 USEPA (n.d.). Plastics – material-specific data. Available at https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/plastics-material-specific-data

24 OECD (2018). Improving Plastics Management: Trends, policy responses, and the role of international co-operation and trade: Background Report. Available at https://www.oecd.org/environment/waste/policy-highlights-improving-plastics-management.pdf

25 ICPE (n.d.). Myths and Realities. Available at http://icpe.in/mythsnrealities.html

26 Hindustan Times (2017). India recycles 95% of its PET waste, outperforms Japan, Europe and US: study by Chatterji B. The Hindustan Times, February 19, 2017. Available at https://www.hindustantimes.com/mumbai-news/india-recycles-90-of-its-pet-waste-outperforms-japan-europe-and-us-study/story- yqphS1w2GdlwMYPgPtyb2L.html

27 Mohanty S. (n.d.). Recycling of Plastics in Indian Perspective. Available at https://www.unido.org/sites/default/files/files/2018-11/Plenary%202%20-%20Plastics%20-%20Mohanty.pdf

28 UNEP (2018). Single-use Plastics: A Roadmap for Sustainability. Available at https://wedocs.unep.org/bitstream/handle/20.500.11822/25496/singleUsePlastic_sustainability.pdf?sequence=1&isAllowed=y

29 Basel Convention (n.d.) Overview. Available at http://www.basel.int/Implementation/Plasticwastes/Overview/tabid/6068/Default.aspx

30 EU (2019). Directive (EU) 2019/904 of the European Parliament and of the Council, of 5 June 2019, on the reduction of the impact of certain plastic products on the environment. Available at https://eur- lex.europa.eu/eli/dir/2019/904/oj

31 Geng Y., Sarkis J., and Bleischwitz R. (2019). How to globalize the circular economy. Nature Comment, Vol 565, pp. 153-155.

32 Jang Y.-C., Lee G., Kwon Y., Lim J., and Jeong J. (2020). Recycling and management practices of plastic packaging waste towards a circular economy in South Korea. Resources, Conservation and Recycling, 158, 104798. doi:10.1016/j.resconrec.2020.104798

33 Semuels A. (2020). To Fix America's Broken Recycling System, States Want Companies to Foot the Bill. Time, February 26, 2020. Available at https://time.com/5790656/fixing-recycling-in-america/

34 PIB (2019). Amendment in Hazardous Waste Management & Transboundary Movement) Rules, 2016. Available at https://pib.gov.in/PressReleseDetail.aspx?PRID=1567682

35 MoEFCC (2019). National Resource Efficiency Policy, 2019 (Draft). Available http://moef.gov.in/draft-national-resource-efficiency-policy2019-inviting-comments-and-suggestions-of-stakeholders-including-publicprivate-organization-experts-and-concerned-citizens/

36 Brink P.T., Schweitzer J.P., Watkins E., Smet M.D., Leslie H. and Galgani F. (2017). T20 Task Force Circular Economy: Circular economy measures to keep plastics and their value in the economy, avoid waste and reduce marine litter. G20 Insights. Available at https://www.g20-insights.org/wp-content/uploads/2017/05/Circular- Economy_The-circular-economy-plastic-and-marine-litter.pdf

37 Ojcius C. and Renard N. (2019). Field Actions Science Reports, Special Issue 19, 2019. Reinventing Plastics [Online]. Available at http://journals.openedition.org/factsreports/4993

38 ETC (2019). Mission Possible: Reaching net-zero carbon emissions from harder-to-abate sectors by mid- century – Sectoral Focus: Plastics. Available at http://www.energy- transitions.org/sites/default/files/ETC%20sectoral%20focus%20-%20Plastics_final.pdf

39 The AirCarbon technology developed by Newlight is able to transform methane gas or CO_2 to some plastics types (https://www.newlight.com/). Similarly, Covestro developed a technology that turns CO_2 into plastic: https://www.co2-dreams.covestro.com/en http://www.cedelft.eu/publicatie/biobased_plastics_in_a_circular_economy/2022). See more examples at http://sugarcane.org/sugarcane-products/bioplastics;https://www.technologyreview'/.com/s/424790/cheap-plastic-made-from-sugarcane/andhttp://www.braskem.com/site.aspx/Im-greenTM-Polyethylene

Examples: Solaiman, D.K.Y. 2006. Conversion of agricultural feedstock and coproducts into poly(hydroxyalkanoates). Appl Microbiol Biotechnol, 71, DOI 10.1007/s00253-006-0451-1; Rostkowski K.H et al. 2012. Cradle-to-gate life cycle assessment for a cradle-to-cradle cycle: biogas-to-bioplastic (and back). Environ Sci Technol, 46, DOI: 10.1021/es204541w; Bluemink, E. D et al. 2016. Bio-plastic (poly-hydroxy- alkanoate) production from municipal sewage sludge in the Netherlands: a technology push or a demand driven process? Water Science and Technology, 74, DOI: 10.2166/wst.2016.191; Revelles, O et al. 2016. Carbon roadmap from syngas to polyhydroxyalkanoates in Rhodospirillum rubrum. Environ Microbiol, 18, DOI: 10.1111/1462- 2920.13087; Myung, J. et al. 2017. Expanding the range of polyhydroxyalkanoates synthesized by methanotrophic bacteria through the utilization of omega-hydroxyalkanoate co-substrates. AMB Express, 7, 118, DOI 10.1186/s13568-017-0417-y

Examples: Mülhaupt, R. 2013. Green polymer chemistry and bio-based plastics: dreams and reality. Macromolecular Chemistry and Physics, 214, DOI: 10.1002/macp.201200439; Sheldon, R.A. 2014. Green and sustainable manufacture of chemicals from biomass: state of the art. Green Chem., 2014, 16, DOI: 10.1039/c3gc41935e; Pellis, A et al. 2016. Fully renewable polyesters via polycondensation catalyzed by Thermobifida cellulosilytica cutinase 1: an integrated approach. Green Chemistry, DOI: 10.1039/C6GC02142E

Papaspyrides, C.D and Kiliaris, P (Eds). 2014. Polymer Green Flame Retardants. Elsevier Science Limited, Amsterdam, Netherlands

40 PTI (2019). Amazon expands 'packaging-free shipment' programme to 9 Indian cities. The Economic Times, June 04, 2019. Available at https://brandequity.economictimes.indiatimes.com/news/business-of- brands/amazon-expands-packaging-free-shipment-programme-to-9-indian-cities/69635710

41 Starbucks (n.d.). Greener Cups and Packaging. Available at https://www.starbucks.com/responsibility/environment/recycling

42 AP (2019). Marriott will ban tiny plastic shampoo and conditioner bottles to reduce plastic waste. Business Insider, August 29, 2019. Available at https://www.businessinsider.com/marriott-banning-tiny-toiletries-by- 2020-to-reduce-plastic-waste-2019-8?IR=T

43 TSG (2017). Closing the Loop: The Circular Economy in Action: Tata Group Companies' Case Studies. Available at http://tatasustainability.com/images/NewsLetter/Files/40_circular%20economy%20bro_Final%2019%20June%202018.pdf

44 PTI (2018). Adani Wilmar to use recyclable plastic for 1 litre pouch of 'Fortune' edible oil. The Times of India, August 30, 2018. Available at https://timesofindia.indiatimes.com/business/india-business/adani-wilmar-to-use-recyclable-plastic-for-1-litre-pouch-of-fortune-edible-oil/articleshow/65613598.cms

45 Flipkart (2019). Flipkart outlines vision to eliminate single-use Plastic. Flipkart News, August 29, 2019. Available at https://stories.flipkart.com/flipkart-eliminate-single-use-plastic/

46 UNCRD (n.d.). Zero Waste Model, Ambikapur, Chhattisgarh. Available at http://www.uncrd.or.jp/content/documents/6501PS-1-P4.pdf

47 Swach (n.d.). Swach Impact 2018. Available at https://swachcoop.com/

48 CSE (2018). Bihar's first solid waste processing site to convert organic waste into compost fertiliser inaugurated in Muzaffarpur – under programme jointly managed by CSE. Centre for Science and Environment, October 2, 2018. Available at https://www.cseindia.org/bihar-s-first-solid-waste-processing-site-to-convert-organic-waste-9046

49 The Hindu (2017). Plastic bottles turn mattresses, quilts & much more. The Hindu, June 03, 2017. Available at https://www.thehindu.com/sci-tech/energy-and-environment/plastic-bottles-turn-mattresses-quilts-much-more/article18714374.ece

50 Nestlé (n.d.). What is Nestlé doing to tackle plastic packaging waste? Available at https://www.nestle.com/ask-nestle/environment/answers/tackling-packaging-waste-plastic-bottles

51 Kumar V.R. (2018). Plastic Recycler Banyan Nation makes it to final at WEF's Circular Economy awards. Business Line, January 08, 2018. Available at https://www.thehindubusinessline.com/companies/plastic- recycler-banyan-nation-makes-it-to-final-at-wefs-circular-economy-awards/article10011138.ece

52 Banyan Nation (n.d.). Our Work. Available at http://banyannation.com/#ourwork

53 Kabadiwalla Connect (n.d.) Available at https://www.kabadiwallaconnect.in/

54 Das R. K. (2017). Chhattisgarh's Ambikapur, a Swachh Bharat model. Business Standard, July 15, 2017. Available at https://www.business-standard.com/article/economy-policy/chhattisgarh-s-ambikapur-a-swachh- bharat-model-117071500016_1.html

55 Kulkarni P. (2019). Now, pay up to Rs 1,000 for not segregating waste. Pune Mirror, December 5, 2019. Available at https://punemirror.indiatimes.com/pune/civic/now-pay-up-to-rs-1000-for-not-segregating- waste/articleshow/72374288.cms

56 MoHUA (n.d.). Transforming Urban Landscapes of India: Success Stories in Solid Waste Management – Swachh Bharat Mission (Urban). Available at http://164.100.228.143:8080/sbm/content/writereaddata/SBM%20Coffee%20Table%20Book_Final.pdf

57 PlasticsEurope (n.d.). How Plastics are Made. Available at https://www.plasticseurope.org/en/about- plastics/what-are-plastics/how-plastics-are-made

58 Ministry of Urban Development (2016). Municipal Solid Waste Management Manual – Part II: The Manual. Available at http://mohua.gov.in/upload/uploadfiles/files/Part2.pdf

Confederation of Indian Industry
125 Years: 1895-2020

The Confederation of Indian Industry (CII) works to create and sustain an environment conducive to the development of India, partnering industry, Government, and civil society through working closely with Government on policy issues, interfacing with thought leaders, and enhancing efficiency, competitiveness and business opportunities for industry.

Founded in 1895 and celebrating 125 years in 2020, India's premier business association has more than 9100 members, from the private as well as public sectors, and an indirect membership of over 300,000 enterprises from around 291 national and regional sectoral industry bodies.

With 68 offices, including 9 Centres of Excellence in India, and 11 overseas offices in Australia, China, Egypt, France, Germany, Indonesia, Singapore, South Africa, UAE, UK, and USA, as well as institutional partnerships with 394 counterpart organizations in 133 countries, CII serves as a reference point for Indian industry and the international business community.

Confederation of Indian Industry
The Mantosh Sondhi Centre
23, Institutional Area, Lodi Road, New Delhi – 110 003 (India)
T: 91 11 45771000 / 24629994-7 • F: 91 11 24626149 • E: info@cii.in • W: www.cii.in

cii.in/facebook | cii.in/twitter | cii.in/linkedin | cii.in/youtube

CII-ITC Centre of Excellence for Sustainable Development

CII-ITC Centre of Excellence for Sustainable Development is a not-for-profit, industry-led institution that helps business become sustainable organisations. It is on a mission to catalyse innovative ideas and solutions, in India, and globally, to enable business, and its stakeholders, in sustainable value creation. It's knowledge, action and recognition activities enable companies to be future ready, improve footprints profiles, and advocate policymakers andlegislators to improve standards of sustainable business through domestic and global policy interventions.

CESD leverages its role of all-inclusive ecosystem player, partnering industry, government, and civil society. It has been a pioneer of environment management systems, biodiversity mapping, sustainability reporting, integrated reporting, and social & natural capital valuation in India, thus upgrading business in India to sustainable competitiveness.

With two locations in India, CESD operates across the country and has also been active in parts of South and South East Asia, Middle East, and Africa. It has held institutional partnerships and memberships of the United Nations Global Compact, Global Reporting Initiative, International Integrated Reporting Council, Carbon Disclosure Project, development agencies of Canada, the USA, the UK, and Germany.

Delhi | Mumbai
www.sustainabledevelopment.in
/ciicesd