Resource Efficiency and Circular Economy Industry Coalition

FICCI | Centre for SUSTAINABILITY LEADERSHIP

PACKAGING REIMAGINED 2.0

ALTERNATE & SUSTAINABLE SOLUTIONS



accenture

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तन्मय कुमार
TANMAY KUMAR

सत्यमेव जयते

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पर्यावरण, वन और जलवायु परिवर्तन मंत्रालय
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& CLIMATE CHANGE



MESSAGE

The packaging industry in India is at a pivotal moment where, while it has immense opportunities it is also required to meet the sustainability challenges. With rising demand—driven by rapid urbanization, economic expansion, and the surge of e-commerce—India's packaging sector is evolving at an unprecedented pace. However, this rapid growth also generates significant waste, posing environmental and health concerns. The environmental impact—ranging from land and water pollution to broader ecological and human health risks—underscores the urgent need for sustainable packaging solutions.

Recognizing these challenges, India has made commendable strides toward a circular economy by integrating the principles of reducing, reusing, and recycling into policy and business strategies. The Ministry of Environment, Forest and Climate Change (MoEFCC) has been instrumental in shaping policies such as the Plastic Waste Management Rules and fostering cross-sectoral collaborations to address packaging waste sustainably.

At this defining moment, the choices we make today will shape the future of packaging industry in India. With collective determination and collaboration, we can drive the industry towards a model that is both economically viable and environmentally responsible, ensuring a sustainable future for generations to come.

In this context, the introduction contribution of the Resource Efficiency and Circular Economy Industry Coalition (RECEIC) working group on ***'Packaging Reimagined: Alternate and Sustainable Solutions'*** is both timely and significant. This initiative is expected to become a vital platform for driving transformative change in the sector. The knowledge paper developed as part of this collaborative effort provides a comprehensive analysis of India's packaging landscape, highlighting key trends, challenges, and actionable policy recommendations. It serves as a valuable resource for policymakers, businesses, environmental advocates, and consumers committed to fostering a more sustainable packaging ecosystem.

The Ministry appreciates the proactive efforts of the Resource Efficiency and Circular Economy Industry Coalition (RECEIC), a G20 initiative during India's Presidency in 2023, in addressing the pressing needs for sustainable packaging solutions. This initiative aligns with India's national priorities and reinforces the country's commitment to build a resilient circular economy.

Let us move forward with shared commitment and decisive action to create a packaging ecosystem that not only meets present and futuristic demands but also safeguards the environment and the well-being of future generations.

(Tanmay Kumar)

Place: New Delhi
Dated: April 2, 2025

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Foreword - Chair, RECEIC

The packaging industry in India stands at a critical juncture, presenting both unprecedented opportunities and significant challenges. As one of the fastest-growing industries, packaging plays a critical role in product protection, logistics, and consumer engagement. However, its rapid expansion has also brought pressing environmental concerns, with packaging waste—especially plastic—becoming a significant challenge for waste management, resource efficiency, and sustainability.

Recognizing the need for a systemic shift, India has taken commendable steps to integrate circular economy principles into packaging. Policies such as the Plastic Waste Management Rules[1], the emphasis on Extended Producer Responsibility (EPR), and initiatives under the Swachh Bharat Mission signal a growing commitment to sustainability. Yet, there remains an urgent need to accelerate action by fostering innovative materials, scalable recycling solutions, and industry-wide collaboration.

I extend my sincere appreciation to the members of the "Packaging Reimagined: Alternate & Sustainable Solutions" working group for their dedicated efforts in compiling this insightful report. Their analysis not only highlights the challenges within India's packaging landscape but also presents a strategic roadmap for transitioning towards sustainable packaging solutions. The report offers key recommendations that can inform policy interventions, encourage industry adoption, and drive investments in circular packaging models.

At RECEIC, we are committed to translating these insights into tangible action by driving collaborative initiatives and implementing projects. By showcasing scalable models of sustainable packaging, we aim to accelerate industry transformation and position India as a global leader in circular packaging solutions.

This is a defining moment for the packaging industry to reimagine its future. With collective action, innovation-driven policies, and a strong commitment from stakeholders, we can create a packaging ecosystem that not only meets present-day demands but also safeguards the environment for future generations.



Mr. Manish Sharma
Chair, RECEIC & Chairman,
Panasonic Life Solutions India and South Asia

1. CPCB | Central Pollution Control Board

Foreword - Chair Working Group

The Indian packaging industry is on the brink of transformative growth. While this growth underscores India's rising prominence as a global packaging hub, it also highlights the pressing challenges that come with rapid industrial expansion.

India's packaging sector, the fifth-largest contributor to its economy, is developing at an astonishing pace of 22-25% annually[2]. With advancements in technology and increasing demand for processed foods, beverages, and e-commerce solutions, innovative packaging formats such as flexible and biodegradable options are gaining traction. Flexible packaging alone commands 65% of the market share and is expected to surge to USD 94 billion by 2029[3]. However, this growth comes with significant environmental costs.

As leaders in the industry, we must act decisively. At Huhtamaki, we envision a future where growth aligns with sustainability. This report delves into India's problematic packaging landscape, examining the environmental impacts of rapid industrialization and presenting actionable strategies for transitioning to circular economy models. By prioritizing eco-friendly innovations, optimizing supply chains, and fostering collaborations to drive innovations in packaging design, we can mitigate risks while capturing opportunities in this dynamic market.

India's packaging sector is at a crossroads. The choices we make today will shape not only the industry's future but also its impact on ecosystems and communities. Let us commit to leading this transformation responsibly—toward a more sustainable and equitable tomorrow.



Mr. Michael Hoffmann

Chair, RECEIC Working Group on Packaging Reimagined &
Vice President Sustainability & Communications, Huhtamaki

2. IBEF Industry Report - https://www.ibef.org/industry/paper-packaging
3. Transformation in India's packaging industry - https://www.imap.com/en/insights/2025/Indias_Packaging_Industry_A_Billion_Dollar_Transformation_Beckons~cv

Preface - Accenture

India's packaging consumption has surged by 200% over the past decade, rising from 4.3 kg per person per annum (pppa) to 8.6 kg pppa as of FY2020[4]. The sector's rapid expansion is fueled by evolving consumer preferences, growing e-commerce adoption, and advancements in packaging technologies, making India a preferred global hub for packaging innovation and manufacturing. Yet, this progress comes with challenges—rising waste generation, resource inefficiencies, and limited recycling infrastructure—that demand immediate attention.

In India, approximately 59% of total plastic consumption is used for packaging[5], with a significant portion allocated to flexible packaging, often for small-format products with limited recycling potential. Additionally, in 2023, India generated over 9 million tonnes of plastic waste, with nearly 43%[6] of this being single-use plastics like bags, straws, and packaging materials. As India's packaging industry expands at a rapid pace, it is crucial to address the challenges posed by problematic, single-use packaging. The growth narrative offers both immense opportunities and an urgent call for sustainable packaging strategies.

At Accenture Strategy & Consulting, we are committed to driving sustainable transformation across industries, and the packaging sector in India is no exception. This study explores these complexities and offers strategies for businesses to embrace circularity and innovation in packaging. The report delves deep into interventions across the upstream, midstream, and downstream stages of India's packaging value chain. These recommendations, spanning material innovation, packaging life extension, and enhanced recycling, are accompanied by a phased action plan. With the right support in policy, financing, and technology, India has the potential to transition to sustainable packaging and unlock a significant value through material value unlock and circular job creation. Together, we can reimagine India's packaging landscape to foster innovation, resilience, and sustainability.



Mr. Ganesan Ramachandran
Managing Director,
Accenture

4. https://www.investindia.gov.in/team-india-blogs/indian-packaging-sector-outlook-industry
5. https://www.mdpi.com/2071-1050/14/8/4425
6. https://www.fortuneindia.com/long-reads/single-use-plastic-indias-battle-far-from-over/118615

Executive Summary



The global packaging market value is approximately $1,175B[9], calculated on the value of finished products, with an annual growth rate of 4% during 2023–2028. In India alone packaging materials such as plastic resins (HDPE, LDPE, PP, PS, PET), MLP, Paper (corrugated cardboard boxes), Glass (coloured glass) has an annual consumption of **18 million metric tons** (based on Accenture analysis)[8] , from the FMCG, HORECA, and E-Commerce sectors, which contribute to a substantial waste stream. It is estimated that **65% of this packaging waste stream remains uncollected**[10,11,12,13] ending up in the landfills. This waste generation is primarily due to challenges with design, limitations on useful life, and potential to add to existing litter volumes. These material categories are being referred to as 'problematic packaging' in the report. Traditionally in India, waste management of these 'problematic packaging' materials with low embedded values, is largely driven by the informal sector, which leads to with significant leakage of waste and material value into the environment, causing negative externalities.

To address the challenges of problematic packaging this study "Packaging Reimagined 2.0," captures insights from stakeholder workshops and consultations with 30+ participants across the packaging value chain to identify potential **upstream interventions** that present credible and innovative pathways, with high economic and social potential, to not only **innovatively design out problematic packaging, but also create a growing ecosystem of green jobs to support the scaling of these alternate solutions, over the next 5 years.**

The study identifies 5 critical findings:

Finding: 1

India's current trajectory with problematic packaging could lead to a staggering material value loss of ~$160B by 2030, a tenfold increase from the current $16B annual material value loss

A detailed Accenture analysis reveals that the material value loss varies across different packaging polymers and types due to factors such as recycling rates, cost economics, and inherent recyclability. Flexible plastics, mainly LDPE and MLP, which together comprise 43% of the entire packaging consumption, are among the least recycled plastics (25% and <1% respectively) and contribute to majority of the material value loss, nearly 27% and 33% of the total, respectively.

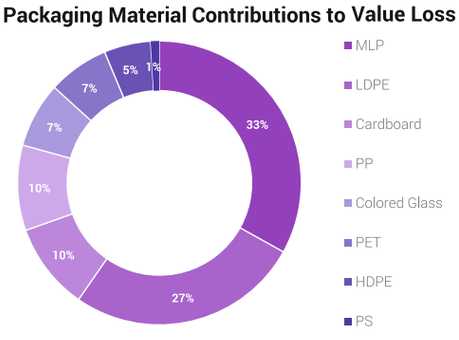


Figure 1 : Material value loss contribution across packaging materials

On the other hand, material value loss from rigid plastic polymers, like HDPE and PET, are comparatively low. Although the recycling infrastructure for these materials are relatively more mature, these polymers incur high downcycling losses. While glass is known to be highly recyclable and paper is seen as sustainable alternative to plastics as it has high recycled content, recycling coloured glass and recovering corrugated paper boxes poses a significant challenge which leads to around 20% of the overall material value loss.

Finding: 2

Barriers to scaling solutions for problematic packaging span the entire value chain. The key challenge in upstream value chain is the unreliable supply of feedstock for bioplastics andalternative materials, while mid-stream reuse/refill phase is impacted by an under-developed ecosystem for returnable or reusable packaging.

The material value loss and inability to shift to sustainable practices can be attributed to challenges stemming across the packaging value chain -

8. As per Accenture analysis
9. World Population Review 2023, https://plasticbank.com/which-country-is-the-most-accountable-for-ocean-plastic
10. TERI Report, 2022, https://www.teriin.org/sites/default/files/2022-06/Sustainable-Beverage-Packaging-Final-Report.pdf
11. TERI Report, 2021, https://www.teriin.org/sites/default/files/2021-12/Circular-Economy-Plastics-India-Roadmap.pdf
12. India Plastics Pact, 2022, https://www.indiaplasticspact.org/uploads/1703753076document.pdf
13. Plastics Packaging Recyclers Attribute Low Recycling Rates

1. Challenges to scaling of upstream solutions - bioplastics and other sustainable alternatives: Over 30 types of sustainable materials have been developed worldwide, yet indigenous production capacity remains limited for all types. The following factors hinder widespread adoption at scale:



Feedstock availability & prices

Sugarcane-based feedstocks dominate bio-plastic production in India. However, as sugarcane is heavily consumed for food, animal feed (bagasse/fibre), and industrial use, its byproducts fluctuate in availability and price. This unpredictability increases operational costs.



Capital investments & risks

Bioplastics plant require higher capital than traditional plastic production facilities and uncertain demand further discourages these investments, leading to negligible indigenous manufacturing capability currently.



Sustainability concerns

Many bioplastics require industrial composting infrastructure. Without proper disposal, they risk littering and ecotoxicity. Additionally, some alternatives are partially fossil-based or not biodegradable at all, raising questions about their environmental benefits.



Fewer scalable solutions for flexibles

Most bioplastics cater to replace rigid packaging (e.g., PET, HDPE). Flexible plastics like LDPE, due to their lower costs and light weight, lack viable bioplastic alternatives with adequate barrier properties for use across applications.

2 .Challenges to midstream solutions - extension of useful life of packaging materials: Currently, less than 2% of FMCG packaging is available for reuse or refill[14]. In India, while most of the packaging is single use, they are also often reused 'at home'. But these efforts are fragmented and leaves little room for a holistic development of reusable models, wherein businesses collaboratively take the responsibility of designing packaging and the ecosystem for extending the useful life.



Reverse logistics

Managing reusable packaging reverse logistics can be complex and costly, especially for products with large volumes or those requiring long-distance transportation.



Maintaining hygiene & safety standards

Reusable/ refillable food and beverage containers necessitate rigorous cleaning processes to prevent contamination, to adhere to prevailing safety standards.

14. Ellen Macarthur Foundation, 2022

Consumer habits

Shifting consumer preferences away from the convenience of disposable packaging towards a system that requires active participation in returning and refilling containers necessitates a change in mindset and habits.

Prevailing infrastructure

Existing infrastructure is currently geared towards recycling, not reuse. This lack of adequate systems for the collection, cleaning, and redistribution of reusable packaging presents a significant impediment to scaling these initiatives.

3. Challenges to downstream solutions - end-of-life management of packaging: Basis Accenture analysis, a staggering 65% of packaging waste remains uncollected leading to significant challenge is packaging waste management. This translates to roughly 12 million tonnes[8] of packaging waste escaping the collection efforts annually.

The root of this problem lies in the unfavorable economics of waste collection and recycling. While certain types of plastic packaging, like PET, have better economic prospects for recycling, the overall costs associated with collecting, sorting, and processing other waste streams like plastic flexibles and MLPs often surpass the revenues generated. Several factors contribute to these economic challenges, most significant is the predominantly fragmented ecosystem, dominated by a very large informal and unorganized collection recycling setup. Informal operations have lower overhead and operational costs, often capturing a larger share of the recyclable materials, leading to valuable materials being lost from the formal recycling stream and hindering the development of a more sustainable industry.

Finding 3:

Circular interventions have the potential to unlock almost ~ $107 B material value by 2030, that is two-third of the total material value loss. 75% of the total material value unlock potential can be captured through upstream strategies focused on eco-design and extension of useful life.

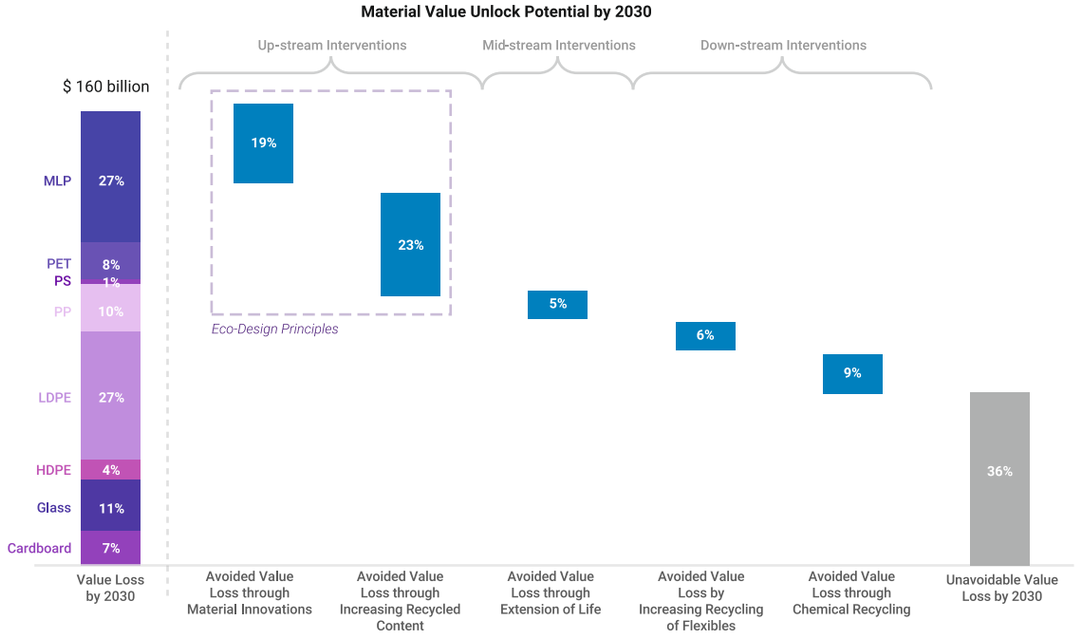


Figure 2 : Breakdown of material value unlock potential across the identified intervention levers

1

Adopt eco-design principles:

Replacing existing packaging materials with alternative material solutions - **biomaterials, mono-materials and packaging optimization** have the potential to unlock **$31.5B** of the material value loss by 2030, which is **30% of the total material value unlock potential.** With the advent of bioplastics and innovative materials, India is poised to become a bioplastics leader in the coming years given its sugarcane and other feedstock generation capacities.

Additionally, recycled input in packaging (as per EPR targets) can unlock material value of almost **$40B, 37% of total material value unlock potential.** A simple and established intervention, this quickly can be scaled with the help of investments in India's closed loop recycling infrastructure.

2

Extension of Useful Life:

It is not always possible to eliminate plastic packaging due to their undeniable benefits, the useful life of the packaging material needs to be extended beyond a single use. Two such models have been explored for packaging materials with high embedded material values, i.e., PET, HDPE and Glass) the take-back system and the refill and retailer system – both of which places the responsibility on the producer to make the packaging available for multiple lifecycles. Circular business models to extend the useful life of packaging materials can unlock 6% of the cumulative material value loss till 2030, i.e., approximately **$9B, which is nearly 8.4% of the total material value unlock potential.**

Achieving the FY 2028 EPR reuse target rates for rigid plastic packaging like HDPE and PET as well as increasing the reuse rate for Glass, have the potential to unlock **$7.8B of material value by 2030.** The refill strategy, which is applicable for the organized private label retail sector dominated by HDPE packaging, can further add another **$1.1B** in material value unlock potential by 2030.

3

Boost collection and recycling infrastructure:

Boosting the collection and recycling rates of packaging materials to meet India's ambitious Extended Producer Responsibility (EPR) targets—80% for rigid plastics and 60% for flexibles by 2028[15] - will unlock about **10% of the material value potential, nearly $10 B by 2030.**

Although the study does not delve deeper into collection and recycling interventions, robust implementation of the EPR policy has significant potential to drive the transition to a circular economy transition, complementing innovative alternatives that will be explored in greater detail in the report.

Finding 4:

To drive Eco-design initiatives, indigenous manufacturing of sustainable packaging materials must be prioritized in the medium term, utilizing imports & low-tech options in the short term to facilitate this transition. National capital investment of ~₹12,000 Cr is required between 2025 and 2028 to support indigenous manufacturing of sustainable materials, along with diversion of ~150 million tons of sugarcane-derived biomass for various feedstocks to support roll-out of multiple bioplastic types.

There are currently more than 30 sustainable packaging alternatives in the global market and a hundred more in nascency. The study carried out comprehensive quantitative analysis to identify India's most feasible options and to develop a roll-out plan.

15. India EPR Targets - https://pib.gov.in/PressReleasePage.aspx?PRID=1881760

1. **Versatile biobased materials like PLA** have the potential to replace PET, HDPE, LDPE and PP resins in multiple applications. Basis Accenture analysis, **PLA can be made to replace 8% of PET in 2027 and scaled to replace 39% of PET profitably by 2030.**
2. **Low-tech biobased options like bagasse** and fiber-based replacements for PS are highly lucrative, established and basis Accenture analysis, can profitably replace **20% of PS packaging in 2027 and 52% PS by 2030.** Options like **TPS** which are already manufactured indigenously today, can also be scaled to profitably **replace 1.5% of LDPE by 2030.**
3. **Patented materials** provide a technologically sound alternative to replace hard to recycle materials like LDPE and MLP. Many are in their nascency but focused efforts on R&D funding can help scale these materials across various applications.
4. **Recycled aluminium packaging** can help bridge the gap between availability of bioplastics locally and need for established sustainable packaging solutions. Beverage cans and bottles are the most optimal application for aluminium. Basis Accenture analysis, replacement of PET with recycled aluminium packaging can be scaled from **1% to 12% from 2027–2030 from indigenous aluminium recycling.**[8] Owing to the high cost of indigenous recycling and aluminium can manufacturing, along with high LCAs of virgin aluminium, aluminium cannot be the sole focus of the material replacement, even with its agreeable functional properties.
5. **High-quality recycled content in packaging** not only helps facilitate the creation of a viable secondary market but also has the potential to avoid **around 28% of the total material value loss, unlocking approximately $46B material value,** cumulatively up to 2030.

Investment & feedstocks:

Being the second largest producer of sugarcane globally, India can lead the mobilization of investments and sugarcane feedstocks to scale indigenous bioplastics production. To execute the recommended scaling plan, the figure below shows investment rollouts to be made at the national level from a combination of stakeholders – mainly private players, supported by government collaborations and grants, subsidies etc. This, coupled with adequate sugarcane volumes for feedstock preparation, will be key in enabling roll-out. Basis Accenture analysis, a national capital investment of ~₹ 12,000 Cr between 2025 and 2028, along with ~150 million tons of sugarcane-derived biomasss diversion for various feedstocks is needed to establish the current scaling plan.

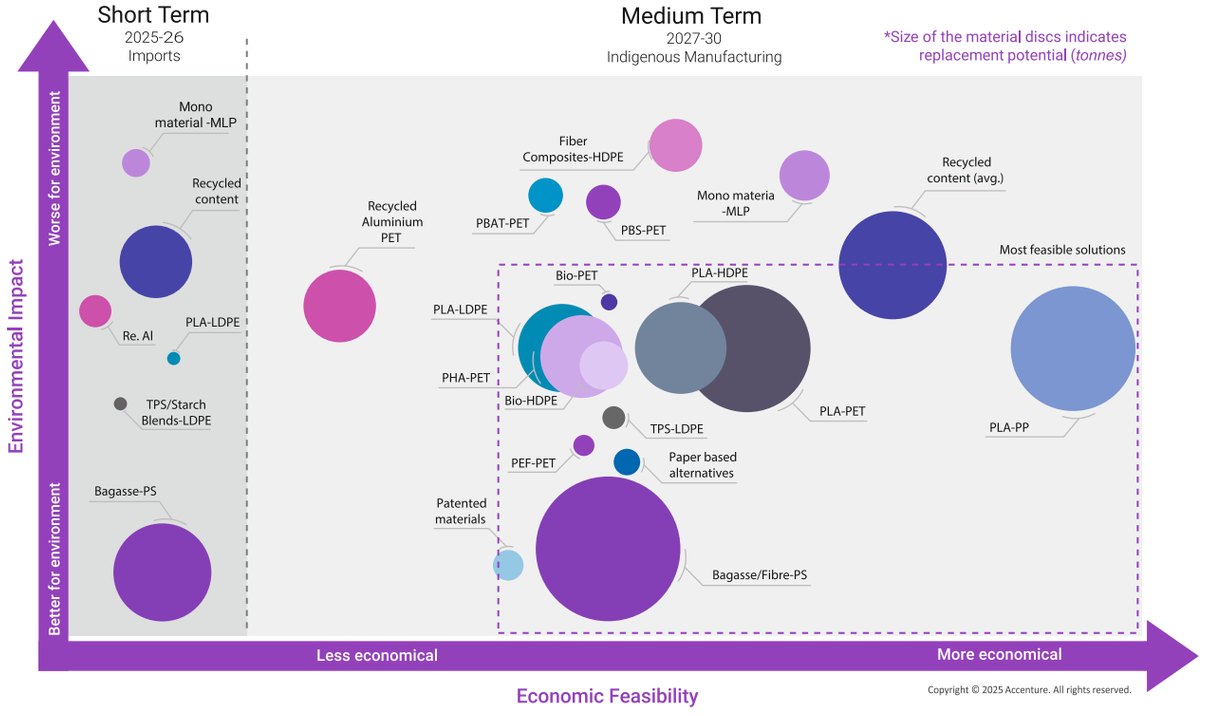


Figure 3 : Prioritise indigenous production of focus materials in the medium term and low-tech materials in short term

Finding 5:

Cumulatively, packaging circularity solutions can drive wholistic positive value for the Indian economy, with the potential to create a social impact of ~6.5 million green jobs while simultaneously generating material value and economic value

Circular business models stand to unlock value across economic, material and social spheres of the Indian economy. The unlocking of material and economic values is enabled by a skilled workforce. Deploying circular packaging solutions creates a wide range of jobs across the packaging value chain. As part of the study, job creation opportunities have been examined through the key models of material innovation, increased recycled content, extension of useful life, increased flexibles recycling and chemical recycling. Basis Accenture analysis, the total job creation potential, across these scenarios is **~6.5 million jobs[8].**

The total formal job creation through packaging circular economy solutions is estimated at approximately 3.3 million. Of this, around 0.4 million jobs are attributed to extending useful life, 0.4 million in material innovation, 0.9 million from increased flexibles recycling and 71,000 jobs from chemical recycling. Additionally, the formalization of India's informal waste management sector has the potential to create around 840,000 jobs.

Additionally, the informal sector job creation potential through packaging circularity has been estimated at **~3.3 million.**

The study examines formal employment, including jobs in collection, cleaning, and sorting, and highlights the growing formalization of jobs, particularly in waste picking. It also emphasizes the increasing opportunities for upskilling and the mechanization of waste-picking activities.

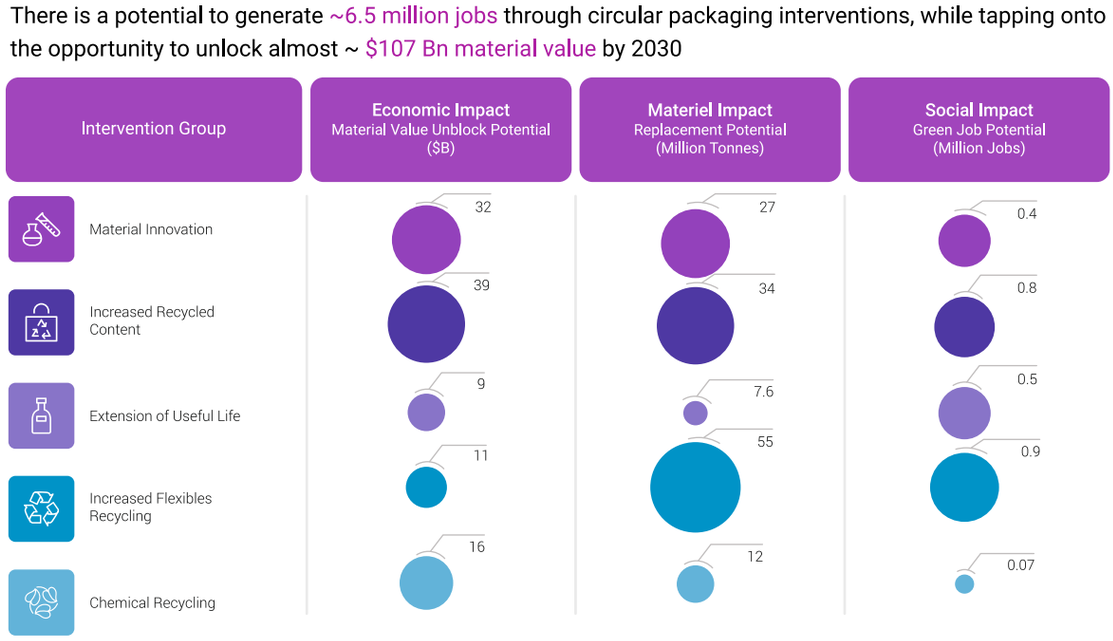


Figure 4: Economic, material and social impacts of recommended interventions

Note: Jobs are based on the assumptions built into the forecast of material and economic impact. Job-creation across individual intervention also implies job creation across multiple industries. The jobs in Figure 4 highlight only the formal job creation potential

Call to Action

India's packaging sector has begun its journey towards circularity, notably with its Plastic Waste Management Rules. To further accelerate this transition, focus must shift towards eco-design and extending the useful life of packaging to **prioritize upstream interventions** and further scaling up the collection and recycling of low-value flexibles.

While material innovation, circular business models and recycling offer substantial economic and social benefits, they are also faced with numerous trade-offs around financial viability, consumer convenience, desirability, demand/supply dynamics, policy favorability as well as competition. A systemic shift is necessary to capitalize on the opportunities presented. To drive meaningful progress in the packaging sector towards circularity in India, a phased approach with clear objectives needs to be defined.

In the **short term,** India should focus on establishing the foundation for circular business models and material innovations in packaging to drive progress through 2030. Key actions include investing in domestic bioplastics and bio-based material manufacturing infrastructure, along with reuse/refill ecosystems, which will yield results in the medium term. Additionally, plans should be developed for sugarcane-derived biomasss diversion towards feedstocks, and standards and policies for the use of recycled content as well as the reuse and refill of traditional packaging should be enforced.

In the **medium term,** efforts can be further strengthened through collaboration, bioplastics raw material production, and sustained policy support. Key actions include partnering with large private manufacturers to scale up the indigenous production of bioplastics and innovative bio-based materials. Policy changes, such as bans and subsidies, should be enforced to promote the use of bioplastics, bio-based materials, and reuse/refill models. Additionally, sufficient sugarcane-derived biomasss should be diverted from recommended states to support bioplastics manufacturing.

The **long-term** view of reimagining packaging will involve not only securing the strides made in the short- and medium-term but also put India on a path to unlocking immense material value as we drive towards a circular future. This includes enforcing policies that strictly regulate and penalize the use of traditional plastic resins in packaging. Additionally, technology can enhance visibility across the value chain, supported by policies on effective take-back schemes and innovative financial solutions, such as sustainability-linked instruments.

By leaning effectively on the levers of policy, technology and finance, India can stand to secure a sustainable future in 2030 and beyond.





Figure 5: Recommended initiatives for the short, medium & long term

1

Need to reimagine the packaging landscape in India



India faces a significant challenge with packaging waste, demanding immediate sustainable actions. The challenge of the packaging landscape arises due to the use of single-use packaging materials, with plastic ranking as among the more challenging materials to circumvent. For instance, in 2022, the most common type of unnecessary or problematic plastic packaging placed on the market (suggested by IPP Members) in India was polystyrene packaging, with a volume of 920 metric tons. Around 580 metric tons of unnecessary PVC shrink sleeves and labels were also placed on the market that year[16]. While the use of problematic packaging can seem anecdotal, a critical element of India's single-use packaging landscape is also the challenge it faces with post-consumer use. Per our analysis, recycling rates of problematic resins such as PS and MLP average at a mere 2.4% and 1% respectively, while contributing to ~25% of the country's annual consumption of problematic packaging[8]. Estimates suggest that India generates ~26,000 tonnes[17] of plastic waste every day, which CSIRO approximates as being proportional to 26,000 small cars!

In order to understand India's challenge with packaging waste, we must first seek to define what "problematic packaging" is. It's important to remember that not all packaging materials are problematic. Based on our analysis, **problematic packaging materials in India are identified** using three main criteria.

1. First, materials are considered problematic if they are **not recyclable, reusable, or compostable, and if they hinder the recyclability or composability of other materials; this includes packaging materials** like LDPE, PP, PS, MLP, metal or plastic lids on glass containers, and colored glass.

2. Second, materials with the potential for useful life extension through circular business or reuse models but they are **not reused to their potential due to a lack of infrastructure;** examples include PET, HDPE, and corrugated cardboard boxes.

3. Lastly, materials that **contribute to litter,** either through being littered, landfilled, or incinerated in substantial volumes without being collected, or by being collected in large volumes but not recycled, are also considered problematic; this includes printed, colored, and coated paper, various cardboard packaging types, colored and mixed glass, HDPE, LDPE, PP, PS, PET, MLP, and other materials.

The scope of problematic packaging materials in this study includes colored glass, cardboard boxes, HDPE, LDPE, PP, PS, PET, and MLP.

In India alone, packaging materials such as plastic resins (HDPE, LDPE, PP, PS, PET), MLP, Paper (corrugated cardboard boxes), Glass (coloured glass) have an annual consumption of **18 M metric tons[8],** from the FMCG, HORECA, and E-Commerce sectors, which contribute to a substantial waste stream. It is estimated that **65% of this packaging waste stream remains uncollected[18,19,20,21]. Evidently, FMCG, HORECA and E-commerce sectors contribute heavily to packaging waste and hence, they form the focus of this study.**



16. Amount of unnecessary plastic packaging India 2022, by type - https://www.statista.com/statistics/1465730/india-problematic-plastic-packaging-by-type/
17. CSIRO – Commonwealth Scientific and Industrial Research Organization - https://www.csiro.au/en/news/all/articles/2023/december/circular-economy-roadmap-india
18. TERI Report, 2022, https://www.teriin.org/sites/default/files/2022-06/Sustainable-Beverage-Packaging-Final-Report.pdf
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20 India Plastics Pact, 2022, https://www.indiaplasticspact.org/uploads/1703753076document.pdf
21 Plastics Packaging Recyclers Attribute Low Recycling Rates
22. World Population Review 2023, https://plasticbank.com/which-country-is-the-most-accountable-for-ocean-plastic

1.1 Aspects and size of India's problematic packaging landscape

The global packaging market, material valued at approximately **$1.175 trillion and projected to grow at 4%** annually through 2028, plays a critical role in modern commerce[22]. However, the current trajectory of packaging consumption, particularly in India, presents significant environmental and economic challenges. With an estimated 18M metric tons of packaging materials – including plastics, paper, glass, and multi-layered packaging (MLP) – consumed annually by the FMCG, HORECA, and e-commerce sectors, a **staggering 65%** ends up in landfills. This unsustainable pattern, largely managed by the informal sector, leads to substantial environmental and social externalities.

For instance, glass manufacturing is energy-intensive with a 35% landfill rate, and coloured glass recycling faces quality degradation. Paper, despite its high production volume (3.7M tons)[24], suffers from high litter and incineration rates, particularly in single-use formats. While certain plastic resins like HDPE, PET, and PP demonstrate higher recycling rates (80-88%)[25], technological and ecosystem limitations hinder their full potential. Polystyrene (PS) and multi-layered packaging (MLP) present even greater challenges, with landfill rates of 91% and 80%, respectively, due to technological constraints and material complexity[26]. These problematic packaging material types – that have a significant negative environmental impact, either due to: 1) the material not being recyclable, reusable, or compostable hindering the recyclability or composability, 2) the material being difficult or unable to recycle or reuse, contributing to waste generation, or 3) the material being littered/ landfilled/ incinerated in substantial volumes without being collected – need to be reimagined for sustainability.

The consequences of inaction are significant. Hence, to combat the challenges of problematic packaging, the report explores upstream solutions through stakeholder engagements to identify viable, innovative alternatives that could drive economic and social progress, over the next five years.

Basis Accenture analysis, India's current trajectory with problematic packaging could lead to a staggering material value loss of approximately **$160B by 2030**, which is a tenfold increase from the current **$16B annual** loss[8].

By 2030, India faces a potential $160B material value loss due to problematic packaging, a tenfold increase from the current $16B annual loss. This loss implies that these materials are spilling entirely out of the material value chain and are not used to the full potential of their material qualities. But the challenges are multifaceted.

Accenture analysis highlights the distribution of this material value loss across different types of packaging materials. This data underscores the urgent need for sustainable packaging solutions to mitigate the economic impact of material value loss, particularly from MLP and LDPE, that contribute to almost 60% of the loss. Our proposed recommendations and interventions attempt to target this scale of material value loss to prolong the productive use of these materials through material and business model innovations.

Packaging Material Contributions to Value Loss

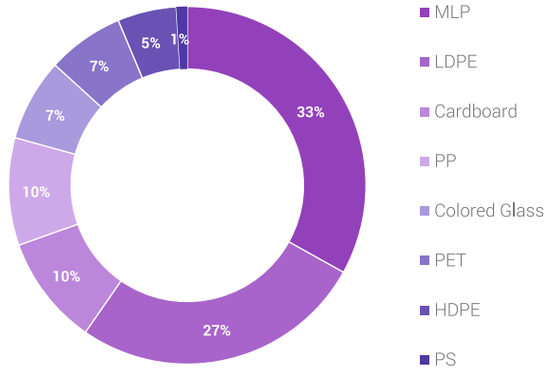


Figure 6: Share of Material Value Loss by Packaging Material Type

23. India Plastic Pact, Roadmap to 2023, https://www.indiaplasticspact.org/website_assets/images/Roadmap-to-2030-1.pdf
24. Recycling Magazine, "Paper-based food packaging at the centre of Europes waste crisis", 2023
25. Lifecycle Assessment Life-Cycle Assessment of Polypropylene Production in the Gulf Cooperation Council (GCC) Region,
26. Science Direct, Polystyrene

1.2 Global best practices in packaging

While India sets ambitious targets and policies to tackle the challenges posed by problematic packaging, other regions offer examples of best practices in terms of regulatory support and technological innovations

The global packaging waste reduction efforts reveal a complex and challenging environment. According to the Ellen MacArthur Foundation's comprehensive analysis[27], the world is currently struggling to meet established sustainability targets for packaging waste elimination.

1.2.1 Packaging and Recycling Regulations

Regulations regarding packaging and recycling vary significantly across regions, with Extended Producer Responsibility (EPR) programs emerging as a key regulatory tool. Implemented in over 55 countries, EPR regulations are designed to manage post-consumer packaging waste efficiently and promote eco-design through eco-modulation of fees. EPR shifts the responsibility to producers, requiring them to oversee and manage the waste generated from their products once they reach the end of their consumer lifecycle.

In the European Union, the Packaging and Packaging Waste Regulation (PPWR), with recent formal adoption in December 2024,[28] sets ambitious targets for packaging optimization, recyclability, reusability, and waste reduction, aiming to foster a circular economy. EPRs are key elements of the PPWR requirements, ensuring that producers are accountable for the full lifecycle of their packaging. Meanwhile, in the United States, legislators are advancing the reintroduction of the Break Free from Plastic Pollution Act in 2023[29], which seeks to reduce plastic waste through extended producer responsibility, enhance recycling infrastructure, and reduce single-use plastic production.



27. Ellen MacArthur Foundation Research - https://www.ellenmacarthurfoundation.org/topics/plastics/overview
28. EU PPWR - https://environment.ec.europa.eu/topics/waste-and-recycling/packaging-waste_en
29. Break Free from Plastic Pollution Act - https://www.merkley.senate.gov/wp-content/uploads/2023/10/BFFPPA-Summary-_branded_FINAL.pdf
30. Japan Packaging Regulations - https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/kenkou_iryou/shokuhin/kigu/index_00003.html



EU's Packaging and Packaging Waste Regulation (PPWR)

The PPWR officially entered into force on February 11, 2025[28], with a general application date set for August 12, 2026. The regulation applies to all forms of packaging and packaging waste across the EU market, encompassing commercial, household, and industrial sectors. It aims to harmonize national measures and strengthen the internal market for packaging materials.

The primary goals of the PPWR include:

1. Waste Reduction: The regulation aims to reduce overall packaging w a s t e by at least 15% by 2040 compared to 2018 levels.
2. Recyclability: By 2030, all packaging on the EU market must be recyclable in an economically viable manner. This includes implementing mandatory quotas for reusable packaging and minimum recycled content in packaging materials.
3. Sustainability: The PPWR seeks to minimize the use of primary raw materials and promote a circular economy by encouraging recycling, reusability, and environmentally friendly design.

Key Provisions:

- Single – Use Plastic Restrictions: The regulation includes specific restrictions on certain single-use plastic items, such as pre-packed fruits and individual condiment portions in food service settings.
- Packaging Minimization: Manufacturers must ensure that the weight and volume of packaging are minimized while still serving their intended purpose. This includes avoiding unnecessary layers or components that do not contribute to functionality.
- Extended Producer Responsibility (EPR): The PPWR reinforces EPR principles, requiring producers to take responsibility for the entire life cycle of their packaging, including disposal and recycling.
- Labelling Requirements: Mandatory labeling will be required on packaging to inform consumers about material composition, sorting instructions, and reuse options.

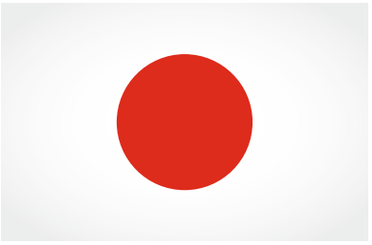


France's National Strategy for Bio-Based Packaging in FMCG[35]

With stringent regulations banning single-use plastics, France has pushed FMCG brands to adopt sustainable alternatives at an accelerated pace.

In 2019, the French government introduced The French National Pact on Plastic Packaging with concrete requirements:

- Defining a list of packaging to be designated as problematic or unnecessary and establishing which measures should be taken to have them eliminated
- Eco-designing packaging to make it reusable, recyclable or 100% compostable by 2025
- Collectively reaching 60% of plastic packaging recycled by 2022
- Incorporating an average of 30% recycled plastic into packaging by 2025
- Leading awareness-raising and educational activities with the general public on the issues related to plastic pollution



In Japan, the Ministry of Health, Labour and Welfare enforces regulations focused on packaging and product safety[30], while the country is also renowned for its high recycling rates, reflecting its commitment to sustainable waste management practices.

Japan's Bold Push for Circularity: A National Success Story

In 2019, Japan announced its Plastic Resource Circulation Strategy, targeting a 60% recycling rate[31] for plastic packaging by 2030 and a drastic reduction of single-use plastics. The government introduced stringent Extended Producer Responsibility (EPR) regulations, requiring manufacturers to take responsibility for the collection and recycling of their plastic packaging. Additionally, tax incentives were provided to companies that incorporated recycled or bio-based plastics into their packaging.

The impact of these policies has been striking:

- Japan's PET bottle recycling rate reached 85% in 2022[32], one of the highest in the world (compared to 30% in the U.S.[33] and 50% in the Eu[34]).
- 40% of all PET bottles in Japan now contain recycled content, significantly reducing dependence on virgin plastic.
- Investments in advanced chemical recycling facilities have enabled Japan to achieve food-grade rPET production at scale, a major breakthrough in sustainable packaging.

1.2.2 Technological & Business Model Innovations in Packaging

The packaging industry is actively exploring alternative business models and material innovations to address sustainability challenges. Innovations are emerging across three major areas: eco-design, extending the useful life of packaging, and improving recycling processes.

Innovations in eco design:

Globally, countries and organizations are developing creative solutions to improve the environmental footprint of packaging. In the Philippines and Singapore, traditional materials like abaca, cassava roots, and agricultural waste are being repurposed as sustainable packaging feedstocks.

In the United States, the development of packaging technologies, including 3D printing, is not only enhancing the visual appeal of packaging but also reducing waste generation – 3D printing creates lightweight, durable packaging, ensuring product protection without unnecessary excess[36]. Additionally, "plantable packaging"[37] is gaining traction, where seed-infused paper packaging can be planted to grow wildflowers, herbs, and other plants.

31 Japan's Resource Circulation Strategy - https://isap.iges.or.jp/2022/pdf/TT15_5_Mizutani.pdf
32 Recycling PET Rates in Japan - https://www.statista.com/statistics/695540/japan-pet-bottles-recycling-rate/
33 US PET bottle collection & Recycling rate - https://www.recyclingtoday.com/news/napcor-reports-rise-in-2023-pet-bottle-recycling-rate/
34 Plastics Recyclers – PET Market in EU - https://www.plasticsrecyclers.eu/wp-content/uploads/2024/05/PET-Market-in-Europe-State-of-Play-2022-Data-V3.pdf
35 European Bioplastics – France's law on bioplastics - https://www.european-bioplastics.org/pr_150723/



Brazil's sugarcane-based Bio-PE Expansion for FMCG Packaging

Brazil is at the forefront of bio-PE production, leveraging its massive sugarcane industry to replace conventional polyethylene in FMCG packaging. Braskem, the world's largest biopolymer producer, has driven this transformation by scaling the production of I'm Green™ bio-based PE, now used by global brands like Nestlé, Johnson & Johnson, and Unilever.

- Unilever Brazil introduced bio-PE bottles[38] for its Omo laundry detergent, reducing Co_2 emissions by 75% compared to traditional plastics.[39]
- Brazil's domestic FMCG brands, like Natura & Co[40], have adopted bio-based materials for shampoo and cosmetics packaging, eliminating 500+ tons of fossil-fuel-based plastic annually.

The success of bio-PE in Brazil is largely due to the readily available feedstock, strong government incentives, and collaboration between FMCG giants and local suppliers.



In Singapore, there has been an effort to create recyclable mono-material packaging to replace multi- layer packaging[41], which can significantly enhance the plastic recycling process.

Innovation in extension of useful life of packaging:

Efforts to extend the life cycle of packaging are also being seen worldwide. In Japan, retail suppliers such as Loop, have partnered with major Japanese retailers[42] to encourage customers to use returnable containers, which are collected, washed, and reused.

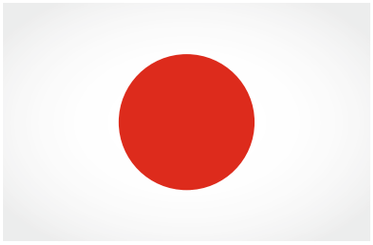
Samsung is acting on the concepts of “eco-packaging” to encourage its customers to repurpose its TV packaging into functional items like bookshelves[43] or cat tunnels, encouraging consumers to reuse the material rather than discarding it.



Innovation in recycling:

The EU-funded CIRCULAR Food Pack project[44] is a standout example, utilizing tracer-based sorting technology (TBS) to recycle flexible food packaging materials. This innovative process involves cleaning and recycling materials using a solvent-based technology, producing polyethylene post-consumer recyclate (PE PCR) that is pure enough to be reused in the production of home and personal care packaging.

36. Sustainable Packaging Solutions with 3D Printing - https://www.objective3d.com.au/resource/blog/developing-sustainable-packaging-solutions-with-3d-printing-technology/
37. Eco-Friendly Packaging Options - https://www.bigblue.co/blog/7-eco-friendly-packaging-options-for-e-commerce-brands
38. Braskem's bio-based PE - https://www.braskem.com.br/europe/news-detail/braskem-expands-its-biopolymer-production-by-30-following-an-investment-of-us-87-M
39. Unilever's eco-friendly packaging - https://www.unilever.com/news/news-search/2021/we-are-creating-the-worlds-first-paper-based-laundry-detergent-bottle/
40. Natura-eco is targeting full circularity in packaging - https://2023ar.naturaeco.report/documents/90/2023_Natura_Co_SustainabilityCompendium_Final.pdf
41. Recyclable packaging in Singapore - https://ensun.io/search/sustainable-packaging/singapore
42. World Economic Forum: Loop packaging innovation in Japan - https://www.weforum.org/stories/2021/09/zero-waste-shopping-japan/
43. Samsung Global Newsroom - https://news.samsung.com/global/interview-the-story-of-eco-packaging-how-upcycling-is-transforming-tv-packaging
44. Fraunhofer EU Project Circular FoodPack - https://www.ivv.fraunhofer.de/en/press/circularfoodpack.html



Aeon, with Loop, launched products with reusable packaging in 19 stores across Japan[45]

Loop, the retail supplier that offers recyclable, reusable packaging, has partnered with one of the largest supermarket chains in Japan, Aeon, to encourage refillable packaging systems in their retail outlets. The alliance has garnered the support of the Tokyo Metropolitan Government.

Consumers will buy Loop products in reusable packages, which are slightly more expensive. After use, they can return the containers to any Aeon store's Loop return box. Once verified, consumers will receive a refund within two weeks, including the deposit and consumption tax, ranging from Yen¥110 to Yen¥880, credited to their bank account through the Loop app. A specialized company will clean the returned items and send them back to manufacturers for reuse.

Suntory Leading the Charge in Circular Packaging in Japan[46]

Among Japan's corporate giants, Suntory Holdings has emerged as a frontrunner in sustainable packaging.

Suntory's key initiatives include:

a. Launching Japan's first 100% plant-based PET bottle, sourced from sugarcane-derived bio-PET, reducing fossil fuel dependency.
b. Partnering with chemical recycling firms to convert low-quality PET waste into high-quality food-grade rPET.
c. Expanding bottle-to-bottle recycling, ensuring discarded PET bottles return to store shelves in a closed-loop system.



France's stringent rules on packaging is translating to innovations in packaging

a. Over 50% of Carrefour's organic food[47] section now uses bio-based or compostable materials instead of plastic.
b. Danone and Nestlé France have invested[48] in bio-PET and PEF-based bottles for their water brands, such as Evian and Volvic.
c. The French government provides tax incentives[49] for bio-based packaging producers, making scaling bioplastics financially viable.

45. Reuse Portal – Loop x Aeon partnership - https://www.reuseportal.org/project-details/loop-x-aeon/a0s68000000PC0pAAG
46. World Economic Forum – Asia-based global beverage is going circular - https://www.weforum.org/stories/2020/01/one-of-asia-biggest-beverage-companies-is-going-circular/
47. Carrefour use of bioplastics - https://www.freshplaza.com/europe/article/9356666/carrefour-spain-50-less-plastic-in-fruit-and-vegetable-packaging/
48. European Bioplastics – Danone and Nestle's waters commit to bio-based PET - https://www.european-bioplastics.org/danone-and-nestle-waters-commit-to-100-percent-bio-based-pet/
49. Ellen Macarthur Foundation - https://www.ellenmacarthurfoundation.org/global-commitment-2021/signatory-reports/gov/the-government-of-france

1.3 Material value loss & unlock potential

Per Accenture Analysis, circular interventions have the potential to unlock almost **~ $107B[8] material value by 2030,** that is two-third of the total loss. **75% of the total material value unlock potential can be captured** through upstream strategies focused on eco-design and extension of useful life.

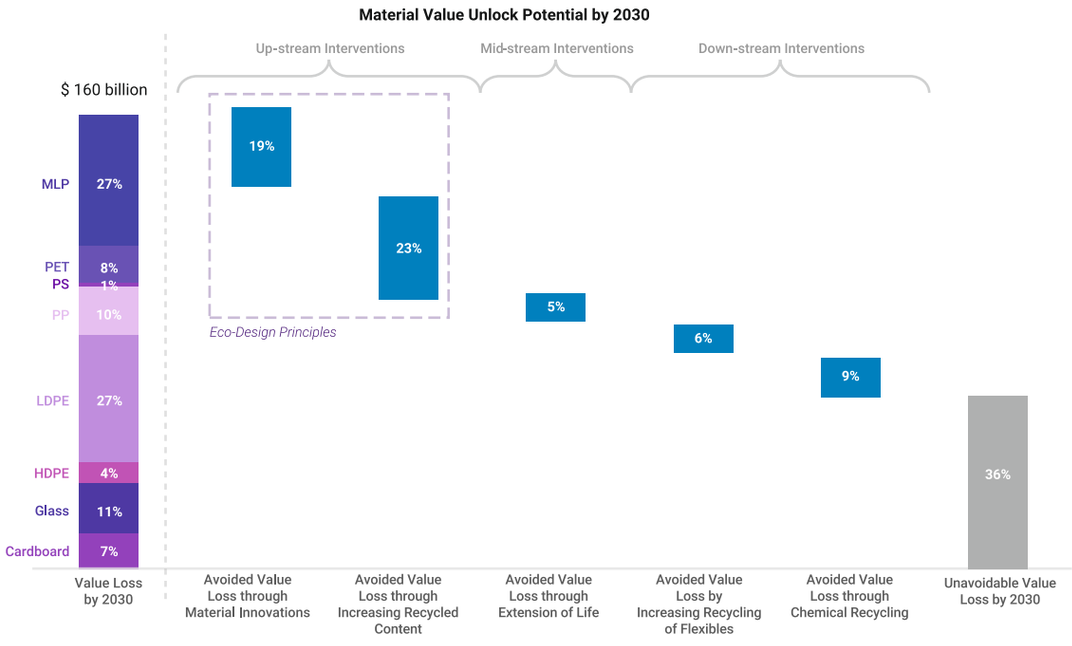


Figure 7: Breakdown of material value unlock potential across the identified intervention levers

The challenge of packaging waste also presents a significant economic opportunity. Current projections indicate a potential loss of $160B in material value by 2030 if current practices persist. However, a multi-pronged approach focusing on innovation and systemic change can unlock substantial material value and mitigate this loss.

1.3.1 Upstream Interventions: Eco-Design to lead the way

A critical first step lies in reimagining packaging design itself in its upstream processes. Eco-design principles, encompassing material substitution with bio-based or mono-materials and lightweighting, offer a powerful means of reducing waste at the source. Basis Accenture analysis, these upstream interventions hold the potential to recover 30% of the projected material value loss, approximately $31.5B, by 2030[8]. India, with its abundant sugarcane and other feedstock resources, is particularly well-positioned to become a leader in bioplastics production and capitalize on this opportunity.

Beyond material selection, incorporating recycled content into new packaging is crucial. Basis Accenture analysis, aligning with Extended Producer Responsibility (EPR) 2028 targets for recycled inputs could unlock an even greater share of the lost material value, potentially reaching $40B, or 37% of the total potential. Realizing this potential hinge on substantial investment in India's closed-loop recycling infrastructure to ensure efficient collection, processing, and recycling of materials.

1.3.2 Midstream Interventions: Extension of Useful Life

It is not always possible to eliminate plastic packaging due to their undeniable benefits, the useful life of the packaging material needs to be extended beyond a single use. For materials like PET, HDPE, and glass, which possess high embedded material value, circular business models such as take-back systems and refill programs offer viable solutions. Basis Accenture analysis, these strategies, which place the onus of multiple lifecycles on the producer, could unlock an additional $9B, representing roughly 8.4% of the total material value at stake. Specifically, achieving the 2028 EPR reuse targets for rigid plastics and enhancing glass reuse rates could contribute $7.8B material value unlock, with refill models adding another $1.1B[8] (based on Accenture analysis).

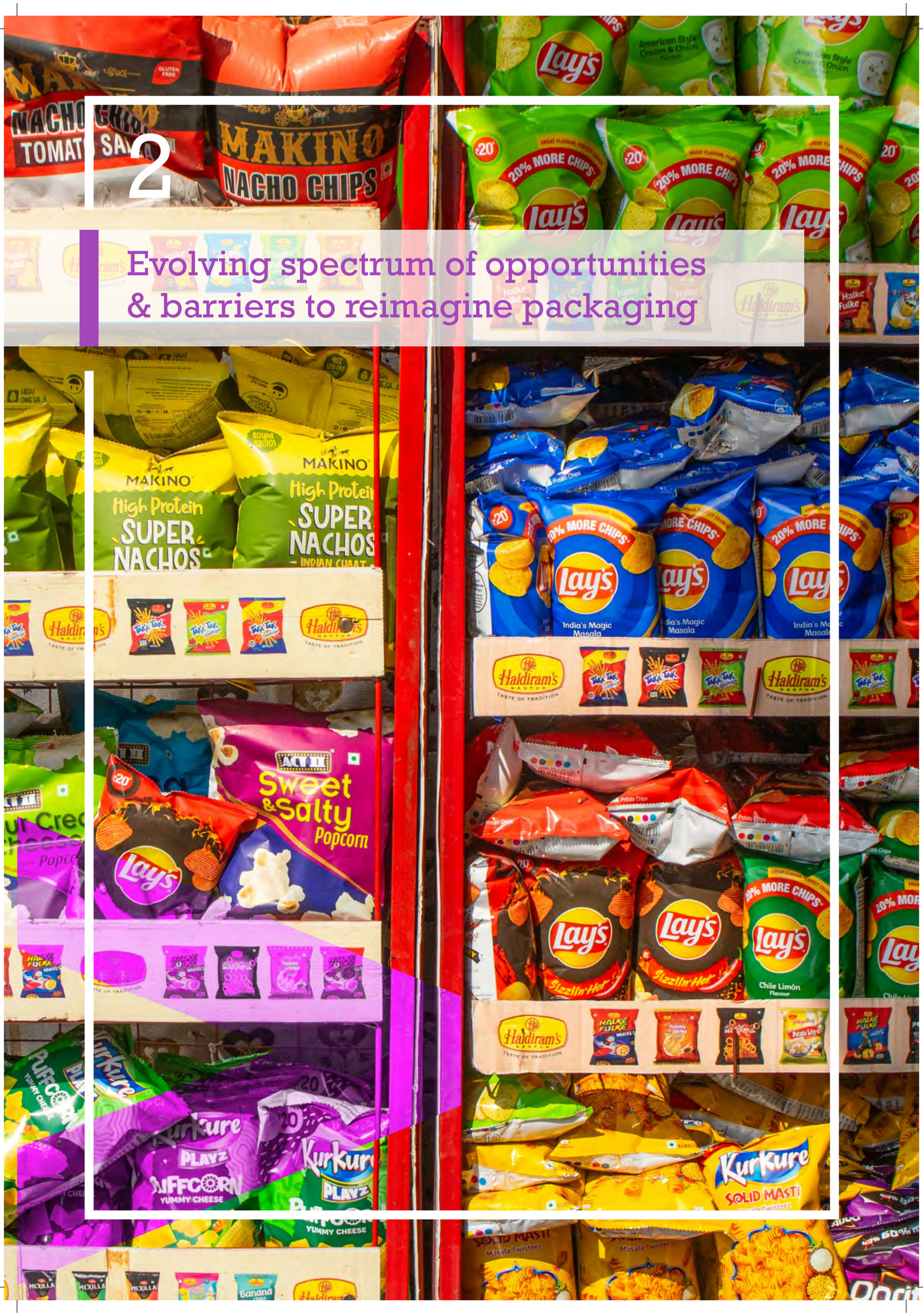
1.3.3 Downstream Interventions: Adherence to EPR Recycling Targets

Finally, robust adherence to EPR recycling targets is essential. While eco-design and extended-use models can address a significant portion of the problem, achieving the ambitious EPR recycling targets of 80% for rigid plastics and 60% for flexible plastics by 2028 is crucial[50]. Additionally, chemical recycling, while still in its nascent stages, offers a promising pathway to reclaim material value from complex plastic waste streams that are otherwise difficult to recycle mechanically, potentially unlocking a portion of the unavoidable material value loss projected for 2030, though its contribution remains relatively small at this point. Basis Accenture analysis, these downstream interventions could unlock approximately 17% of the total material value unlock potential[8]. While chemical recycling holds promise, its environmental sustainability remains unconfirmed and requires further critical study.

While collection and recycling interventions are not specifically detailed, their effective implementation is undeniably critical for a successful transition to a circular economy. Even with these combined efforts, some material value loss, estimated at 33%, appears unavoidable based on current projections to 2030. This underscores the need for continuous innovation, technological advancements, and evolving strategies to further minimize waste and maximize resource recovery. The path towards a truly circular economy for packaging requires a holistic approach, integrating sustainable design, robust recycling infrastructure, and collaborative efforts across the value chain.



50. Press Release: Ministry of Environment, Forest and Climate Change, India


2
Evolving spectrum of opportunities
& barriers to reimagine packaging
MAKINO
NACHO CHIPS
20% MORE CHIPS
Lay's
MAKINO
High Protein
SUPER
NACHOS
Haldiram's
Sweet
&Salty
Popcorn
Kurkure
PLAYZ
PUFFCORN
YUMMY CHEESE
Sizzlin' Hot
Chile Limón
SOLID MASTI
Masala Twisteez

2.1 Upstream interventions

2.1.1 Packaging alternatives gaining momentum in India

India has developed over **30 commercially viable sustainable material alternatives,** yet they **account for less than 1%** of FMCG packaging consumption currently[51]. While recycling has expanded significantly in the past decade, the quality of recycled content remains largely non-food grade and of lower quality.



Figure 8: Landscape of sustainable packaging alternatives in India

As the world grapples with the mounting environmental crisis caused by plastic waste, India has emerged as a key battleground in the fight for sustainable packaging. With increasing regulatory pressures, consumer awareness, and corporate sustainability commitments, the Indian FMCG (Fast-Moving Consumer Goods) and HORECA (Hotels, Restaurants, and Catering) sectors are witnessing a paradigm shift towards alternative packaging materials. From bio-based polymers to fiber composites to recycled materials and mono-materials, companies are exploring a wide array of solutions to replace traditional plastics and problematic packaging. For detailed explanation with comparisons, refer to the Table 5 in Appendix.

51. India bio-based packaging market forecast https://www.futuremarketinsights.com/reports/global-fmcg-packaging-market

India has seen a steady increase in sustainable packaging material adoption, but the journey is far from complete. Some highlights below[8]

Polymateria's Biotransformation Technology[52]

Polymateria's **Biotransformation Technology** enables polyolefin-based plastic alternatives to **biodegrade in nature within two years** while remaining **fully recyclable** when properly collected. Recognized under India's Plastic Waste Management Rules, this innovation addresses the challenge of plastic waste without disrupting existing recycling streams.

Key Benefits

- **Dual End-of-Life Options:** These can be recycled traditionally or, if littered, can safely biodegrade.
- **Maintains Functional Properties:** Retains the strength, durability, and usability of conventional plastics.
- **Technical fit:** Easily integrates into existing production processes with no major infrastructure changes.
- **Minimal Environmental Impact:** Works with both fossil-based and biobased polyolefins, with a negligible carbon footprint at just 2wt% inclusion.

Challenges to scaling

- **Regulatory Delays:** India's certification process takes up to two years, slowing market entry.
- **Testing Constraints:** Limited lab capacity in India for biodegradation assessments.
- **Market Awareness & Costs:** Adoption requires clear labeling, cost competitiveness, and consumer education.

Environmental Impact & Life cycle Benefits

- **Feedstock Agnostic:** The technology works with both conventional and bio-based polyolefins, making it adaptable for both today's fossil-based plastics and future bio-based transitions.
- **Minimal Carbon Footprint:** At just 2wt% concentration in plastic formulations, the technology has no significant impact on lifecycle emissions.
- **Prevents Marine Pollution:** Given that 80% of ocean plastics originate from land-based pollution, ensuring plastic breaks down before reaching the ocean is a key advantage.



52. Discussions with sustainable packaging team, https://www.polymateria.com/

2.1.2 Barriers to scaling sustainable packaging solutions

With 30+ existing alternatives for packaging materials, alternative packaging solutions often do not reach end consumers. India's bioplastics market, valued at $ 447.25M in 2023, is projected to reach USD 1,809.51M by 2030, growing at a 22.1% CAGR[53]. This growth is driven by sustainability initiatives but faces challenges in feedstock availability and quality. Globally, bioplastics could reach 7.43 million tonnes by 2028, requiring just 0.073% of agricultural land[54], a figure expected to shrink with increased use of food residues and non-food crops.

Despite growing demand, bioplastics in India face key challenges in scaling. Feedstock availability is volatile, with sugarcane and corn yields fluctuating due to climate impacts, while some bioplastics require 2.5-3x more raw material than others, affecting viability. Functional limitations like weak barrier properties, brittleness, and poor thermal stability restrict applications, and high costs along with machinery modifications slow down FMCG adoption. At the same time, high-quality, food-grade recycled content remains limited, preventing a true closed-loop system. Overcoming these hurdles is essential for bioplastics to become a mainstream sustainable alternative.

2.1.2.1 Feedstock shortages push the supply chain into a constant state of volatility

"The surface required to grow sufficient feedstock for today's bioplastics production just reaches a little bit more than 0.01% of the global agricultural area. Metaphorically speaking, this ratio correlates to the size of an average cherry tomato next to the Eiffel Tower." ~ European Bioplastics[54].

Scaling bioplastics in India is constrained by feedstock availability, quality, and competition. PLA production depends on high-quality fermentable sugars, while other bioplastics require excessive raw materials due to inefficiencies. Seasonal fluctuations, such as a drop in sugarcane yield, disrupt supply chains for PLA, PBS, and Bio-PE. Corn-based[55] PLA faces yield declines from heatwaves, and cassava-based TPS is impacted by erratic monsoons[56]. Competition with food and ethanol production further limits feedstock allocation, making large-scale bioplastic expansion challenging without alternative non-food sources.

Factors obstructing feedstock availability:

a. **Quality & efficiency challenges:** The production of bioplastics necessitates high-quality feedstocks to ensure material performance and sustainability. For instance, PLA, a commonly used bioplastic, requires fermentable sugars[57,58] derived from crops like corn or sugarcane. Efficient PLA production yields approximately 1.0 kg of polymer from 1.6 kg of fermentable sugar. In contrast, other bioplastics may require 2.5 to 3 times more sugar feedstock to produce the same amount of plastic, highlighting the importance of feedstock efficiency.[54]

b. **Seasonal variations:** The reliance on specific agricultural commodities introduces vulnerabilities in the supply chain. Factors such as seasonal variations, climate change, and competition with food production can lead to feedstock shortages, affecting the consistent production of bioplastics.

   India's sugarcane production (key for PLA, PBS, and Bio-PE) is concentrated in Uttar Pradesh, Maharashtra, and Karnataka. However, due to erratic rainfall and water shortages, India's sugarcane yield dropped by 15% in the 2023–24 season, tightening feedstock supply for both sugar and bioplastic production[59].

   Corn production, essential for PLA, is highly seasonal and has been affected by heatwaves, with a verage global crop yields for maize (corn) may see a decrease of 24% by late century, with declines becoming apparent by 2030.[60]

   Cassava (used for TPS) is grown in Thailand, Indonesia, and Nigeria, where irregular monsoons have caused yield drops of 12–15% since 2020.[61]

c. **Competing forces:** Over 80% of sugarcane is used for sugar and ethanol production, leaving limited room for bioplastics manufacturing[55]

53. Maximize market research report on India's bioplastics market https://www.maximizemarketresearch.com/market-report/india-bio-plastics-market/21457/
54. https://www.european-bioplastics.org/bioplastics/feedstock/
55. https://www.sciencedirect.com/science/article/abs/pii/S0308521X23001518
56. https://pubmed.ncbi.nlm.nih.gov/27252148/
57. https://www.eai.in/blog/2017/02/non-food-crops-as-feedstock-for-bioplastics-is-there-a-critical-need.html
58. https://www.totalenergies-corbion.com/media/ulgpzelr/totalenergies-corbion-biobased-pla-plant-the-future-whitepaper.pdf
59. Open Government Data (OGD) Platform India https://www.data.gov.in/keywords/sugarcane

2.1.2.2 Indigenous material manufacturing involves sizeable investments with long turnaround timelines

India's transition to bioplastics faces a significant roadblock due to the high capital investment required for large-scale indigenous production. Accenture Analysis suggests setting up a commercial-scale bioplastics plant involves investments ranging from ₹5–₹35 billion[8], depending on the type of biopolymer and production capacity. These costs include bioreactors, fermentation units, purification facilities, and polymerization infrastructure, making it a high-risk venture for investors.

a. High capital costs and long turnaround timelines

- PLA production requires advanced fermentation and polymerization units, with estimates suggesting over INR 20 billion ($120 M) investment for a 75,000-tonne per annum capacity plant, similar to INR 2000 Cr[62]. Investment for same capacity at Balrampur Chini Mills PLA plant. In India, such investments are currently unattractive due to low demand certainty and lack of policy incentives.
- PHA production, which relies on bacterial fermentation, is even costlier due to complex microbial feedstock requirements. Indian companies like Lucro and Praj Industries have been researching PHA but have not yet scaled due to funding constraints.
- Bio-PE and Bio-PET production Bio-PET is chemically identical to conventional PET and can be processed using the same equipment, such as injection molding, blow molding, and extrusion. However, production process for the raw materials might require additional steps or investments.

b. Risk of Low Market Uptake & Policy Uncertainty

Pricing pressures: Bioplastics in India are 20%-70%[63] more expensive than conventional plastics, limiting their adoption in FMCG sector. Companies hesitate to commit to long-term contracts due to cost volatility.[64]

Uncertain government support: While India has banned certain single-use plastics, there are no clear subsidies or tax incentives to offset capital costs for bioplastic manufacturers, unlike in Thailand[65] or Brazil[66], where bio-based materials receive fiscal benefits.

c. Limited Domestic Technology & Infrastructure

India lacks local suppliers for key bioplastic intermediates, forcing dependency on imported technology from Europe and China.

Industrial composting infrastructure is underdeveloped, making **industrially** compostable bioplastics (PLA, PBS) hard to scale, reducing investor confidence in end-of-life sustainability.

60. NASA Corn Yield data https://www.nasa.gov/earth-and-climate/global-climate-change-impact-on-crops-expected-within-10-years-nasa-study-finds/
61. Effect of rainfall patterns on cassava yield https://advancedscholarsjournals.org/full-articles/effect-of-rainfall-variation-on-cassava-(manihot-esculenta)-yield-in-owerri-west-local-government-area-of-imo-state-nigeria.pdf?view=inline
62. Balrampur Chini Mills announces PLA plant investment https://chini.com/wp-content/uploads/2024/02/BCML_SE_Outcome_18022024.pdf
63. https://tspcb.tripura.gov.in/storage/2022/02/BIOPLASTICS.pdf
64. Tripura state pollution control board https://tspcb.tripura.gov.in/storage/2022/02/BIOPLASTICS.pdf
65. https://www.oecd.org/content/dam/oecd/en/publications/reports/2021/04/guidance-for-a-biorefining-roadmap-for-thailand_b22d33f3/60a2b229-en.pdf
66. https://www.sciencedirect.com/science/article/pii/S2530064423000731

2.1.2.3 Not all alternative packaging materials are sustainable

While bio-based plastics are often seen as a sustainable alternative to fossil-based plastics, they come with significant environmental trade-offs.

The sustainability of these materials depends on factors like land and water use, carbon emissions, and waste management infrastructure. Not all bio-based materials are home compostable or biodegradable and may require specialised EoL management to prevent littering (For detailed explanation with comparisons, refer to the Table 6 in appendix).

2.1.2.4 Functional properties often limit the versatility of alternative material usage in packaging

Bio-based materials face multiple performance challenges, limiting their scalability in packaging. PLA rigid packaging, for instance, shows 40% lower drop-impact resistance than PET, making it unsuitable for beverages. PHA films have 4-5 times higher oxygen transmission rates than PP, accelerating food spoilage. Thermal stability is another concern, with bio polyester films softening at 60°C, restricting use in UHT milk pouches. Production infrastructure compatibility is also a hurdle, Bio-PE trials in India required 80% of injection molding systems to be modified, increasing costs. Additionally, impurities in natural materials, like bagasse containers, lead to inconsistent rigidity and food safety issues.

a. **Mechanical Strength & Structural Integrity**
   Many bio-based materials lack the tensile strength, impact resistance, and flexibility ofconventional plastics. Rigid options can be brittle, while flexible ones often lack durability fortransport and storage. PLA-based bottles, for instance, showed 40% lower drop-impact resistance than PET, causing handling failures.

b. **Barrier Properties (Oxygen, Moisture, and Oil Resistance)**
   Alternative materials often exhibit weaker barrier properties against oxygen, moisture, and oils, leading to reduced shelf life and increased spoilage risks for food and pharmaceutical applications. Some materials tend to be hydrophilic, absorbing water over time, which compromises product integrity. PHA-based films used for snack packaging were found to have 4-5 times higher oxygen transmission rates compared to traditional PP films, accelerating product degradation.

c. **Thermal Stability and Processability**
   Many bio-based plastics degrade at lower temperatures compared to fossil-based plastics, limiting their suitability for applications involving heat sealing, hot-filling, and microwave use. This also impacts recyclability, as some materials cannot withstand standard polymer recycling processes. Bio-polyester films tested for dairy pouches showed thermal softening at 60°C, preventing their use in UHT milk packaging, which requires resistance up to 90°C.

d. **Compatibility with Existing Production Infrastructure**
   Most alternative materials require significant modifications to existing machinery due to differences in melting points, flow behavior, and adhesion properties. The need for equipment recalibration and specialized processing conditions adds to manufacturing costs. A Bio-PE trial at an Indian FMCG plant revealed that 80% of existing injection molding systems needed modification, increasing upfront capital requirements.

e. **Impurities and Material Consistency**
   Natural-based alternatives often contain impurities, variability in composition, and batch-to-batch inconsistencies that can affect processing efficiency and product quality. Achieving uniform melt flow index (MFI) and molecular weight distribution is crucial for consistent production. Bagasse-based takeaway containers exhibited varying moisture content, leading to inconsistent rigidity and warping after sealing, affecting food safety compliance.

2.2 Midstream interventions

2.2.1 Evolving business models that extend the useful life of packaging

Sustainable packaging models that extend packaging lifespan fall into 4 main categories, with a fifth emerging model blending consumer and producer responsibility.

These are as follows-

1. **Refill at home:** Users refill a reusable container at home with refills either delivered to the door (for example, through a subscription service) or bought in a shop. Users retain ownership of the main packaging and are responsible for cleaning.
2. **Refill at retailer:** Users refill the reusable packaging at a dispensing point away from home, such as at a store. Users retain ownership of the reusable packaging and are responsible forcleaning.
3. **Reuse at home:** Users repurpose the packaging container at home for the same or different uses. They retain the full ownership and responsibility of use and disposal.
4. **Reuse at retailer:** Users purchase a product in a reusable container and return the packaging at a store or drop-off point after use. The packaging is either cleaned where it is returned, or a business or service provider takes care of the cleaning and redistribution.
5. **Reuse via Doorstep Collection:** Users subscribe to a delivery and collection service that allows them to return empty packaging from home. A business or service-provider then takes care of cleaning and redistribution of the packaging Despite the emergence of innovative startups, pilot programs, and even some national policies promoting reusable packaging, its adoption remains disappointingly low, with less than 2% of plastic packaging currently being reused[67]. This sluggish uptake highlights the critical challenge of scaling reusable systems, resulting in a limited supply of reusable packaging options that hinders the viability of this promising model.

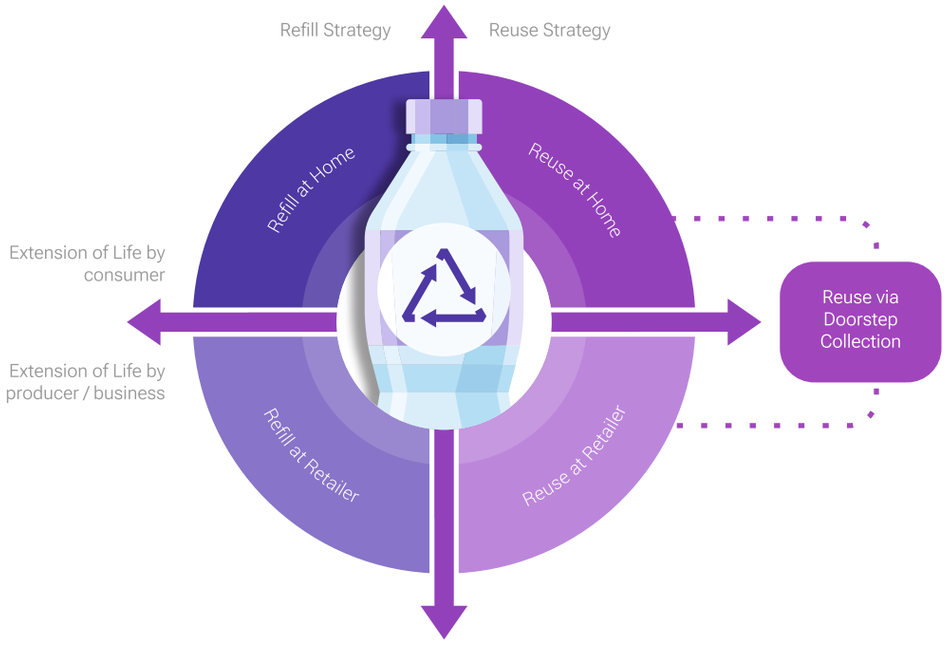


Figure 9: Types of business models to extend the useful life of packaging

67. Ellen Macarthur Foundation, 2022

2.2.2 Barriers to scaling circular business models

2.2.2.1 Reusable packaging

Implementing reusable food packaging systems faces significant challenges across logistics, hygiene, cost, and supply chain acceptance, requiring innovative solutions to address collection, cleaning, transportation, safety, and economic viability

a. **Logistic complexities**
   - Setting up reverse logistics for collection, sorting, and transportation creates a complex monitoring challenge. Determining responsibility for container collection and ensuring their return are key issues that need to be addressed in reverse logistics.
   - Transporting empty, bulky containers, especially for food, milk or juices, back for cleaning can be inefficient and expensive, especially if long distances are involved.
   - Long-distance transport for cleaning can offset reuse benefits- both from carbon and cost perspective. This highlights the need for localized cleaning and distribution networks to minimize transport distances.

b. **Hygiene, food safety, and quality challenges**
   - Ensuring reusable packaging meets food safety standards can limit material choices and increase costs, while robust cleaning and inspection processes are needed to maintain hygiene and prevent contamination.
   - Improperly cleaned containers can attract pests and create hygiene issues, highlighting the need for consumer education on proper cleaning before returning containers.

c. **High capital and operating Costs**
   - Reusable packaging is often more durable and made from higher-quality materials than single-use packaging, making it more expensive to produce initially.
   - Implementing reusable systems requires investment in collection and cleaning infrastructure, including space for storage, specialized cleaning equipment, and potentially increased labor costs. These upfront costs can be a barrier for businesses.

d. **Lack of adoption**
   - Standardized reusable containers can clash unique branding for companies, making companies reluctant to adopt them.
   - Currently, there are insufficient incentives, such as deposit-refund schemes, loyalty programs, etc., for consumers to participate in reusable systems.

2.2.2.2 Refillable packaging

The adoption of refillable packaging systems is hindered by logistical and hygiene complexities for retailers, increased costs, consumer inconvenience, and the potential for limited sustainability benefits due to the use of difficult-to-recycle refill bottles.

a. **Logistical and hygiene hurdles**
   This is a multifaceted issue, imagine a grocery store offering refills. They need bulk storage, potentially needing different tanks or containers for various products. Then there's the dispensing system – it needs to be user-friendly, accurate, and easy to clean to prevent cross-contamination. Think about liquids like oils or sauces – how do you ensure a hygienic refill process that meets stringent food safety regulations? This complexity often necessitates specialized equipment and processes, adding to the logistical burden.

b. **Cost concerns for retailers**
   Retailers operate on thin margins. Refillable systems might require upfront investments in equipment, staff training, and potentially even redesigning store layouts. There is also the potential for product loss due to spillage or spoilage during refills. If these costs outweigh the potential savings from reduced packaging, retailers might be hesitant to adopt such systems.

c. **Inconvenience for consumers**
   Refilling requires a conscious effort to bring your own containers, potentially clean them beforehand, and then navigate the refilling process in the store. This can be perceived as more time-consuming than simply grabbing a pre-packaged product off the shelf. This inconvenience factor can be a significant barrier to widespread adoption.
d. **Sustainability issues**
   While refillable packaging aims to be eco-friendly, the reliance on multilayer pouches for refills often negates some of the benefits. These pouches are often made from mixed materials, making them difficult to recycle.

Overcoming these barriers requires a collaborative effort from businesses, consumers, and policymakers is critical to innovate for refill technologies, to encourage behavioral change, and design supportive policies that can revolutionize consumption patterns with minimal environmental impact.

Khalibottle - Incentivizing Waste Recycling in Bengaluru[68]

Khalibottle, a Bengaluru-based startup founded in 2016, offers a unique service where they collect recyclable waste directly from homes and businesses, paying customers for their trash.

The key to their success includes:

a. Source segregation: Educating residents and housekeeping staff in apartments on proper waste separation and recycling practices through meetings, workshops, and creative initiatives like plays.
b. Door-to-door collection services: Making it more convenient for customers to participate in recycling efforts.
c. Payment and donation options: Allowing customers to choose between receiving payment for their recyclable waste or donating the earnings to a cause.
d. Collaboration with BBMP: Partnering with Bruhat Bengaluru Mahanagara Palike to manage and operate two dry waste collection centers, with 36 vehicles transporting waste from various wards.

Impact:

a. They recycle over 13 tons of waste every month.
b. The startup serves over 0.5 million citizens, including entire apartment communities.
c. Customers are paid Rs. 8 per kg of recyclable waste, while corporate clients receive Rs. 12-13 per kg.
d. In several apartment complexes, Khalibottle's efforts have led to a significant reduction in waste, from 300 kg per month to 120-130 kg per month.

Challenges to Scale:

a. Limited range of recyclables: Focusing only on plastic/ PET bottles at the moment. This restricts the range of waste they can handle and potentially leaves some recyclable materials uncollected.
b. Expansion challenges: In other cities while maintaining efficiency and quality posed challenges of ensuring consistent service quality and customer satisfaction across different locations, which require significant resources and operational adjustments.
c. Profitability challenges: While the company pays customers for their waste and collaborates with the BBMP, maintaining financial sustainability and profitability in the long term, while balancing operational costs, customer incentives, and potential revenue streams, offers insignificant margins for expansion.

68. TheBetterIndia.com

2.3 Downstream interventions

India faces significant challenges in sourcing recycled plastics for packaging due to a fragmented waste collection system, contamination issues, and a complex interplay of infrastructural, technological, and socioeconomic factors.

a. **Inadequate Infrastructure for Collection:** India's waste collection infrastructure is underdeveloped, with many regions lacking organized systems despite policy mandates. While Gram Panchayats are responsible for collecting segregated waste, implementation is inconsistent, particularly in rural areas. The gap is further exacerbated by the uneven distribution of waste generation, making collection in rural areas logistically and economically challenging without proper planning.

b. **Source Segregation Issues:** Only about 14% of plastic waste is segregated at source in India[69], despite the Plastic Waste Management Rules making source segregation mandatory. The responsibility for sorting through mixed waste primarily falls on the informal waste pickers. The informal sector's role in waste segregation, while crucial, introduces inefficiencies due to manual processes and lack of standardization. Without effective source segregation, even collected waste often becomes too contaminated for efficient recycling.

c. **Inadequate Recycling and Processing Infrastructure:** India faces significant challenges in processing and recycling plastic waste due to outdated technology and limited capacity. Most municipalities lack modern segregation and processing facilities, and informal recycling operations, which account for 60% of recycling activities, rely on rudimentary methods that hinder efficiency and quality. Additionally, manual segregation and obsolete equipment are unable to effectively process complex plastics, leading to inconsistencies in recycled materials and making their integration into manufacturing supply chains difficult.

d. **Low Quality Food-Grade Recycled Plastics:** India lacks a closed-loop collection, sorting, and decontamination system for food-grade recyclates. Most recycled plastics are contaminated with inks, additives, and non-food-grade polymers, making them unsuitable for food packaging. Additionally, there are no uniform national standards, unlike the EFSA (European Food Safety Authority) or US FDA regulations, which outline strict criteria for recyclates purity and processing. As of now, Food Safety and Standards Authority of India (FSSAI) has established guidelines only on rPET usage. Consequently, FMCG brands that aim to use recycled content must rely on imported food-grade PCR resins, which significantly increases costs and carbon footprint, limiting the viability of recycled packaging solutions at scale.



69. Beat-Plastic-Pollution.pdf



3

Upstream Interventions: Packaging Design & Material Selection

3.1 Prioritization of eco-design solutions for Indian context

The current prioritization of sustainable packaging alternatives has been carried out based on 3 key levers: 1) Sustainability 2) Technical feasibility 3) Economic feasibility

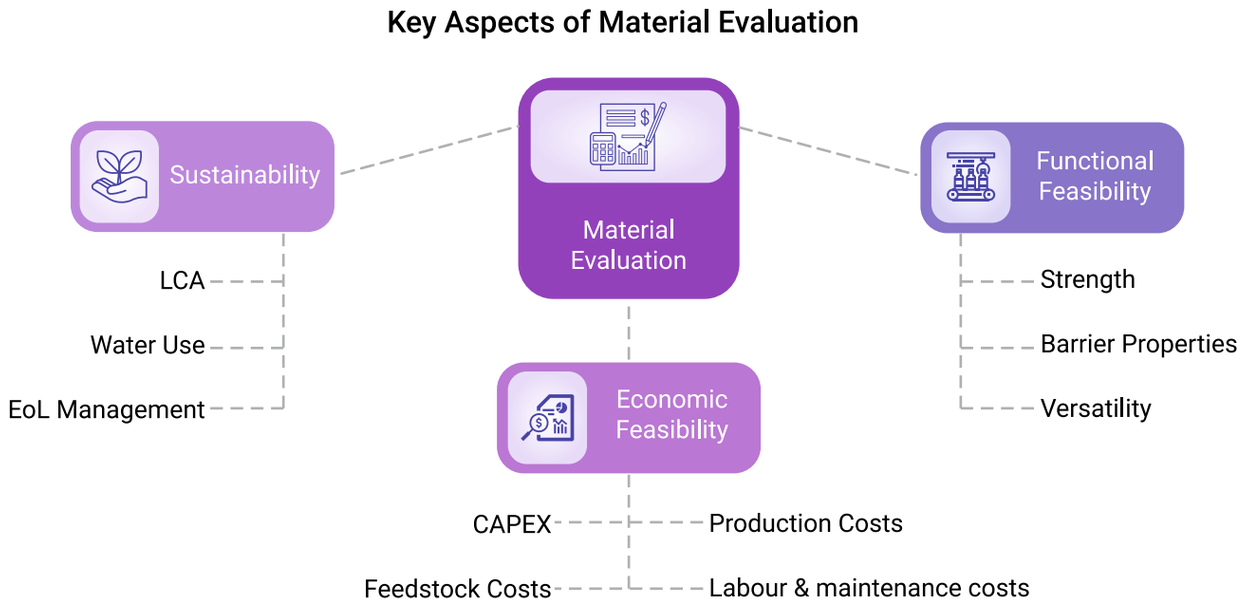


Figure 10: Sustainability factors, Economic metrics and functional aspects were taken into consideration for prioritization

The assessment of sustainable packaging materials highlights a diverse range of options, each with distinct benefits and challenges. As industries shift toward alternatives to conventional packaging materials, evaluating the viability, scalability, and environmental impact of these materials is essential. From cost-effective solutions like PLA to emerging technologies like PHA, the landscape is evolving to meet sustainability demands. However, economic feasibility, application limits, and scalability are key factors in transitioning to sustainable packaging.

Below are the key insights across sustainable packaging materials highlighting several critical focus areas:

- PLA (Polylactic Acid) emerges as a versatile, sustainable, and cost-effective alternative with significant potential for scaling. It can replace multiple resin types, including key flexible and rigid resins.
- Bagasse, a promising option, has limited applications and is mainly suited for specific packaging needs in the HORECA sector.
- PHA (Polyhydroxyalkanoates) offers good functional properties with a low environmental impact, but its high-cost limits large-scale adoption.
- Materials like Bio-PET and PBS rely on non-renewable inputs, making them short-term transitional options as sustainability concerns grow.
- Low-tech options like TPS (thermoplastic starch) and bagasse can help fill gaps in the short term, but their applications are limited to specific packaging types.
- Patented materials offer strong functional and environmental benefits, but they cannot be generalized as a category. They tend to be less economical compared to established, generic materials.

Table 1: Findings of comparative study on sustainable materials

A national investment of ~INR 12,000 Cr. over 4 years (2025-28) is needed to scale indigenous manufacturing of alternatives in an optimal way

Top material replacement Priority materials	Replacement for Traditional material replaced	Preferred feedstock Optimal, readily available feedstock	Economic Feasibility Profitability	Functional Feasibility Functionality	Sustainability Global Warming Potential
			More filled = better		Less filled = better
PLA (Polylactic Acid)	PET	Sugarcane: fermented sugars			
PLA (Polylactic Acid)	HDPE	Sugarcane: fermented sugars			
PLA (Polylactic Acid)	LDPE	Sugarcane: fermented sugars			
PLA (Polylactic Acid)	PP	Sugarcane: fermented sugars			
PHA	PET	Molasses			
PEF (Polyethylene Furanoate)	PET	Sugarcane: fructose			
Bagasse/Fibre Packaging	PS	Sugarcane: waste fibre			
Bio-PET	PET	Sugarcane: ethanol			
Bio-PE	HDPE	Sugarcane: ethanol			
Natural Fiber Composites	HDPE	Rice Husk			
Polybutylene Succinate (PBS)	PET	Sugarcane: fermented sugars			
PBAT	PET	Sugarcane: ethanol			
TPS/Starch Blends	LDPE	Corn			
Aluminium	PET	Recycled aluminium coils			
Paper based alternatives	LDPE	Recycled/virgin pulp			
Patented materials	LDPE, MPL, PET	Various			

3.1.1 Sustainability - based assessment

Not all bio-based materials naturally degrade in the ambient environment; many require industrial composting or specialized recycling processes, while others necessitate careful cultivation to avoid ecological impacts. It's important to recognize that "bio-based" does not inherently mean more environmentally friendly. A comparison of various bio-based and alternative packaging materials reveals key factors such as compostability, recyclability, carbon footprint, water usage, and overall life cycle assessment (LCA) relative to traditional packaging. This highlights the environmental trade-offs of each material, providing valuable insights for stakeholders considering large-scale adoption.

Sustainable packaging alternatives come with inherent trade-offs. PLA and Bio-PE offer lower carbon footprints but raise concerns over water and land use. PHA, PBS, and PBAT are compostable but require high energy and infrastructure, reducing their sustainability. Bagasse and TPS stand out due to their low environmental impact and minimal processing needs. PEF, although bio-based, has energy-intensive production, and recycled aluminum reduces LCA but demands high energy. Conventional plastics remain the least sustainable, underscoring the need for a balanced, impact-driven approach when selecting alternative materials.

For detailed explanation with comparisons, refer to the table 3 in appendix.

3.1.2 Functional properties comparison

When evaluating sustainable packaging materials, it is crucial to focus on their functional performance, as this determines their suitability for various applications. Different materials exhibit varying strengths, barrier properties, and versatility, making them better suited for specific packaging needs.

Non-compostable or biodegradable alternatives offer stronger mechanical properties and better barrier performance but often come with a higher environmental impact. PLA provides a more balanced option for both rigid and flexible packaging, though it has limitations in barrier strength. PHA offers flexibility but is highly permeable. PEF competes with PET in strength and barrier properties, making it a strong alternative. Bio-PET and Bio-PE are compatible with traditional plastic systems, making them ideal for bottles and films. PBS and PBAT are flexible but have weak barrier properties, limiting their use. Bagasse and TPS are moisture-resistant but require coatings for durability. Paper, unless laminated, struggles with barrier properties, while aluminum excels in protection but needs separate recycling processes. Patented materials continue evolving to enhance durability and MLP alternatives.

For detailed explanation with comparisons, refer to the table 4 in appendix.

3.1.3 Economic feasibility

Economic feasibility plays a crucial role in determining the scalability of sustainable packaging materials. Materials like PEF, PLA, and recycled aluminum require significant capital investment, making large-scale adoption riskier. In contrast, low-tech options such as bagasse and TPS offer more affordable entry points but come with other challenges that could limit widespread use.

PLA and PBS require substantial capital investment, typically in the lakhs per tonne range, with feedstock costs being a major factor influencing their scalability. PHA and PEF are even more costly, which limits their broader adoption. On the other hand, materials like Bio-PET, Bio-HDPE, and natural fiber composites offer more feasible scaling potential with moderate costs. Bagasse-based packaging requires minimal initial investment (in the thousands per tonne), but its production costs remain significant. Aluminum, while offering strong protective qualities, demands high capital expenditure **(CAPEX) and energy-intensive processing, making it less economically feasible for widespread use. Additionally, while glass offers excellent reuse or refill potential, its substantial weight and complex logistics limit its widespread adoption as a scalable packaging solution. Paper remains the most cost-effective option, benefiting from an established supply chain and low feedstock expenses.**

For detailed explanation with comparisons, refer to the table 5 in appendix.

3.2 From import to indigenous: recommendations to shift India's packaging material priorities

Indigenous manufacturing of sustainable materials must be prioritized in the medium term, utilizing low-tech options and imports in the short term to facilitate this transition. Consistent investments in indigenous manufacturing of materials like PLA and continued phase-out of PS through bagasse packaging are essential to support sustainable growth.

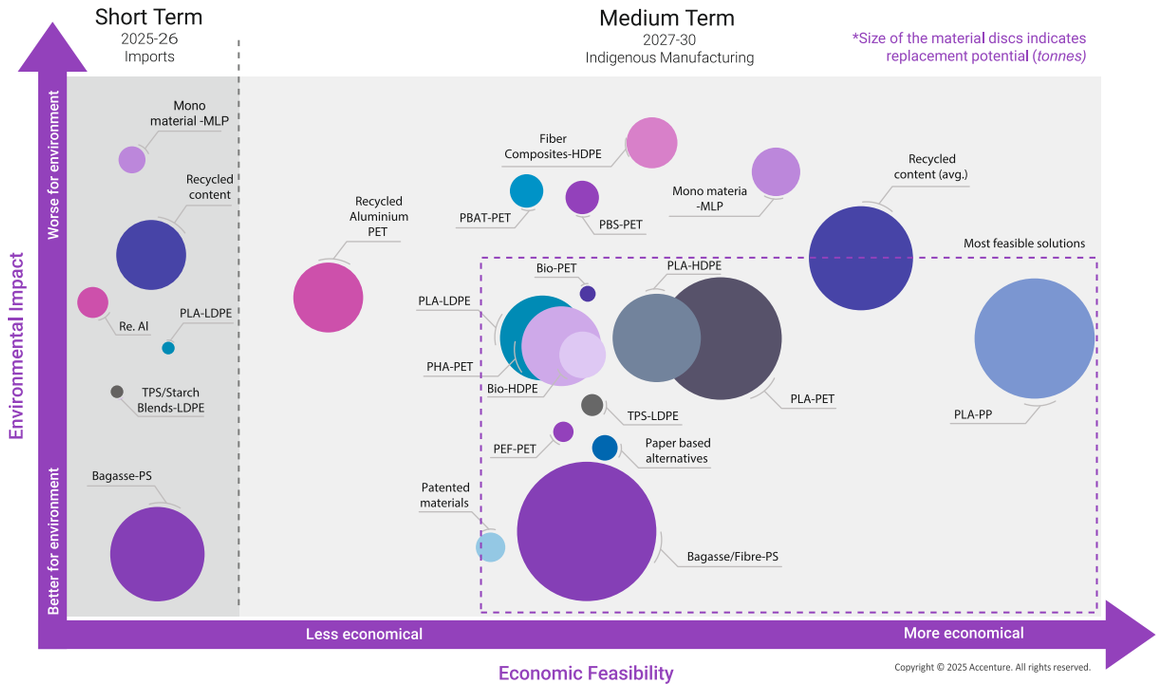


Figure 11: Prioritise indigenous production of focus materials in the medium term and low-tech materials in short term

Accenture analysis leads us to key recommendations across time periods to enable Indian FMCG & packaging industry to transition to sustainable packaging solutions by 2030.[8]

Key short term (2025-27) recommendations:

a. **Invest in indigenous capacity for medium-term gains**
   Manufacturing plants for materials like PLA require at least two years to become fully operational. Therefore, building indigenous capacity should be prioritized now, with investments directed towards this goal. (further details in section 3.2.1).

b. **Leverage low-tech materials like TPS**
   While starch-based blends like TPS may not be suitable for all packaging applications and may lack durability, their low cost and low-barrier manufacturing process make them a viable option to replace LDPE. This approach is particularly effective with the established small manufacturers in India.

c. **Scale recycled content integration**
   Although recycled content is not a long-term solution for problematic packaging due to limited recycling cycles, it offers a way to reduce reliance on virgin materials and meet EPR targets. Recycled PET and HDPE are more readily available in high quality, while other materials, especially for food-safe applications, are still emerging in India.

d. **Use recycled aluminium imports as a stop-gap arrangement**
   India currently lacks large-scale recycled aluminum coil production. In the short term, to meet the demand for aluminum beverage cans as a replacement for PET and virgin aluminum, imports can serve as a temporary solution at low volumes.

e. **Bank on PLA imports in the short term**
PLA, used as a replacement for LDPE, is being imported in small quantities by private players to meet scattered demand in India. This can be formalized and scaled in the short term until domestic PLA manufacturing capacity is established.

f. **Scale bagasse packaging in HORECA**
Bagasse is already an established alternative for PS tableware in India, with companies like Chuk and Ecoware leading the way. Although it is mainly used for PS replacements, bagasse-based packaging can be scaled in the short term and further adopted in the medium term for wider application in the HORECA sector.

Key Medium-term (2027-30) recommendations:

a. **Scale Indigenous PLA Manufacturing**
PLA plays a pivotal role in India's sustainable packaging landscape. A versatile and relatively well-established material, **scaling PLA production to approximately 3 million tonnes capacity by 2030** is essential to replace traditional packaging materials like HDPE, PET, LDPE at significant rates. As India is a major sugarcane producer, the feedstock supply can be internally managed through government interventions. However, since PLA is only industrially compostable, scaling industrial composting capacity will be crucial. Despite the need for composting infrastructure, PLA remains economically and functionally viable.

b. **Formalize and Scale Bagasse-Based Solutions**
Polystyrene (PS) has been recognized as highly detrimental to the environment, with several countries imposing total bans. Bagasse-based alternatives present a feasible solution to **completely phase out PS** packaging and tableware in India by 2030, given the industry's established nature. Formalizing the sector and scaling production capacity will be key to achieving widespread adoption.

c **Adopt Bio-PE and PBAT, where Bio-Based Materials Cannot Meet Demand**
Materials like Bio-PE and PBAT, which are produced using non-renewable or fossil-based inputs, are easier to scale due to their compatibility with existing manufacturing equipment. In the medium term, these materials can fill gaps where specialized materials like PLA and PHA cannot meet demand, such as **replacing up to 5%** of HDPE in packaging.

d. **Focus on R&D for Efficiency in PHA/PEF and Other Nascent Materials**
PHA, PEF, and other emerging materials show great promise in terms of functionality and sustainability but are still in the early stages of research and development. These materials are expensive to produce and difficult to scale. Given current constraints, PHA can be scaled to around **3 lakh tonnes capacity nationally by 2030.** Continued R&D efforts and pilot capacity development will be essential to enable large-scale production in the long term.

e. **Leverage Mono-materials to Replace MLP While Sustainable Solutions are Developed**
Multilayered plastics (MLP) replacements are actively being researched in India, though many proprietary solutions remain scattered and lack public data on production scalability. **Mono-materials,** particularly mono-PP present a promising and scalable alternative for replacing MLP across various applications in the medium term.

f. **Utilize Food-Grade Recycled Content Where Available**
To address the scarcity of high-quality recycled content, **closed-loop recycling must be scaled nationwide,** with stronger efforts in collection and segregation. Additionally, chemical recycling can be explored to produce high-quality recycled resins, especially for food-grade applications.

g. **Scale Technically-Sound Patented Materials**
While still in their nascent stages, patented materials hold potential for addressing **flexible packaging waste.** Focused R&D to improve production efficiency, along with government support through subsidies and grants, will be essential to scale these materials, particularly for MLP replacements, and help solve major packaging waste challenges.

3.2.1 To scale indigenous manufacturing of sustainable packaging, an investment of approximately ₹120 billion over the next four years is required

Being the second largest producer of sugarcane globally, India has potential to lead the bioplastics revolution worldwide. To scale indigenous manufacturing of sustainable packaging, an investment of approximately **₹120 billion over four years (2025-28)** is required. This would necessitate **diverting around 150 million tonnes of sugarcane-derived biomass for feedstock** to establish the necessary production infrastructure.[8]

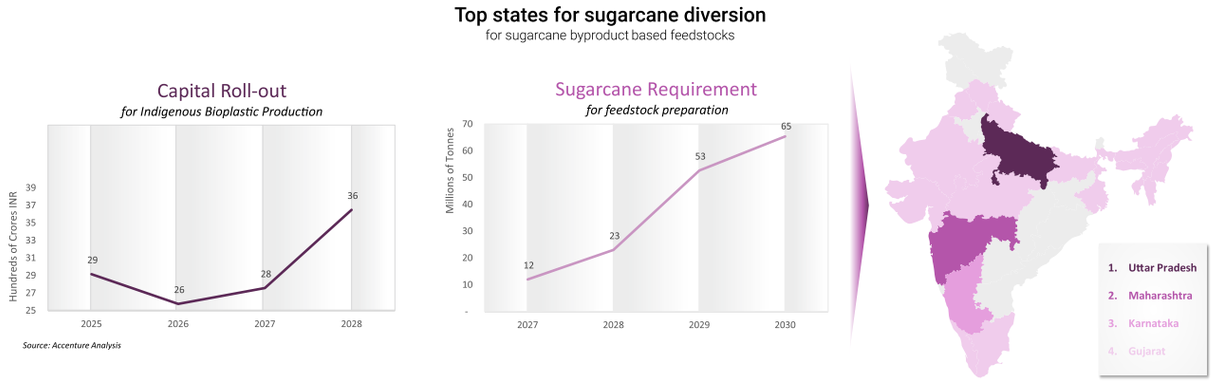


Figure 12: Recommended resource roll-out for sustainable material indigenous production scale-up

While the recommendations for material prioritization highlight key focus areas, there are several trade-offs that must be considered to scale these efforts effectively:

1. Invest in indigenous capacity for sustainable packaging material manufacturing

While indigenous manufacturing of sustainable materials will provide the Indian FMCG and packaging industry independence and economic growth, a national investment of **~INR 120 billion over 4 years (2025-28)** is needed to scale indigenous manufacturing of sustainable packaging. There will need to be a gradual influx of large capital investments to stand up and scale manufacturing. To meet the required capacity by 2027-30, substantial capital investments, expected to reach **INR 36 billion by 2028,** must begin in 2025.

2. Secure feedstock requirement

A significant portion of alternative packaging materials depend on sugarcane-derived biomass or waste. As the world's second-largest producer of sugarcane, India has the potential to secure a steady supply by **diverting 12 million tonnes of sugarcane-derived biomass in 2027, ramping up to 65 million tonnes by 2030,** to meet the growing demands of sustainable packaging manufacturing.

3. Balance impact of feedstock cultivation and its impact on ecology & food production

Expanding sugarcane cultivation for PLA production raises concerns over water usage, particularly in water-stressed regions like Maharashtra and Karnataka. Additionally, diverting sugarcane from sugar and ethanol production to bioplastics (sugarcane-derived biomass) could also impact supply chains. However, if managed sustainably—by utilizing bagasse-derived feedstock or integrating with existing sugar mills—PLA production could offer a high-value alternative for farmers while reducing dependency on fossil-based plastics. Policymakers must ensure a balanced approach, promoting agroforestry models, drip irrigation, and lifecycle assessments to mitigate environmental trade-offs and prevent land-use conflicts. Land availability also needs to be balanced, but should be relatively feasible owing to very low bioplastic-related land use globally (0.073%)[54]

4. Set up and scale industrial composting & advanced recycling facilities

To effectively manage PLA at the end of its life, India will need to establish industrial composting facilities with a cumulative capacity of at **least 0.8 million tonnes by 2030.** Significant capital investment will be required, which could be accelerated through government subsidies and support to facilitate the development of a robust waste management infrastructure.

4

Midstream Intervention: Extension of Useful Life

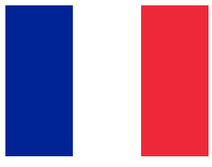


4.1 Prioritized Circular Business Models for Extending the Life of Packaging

Recognizing the limitations of single-use packaging, there is a growing interest in investigating how scalable business-led extension of life models for packaging can reduce material consumption, minimize material value loss and drive a transition towards a circular economy.

Most packaging today is designed for single use, but extending its life is key to sustainability. In a circular economy, reusing packaging means reapplying it for the same purpose without major alterations, distinct from recycling, which reprocesses materials into new products. Reusable packaging reduces material waste and consumption, preventing packaging from being downcycled or sent to landfills. Although it may require more material for sturdier design, the overall packaging used per cycle is significantly lower.

Reusable packaging can also reduce the carbon footprint, though the exact impact depends on factors such as material type, reuse cycles, and transportation emissions, making direct comparisons with recycling complex. As sustainability pressures rise, interest in reusable packaging solutions is growing, with many countries implementing bans and taxes on single-use packaging to promote more circular models.



France - Specific reuse targets have been introduced (5% by 2023 and 10% by 2027) with an increased focus on standardization of containers as an enabler; there will also be a ban on premises serving via single-use solutions from January 2023[70].



Germany -Restaurants, bistros, and cafes that sell food or drinks “to go” are obliged to also offer their products in reusable packaging from 2023[71].



India too, has mandated the ban of several single-use plastics and launched reuse targets for rigid plastic packaging under its EPR regulation (10% by 2025-26; 15% by 2026-27; 20% by 207-28; and 25% 2027-28 onwards)[72].

70. The French Anti-Waste Law for a Circular Economy
71. German Packaging Act, 2022.pdf
72. Ministry of Environment, Forest and Climate Change

Digital DRS in Char Dham with Recykal[73]

The focus of this study is on the role of scaling reuse models for packaging, where customers return or refill empty packaging for it to be cleaned and refilled professionally by business, that is, putting the responsibility back onto the producers to manage the end-of-life of packaging. Such models that extend the life of packaging materials not only present complementary opportunities to the inherent reuse culture that exist in India, thereby saving millions in material savings alone; but they are also likely to offer the biggest opportunity for scaling the breadth and volume of product revenues through reuse.

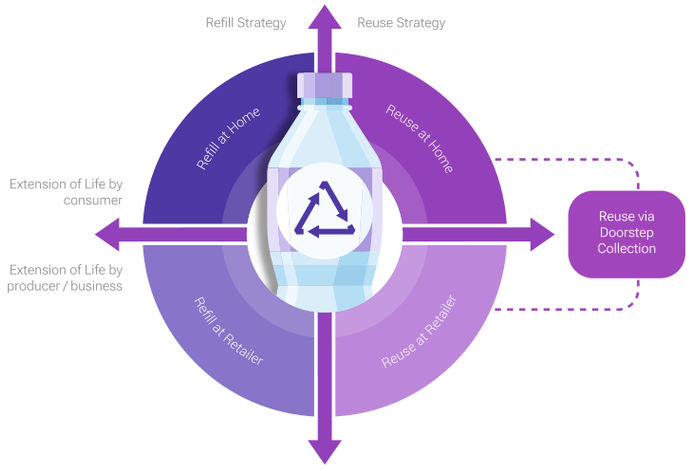


Figure 4: Types of business models to extend the useful life of packaging

The Char Dham Yatra, a significant pilgrimage in India, sees a massive influx of pilgrims, resulting in a substantial amount of plastic waste in the ecologically sensitive region. A QR-based Deposit Refund System (DRS) was implemented to address this challenge, involving a deposit on plastic bottles and packaged snacks, which is refunded upon return. The implementation of the DRS followed a phased approach with a focus on collaboration and awareness:

Phase 1: May-July 2022 in Kedarnath

- Collaboration: The District Administration partnered with Recykal for technical and operational support, and engaged with various stakeholders like hotels, stores, trade groups, temples, and mule associations.
- QR Code Distribution: Ground teams physically delivered QR codes to each location, navigating challenging terrain to ensure proper implementation.

Phase 2: Sept-Nov 2022 in Kedarnath

- Mandatory QR Codes: The administration mandated QR code adoption for all retailers and shopkeepers.

Phase 3: Expansion to Gangotri, Yamunotri & Badrinath (2023-2024)

- Collaboration: District Administrations signed MoUs with Recykal to implement the DRS in their regions.
- Recykal worked directly with distributors and the PRD (Prantiya Rakshak Dal) to manage collection points, ensure QR code implementation, and raise awareness.

Impact

- QR Code Distribution: Over 1 M QR codes were distributed on bottles and packages, showing a **4X increase since the program's inception.**
- The DRS led to the collection and recycling of 2 M bottles, with a **300% rise in collections in Kedarnath.**
- The **collection rate of QR-coded items reached approximately 80%** in FY 2024, a 25% increase from the previous year.
- Recycling efforts s**aved approximately 66 metric tons of CO_2 emissions.**
- The initiative **generated 110 new jobs** and increased the informal sector's revenue by 37.5%. **Retailers also saw a total revenue increase of INR 0.314 million.**
- The DRS led to a **21% increase in proper waste disposal practices** among pilgrims and local communities.

73. Recykal.com

Retail reuse models offer significant potential, projecting a 6% reduction in material value loss from all packaging by 2028, which amounts to approximately $9B. (based on Accenture analysis)

Accenture's analysis highlights the substantial potential of "Refill at Retailer" and "Reuse at Retailer" models to mitigate material value loss from discarded Glass, HDPE, and PET packaging. Current projections, based on existing Extended Producer Responsibility (EPR) targets, indicate a 6% reduction in material value loss by 2028, assuming a 25% reuse potential for HDPE and PET, and 45% for Glass.[8] However, the true potential lies in scaling these initiatives, as significant additional material value can be unlocked through broader adoption.

HDPE packaging: Both refill and reuse models demonstrate significant potential for material value recovery. Accenture analysis estimates a $2.3M[8] in avoided material value loss through efficient HDPE reuse. The current feasibility of HDPE for both refill and reuse offers a unique opportunity to focus on optimizing packaging design and durability to expand the addressable market size to maximize material value retention.

PET packaging: Basis Accenture analysis, PET reuse offers substantial opportunities with an estimated $2.5M[8] in avoided material value loss by 2030. Given its widespread use and large addressable market for reuse, prioritizing the expansion of robust collection and recycling systems, coupled with targeted initiatives to promote reuse at retail, is paramount.

Glass packaging: This exhibits the highest potential for material savings and material value recovery through reuse models. Basis Accenture analysis, establishing efficient return systems for colored glass beverage bottles at retail locations can prevent approximately $4.1M[8] in material value loss. The focus should be on building a comprehensive infrastructure that facilitates the return, cleaning, and redistribution of glass bottles (based on Accenture analysis).

Overall reuse models at retail significantly outperform refill models in terms of material value recovery, accounting for approximately 88% of the material value unlock potential, that is close to $7.9B[8], (based on Accenture analysis). This underscores the crucial role of reuse in maximizing material value retention and minimizing waste, especially for materials with higher addressable markets, like PET and glass packaging. Moreover, while all three materials, total packaging consumption and the potential reuse market are projected to grow. This growth indicates increasing opportunities to capture value from these materials and emphasizes the need for proactive measures to leverage this potential and integrate circularity into the packaging lifecycle, thereby capturing material economic benefits.

4.2 Success Factors for Scaling Circular Business Model

The success of the models to extend the useful life of packaging materials and capturing the economic advantages depends on achieving significant scale. To successfully scale these retail-level reuse and refill packaging programs, 5 key actions are crucial: 1) achieving high return rates for cost-effectiveness and environmental benefits, 2) establishing shared infrastructure for optimal efficiency, 3) balancing packaging standardization with brand differentiation for simplified returns, 4) meeting stringent hygiene requirements for customer satisfaction, and 5) fostering a supportive ecosystem with enabling regulations and collaborative business models.

1. **High Return Rates Ensures Cost Competitiveness**
   - Reusable packaging needs to be affordable, ideally at parity with or cheaper than single-use options. This is crucial to incentivize consumers to adopt new behaviors like returning containers.
   - Optimize packaging design for durable packaging to withstand the expected number of uses based on anticipated return rates. This ensures the system operates at scale to achieve cost degression (lower per-unit costs) through multiple reuse cycles, thereby offsetting the higher initial costs.
   - While cost is crucial, environmental performance can't be ignored. Reusable systems should aim for equal or lower GHG emissions compared to single-use options. Data generation is essential to prove these environmental benefits and justify any potential price premium.
2. **Shared Infrastructure Maximizes Efficiency**
   - Implement pooled packaging systems across brands where cleaned packaging is sent to the nearest filling location, regardless of the brand, minimizing transportation distances and maximizing efficiency.
   - Decentralize manufacturing and filling by increasing the number of regional sorting and cleaning centers to reduce transport distances and optimize logistics, particularly with standardized and pooled packaging.
   - Optimize the entire network by maximizing the use of collection points, allowing returns at any location, and unifying the sorting/ cleaning network to create a seamless and efficient system.
3. **Balanced Packaging Standardization Simplifies Returns**
   - Scaling reusable packaging requires a degree of standardization to enable efficient logistics and cross -utilization across products and brands. However, this can clash with brand differentiation strategies that rely on unique packaging.
   - Less differentiated products are ideal frontrunners for reusable packaging. For highly differentiated products, solutions like late-stage customization, digital printing, and reusable labels can help balance standardization with branding needs.
   - Use clear labeling and design to help customers recognize and understand the returnable packaging system. Provide simple, easy-to-understand instructions on how to return the packaging and maintain consistent branding across all returnable packaging and communication materials to reinforce the program's identity and build customer recognition.
   - Optimize packaging design to allows for automated sorting processes and easier cleaning processes reducing manual handling and improving efficiency. Additionally, standardized dimensions enable efficient stacking and packing of packaging during transportation, maximizing space utilization and reducing transportation costs and emissions.
4. **Meeting Hygiene Requirements for Customer Satisfaction**
   - Not all products are equally suited for reusable packaging. Non-perishable items, those with low barrier requirements (like dry goods), are prime candidates for reuse.
   - Reusable packaging must meet the same safety and hygiene standards as single-use options. This includes preserving food quality, extending shelf life, and preventing contamination.
5. **Supportive Ecosystem and Regulations**
   - Scaling reusable packaging requires a supportive ecosystem which includes consumer education, harmonized standards across borders, and new business models that incentivize all stakeholders in the reuse value cycle.
   - A robust infrastructure for collection, cleaning, and quality control is essential, which is convenient, affordable, and environmentally sound, while also addressing the needs of brands and consumers. This requires innovative collaboration models among brands, manufacturers, fillers, and retailers to drive the transition.

5

Employment opportunities in India's sustainable packaging landscape



Basis Accenture analysis, there is a potential to generate ~6.5 million jobs through circular packaging interventions, while tapping onto the opportunity to unlock almost ~ $107B material value by 2030[8].

Employment opportunities play a crucial role in the economic landscape of any nation, particularly in India, where both the government and private sector are increasingly focusing on growth-oriented strategies. As these strategies evolve to incorporate sustainable and climate-neutral practices, it becomes essential to assess their potential for job creation. Research indicates that zero waste approaches can generate significantly more employment than traditional disposal methods, which typically involve incineration or landfilling waste.

Addressing problematic packaging through innovative design and business model solutions can contribute to creating **~3 million formal jobs.**

The study assessed job creation across various intervention strategies, identifying both formal and informal employment opportunities in eco-design, extension of packaging's useful life and recycling. Additionally, the study also analyzed the addition of formal jobs and the increasing rate of formalization of newly added jobs.

A comprehensive waste management strategy focuses on waste prevention and resource recovery, aiming to redesign product life cycles so that materials are reused rather than discarded. In contrast, disposal-based systems incur higher economic costs and environmental impacts due to their reliance on incineration and landfills.

As per the study analysis, the total estimated formal job creation through packaging circular economy solutions is approximately 3M. Of this, around 0.5 million jobs are attributed to extending useful life, 0.44 million in material innovation, 0.93 million from increased flexibles recycling and 71,000 jobs from chemical recycling. Additionally, the formalization of India's informal waste management sector has the potential to create ~0.84 million formal jobs.

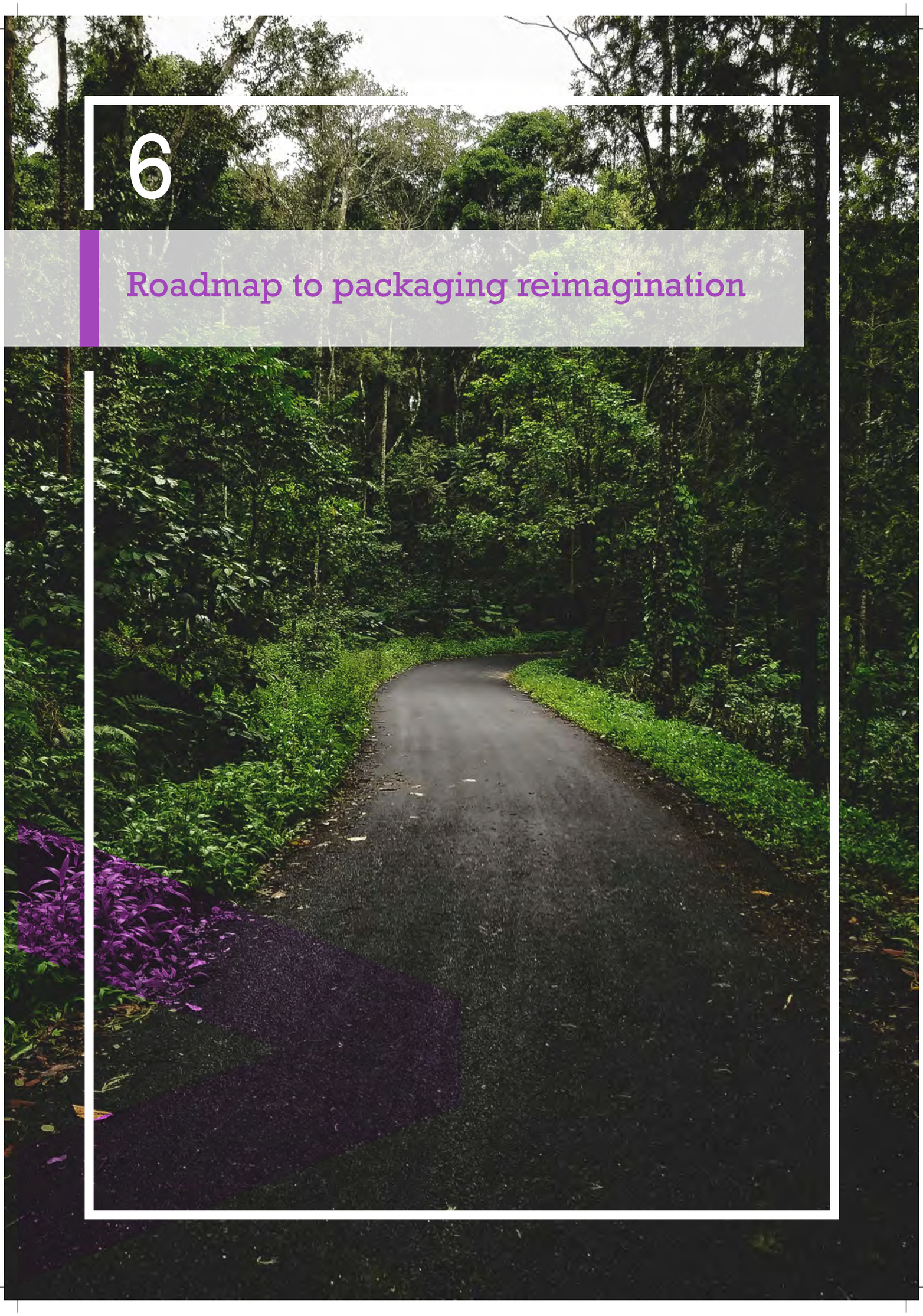
Furthermore, the potential for job creation in the informal sector through packaging circularity has been estimated at **approximately 3.5 million.**

Addressing the problematic packaging landscape in India offers an immense potential to create a highly skilled workforce, all contributing in tandem to add value to India's circular economy.



6

Roadmap to packaging reimagination



By leaning effectively on the levers of Policy, Technology and Finance, India can stand to secure a sustainable future in 2030 and beyond.[8]

There is a potential to generate ~6.5 million jobs through circular packaging interventions, while tapping onto the opportunity to unlock almost ~ $107 Bn material value by 2030



The depiction accounts for formal job creation. Circular Packaging Interventions also contribute to informal job creation of ~3.3mn. Lightweighting and Monomaterials as circular solutions are not expected to have an additional external impact on green job contribution

Figure 13: Economic, material and social impacts of recommended interventions

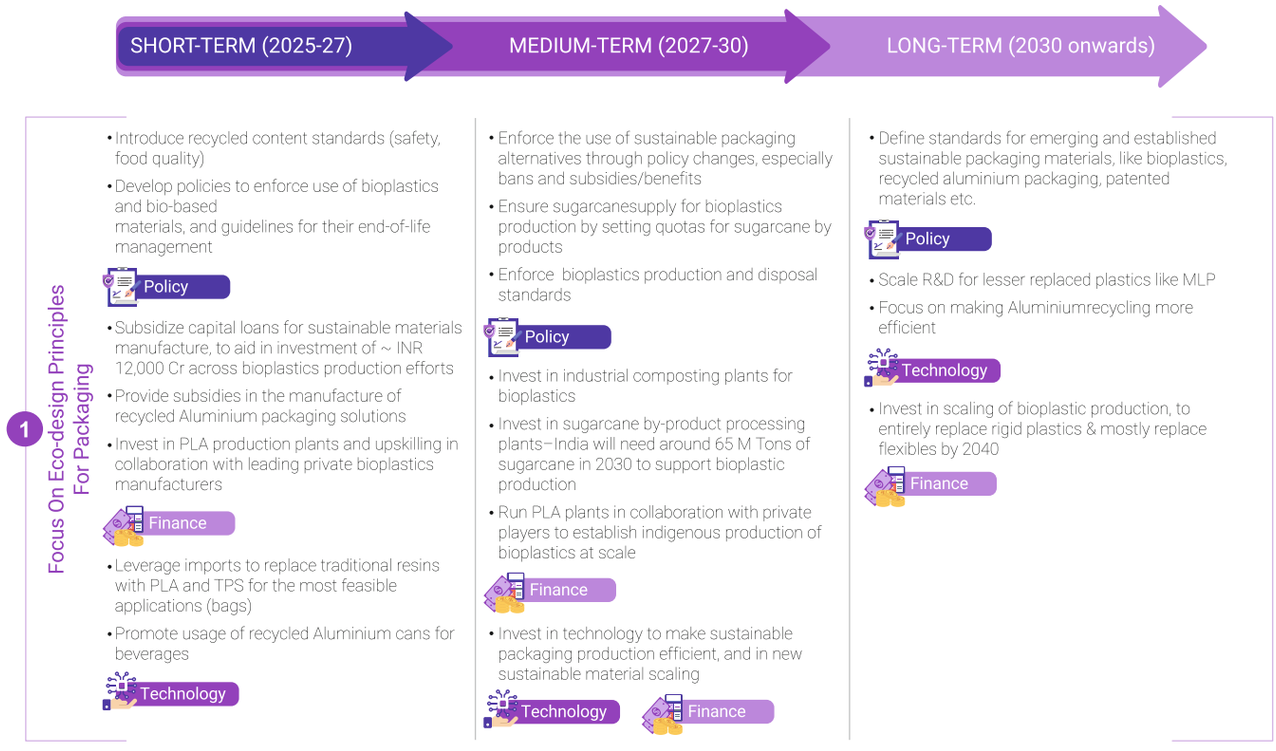
Note: Jobs are based on the assumptions built into the forecast of material and economic impact. Job-creation across individual intervention also implies job creation across multiple industries. The jobs in Figure 13 highlight only the formal job creation potential

There is value across the levers of economic, material and social which can be unlocked through interventions which address India's problematic packaging landscape

The intervention groups, of material innovation, increased recycled content, extension of useful life, increased flexibles recycling and chemical recycling can stand to unlock economic, material and social impact, driving holistic value to India's circular economy ambitions. In order to realize the impact across these three levers, a well-defined roadmap for each intervention group, would be necessary to guide coordinated efforts across Policy, Technology and Financial levers, in a phase-wise, short-term, medium-term and long-term approach.

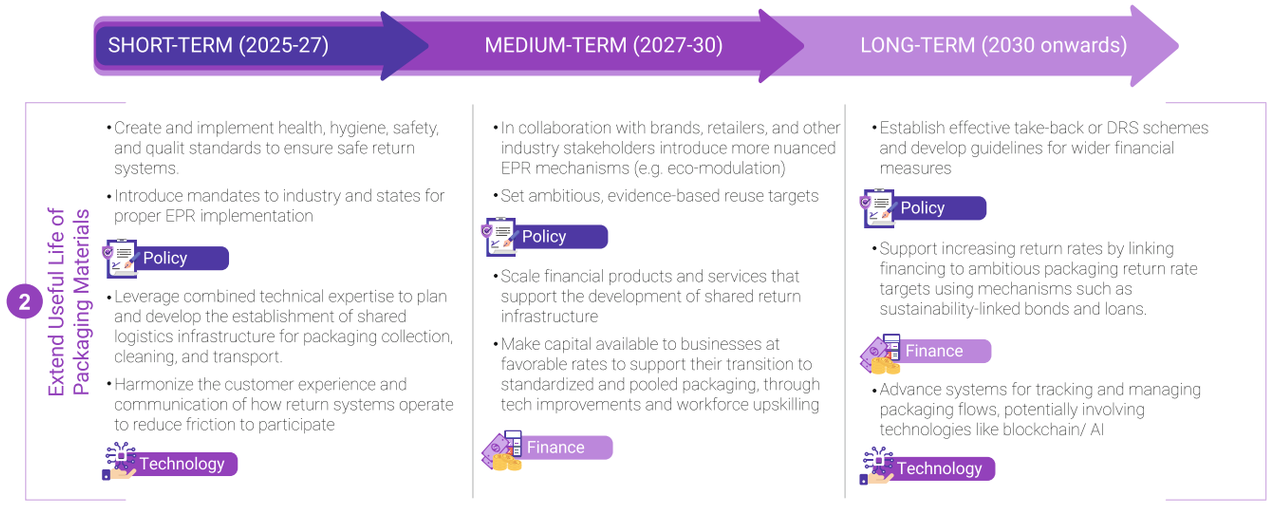
Upstream: Widespread adoption of eco-design & useful life extension in packaging relies heavily on India's indigenous industrial capacity and hence investments become the immediate focus. Scaling indigenous production of bioplastics leveraging sugarcane as feedstock will position India well in terms of sustainable packaging progress in the medium term.

India's transition to a circular economy in packaging necessitates a strong emphasis on eco-design. This involves prioritizing sustainable materials and practices from the outset. In the short term, this means investing in domestic bioplastics and bio-based material manufacturing infrastructure, while simultaneously promoting reuse and refill systems. Policies should be implemented to enforce the use of recycled content and incentivize the adoption of bioplastics. In the medium term, collaboration with private manufacturers will be crucial to scale up the production of innovative bio-based materials. Policy interventions, such as bans on certain traditional plastics and subsidies for bio-based alternatives, will further drive the shift towards eco-design. Looking ahead to the long term, stringent regulations and penalties will be necessary to discourage the use of conventional plastic resins, paving the way for a packaging sector dominated by sustainable materials and practices.



Midstream: Extending the useful life of packaging will necessitate adapting global success stories of take-back schemes and deposit refund systems in the Indian context to incentivize reuse.

Extending the lifespan of packaging materials is another vital pillar of India's circular economy strategy. Short-term efforts should focus on establishing the foundation for circular business models, including reuse and refill systems. This will involve developing clear standards and policies for the reuse and refill of traditional packaging, as well as promoting consumer awareness and participation. In the medium term, these efforts can be strengthened through increased collaboration among stakeholders and sustained policy support. Long-term success will require the implementation of effective take-back schemes and innovative financial solutions, such as sustainability-linked instruments, to incentivize higher return rates and responsible end-of-life management of packaging.



Downstream: Boosting collection and recycling systems will require mandating source segregation and investing in MRFs to optimize waste management – which will enable high quality recycled content to become available for packaging applications.

A robust and efficient collection and recycling system is essential to support India's transition to a circular packaging economy. In the short term, this requires mandating source segregation and investing in the development of Material Recovery Facilities (MRFs). Financial support should be provided to incentivize the collection and sorting of recyclable materials, particularly low-value flexibles. In the medium term, integrating the informal sector into the formal waste management system and leveraging AI and machine learning for efficient waste sorting will be crucial. Long-term efforts should focus on establishing a national waste data repository and promoting continuous research and innovation in waste management and recycling technologies. This will require a dedicated fund for waste management and circular economy initiatives, ensuring sustained progress towards a future where packaging waste is minimized, and valuable resources are recovered.

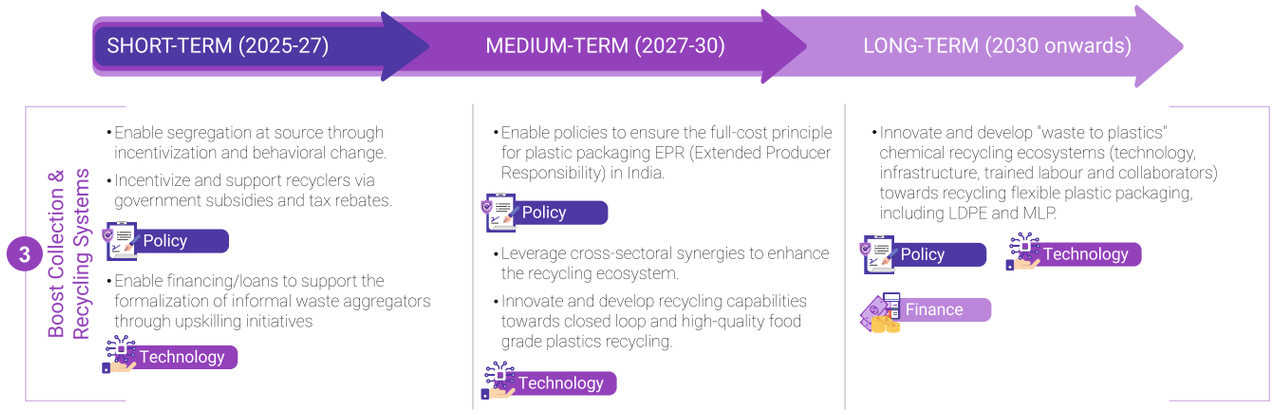


Figure 14 (c): Boosting collection and recycling systems will require mandating source segregation and investing in MRFs to optimize waste management – which will enable high quality recycled content to become available for packaging applications



7

Call to action: Next Steps and Pilot Recommendation

To drive large-scale impact in sustainable packaging, pilot programs are being designed around materials and strategies that address key environmental challenges while ensuring feasibility in adoption.

The focus is on upstream interventions that contribute to 75% of the total material value unlock potential. The selected pilots aim to replace conventional plastic packaging with viable alternatives, integrate recycled content into packaging, and extend packaging life cycles through reuse models.

7.1 Piloting Sustainable Packaging Alternative Materials

The transition to bioplastics and mono-materials is being explored to reduce reliance on conventional fossil-fuel-based plastics while ensuring functional feasibility. These materials have been chosen due to their potential to degrade more efficiently or be more easily recycled compared to multi-material laminates (MLP), which currently pose significant waste management challenges.

a. PLA as a replacement for PET, PP, HDPE, and LDPE offers a compostable alternative with increasing commercial viability.
b. Mono-materials are being tested to replace MLP, improving recyclability and reducing the complexity of waste processing.

7.2 Embedding Recycled Content in Packaging

Recycled plastics are crucial to creating a circular economy, reducing virgin plastic use, and lowering carbon footprint. The pilots focus on post-consumer recycled (PCR) materials that can maintain food-grade safety and packaging durability.

- rHDPE and rPP are being tested for applications where durability and recyclability are critical.
- rPET is being prioritized for its potential in food-grade closed-loop recycling, supporting circularity in beverage and FMCG packaging.

7.3 Extending the Useful Life of Packaging

Reuse-based models are being piloted to address single-use packaging waste by shifting consumer behavior towards refill and return systems. The goal is to test operational feasibility and consumer acceptance while reducing overall material demand.

- Refill-at-store models allow consumers to replenish products using their own or returnable containers, minimizing single-use packaging.
- Return-at-store (DRS) models explore deposit return systems to incentivize packaging recovery and reuse.

These pilots will generate insights on material performance, consumer acceptance, and supply chain integration, guiding future large-scale adoption of sustainable packaging solutions.

8

Appendix



Glossary

No	Taxonomy	Definition
01	**Bio-based plastics**[74]	Biobased plastics are fully or partially made from biological resources, rather than fossil raw materials. They are not necessarily biodegradable or compostable. It is important to examine the full life cycle of biobased plastics, to ensure that they are beneficial to the environment beyond the reduction in use of fossil resources. This includes changes in land use.
02	**Bioplastics**[75]	Biobased polymer derived from the biomass or issued from monomers derived from the biomass and which, at some stage in its processing into finished products, can be shaped by flow. Note: Bioplastic is generally used as the opposite of polymer derived from fossil resources.
03	**Biodegradable Materials**[74]	Biodegradable plastics biodegrade in certain conditions at their end of life. Biodegradable and compostable plastics may be made from biological resources or fossil raw materials. These plastics should be used when it is not possible to reduce, reuse or recycle, in line with the circular economy and waste hierarchy principles.
04	**Compostable Materials**[74]	Compostable plastics - a subset of biodegradable ones – typically decompose in industrial composting facilities, and first need to be collected.
05	**Circular Economy**[76]	The circular economy is a system where materials never become waste and nature is regenerated. In a circular economy, products and materials are kept in circulation through processes like maintenance, reuse, refurbishment, remanufacture, recycling, and composting. The circular economy tackles climate change and other global challenges, like biodiversity loss, waste, and pollution, by decoupling economic activity from the consumption of finite resources.
06	**Eco-design**	A design approach that considers the environmental impacts of a product throughout its entire lifecycle, from raw material extraction to disposal.
07	**Extended Producer Responsibility (EPR)**	A policy approach that holds producers responsible for the nvironmental impacts of their products throughout their lifecycle, including end-of-life management.
08	**Flexible Packaging**	Packaging made from materials that can be readily bent, folded, or deformed, such as films, pouches, and bags.
09	**Food-Grade Recycled Plastics**	Recycled plastic materials that meet the safety standards for use in food packaging.

Glossary

No	Taxonomy	Definition
10	**Industrial Composting**[77]	Industrial composting is the large-scale processing of organic waste into compost. This helps to prevent biodegradable organic materials ending up in landfill and allows commercial composting companies to create a valuable product from garden waste and food scraps that would otherwise be thrown away.
11	**Lightweighting**	A design strategy to reduce the weight of packaging without compromising its functionality.
12	**Material Value Loss**	The economic value lost when materials are discarded rather than being reused or recycled.
13	**Mono-materials**	Packaging made from a single type of material, making it easier to recycle.
14	**Material Value Loss**	The economic value lost when materials are discarded rather than being reused or recycled.
15	**Multi-Layered Packaging (MLP)**	Packaging made from multiple layers of different materials, often combining plastic, paper, and aluminum, making it difficult to recycle.
16	**Problematic Packaging**[78]	Refers to a subset of packaging materials that have a significant negative environmental impact, due to - 1) the material not being recyclable, reusable, or compostable hindering its recyclability or composability, 2) being difficult or unable to recycle or reuse, contributing to waste generation, and 3) the material is being littered/ landfilled/ incinerated in substantial volumes without being collected.
17	**Recycled Content**	Inclusion of recycled materials in the production of new packaging.
18	**Reuse**	Using a product or packaging multiple times for the same or different purpose.
19	**Take-Back Schemes**	Systems where producers take responsibility for collecting and managing their products at the end of their life.

74. What are biobased, biodegradable and compostable plastics? https://environment.ec.europa.eu/topics/plastics/biobased-biodegradable-and-compostable-plastics_en
75. IUPAC definition https://publications.iupac.org/pac/pdf/2012/pdf/8402x0377.pdf
76. Circular Economy Introductionnhttps://www.ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview
77. What is Industrial Composting? https://www.zerowaste.com/blog/what-is-industrial composting/#:~:text=Industrial%20composting%20is%20the%20large,that%20contributes%20to%20climate%20change.
78. From Accenture analysis

Acronyms

No.	Acronyms	Definition
1	B	Billion
2	EFSA	European Food Safety Authority
3	EPR	Extended Producer Responsibility
4	FAO	Food and Agriculture Organization (of the United Nations)
5	FDA	Food and Drug Administration (US)
6	FMCG	Fast-Moving Consumer Goods
7	GHG	Greenhouse Gas
8	HDPE	High-Density polyethylene
9	HORECA	Hotels, Restaurants, and Catering
10	ICAR	Indian Council of Agricultural Research
11	ISMA	Indian Sugar Mills Association
12	LCA	Life Cycle Assessment
13	LDPE	Low-Density Polyethylene
14	M	Million
15	MLP	Multi-Layered Packaging
16	MRF	Materials Recovery Facility
17	OECD	Organization for Economic Co-operation and Development
18	PBAT	Polybutylene Adipate Terephthalate
19	PBS	Polybutylene Succinate
20	PCR	Post-Consumer Recycled
21	PEF	Polyethylene Furanoate
22	PET	Polyethylene Terephthalate
23	PHA	Polyhydroxyalkanoates
24	PLA	Polylactic Acid
25	PP	Polypropylene
26	PPWR	Packaging and Packaging Waste Regulation (EU)
27	PS	Polystyrene
28	ROI	Return on Investment
29	TPS	Thermoplastic Starch
30	UHT	Ultra-High Temperature
31	USDA	United States Department of Agriculture

Table 2: Spectrum of options available in terms of sustainable packaging in India

Material	PET	HDPE	LDPE	PP	PS	MLP	PET	Industry Example
PLA	✔	✔	✔	✔			Sugarcane: fermented sugars	Coca-Cola introduced PlantBottle with up to 30% PLA content for bottles, reducing reliance on fossil plastics (Source)
PHA	✔		✔	✔			Sugarcane: fermented sugars	Nestlé uses PHA for biodegradable coffee pods (Source).
PEF	✔						Sugarcane: fructose	Carlsberg is piloting PEF-based bottles for beer packaging to replace PET bottles (Source).
Bio-PET	✔						Sugarcane: ethanol	Nestlé uses bio-PET in water bottles under its "Nature's Promise" range (Source).
Bio-PE		✔	✔				Sugarcane: ethanol	J&J applies bio-PE in personal care products (Source).
PBS	✔		✔	✔			Sugarcane: fermented sugars	Mondelēz uses PBS in select bakery packaging (Source).
PBAT	✔						Sugarcane: ethanol	Amul is piloting PBAT-based dairy packaging (Source).
Bagasse					✔		Sugarcane: waste fibre	Starbucks India replaced plastic straws with bagasse based straws (Source).
TPS			✔				Starchy crops like casava and potato	Dabur uses starch-based sachets in herbal product lines (Source).
Fibre-based omposite		✔					Rice Husk	P&G utilizes fiber composites for reusable packaging of premium skincare (Source).
Aluminium	✔						Recycled aluminium coils	Ball Corporation has enhanced the sustainability of its packaging by increasing the recycled content in its aluminum beverage cans to 70% in 2023, up from 66% the previous year.
Paper based alternatives		✔			✔		Recycled/ virgin pulp	Bellator Beverages has introduced Papel, India's first plastic-free alkaline water packaged in a 100% recyclable carton bottle, comprising 75% paper-based material.
Mono-materials						✔		Huhtamaki India has developed recyclable mono-material packaging solutions under its blueloop platform, catering to the food and beverage industry to enhance packaging circularity.
Patented materials	✔	✔	✔	✔	✔	✔		Polymateria has pioneered biodegradable plastic technology, achieving full biodegradation of commonly littered polyethylene and polypropylene packaging within 226 to 336 days under real-world conditions, without leaving microplastics.

Table 3: Environmental Impact & End-of-Life Comparison of Bio-Based Materials

Material	Nature-Based Impact	Water Use	End-of-Life	LCA Compared to Traditional Counterpart (Higher/Lower)
PLA	Sugarcane monoculture; fertilizer impact	High	Industrial composting, recycling	Lower (non-fossil based)
PHA	High energy input for fermentation	High	Home/industrial compostable, marine biodegradable	Similar (high energy requirement)
Bio-PE	Land-use change, but lower emissions	Medium	Recyclable in PE streams	Lower (if sourced from waste biomass)
Bio-PET	Competes with food crops	Medium	Recyclable in PE streams	Higher (due to agricultural inputs and energy-intensive processing)
PBS	Requires fermentation infrastructure	High	Industrial composting, biodegradable	Higher (due to high energy needs)
PBAT	Fossil-fuel dependent but compostable	Medium	Industrial composting	Higher (due to reliance on fossil-derived adipic acid)
Bagasse	Utilizes waste fiber, low impact	Low	Home Compostable	Lower (since it upcycles agricultural waste)
TPS	Uses non-food starch, low carbon impact	Low	Home Compostable	Lower (due to biodegradability and minimal processing)
PEF	Risk of feedstock diversion from food supply, potential land-use concerns	High	Industrial composting	Lower (biomass-based feedstock, but energy-intensive polymerization process)
Aluminium	Bauxite mining causes deforestation, habitat destruction, and toxic red mud waste	Medium (recycled)	Recycle	Higher-comparable (recycled)

Table 4: Functional properties of Bio-Based Materials

Material	Mechanical Strength	Barrier Properties	Versatility in Applications	Integration with Existing Machinery
Polylactic Acid (PLA)	Tensile strength: 50–70 MPa; Elongation at break: <10% (brittle nature)	Good moisture barrier; Limited oxygen barrier	Suitable for rigid packaging, utensils, and thermoformed trays; Less ideal for flexible packaging	Requires modifications for heat resistance and sealing processes
Polyhydroxyalkanoate (PHA)	Tensile strength: 10–30 Mpa; More flexible than PLA	Decent moisture barrier; Higher oxygen permeability	Applicable for films, food service items, and biodegradable coatings	Compatible with existing bioplastic processing lines; Minor adjustments needed
Polyethylene Furanoate (PEF)	Tensile strength: ~80 MPa; Superior to PET	Excellent oxygen and CO_2 barrier; Good moisture barrier	Ideal for beverage bottles, flexible films, and food trays	Mostly compatible with PET machinery; Minor adjustments required
Bio-based Polyethylene Terephthalate (Bio-PET)	Comparable to conventional PET	Similar barrier properties to traditional PET	Suitable for beverage bottles, food containers, and films	Fully compatible with existing PET processing infrastructure
Bio-based Polyethylene (Bio-PE)	Similar to conventional PE	Good moisture resistance; Moderate oxygen barrier	Suitable for films, pouches, and bottles	Fully compatible with existing PE processing lines
Polybutylene Succinate (PBS)	Flexible; Weaker than PET	Good grease and moisture barrier; Low gas barrier	Suitable for rigid packaging, utensils, and thermoformed trays; Less ideal for flexible packaging	Requires modifications for heat resistance and sealing processes
Polylactic Acid (PLA)	Tensile strength: 50–70 MPa; Elongation at break: <10% (brittle nature)	Good moisture barrier; Limited oxygen barrier	Used for compostable films, food trays, and cutlery	Requires lower processing temperatures; Slight modifications needed

Material	Mechanical Strength	Barrier Properties	Versatility in Applications	Integration with Existing Machinery
Polybutylene Adipate Terephthalate (PBAT)	Soft and flexible; Lower strength	Good flexibility; Weaker barrier properties	Used for biodegradable films and compostable bags	Runs on standard flexible film machinery
Bagasse-based Packaging	Good rigidity; Lower impact strength	Naturally breathable; Limited moisture resistance	Used for clamshells, trays, and food service packaging	Requires molded pulp technology; Not suitable for standard plastic machines
Thermoplastic Starch (TPS)	Brittle; Weak under humidity	Poor moisture resistance; Low oxygen barrier	Limited to films, coatings, and compostable bags	Needs blending with other materials for industrial processing
Patented Materials (e.g., Molded Fiber, Specialty Biopolymers)	Varies; Some highly durable, others less so	Customizable barriers depending on formulation	Emerging in mono-material solutions for MLP alternatives	May require specialized processing equipment
Fiber-Based Composites	Similar to conventional PE	Limited moisture resistance; Often requires coatings	Used for rigid trays, secondary packaging, and bottle replacements	May require specialized molds; Generally adaptable
Aluminium	High strength and durability; resistant to deformation	Excellent barrier against light, gases, and moisture	Limited to rigid and semi-rigid packaging (e.g., beverage cans, foils); poor flexibility	Requires separate machinery; not compatible with most plastic-forming lines
Paper based packaging	Low strength unless laminated/coated; prone to tearing under stress	Poor natural barrier properties; coatings (plastic/wax) improve performance but reduce recyclability	Mostly used for dry goods, some applications in liquids with coatings	Can run on existing carton/paperboard lines; needs adaptation for flexible formats

Table 5: Economic feasibility assessment

Material	CAPEX/Tonne (Indicative ranges in INR)	Feedstock cost per tonne
PLA (Polylactic Acid) – PET	High	Medium
PLA (Polylactic Acid) – HDPE	High	Medium
PLA (Polylactic Acid) – LDPE	High	Medium
PLA (Polylactic Acid) – PP	High	Medium
PHA (Polyhydroxyalkanoates) – PET	High	High
PEF (Polyethylene Furanoate) – PET	Very high	High
Bagasse/Fibre Packaging – PS	Low	Medium
Bio-PET – PET	Low (traditional)	High
Bio-HDPE – HDPE	High	Medium
Natural Fiber Composites – HDPE	Low (traditional)	Medium
Polybutylene Succinate (PBS) – PET	Low	High
PBAT (Poly Butylene Adipate Terephthalate) – PET	Medium	High
Aluminium – PET	High	High
Paper	Medium	Low



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Resource Efficiency and Circular Economy Industry Coalition

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Praj Industries Limited | Tetra Pak International S.A. | Polymateria Limited
Saudi Basic Industries Corporation | Indian Oil Corporation Limited
Ball Corporation (Beverages segment) | Banyan Nation Private Limited

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About Centre for Sustainability:

The FICCI Centre for Sustainability Leadership is an initiative of Federation of Indian Chambers of Commerce & Industry (FICCI), launched in June 2023 with Hindustan Unilever Limited (HUL) and The Hongkong and Shanghai Banking Corporation Limited (HSBC) as Centre's founding members, FICCI Centre for Sustainability Leadership is a transformative initiative driving climate action in alignment with India's net-zero ambitions and the Panchamrit framework. It aims to accelerate the sustainability journey of businesses—spanning SMEs, startups, and large corporates—by institutionalizing sustainable practices and promoting climate solutions focused on circular economy, sustainable consumption, and climate tech innovation. The Centre aligns with the Government's Mission LiFE, encouraging businesses to adopt sustainable production and consumption practices while actively contributing to climate action.

About RECEIC:

G20 New Delhi Leaders' Declaration acknowledges the critical role being played by circular economy, extended producer responsibility and resource efficiency in achieving sustainable development.

The Resource Efficiency Circular Economy Industry Coalition (RECEIC) is a global industry coalition, launched under India's G20 presidency with a focus on promoting resource efficiency and circular economy practices. It aims to facilitate and foster greater company-to-company collaboration, build advanced capabilities across sectors and value chains, bring learnings from diverse and global experiences of the coalition members, and unlock on-ground private sector action to enhance resource efficiency and accelerate circular economy transition.

FICCI is managing RECEIC as its secretariat.

For more information and to join as a member, visit https://receic.com/

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