INDIA PLASTICS PACT

Material Flow of PET Used in Packaging Applications in India

for the year 2021-22

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List of abbreviations

BoPP	Biaxially Oriented Polypropylene
BoPET	Biaxially Oriented Polyethylene Terephthalate
CAGR	Compound annual growth rate
CSD	Carbonated soft drinks
EPR	Extended Producer Responsibility
FSSAI	Food Safety and Standards Authority of India
HDPE	High Density Polyethylene
ITC-HS	Indian Trade Classification (Harmonized System)
IRR	Input recycling rate
IV	Intrinsic viscosity
MoEFCC	Ministry of Environment Forest and Climate Change
ORR	Output recycling rate
PE	Polyethylene
PET	Polyethylene Terephthalate
POM	Placed on the market
PP	Polypropylene
PVC	Polyvinyl Chloride
rPET	Recycled PET
SKUs	Stock-keeping-units
vPET	Virgin PET

Executive summary

Polyethylene terephthalate (PET) is a polymer used extensively in packaging applications and in textile manufacturing (as polyester fibre). As packaging, it is used to make rigid packs, such as bottles and trays, and in flexible formats as packaging films. PET bottles have many positive attributes as they are clear, strong, lightweight, chemically inert, durable, safe, and recyclable. As such, their use in the Indian beverage industry is widespread with a well-developed post-use collection and recycling system in place.

Recent regulatory changes in India, including, allowing recycled content in contact with food packaging, specifying acceptance criteria for recycled PET (rPET) resin for food contact applications, and fixing quantitative targets for recycled content in packaging, are likely to motivate investment in upgraded recycling machinery and create stronger markets for recycled PET.

To help prioritise interventions, identify investment and infrastructure needs, and establish a useful reference point when monitoring progress towards regulatory targets, it is imperative to understand the flow of PET through the value chain.

While the usefulness of reliable, verified data on the flows of PET in India is clear, it is somewhat hard to come by in this form. The work in this report addresses this gap.

The material flow presented in this report was composed by extensive literature review, one-to-one interviews with industry experts and through consultations. The interviews were also used to corroborate collected data and gain contextual insights and information. Given that many sources were used and not all quantities/numbers are verifiable or available, assumptions and uncertainties are reported wherever relevant. The data was analysed using Microsoft excel and the material flow created using e!Sankey software.

In 2021-22, 1,698 kt of PET for packaging applications was placed on the market (POM) in India: 58% used for rigid packaging (bottle, sheets and straps) and the rest (42%) for flexible packaging (films, pouches and wrappings). A similar quantum of PET also entered the waste stream after use. PET bottles have a well-developed and robust post-consumer collection system: it is estimated that of the total PET bottle waste generated (936 kt), 80% is collected, 2.5% repurposed, and the remainder ends up in landfills.

While 80% of PET bottles are collected, the output recycling rate[1] for PET bottles is estimated to be 64% because of losses after collection, and during the recycling process. 599 kt of washed rPET flakes were produced in 2021-22: three-quarters of these were sent to the textile industry, one-fifth to sheet and strap manufacturers, and 5% converted to rPET pellets. In theory, the quantity of food and drinks contact PET bottles which could be made available to be converted to rPET pellets for food grade bottle applications (bottle-to-bottle) was 409 kt in 2021-22.

While there are challenges associated with regulatory change, early indications suggest that PET recyclers, brands and bottle manufacturers and waste collection organizations are already responding to the new environment. For change to be impactful, all stakeholders must come together in a concerted effort to tackle problems and search for solutions: the India Plastics Pact, a business-led voluntary platform, provides such a collaborative platform for science-based actions to help realise the value of plastic.

[1] Weight of PET flakes obtained after post-consumer PET bottles are washed and flaked, divided by, weight of PET material placed on the market.

Introduction

Polyethylene terephthalate (PET) is a polymer used extensively in packaging applications (rigids and flexibles) and in textile manufacturing (as polyester fibre). A circular economy for PET would mean that products made of virgin PET are recycled back into the same application (such as bottles being recycled back to bottles, and trays being recycled back to trays), reducing the demand for virgin PET (vPET).

Until recently, the use of recycled content in food-contact plastic packaging was banned in India. However, in September 2021, the Government of India allowed the use of recycled material in food contact packaging subject to approval from the Food Safety and Standards Authority of India (FSSAI), through the Plastic Waste Management (Second Amendment) Rules 2021.[2] In January 2022, the FSSAI amended the Food Safety and Standards (Packaging) Regulation, 2018, to allow the use of recycled plastics as food contact material. In the same notification, FSSAI published guidelines for recycling of post-consumer Polyethylene Terephthalate (PET) beverage bottles for food contact applications along with the acceptance criteria for recycled PET (rPET) resin for food contact applications.[3] The Ministry of Environment Forest and Climate Change (MoEFCC) also published guidelines for Extended Producer Responsibility (EPR) for plastics packaging in February 2022, which set quantitative targets for the use of recycled content in packaging.[4]

These developments have made the need for reliable data on the flows of PET in India (used, collected, sorted and recycled) of interest in the near-to-medium term. However, in the Indian context, high quality data for PET flows (especially food-grade PET) is scattered and with high levels of uncertainty. Data is needed to:

- *understand scales of usage:* amounts of PET used, collected, sorted, recycled and disposed. This can help determine the magnitude of the challenge and solutions required,
- *prioritise interventions, identify infrastructure and investment needs:* to focus resources on interventions that can create the most impact, and
- *monitor progress:* to measure and determine whether targets have been met.

With this background, this report has the following objectives:

- quantify the flow of virgin PET used for packaging applications in India (production, consumption, trade, end-use, end-of-life management) for the year 2021-22,
- characterize the use of PET in different packaging applications,
- identify the fate of virgin PET, and
- quantify post-consumer PET going to textiles and other applications.

[2] Ministry of Environment Forest and Climate Change. (2021). *Plastic Waste Management (Second Amendment) Rules, 2021* (Notification No. G.S.R. 647(E)). https://egazette.nic.in/WriteReadData/2021/229867.pdf

[3] Food Safety and Standards Authority of India. (2022). *Food Safety and Standards (Packaging) Amendment Regulations, 2022* (Notification No. STD/SC/A-40). https://www.fssai.gov.in/upload/advisories/2022/01/61ea5c8e8713cDirection_Recycled_Plastics_19_01_2022.pdf

[4] Ministry of Environment Forest and Climate Change. (2022). *Plastic Waste Management (Second Amendment) Rules, 2022* (Notification No. G.S.R. 133(E)). https://egazette.nic.in/WriteReadData/2022/233568.pdf

Methodology

The aim of this study is to create a material flow of PET used for packaging applications in India for the year 2021-22. To understand the supply chain of PET, raw data have been collected and corroborated through extensive secondary research (publicly available sources and online reports), direct one-to-one conversations, and consultations with stakeholders from across the value chain. The collected data were analysed using Microsoft Excel, and the material flow of PET has been created using e!Sankey software.[5] The sources of data used to construct the material flow, methodology used for data computation and assumptions made are described below.

Production

Data for PET (PET pellets/chips) produced in India were obtained from Ministry of Chemicals and Fertilizers reports for the years 2007-08 to 2020-21 (Annex 1). Data for 2021-22 have been calculated based on Compound Annual Growth Rate (CAGR) for the years 2007-08 to 2020-21. It has been assumed that the entire production data mentioned in the report are used for rigid applications. Discussions during industry consultations indicated that this data was under-reported by 10% to 20%. Thus, for the purpose of this report the collected production data have been corrected by a factor of 15% (middle value of the error range).

Production data for the PET used in film applications have been calculated based on the installed capacity of the seven large scale PET film manufacturers in India (Annex 1). Capacity utilisation is assumed to be 100%. The calculated production value is adjusted by a factor of 15%, to account for the production from other medium and small-scale PET film manufacturers in India.

Trade

Import and export data have been collected from Ministry of Commerce and Industry data bank, based on Indian Trade Classification (Harmonized System) codes (ITC-HS codes) for PET resin (Annex 2).

Theoretically, each HS codes represents a different category based on the end-use applications. However, it was observed that large quantities were categorized as 'others/ uncategorized'. Thus, it was difficult to segregate the data obtained through the HS codes to different end-use applications. As an assumption, the consumption figure for rigids available in the PlastIndia Foundation (2019) report[6] which is widely recognized to be accurate for the year 2018-19 was used to balance the trade figures obtained through the HS codes. Therefore, the import and export numbers have been corrected by a factor of 34% across all the years.

[5] iPoint. *e!Sankey – show the flow.* https://www.ifu.com/e-sankey/

[6] PlastIndia foundation. (2019). *Indian Plastics Industry Report 2019.* https://www.plastindia.org/plastic-industry-status-report.php

Consumption

Consumption of PET (Annex 1) is calculated from production, import and export data using the formula mentioned in Annex 3.

Sectoral use (end-use applications)

Data for the end-use applications for PET rigid packaging applications have been taken from the PlastIndia Foundation (2019) report,[6] CSIR-NCL (2017) report[7] and PACE (2019) presentation[8] (Annex 4).

Waste generation

The calculation of PET waste generated each year is based on the consumption for that year and average lifetime (Annex 5) of each end-use product. Some products may have lifespans of over a year, and could enter the waste stream at any point after that across their lifetime. To account for this, it is assumed that the quantity of a product entering the waste stream is uniformly distributed across its lifetime. The formula mentioned in Annex 6 is used to estimate quantity of waste for each end-use product entering the end-of-life stage between the years 2007-08 and 2021-22 (Annex 7).

Thus, the quantity of PET entering the waste stream each year is comprised of two parts

- waste that was generated from a PET product placed on the market in the current year, and
- waste that was generated from a PET product placed on the market prior to the current year. This category has been termed legacy waste.

Lifespan of flexibles is assumed to be zero years, i.e., the entire flexibles placed on the market will enter the waste stream in the same year.

Waste management

Data on how PET waste is collected and sorted have been collected through stakeholder consultations.

End-product of recycling

The end-products of PET recycling were identified through secondary research, understanding of the PET value chain in India and one-to-one discussions with industry members to corroborate the information (Annex 8).

[7] CSIR-NCL. (2017). *PET recycling in India: mapping the recycling landscape.* http://www.in-beverage.org/lca-pet/NCL%20Report_Indian%20PET%20Recycling%20Landscape__Final_Ver%2003_December%202017.pdf

[8] PACE. (2019, September 4). *Socio-Economic Impact of PET packaging & its Recycling* [Presentation]. http://www.in-beverage.org/lca-pet/Presentation%20For%20GoI%20Stakeholders_4th%20September%202019.pdf

Material flow of PET in India

The material flow[9] of PET in India for the year 2021-22 is presented in Figure 1. The figure is to be viewed from left to right.

- The left side of the figure shows total PET (flexibles and rigids) production and imports into India. Caps, lids and labels also enter the PET value chain, even though they are not made of PET- they are integral components of a PET bottle.
- PET (flexibles and rigids) production and imports then lead to exports and consumption.
- PET rigids consumption is segregated into sheets and straps and bottle application.
- Bottle applications are then sub-categorised into final products (such as bottled water, pharmaceutical products, liquor, homecare and personal care).
- Depending on what product is packaged in the bottles, two categories, food and drinks contact applications and non-food contact plus mixed applications,[10] are identified. For the purpose of this study, flexible packaging, sheets and straps have been categorised into non-food contact plus mixed applications.
- This is followed by the waste generation figures.
- The waste is then bifurcated into collected and sorted bottle waste, collected flexible packaging waste (as films, wrappings and multilayer packaging[11]), uncollected waste and repurposed bottles.
- Collected bottle waste enters the recycling system, while collected flexible waste mainly goes for energy recovery at cement kilns, and uncollected waste goes to landfills or is littered.
- Losses between the collected post-consumer PET bottle waste and post-consumer PET waste reaching the recycler have not been accounted separately. These have been estimated together with the wash and flake losses occurring at the recycler's facilities. This is because PET waste collection relies heavily on the informal sector, and the losses after collection and before reaching the recycler are not uniform across the country.
- At this stage caps, lids and labels will exit the PET value chain, along with leakages from various stages of collection and recycling. The losses occurring at the washing and flaking stage have been represented as leakage. However, in some cases these losses (described in detail in the subsequent section) may be collected and sold to other recyclers.
- In the far right, the end routes of washed rPET flakes are present, i.e., washed flakes are sent to textile industry and to sheet and strap manufacturers. A small quantity of rPET flakes are converted to rPET pellets for use in non-food grade bottle applications. Losses during the conversion of flakes to pellets are also accounted for.

The figure helps visualise the flow of PET through the Indian economy with the thickness of the lines representing the relative quantity of PET in kilotonnes (kt).

[9] There is a degree of error in the estimates. Data may differ from other publicly available sources. It will be updated in future as data improves.

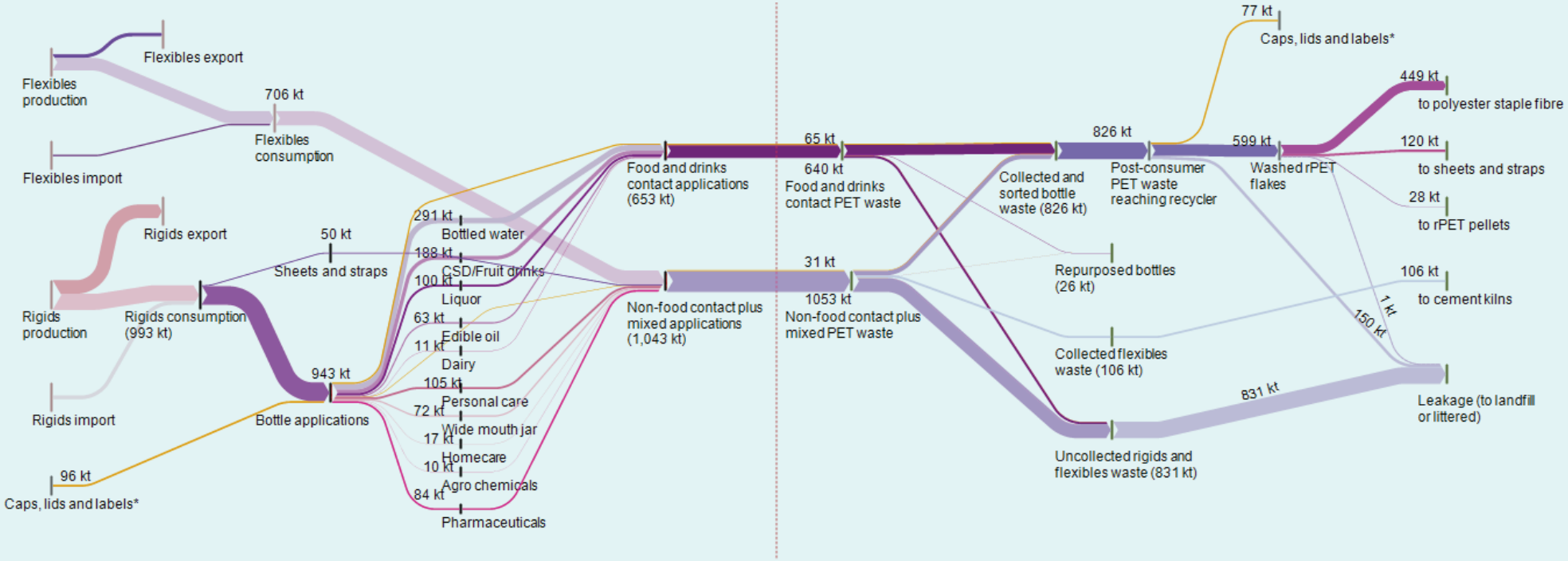
[10] 'Non-food contact plus mixed applications' might have some applications that are food contact. For instance, PET film as a part of MLP is used for food packaging. However, since at end-of-life these applications cannot be recycled back into food grade rPET, it has been classified into 'Non-food contact plus mixed applications'.

[11] For multilayer packaging only the weight of PET film layer is estimated in this report.

Material flow of PET in India for 2021-22

PET production and consumption

PET waste generation and management



There is a degree of error in the estimates. Data may differ from other publicly available source. It will be updated in future as data improves.

*Caps, lids and labels are not made of PET. These have been included, as they are components of PET bottle.

Figure 1: Material flow of PET in India for 2021-22 (in kt)

PET production, import and exports

In India the estimated production of virgin PET resin, used for packaging applications (flexibles and rigids) was 2,301 kt in 2021-22. Production, imports and exports have been growing year-on-year since 2007-08 to 2019-20. There was a decline in 2020-21 due to the COVID-19 pandemic when all manufacturing activity was halted due to the imposition of lockdowns. Since then, production, import and exports have rebounded to pre-pandemic levels on the back of growing demand for packaged products (particularly, beverage and food items). The imports and exports of PET rigids have increased at 14% and 9% CAGR respectively, and PET flexibles import and export have grown at 15% and 13% CAGR, respectively.

In 2021-22, about half (46%, 686 kt) of the total bottle-grade PET chips were exported. The balance (807 kt) was used for domestic consumption, along with imported bottle-grade PET chips (185 kt). One-fifth (21%, 173 kt) of total PET flexibles produced in India in 2021-22 were exported. The balance (635 kt) was used for domestic consumption, along with imported flexible-grade PET chips (70 kt).

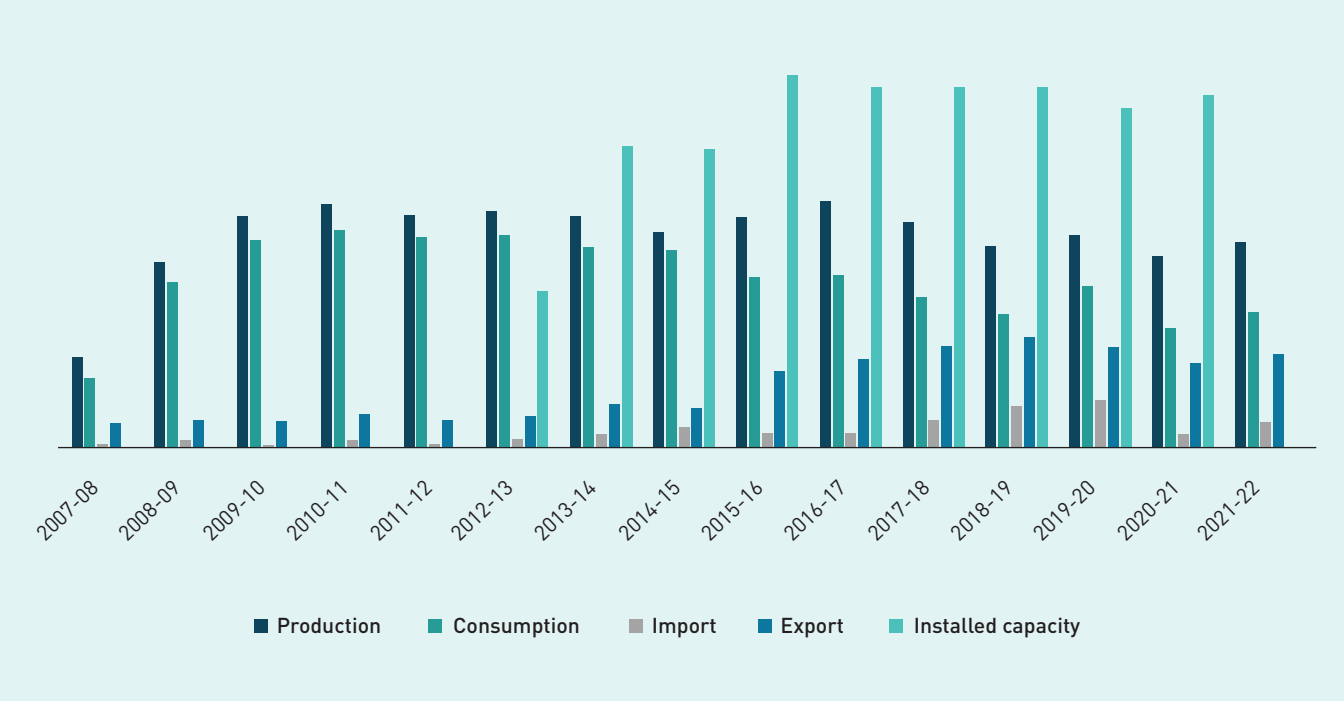


Figure 2: Trends in production, consumption, import, export and installed capacity of PET rigids in India between 2007-08 and 2021-22[12]

PET consumption by application

Total PET consumption in 2021-22 is estimated to be 1,698 kt (rigids: 993 kt and flexibles: 706 kt). Industry estimates suggest that of the total PET rigids placed on the market, between 94% and 96% were used for bottle applications in 2021-22 (for instance bottles used to store water, carbonated soft drinks and homecare products), and the remaining 4% to 6% were used for sheets and straps (such as those used in food and beverage packaging, pharmaceuticals, and consumer products). Figure 3 below has images of typical rigid PET applications.

[12] Time series data for PET flexibles are not available, and installed capacity data for PET rigids are available from 2012-13 till 2020-21.

Figure 3: Images from left to right of bottled water, liquor bottle, CSD bottle, wide mouth jar, straps, and trays

Flexibles (such as BoPET films) are commonly used in food and medical packaging, plastic wrap, protective coatings and other applications. These are commonly present as a middle or outer layer in a multi-layer packaging (for instance packaging for chips, biscuit and wheat flour). The share of flexibles and rigids (bottle applications and sheets and straps) in the overall PET resin consumption is presented in Figure 4.

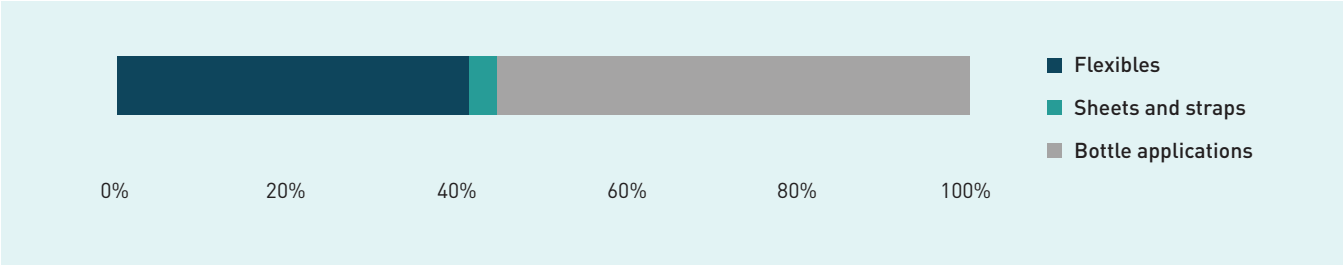


Figure 4: Share of consumption of PET for different packaging applications in 2021-22

About 63% of bottles are used to package beverages (water, carbonated soft drinks, fruit drinks, dairy and liquor). As per the FSSAI regulations, only bottles used for food packaging can be recycled and processed back into food grade rPET. Therefore, beverage bottles along with bottles used for packing edible oil, have been clubbed together as 'food and drink contact applications' (Figure 1). Packaging which was used as a food contact material does not mean it will automatically be food grade rPET; it will still require decontamination and processing steps.

A few rigid packaging applications (sheets and straps and bottles used for personal care, homecare, agrochemicals and wide mouth jars) have been clubbed together as 'non-food contact plus mixed applications' along with flexibles. Even though flexibles and sheets (used to make trays) might be used to package food, they are still considered 'non-food contact plus mixed applications', because:

- flexibles are hard to collect, and they rarely enter the recycling system, and
- the ones that enter the recycling system are not suitable for recycling to bottles.

rPET granules from flexibles and sheets are not suitable for use for bottle applications, as bottles need higher intrinsic viscosity to maintain structural integrity in the blow-moulding stage.

Use of rPET in pharmaceutical sector is currently not achievable due to regulatory restrictions. Packaging used in the pharmaceutical sector has also been included in the category, 'non-food contact plus mixed applications'.

Based on the categories described above,

- food and drinks contact application PET accounts for 39% (653 kt) of total PET consumption.
- non-food contact plus mixed application PET accounts for 61% (1043 kt) of total PET consumption.

Caps, lids and labels placed on PET bottle are essential components of the bottle and have been quantified in the material flow. It is estimated that based on the stock-keeping-units (SKUs) of PET bottles, the cumulative weight of caps, lids and labels form on average 7% to 14% of an empty PET bottle's weight.[13] For this study, the average weight of caps, lids and labels is taken as 10% (96 kt) of the weight of PET bottles placed on the market. Caps are usually made of Polypropylene (PP) or High Density Polyethylene (HDPE), while labels can be made of Polyvinyl Chloride (PVC), Biaxially Oriented Polyethylene terephthalate (BoPET) and Biaxially Oriented Polypropylene (BoPP).These entered the material flow through bottle applications: 67 kt of caps, lids and labels were used in food and drinks contact applications and 29 kt in non-food contact plus mixed applications.

Waste generation

It is estimated that in 2021-22, 1,692 kt of PET waste was generated in India, of which 38% (640 kt) came from food and drink contact packaging applications and 62% (1,053 kt) came from non-food contact plus mixed packaging applications.

Bottle applications are responsible for more than half of PET waste generated (936 kt), followed by flexibles (42%, 706 kt) and sheets and straps (3%, 51 kt).

It is important to note that the total quantity of PET consumed in a particular year, will not enter the waste stream in the same year. The point at which a rigid or flexible packaging item enters the waste stream will depend on the lifetime of the product/commodity packaged within it (Annex 4). Thus, PET entering the waste will have two components:

- **Current waste:** PET waste from packaging that was placed on the market in the current year
- **Legacy waste:** PET waste from packaging that was placed on the market in any previous year.

Based on this categorization, in 2021-22, 30% of PET waste was legacy waste (waste generated from PET placed on the market in years prior to 2021-22). About two-fifth (39%, 247 kt) of food and drinks contact PET waste was legacy waste, while one-fourth (266 kt) of non-food contact plus mixed PET waste was legacy waste.

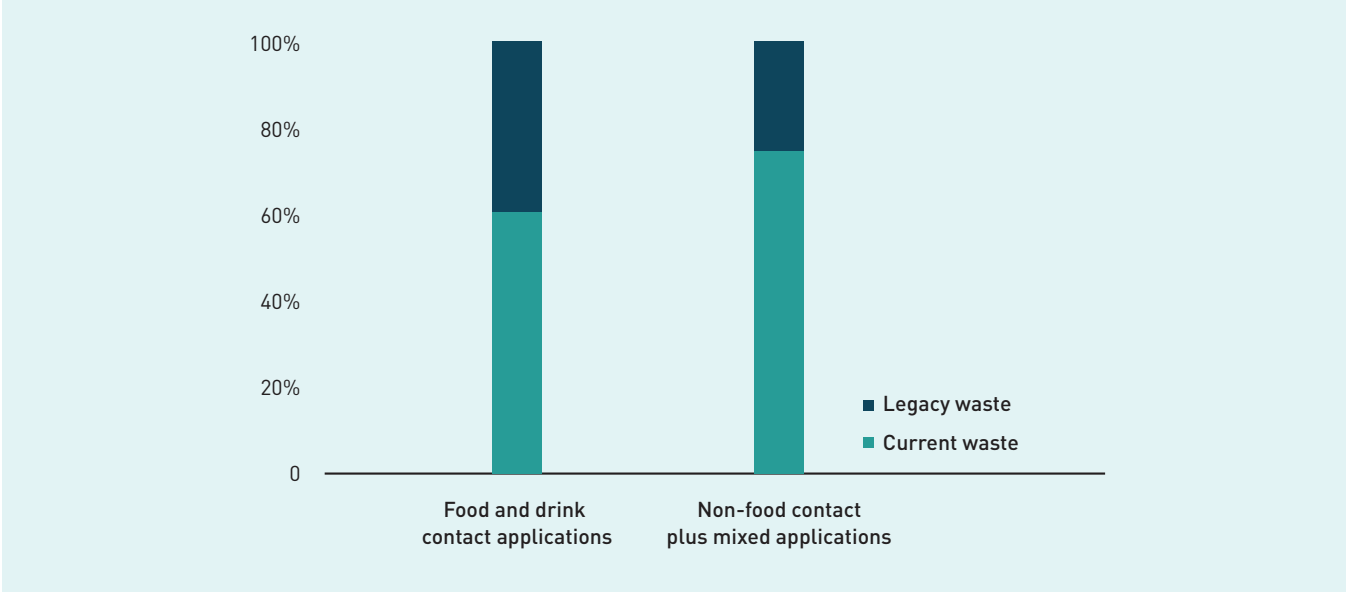


Figure 5: Application wise legacy and current PET waste generated in 2021-22

[13] Stakeholder consultations

Current end-of-life management practices for PET in India

Waste segregation at source is not practiced systematically and consistently at significant scale in the country. As a result, plastics (all resins and formats) enter the waste stream as a part of the municipal solid waste, and a significant portion of it is contaminated with food, chemicals, and dirt. Waste collection and sorting rely heavily on workers in the informal sector,[14] with the same facts true for PET.

Among all the applications of PET packaging, the collection and segregation value chain for PET bottles is the most developed and robust. This is because PET bottles are mostly used for water and CSD which leaves very little residue in the bottle, and they are clearly identifiable in the municipal waste stream. The average weight of 10 grams to 50 grams (depending on size),[15] allows waste-pickers to collect a reasonable quantity (by weight) in a short time. Waste-pickers are paid by weight of material collected, hence, sheets and straps are usually not collected, as they are extremely light, tend to be scattered about, and have a lower value than bottles.

Due to the reasons mentioned above, flexible packaging is also not collected at scale in India. However, with EPR regulations being implemented, the collection rate of flexibles has increased. With the lack of concrete data for flexible packaging collection rates, different stakeholders quote different figures, ranging from 10% to 35%.[16] For this report, it is assumed that 15% of PET flexibles placed on the market are collected. Please note that only the weight of PET layer in the multilayer packaging is mentioned in Figure 1. The collected flexibles are, in most cases, sent to cement kilns where they are used as an energy source.[15]

It is estimated that 80% of PET bottles entering the waste stream are collected, sorted, baled, and sent to recyclers. The sorting is based on colour, since light or transparent bottles have higher post-consumer prices. In India it is estimated 10% to15% of PET bottles are green, 2% to 3% are amber or blue or other colours, and the remainder, about 80%, are transparent/clear bottles.[15] Typical stakeholders in the PET post-use value chain include waste collectors, *kabadiwallahs* , aggregators, balers, and recyclers. Based on the colour of the bottles, each player in the value chain receives a renumeration, with transparent PET bottles of the highest value, followed by blue/green, and other colours. There is low value associated with coloured bottles, as they can be recycled back into limited applications since after flaking they provide dark colour flakes. Some bottles are repurposed in homes into storage containers, flowerpots, and other long term uses: some sources estimate this to be between 1% and 10% of total PET placed on the market. In the current study, based on industry consultation, this has been estimated to be 2.5%. The two post-consumer pathways, collected PET bottles and repurposed PET bottles, together account for 70% to 90% of PET bottles placed on the market. In many reports, this number is described as or termed the recycling rate.[17]

In technical terms, collection rate refers to weight of PET bottles collected, divided by, weight of PET bottles placed on the market (including caps, lids and labels but excluding weight of beverage/ product). The input recycling rate (IRR) is the weight of PET bottles that reaches the recyclers divided by the weight of PET materials placed on the market. IRR accounts for the losses in collected PET bottles before reaching the recycler. As the PET waste collection relies heavily on the informal sector, the losses after collection and before reaching the recycler are not uniform across the country. In some cases, the caps and lids are removed at the material recovery facility (MRF) and in others, after they reach the recycler. Therefore, it was not possible to estimate the input recycling rate.

Output recycling rate (ORR) is the weight of PET flakes obtained after post-consumer PET bottles are washed and flaked at the recycling facility, divided by, weight of PET material placed on the market. This accounts for all losses at the recycling stage.

The collected PET bottles received by the recyclers are usually contaminated with moisture, dirt and food residue from the residual waste

[14] To learn more about the role of informal sector in plastics waste management, read India Plastic Pact's report *Ecosystem approach for engagement with the informal plastic waste sector.*

[15] Stakeholder consultations

[16] Range is based on inputs received from a number of one-to-one conversations with stakeholders from across the plastics value chain.

[17] Stakeholder consultations, in the India Plastics Pact terminology, repurpose, is not considered as recycling.

streams. The bottles might also include caps, lids and labels. These are removed manually after they reach the recyclers, as well as through automated processes at the washing stage. These losses, often termed as 'invisible waste' range between 15% to 25% of total PET input material to the recycling process. We have assumed invisible waste to be 20% of the total PET input material weight, this excludes the weight of caps, lids and labels.
The caps and lids, usually made of PP or Polyethylene(PE), are collected separately after the washing process and sent to polyolefin recyclers. These can be made into reusable vegetable trays and construction products. PE and PP labels which are attached to the bottle with glue will be removed during the hot wash, while shrink sleeve labels need a separate sorting process. The separated labels are usually sent to cement kilns. Some quantity of PET waste lost at the recycling stage is collected and sent to other resin manufacturers (In Figure 1, this PET waste has been categorized as 'sent to landfill', since it was not possible to arrive at a precise number. However, industry estimates suggest this number to be low).

Based on the definitions and discussions above, in India, 80% of PET bottles (826 kt) are collected, 2.5% are repurposed and the remaining PET bottles are uncollected and get littered or end up in landfills. The output recycling rate of PET bottles in India is estimated to be 64% (599 kt) (Figure 6).

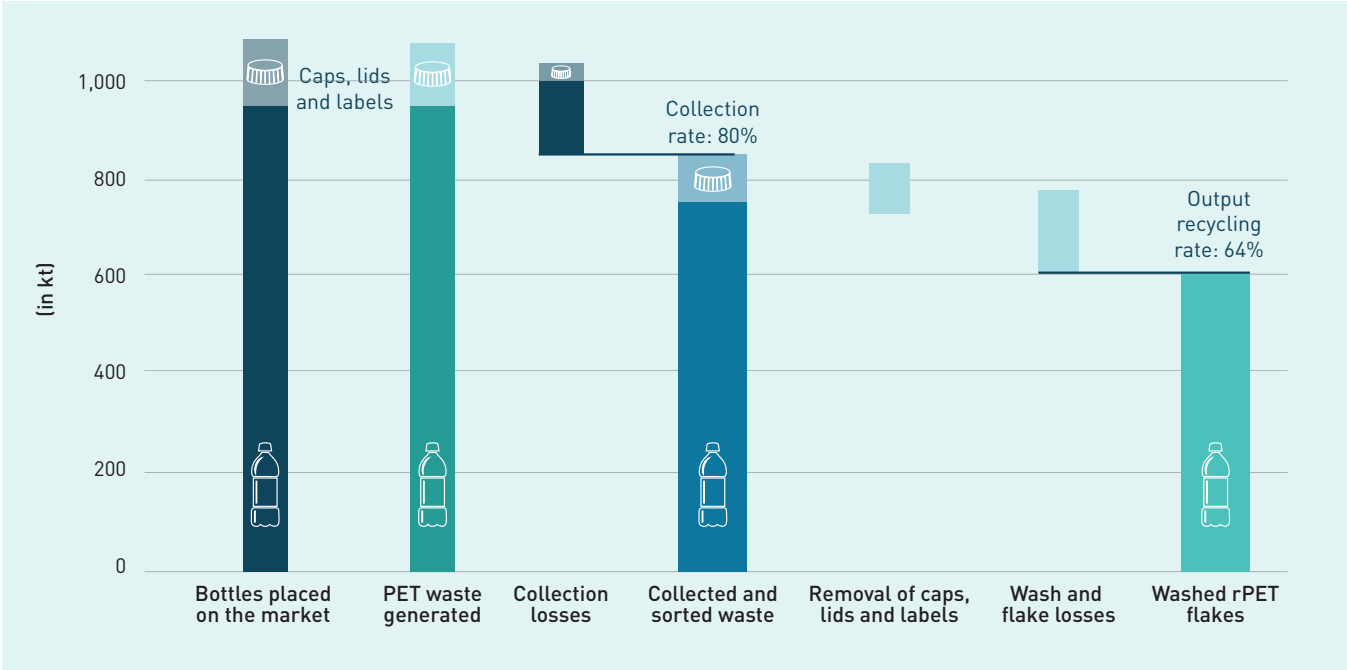


Figure 6: Collection and recycling rate of PET in India in 2021-22

End-products of recycling

In 2021-22, 599 kt of washed rPET flakes were available for recycling. Of this, it is estimated that 75% (449 kt) are recycled to polyester staple fibres which are in demand by the textile industry. A significantly high percentage of post-consumer PET bottles are converted to textiles because of a lack of food sector end-markets due to the earlier policy, strong local textile sector and strong demand. Also, the intrinsic viscosity (IV) of the rPET flakes is similar to textile-grade PET chips. This makes it economical to convert post-consumer bottles to fibres through an established mechanical recycling and extrusion process.

Out of the remaining 25% of washed rPET flakes, 20% (120 kt) are recycled to sheets and straps. Sheets are commonly used to pack fruits, vegetables, and bakery items in PET trays. Since the COVID-19 pandemic began, the demand for

packaged fruits and vegetables has increased in India. As the use of rPET in food contact application was not allowed before the amendments in the regulations in 2021, rPET was used in the middle or outer layer of the trays.[18]

The remaining 5% (30 kt) of the washed rPET flakes are converted into rPET pellets. Based on industry inputs, it was identified that there are 5% losses at this stage i.e., conversion of rPET flakes into rPET pellets. After accounting for the losses, 28 kt of rPET pellets are available. Of this, a significantly small share is exported, and the remaining pellets are used by the brands for non-food grade PET packaging applications (homecare products such as floor cleaners, liquid dishwashers, and insect repellents).

In most cases, downcycled rPET applications might come to end-of-life after a single additional cycle. This happens because of lack in infrastructure for collection and recycling of certain products (textiles, straps, etc.), or the low value associated with the collection of these products. Hence, the use of rPET back into the same application should be preferred (i.e., bottles back into bottles, trays back into trays, etc.), whilst the quality of the products can be maintained, before recycling them into a lower quality product. This will promote creation of a circular economy for PET in India.

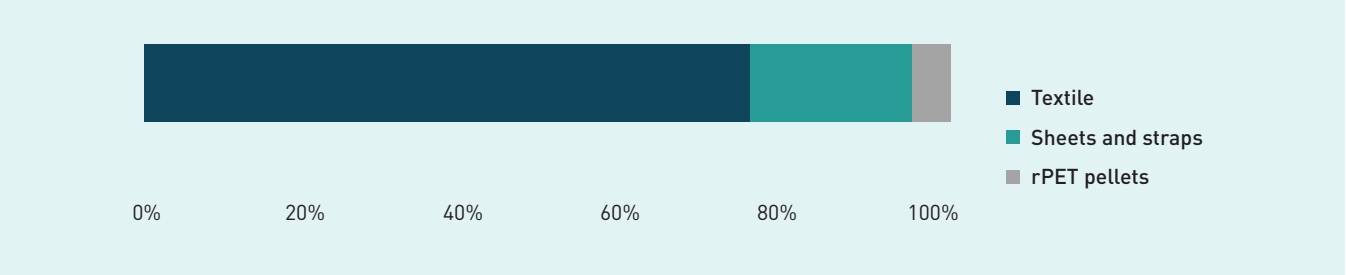


Figure 7: End-products of PET recycling

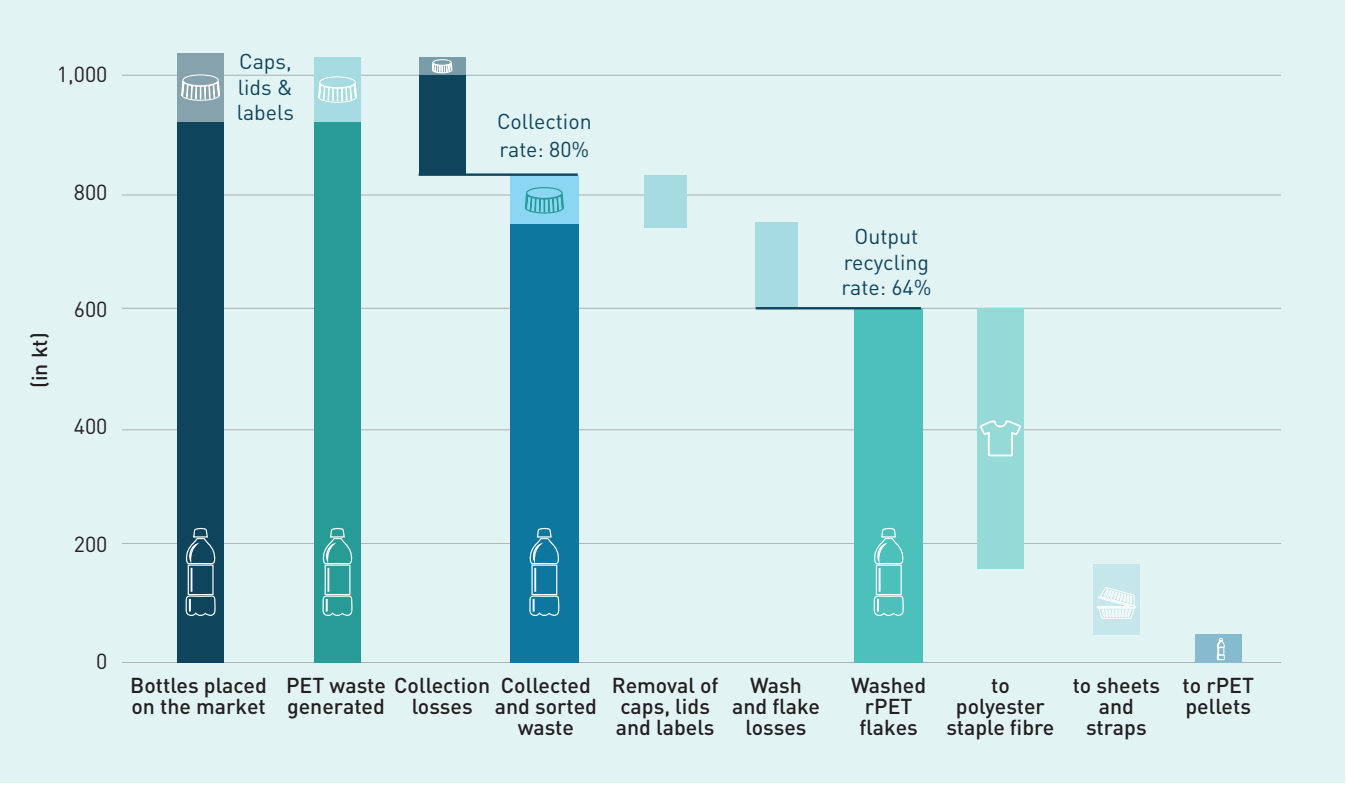


Figure 8: Collection rate, recycling rate and end-products of PET recycling in 2021-22

[18] Stakeholder consultations

Conclusions and next steps

This report presents a material flow of PET used for packaging applications in India for 2021-22. The aim of the material flow is to provide stakeholders with clear information about the quantities of PET flowing through the value chain, including its use and disposal routes. Such data will help inform future investment and infrastructure needs supporting the use of rPET in food contact packaging applications.

In 2021-22, it was estimated that 2,301 kt of virgin PET was produced in India, and 1,698 kt PET was placed on the Indian market (after accounting for exports and imports). Rigid packaging made up 58% (993 kt) of total PET placed on the Indian market: 95% used to make bottles and 5% for sheets and straps. It is estimated that 1,692 kt of PET waste was generated.

India has a high collection rate of PET bottles: 80% of PET bottle post-consumer waste is collected and sorted. Out of the total quantity of PET bottles collected, 599 kt of washed rPET flakes were produced in 2021-22 which corresponds to an output recycling rate of PET resin in India of 35%. The specific recycling rate for PET bottles in India, for the year 2021-22, was 64%. The total quantity of food and drink contact PET bottles available in 2021-22 for potential conversion to rPET pellets for food grade bottle applications was 409 kt.

Even though almost half of the PET bottles can be recycled back to bottles, in practice this does not happen for the following reasons:

- channelling of post-consumer PET bottles to polyester staple fibre
- lack of segregation at source which leads to contamination of input material and a reduction in the available input feedstock
- recycling-unfriendly design of PET bottles, including:
  - use of coloured PET which reduces the number of applications of rPET
  - use of additives
  - choice of material/resin for caps, lids and labels
- higher market price for food-grade rPET compared to vPET due to:
  - expensive machinery to produce rPET pellets
  - current regulations prohibiting import of PET (pellets and waste)
  - large share of post-consumer food grade PET bottles being used to make fibre.

In order to close loops and make the PET value chain more circular,

- put in place a hierarchy of end markets to ensure rPET is used for the same application, as long as the quality of the output material is not hampered,
- develop design guidance for adoption by PET bottle manufacturers for PET rigid and flexible packaging formats to ensure packaging is designed for economical recycling after use, and
- provide access to infrastructure and investment.

Recent regulatory changes have paved the way for action by stakeholders across the PET bottle value chain to take concrete steps towards bottle-to-bottle recycling. Clear policy direction from the government has allowed investors to take decisions on investing into newer recycling technologies. Many large brands have set quantitative targets for recycled content in packaging. Also, new PET bottle-to-bottle recycling plants are being set up.

Collaborative, business-led initiatives such as the India Plastics Pact will help resolve some of the challenges by providing a platform for cross-fertilization of ideas between stakeholders at all parts of the value chain. The Pact will also help in developing design guidelines for food contact grade PET bottles and a business case for food grade recycled PET.[19] Through this report, the India Plastics Pact aims to bridge the gap in terms of the data on PET, identify gaps and map the flow of PET in the Indian economy.

[19] Please visit https://www.indiaplasticspact.org/ to see more of the Pact's work on recycled PET.

Annexure 1

Production, trade, and consumption data

Table 1: Production, trade, and consumption data for PET used for rigid packaging applications in India from 2006-22 (in kt)[20, 21]

Year	Production (reported)	Production (adjusted)[22]	Import	Export	Consumption
2006-07	-	-	65	302	-
2007-08	573	659	30	263	506
2008-09	1,177	1,354	62	279	1,210
2009-10	1,462	1,681	25	284	1,510
2010-11	1,533	1,762	60	346	1,574
2011-12	1,473	1,694	36	291	1,525
2012-13	1,487	1,710	80	324	1,549
2013-14	1,460	1,679	106	443	1,457
2014-15	1,362	1,566	167	375	1,429
2015-16	1,453	1,671	122	783	1,235
2016-17	1,549	1,781	118	932	1,244
2017-18	1,425	1,638	219	1,039	1,097
2018-19	1,271	1,462	335	1,082	969
2019-20	1,345	1,546	392	959	1,172
2020-21	1,209	1,390	108	885	878
2021-22	1,298	1,493	197	955	993

Table 2: Production, trade, and consumption data for PET used for flexibles in India (in kt)[23,21]

Year	Production (reported)	Production (adjusted)[24]	Import	Export	Consumption
20021-22	703	809	77	233	706

[20] Data for 2006-07 to 2011-12 from:
Government of India. (2014). *Chemicals & Petrochemicals Statistics at a Glance: 2014.* https://chemicals.nic.in/sites/default/ files/MLCPCSTAT14_2.pdf.
Data for 2012-12 to 2019-20 from:
Government of India. (2019). *Chemicals & Petrochemicals Statistics at a Glance: 2019.* https://chemicals.nic.in/sites/default/files/Chemical_and_ Petrochemical_ Statistics_at_a_Glance_2020_compressed.pdf.
Data for 2020-21 from:
Ministry of chemicals and fertilizers. (2022). *Annual report 2021-22.* https://chemicals.nic.in/sites/default/files/Annual%20Report%202022%20 Date%2017-2-2022%20final%20LOW.pdf

[21] Data for 2006-07 to 2021-22 from:
Ministry of Commerce and Industry database. (n.d.). *Export Import Data Bank Version 7.1 – Tradestat.* https://tradestat.commerce.gov.in/eidb/default.asp

[22] Based on industry consultations it was concluded that this data were under-reported by 10% to 20%. Thus, for the purpose of this study the reported production data have been corrected by a factor of 15% (assuming a middle value of the error range).

[23] Production data have been collected from 7 large scale PET film manufacturers in India.

[24] The reported production data have been corrected by a factor of 15% to account for other small and medium scale PET film manufacturers.

Annexure 2

HS codes

Table 3: HS codes for PET resin

PET HS codes (in use from 2006-07 to 2016-17)	
39076010	Polyethylene terephthalate with intrinsic viscosity <0.64 dl/g
39076020	Polyethylene terephthalate with intrinsic viscosity >= 0.64 dl/g and <=0.72 dl/g
39076090	Other polyethylene terephthalate (including clean, clourless grades)
PET HS codes (in use from 2017-18 to 2019-20)	
39076100	Poly(ethylene terephthalate): having a viscosity number of 78 ml/g or higher
39076910	Poly(ethylene terephthalate): having a viscosity number less than 78 ml/g but not less than 72 ml/g
39076920	Poly(ethylene terephthalate): having a viscosity number less than 72 ml/g but not less than 64 ml/g
PET HS codes (in use since 2017-18)	
39076990	Other
PET HS codes (in use since 2020-21)	
39076110	PET flake (chip)
39076930	PET flake (chip)
39076190	Other primary form
PET HS codes (in use since 2007-08)	
39206220	Plastic sheets etc of polyethylene terephthalate flexible, plain
39206290	Plastic sheets of polyethylene terephthalate NES
39206939	Other film of other polyester NES
39206999	Other plastic sheets etc of other polyester NES
39206929	Sun/dust control film of other polyester NES
39206919	Packaging film of other polyesters NES
39206992	Other plastic sheets etc of other polyesters flexible, plain
39206912	Packaging film of other polyester flexible plain
39206922	Sun/Dust control film of other polyesters flexible, plain

Annexure 3

Consumption

Consumption of PET is calculated using the following formula,

$$C_i = P_i + I_i - E_i$$

where,

C_i is Consumption of PET in i^{th} year

P_i is Production of PET in i^{th} year

I_i is Import of PET in i^{th} year

E_i is Export of PET in i^{th} year

Annexure 4

End-use applications

Table 4: End-use applications of rigid packaging in India[25,26]

Applications	Value (%)	Value considered based on consultation (%)
Sheets and straps	4 to 6	5
Bottle applications	94 to 96	95

Table 5: End-use applications of sub-division of bottle applications[27]

Applications	Value considered (%)
Bottled water	30.9
CSD/Fruit drinks	19.9
Personal care	11.1
Liquor	10.6
Pharmaceuticals	8.9
Wide mouth jar	7.6
Edible oil	6.7
Homecare	1.8
Dairy	1.2
Agro chemicals	1.1

[25] CSIR-NCL. (2017). *PET recycling in India: mapping the recycling landscape.* http://www.in-beverage.org/lca-pet/NCL%20Report_Indian%20PET%20Recycling%20Landscape__Final_Ver%2003_December%202017.pdf

[26] PACE. (2019, September 4). *Socio-Economic Impact of PET packaging & its Recycling* [Presentation]. http://www.in-beverage.org/lca-pet/Presentation%20For%20GoI%20Stakeholders_4th%20September%202019.pdf

[27] PlastIndia foundation. (2019). *Indian Plastics Industry Report 2019.* https://www.plastindia.org/plastic-industry-status-report.php

Annexure 5

Lifetime of end-products

Table 6: Lifespan considered for PET end products[28]

Applications	Lifetime considered (years)
Film	0
Sheets and straps	0 to 2

Table 7: Lifespan of bottle applications

Applications	Lifetime (months)[28]	Lifetime (years)[29]	Lifetime considered (years)
Bottled water	12	0 to 1	0 to 1
CSD/Fruit drinks	3 to 4	0	0
Personal care	18	1 to 2	0 to 3
Liquor	> 24	2 to 3	0 to 5
Pharmaceuticals	18	1 to 2	0 to 3
Wide mouth jar		2 to 4	0 to 6
Edible oil	12	0 to 1	0 to 1
Homecare	24	1 to 2	0 to 3
Dairy	6	0	0
Agro chemicals	24	1 to 2	0 to 3

[28] Estimated values

[29] CSIR-NCL. (2017). *PET recycling in India: mapping the recycling landscape.* http://www.in-beverage.org/lca-pet/NCL%20Report_Indian%20PET%20Recycling%20Landscape__Final_Ver%2003_December%202017.pdf

Annexure 6

Waste

PET waste entering the market in 2021-22 is calculated using the following formula,

$$W_i = \frac{\sum_{L=1}^{L=L} C_{(i-(L-1))}}{L}$$

where,

W_i is waste generated in i^{th} year

C is consumption of PET

L is lifespan of the product in number of years

Annexure 7

Quantity of PET waste generated in 2021-22

Table 8: Quantity of PET waste generated in 2021-22

Applications	Waste (kt)
Film	706
Sheets and straps	51
Bottle applications	936
Total PET waste	1,692
Sub-division of bottle applications	
Bottled water	275
CSD/Fruit drinks	188
Personal care	106
Liquor	107
Pharmaceuticals	85
Wide mouth jar	78
Edible oil	60
Homecare	17
Dairy	11
Agro chemicals	10

Annexure 8

End products of recycling

Table 9: End-products of recycling[30]

End-use categories	Value (%)	Value considered (%)
Textiles	65 to 75	75
Sheets and straps	10 to 20	20
rPET pellets	5	5

[30]Stakeholder consultations

Glossary

Capacity utilization: it is defined as PET produced in a year upon installed capacity of PET in the same year

Collection rate: collection rate refers to weight of PET bottles collected divided by weight of PET bottles placed on the market bottles, including caps, lids and labels but excluding beverage/product

Input recycling rate: input recycling rate is the weight of PET bottles that reaches the recyclers divided by the weight of PET materials placed on the market

Output recycling rate: output recycling rate is the weight of PET flakes obtained after wash and flake divided by the weight of PET materials placed on the market

Current waste: waste that was generated from a PET product placed on the market in the current year

Formal recycling: recycling of PET in facilities registered in the CPCB portal

Informal recycling: recycling of PET in facilities which are not registered in the CPCB portal

Legacy waste: waste that was generated from a PET product placed on the market prior to the current year

About the India Plastics Pact

The India Plastics Pact is a collaboration between the Confederation of Indian Industry (CII) and WWF India that unites businesses, governments, NGOs and citizens to create a circular plastics economy in India. The CII-ITC Centre of Excellence for Sustainable Development (CESD) anchors the India Plastics Pact, within CII. The initiative is supported by WRAP, a global NGO based in the UK.

Launched in September 2021, the India Plastics Pact is the first Plastics Pact in Asia. As of June 2022, there are 13 Plastics Pacts spread across the globe. 33 organizations are currently part of the India Plastics Pact. The Pact works on all plastic resins at all stages of the plastics value chain.

Confederation of Indian Industry

About Confederation of Indian Industry

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 advisory and consultative processes. For more than 125 years, CII has been engaged in shaping India's development journey and works proactively on transforming Indian Industry's engagement in national development. CII engages closely with Government on policy issues and interfaces with thought leaders to enhance efficiency, competitiveness and business opportunities for Industry through a wide portfolio of specialized services and strategic global linkages.

India's premier business association has around 9,000 members, from the private as well as public sectors, and an indirect membership of over 300,000 enterprises from around 286 national and regional sectoral industry bodies. With 62 offices, including 10 Centres of Excellence in India, and 8 overseas offices in Australia, Egypt, Germany, Indonesia, Singapore, UAE, UK, and USA, as well as institutional partnerships with 350 counterpart organizations in 133 countries, CII serves as a reference point for Indian Industry and the international business community.

WWF

About WWF India

WWF India is committed to creating and demonstrating practical solutions that help conserve India's ecosystems and rich biodiversity. With more than 50 years of conservation journey in the country, WWF India works towards finding science-based and sustainable solutions to address challenges at the interface of development and conservation. WWF India is part of the WWF network, with offices in over 100 countries across the world. WWF India works in many states of India, through our state and field offices. The organisation works in different geographical regions and across thematic areas, including the conservation of key wildlife species and their habitats, management of rivers, wetlands and their ecosystems. On the sustainability side, the focus areas are climate change adaptation, driving sustainable solutions for business and agriculture and empowering local communities as stewards of conservation. WWF India also works in combatting illegal wildlife trade and in bringing environment education to students through outreach and awareness campaigns.

About WRAP

WRAP is a global NGO based in the UK. It is one of the UKs top 5 environmental charities and works with governments, businesses and individuals to ensure that the worlds natural resources are used sustainably. WRAP collaborated with the Ellen MacArthur Foundation to launch the first Plastics Pact in the UK in 2018. WRAP is the charity leading The UK Plastics Pact (a world first) and the Plastics Pact in Europe, Canada, US, South Africa, Kenya and India; as well as, Love Food Hate Waste, the Courtauld Commitment, the Sustainable Clothing Action Plan, Textiles 2030, and Recycle Now. WRAP works collaboratively and develops and delivers evidence-based, impactful solutions to reduce the environmental cost of the food we eat, the clothes we wear and the plastic packaging we use. Founded in 2000 in the UK, WRAP now works around the world and is a Global Alliance Partner of The Royal Foundation's Earthshot Prize.

About UKRI

Launched in April 2018, UKRI is a non-departmental public body sponsored by the Department for Business, Energy and Industrial Strategy (BEIS).

Our organisation brings together the seven disciplinary research councils, Research England, which is responsible for supporting research and knowledge exchange at higher education institutions in England, and the UK's innovation agency, Innovate UK.

Our nine councils work together in innovative ways to deliver an ambitious agenda, drawing on our great depth and breadth of expertise and the enormous diversity of our portfolio.

Through our councils we maintain and champion the creativity and vibrancy of disciplines and sector-specific priorities and communities. Our councils shape and deliver both sectoral and domain-specific support.

Whether through research council grants, qualityrelated block grants from Research England, or grants and wider support for innovative businesses from Innovate UK, we work with our stakeholders to understand the opportunities and requirements of all the different parts of the research and innovation landscape, maintaining the health, breadth and depth of the system.

UKRI India

UKRI India plays a key role in enhancing the research and innovation collaboration between the UK and India. Since 2008, the UK and Indian governments, and third parties, have together invested over £330 million in co-funded research and innovation programmes.

This investment has brought about more than 258 individual projects. The projects were funded by over 15 funding agencies, bringing together more than 220 lead institutions from the UK and India. These research projects have generated more than £450 million in further funding, mainly from public bodies but also from non-profit organisations and commercial entities, attesting the relevance of these projects.

Notes

Notes

INDIA PLASTICS PACT

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Confederation of Indian Industry

CII-ITC Centre of Excellence for Sustainable Development

WWF

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