CII WOW
Waste to Worth Transformation

CII
Confederation of Indian Industry

National Circular Economy Framework

Roadmap for a Sustainable & Resilient India

THIRD EDITION | NOVEMBER 2025

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ACKNOWLEDGEMENT

The Confederation of Indian Industry (CII) extends its sincere gratitude to all esteemed members, industry leaders, academic and research professionals, and every stakeholder who contributed to the development of the third edition of the National Circular Economy Framework (NCEF). Building on the first edition with 4 focus materials and the second with 16, this third edition now covers 20 focus materials, thanks to the invaluable insights and collaborative spirit of these stakeholders and the members of CII National Committee on Waste to Worth Technologies community.

The vision to develop this third edition of the framework – expanding to 20 focus materials and emphasizing not only *what* needs to change but also *how* change will be delivered through a robust implementation framework – was led by **Mr. Masood Mallick**, Chairman, CII National Committee on Waste to Worth Technologies. We extend our sincere appreciation for his exemplary thought leadership and guidance.

We extend our sincere gratitude to **Re Sustainability Limited (ReSL)** for its pivotal role in developing this document, contributing the vast majority of the effort, insights, and expertise. We are particularly grateful to **Mr. Vinod Babu (Principal Advisor)**, **Dr. Y. Malini Reddy (Head – Sustainability Policy, Research and Advocacy)**, **Mr. Sanjiv Kumar (Head – Policy and Strategy), and Mr. Krishna Rao Thota (Head – Circular Economy Business)** for their comprehensive review of circular economy action plans, including the implementation framework. Their valuable insights greatly enhanced the relevance, quality, and coherence of the content. We also extend our gratitude to all the team members who worked diligently under their guidance for their dedicated efforts and contributions. Furthermore, we acknowledge **Mr. Subash Koduri (Sustainability Lead)** for conceptualizing the structure of this report and **Mr. Ramesh Bitra (Head – Corporate Communications)** for his design support which enhanced the readability of this publication.

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It is hoped that this framework will serve as a valuable resource for the Indian Environment Sector, contributing significantly to the promotion of a Circular Economy in India.

नितीन गडकरी
NITIN GADKARI

सत्यमेव जयते
आज़ादी का अमृत महोत्सव

मंत्री
सड़क परिवहन एवं राजमार्ग
भारत सरकार
Minister
Road Transport and Highways
Government of India

03 NOV 2025

MESSAGE

Achieving our national ambition of becoming a 'Viksit Bharat' by 2047 necessitates a fundamental paradigm shift in how we view economic growth and resource management. We must decisively move from a resource-intensive linear economy to a resource-efficient circular one. This transition is not merely an environmental obligation but a strategic economic imperative. By embracing circularity, we can unlock immense opportunities for innovation, value creation, and large-scale green job creation, directly contributing to our goal of 'Atmanirbhar Bharat' and ensuring sustainable prosperity for all.

The Hon'ble Prime Minister, Shri Narendra Modi, has given a clear clarion call for this change through Mission LiFE (Lifestyle for Environment). This global mass movement guides us to move away from a 'use and throw' culture towards a circular lifestyle. The Government of India is committed to fostering an enabling ecosystem for this transformation. We are focusing on robust policy frameworks, promoting sustainable public procurement, and building strategic partnerships that operationalize the 'waste into wealth' concept, ensuring our development path is both climate-resilient and resource-secure.

To accelerate this national endeavor, a practical, industry-driven roadmap is essential. I am therefore delighted to see the proactive and consistent leadership demonstrated by the Confederation of Indian Industry (CII). This third edition of the National Circular Economy Framework (NCEF) is a significant contribution to our collective efforts. By substantially expanding its scope to 20 priority waste streams/materials and building upon the previous editions, this framework provides the granular, actionable insights that our industries need to implement circular models effectively.

My sincere compliments to CII and all the domain experts who have contributed to this comprehensive document. The NCEF is a crucial resource, but its true value will be realized through widespread adoption and implementation. I call upon our industry leaders, innovators, financial institutions, and academic bodies to forge strong partnerships. Let us use this framework as a catalyst to scale up proven circular solutions, build globally competitive sustainable supply chains, and firmly establish India as a world leader in the circular economy. I am confident that together, we can build a prosperous and sustainable future for generations to come.

Yours

(Nitin Gadkari)

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FOREWORD FROM THE CHAIRMAN

MASOOD MALLICK
Chairman – CII National Committee on Waste to Worth Technologies

Dear Members and Stakeholders,

India's journey toward a resource-efficient and circular economy has entered a defining phase. The Confederation of Indian Industry (CII) has been at the forefront of India's circular economy movement through our National Committee on Waste to Worth Technologies. The National Circular Economy Framework (NCEF) marks another milestone in our collective commitment to reimagining how we design, produce, consume, and recover resources in a rapidly developing nation.

When the Confederation of Indian Industry introduced the first NCEF in 2023, our goal was to set a foundation — a common language for circularity in India's industrial and policy landscape. The second edition in 2024 built on that momentum, expanding from four to sixteen materials and embedding life cycle thinking and action plans for different key materials into national discussions. Edition 3 takes this vision forward with 20 materials, reflecting the depth and potential of India's circular transition. It focuses not only on identifying what needs to change, but more importantly, on how change will be delivered — through a robust implementation framework, clearly defined roles, and accountability across government, industry, and other key stakeholders.

This edition comes at a critical juncture. India's leadership at the G20 and the establishment of the Resource Efficiency and Circular Economy Industry Coalition (RECEIC) have positioned our nation at the forefront of global circular economy discourse. The NCEF aligns strongly with these international commitments, and with national missions such as Lifestyle for Environment (LiFE) and Atmanirbhar Bharat, providing a structured pathway to translate intent into measurable action.

This framework integrates the voices of policymakers, industries, research institutions, urban local bodies et al. to operationalize circularity across twenty key material streams — from plastics, construction materials, and textiles to metals, electronics, tyres, and agricultural residues. Each material chapter outlines realistic targets, actionable measures, and an implementation roadmap designed to create value from waste, promote innovation, and build circular supply chains.

I extend my sincere appreciation to all our partners, experts, and contributors who have worked tirelessly to shape this edition. Together, we reaffirm our commitment to transforming India into a global leader in the Circular Economy, steering growth that is inclusive, sustainable, and enduring. It is anticipated that CII members and relevant stakeholders will find this framework valuable, as it is expected to encourage them to explore and deepen their understanding of the principles and interrelated aspects of circularity.

Let us continue to collaborate and innovate — turning waste into worth, and ambition into action.

MESSAGE FROM THE DIRECTOR GENERAL

CHANDRAJIT BANERJEE
Director General, CII

India is steadily emerging as a global leader in the circular economy by integrating circularity into its growth strategy. With its vast population and rapidly expanding industries, India recognises the importance of waste minimisation, resource efficiency, and promoting recycling to ensure long-term environmental and economic resilience.

The Confederation of Indian Industry (CII) places a strong emphasis on advancing India's circular economy transition through its 'Waste to Worth Movement', aimed at promoting innovative waste-management technologies and converting waste into valuable products.

The National Circular Economy Framework (NCEF) serves as a concise roadmap for India's transition to a circular economy and guides the development of new business models.

The National Circular Economy Forum (NCEF) has evolved significantly since its inception. In its first edition (2023), NCEF reflected the Industry's leadership in advancing sustainable and circular approaches to waste management, while focusing on four high-impact material streams. In the second edition (2024), the focus expanded to sixteen materials, ranging from municipal solid waste and e-waste to textiles, end-of-life vehicles, tyres, hazardous waste, and scrap metals.

The third edition further accelerates this momentum by encompassing twenty materials, including sectors critical to India's resource security, such as used cooking oil, catalytic converters, paper and cardboard, and absorbent hygiene products. This progression reflects India's response to shifting consumption patterns, regulatory developments, and technological advances.

I am glad to see that this edition of NCEF emphasises execution, measurable outcomes, and accountability, underscoring the maturity of India's circular-economy discourse and its readiness to operationalise circularity at scale. It will serve as a vital guide for both Industry and policymakers, facilitating the adoption of circular-economy practices that support economic growth and environmental health.

This edition is designed to enable India to lead in circular transformation, securing a resilient future for current and future generations by supporting India's Net Zero landfill waste goal.

EXECUTIVE SUMMARY

India's circular economy ambitions are driven by unprecedented resource demands, escalating waste generation, and climate imperatives. Building on the foundational principles and collaborative models of Editions 1 and 2, the **National Circular Economy Framework Edition 3 (NCEF–3)** marks a significant evolutionary step in India's circular economy journey by expanding its breadth, deepening its analysis, and introducing robust implementation mechanisms for **twenty priority materials**—four more than in Edition 2.

Edition 1 focused on four high-impact materials: plastics, construction materials, electrical and electronic goods, and mixed municipal waste (dry and wet fractions). Edition 2 expanded this to sixteen materials, reflecting the diversity and scale of India's industrial and urban systems, with inclusions such as municipal solid waste, e-waste, textiles, end-of-life vehicles, batteries, hazardous waste, tyres and rubber, and scrap metals, among others.

NCEF Edition 3 further accelerates this momentum—now encompassing twenty materials, including new and emerging sectors critical to India's resource security and sustainability (used cooking oil, catalytic converters, paper and cardboard, and absorbent hygiene products). This expansion reflects India's response to rapid shifts in consumption patterns, regulatory developments, and technological advancements.

In the first two editions of the National Circular Economy Framework, the document was structured in two parts. The first part in both editions provided a comprehensive introduction - explaining the importance and relevance of circular economy for India, the core concepts of circular economy, enabling principles, and key strategies that are essential for transitioning from a linear to a circular model. This section played a vital role in building a shared understanding among policymakers, industries, and stakeholders at a time when circularity was still an emerging concept in India's policy landscape.

Given that this conceptual foundation is now well established and widely disseminated through the previous editions, NCEF–3 takes a deliberate step forward. This edition does not revisit the conceptual or narrative overview; instead, it focuses squarely on execution, outcomes, and accountability, reflecting the maturity of India's circular economy discourse and the country's readiness to operationalize circularity at scale. By emphasizing material-specific action plans, measurable targets, and implementation mechanisms, NCEF–3 represents a natural progression—from defining what and why circularity matters to demonstrating how it will be implemented on the ground.

NCEF Edition 3 is built on a standardized, yet nuanced, structure for each focus material, enabling comparability and sectoral customization. Each material chapter follows a four-part structure:

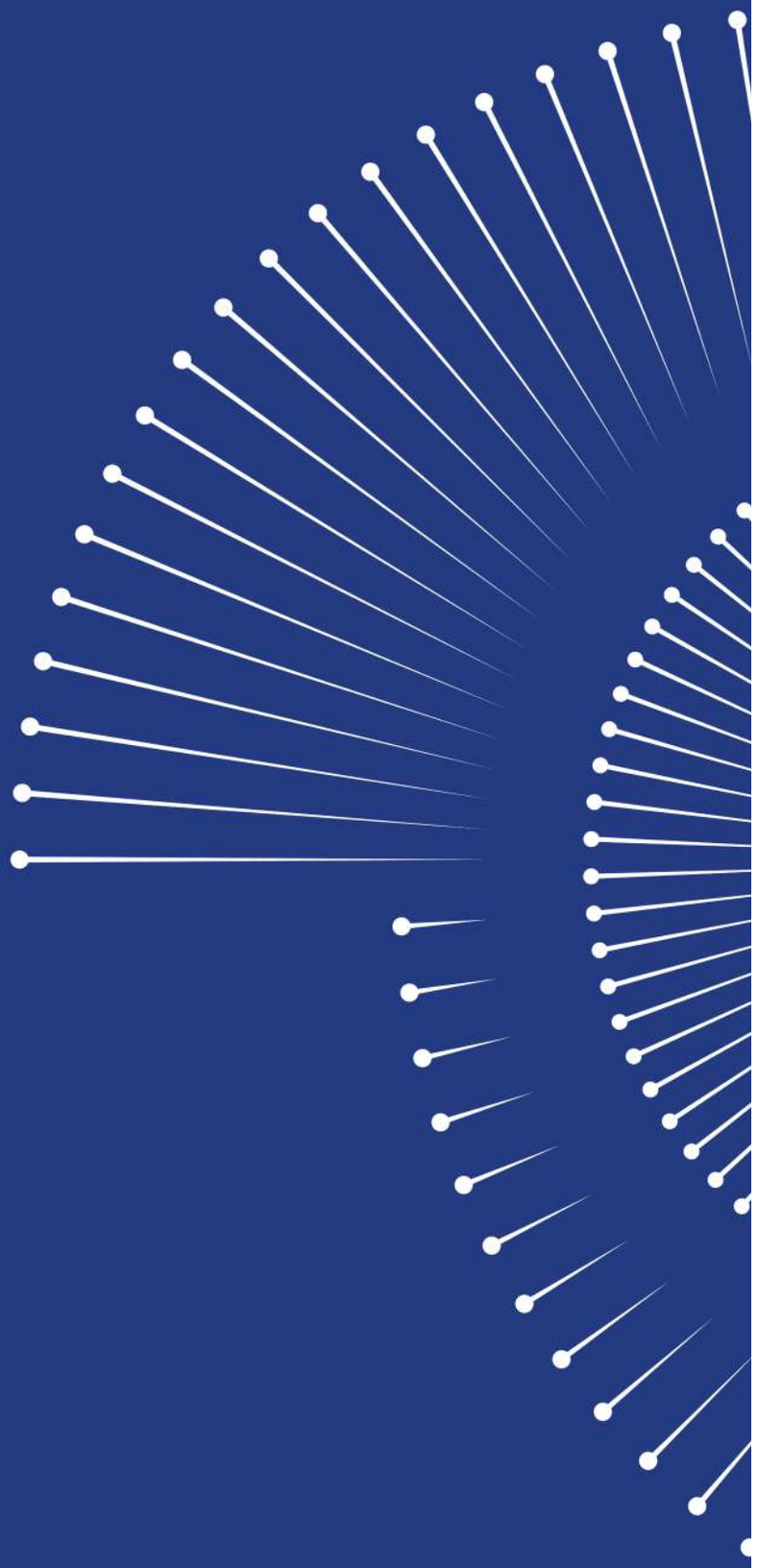
- **Material Landscape and Circularity Baseline:** Mapping the full value chain from extraction to end-of-life domestically and globally, quantifying current circularity adoption, and benchmarking India with global standards.
- **Gaps and Challenges:** Identifying regulatory, market, technological, social, and enforcement barriers, informed by best practices and case studies.
- **Vision and Targets:** Articulating a clear future state (with SMART goals), setting targets for 2030 and optionally for 2035/2040/2047, aligned to India's national ambitions and sectoral baselines.
- **Enablers and Implementation Framework:** Outlining interventions (policy, market instruments, standards, EPR, capacity building, PPP, infrastructure, etc.), with detailed assignments of stakeholder roles and risk mitigation strategies.

NCEF Edition 3 is India's one of the ambitious and comprehensive circular roadmap. It marks a strategic inflection in India's circular journey. With its expanded materials coverage, rigorous sectoral baseline analysis, advanced implementation roadmap, and clearly proposed accountability structures, it provides the granular tools required to operationalize circularity in India's complex socio-economic landscape.

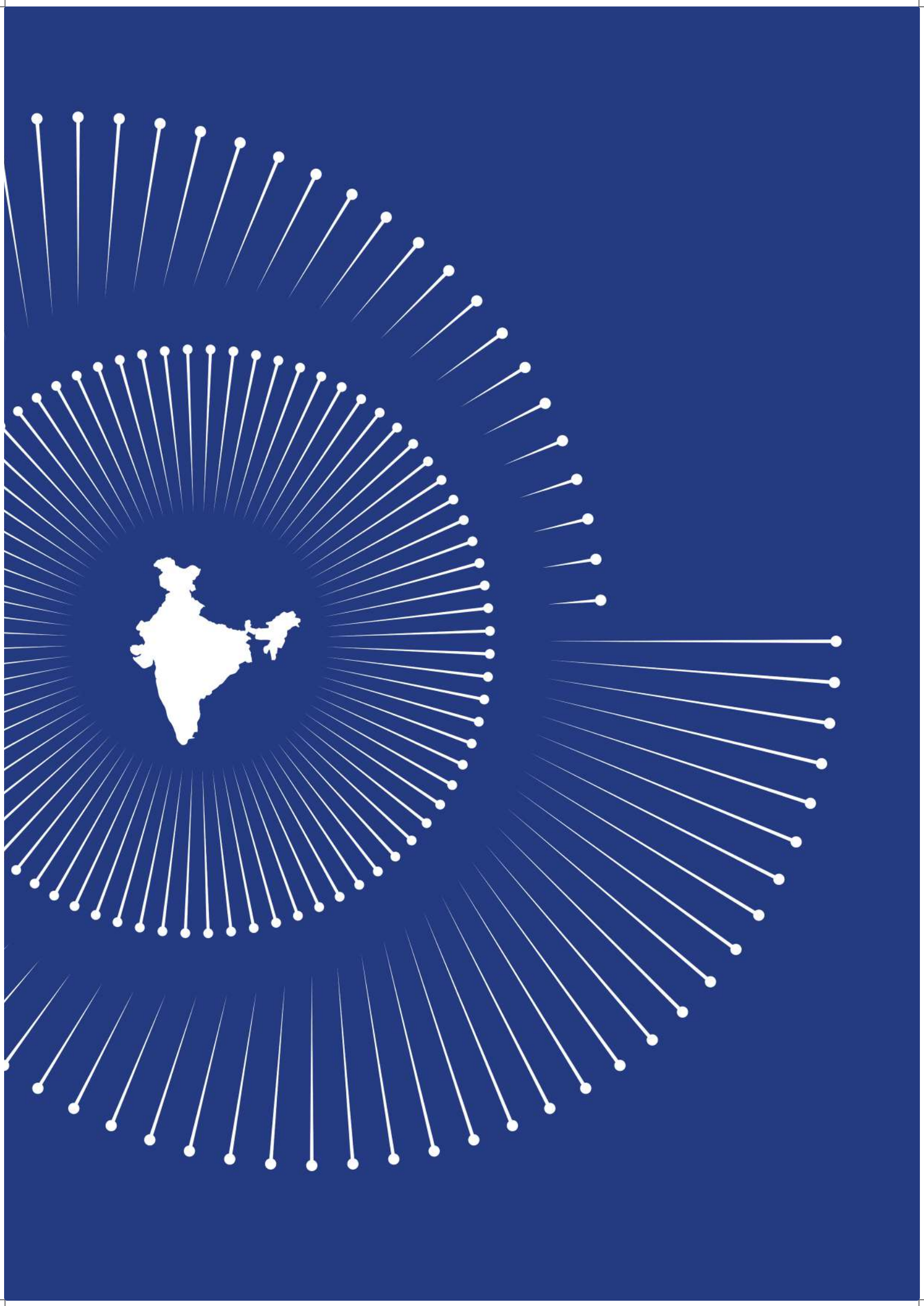
The framework aligns strongly with the international commitments, and with national missions such as Lifestyle for Environment (LiFE) and Atmanirbhar Bharat, providing a structured pathway to translate intent into measurable action. NCEF Edition 3 empowers India's commitment to measurable impact, global competitiveness, policy leadership, and just transition—setting a definitive path towards a resource-resilient, sustainable, and circular future.

TABLE OF CONTENTS

National Circular Economy Framework - Edition 3



National Circular Economy Framework



Chapter 1

PRINCIPLES, STRATEGIC PATHWAYS, AND IMPLEMENTATION ARCHITECTURE

1.1. INTRODUCTION

India, aspiring to becoming a developed nation by 2047, stands at a defining moment in its development trajectory. As the world's fastest-growing major economy and home to more than 1.4 billion people, India's resource requirements are expanding at an unprecedented pace. This surge in demand for materials, energy, and infrastructure brings with it complex challenges—rising waste generation, growing import dependence, and the need for climate-resilient growth.

At the same time, India's demographic dividend, digital innovation, and entrepreneurial dynamism present an unparalleled opportunity: to decouple economic growth from material consumption and to pioneer a regenerative model of prosperity rooted in circularity. Circular Economy (CE) offers India the framework to do precisely that—to create value, not waste; to extend life cycles, not discard them; and to achieve growth that regenerates rather than depletes.

The Confederation of Indian Industry (CII) has been instrumental in transforming circular economy thinking into a national movement. Recognizing early that sustainability and competitiveness must evolve together, CII established the National Committee on Waste to Worth Technologies in 2018 to promote innovative waste management solutions, promote circular business models, and support policy reform. Since then, CII's Waste to Worth Mission has become a flagship national initiative—bringing together industry, government, and technology providers under one platform to accelerate circularity in practice.

> CIRCULARITY IS ESSENTIAL FOR INDIA TO ACHIEVE RESOURCE SECURITY, ECONOMIC STABILITY, AND RESILIENCE, POSITIONING THE NATION AS A LEADER IN GLOBAL CLIMATE ACTION.

In 2023, these efforts culminated in the launch of the first edition of the National Circular Economy Framework (NCEF) — the first comprehensive attempt to codify India's circular economy vision in a single strategic document. The inaugural edition of NCEF was a landmark publication. It emerged from the recognition that India needed a unified national framework—a roadmap that connected government policy, industrial practices, and societal participation within a single, coherent vision of circularity.

NCEF First Edition (2023) was therefore designed as a conceptual and educational document, introducing: (a) the core principles of circular economy: prevention, reuse, repair, recycling, and recovery; (b) the economic rationale - circularity as a tool for competitiveness, innovation, and self-reliance; and (c) the strategic alignment with India's flagship missions—Atmanirbhar Bharat, Make in India, Mission LiFE etc. The first edition included circular economy action plans for four priority material streams: plastics, construction & demolition waste, electrical and electronic waste, and municipal solid waste.

NCEF Second Edition (2024) represented a major expansion—

both in scope and influence. In addition to presenting the enhanced version of core principles and strategies for circular economy, this edition covered sixteen focus materials, mirroring India's growing circular ambition. It broadened the framework to include critical and emerging sectors such as textiles, tyres, lithium-ion batteries, solar panels, scrap metals, and hazardous waste etc.

NCEF Third Edition (2025) marks a strategic inflection point in India's circular journey. Moving from conceptual advocacy to execution and accountability, this edition focuses on translating circular economy principles into measurable actions across twenty material streams. It reflects a deliberate evolution of purpose—from "what and why" circularity matters to "how" it can be implemented at scale. This edition presents clear, measurable 2030 targets for every material category, with optional milestones for 2035/2040/2047 for some materials. Initiatives to be taken up by different stakeholders along with timelines have been proposed to achieve the proposed targets.

Evolution of National National Circular Economy Framework

NCEF aligns directly with the national missions that define India's 21st - century development model, as shown in **Figure 1-1** below:

Figure 1-1: Alignment of NCEF with National Missions

INDIA'S ECONOMIC DEVELOPMENT MUST ALIGN WITH THE PRINCIPLES OF CIRCULARITY, ELIMINATING WASTE AND POLLUTION, CIRCULATING PRODUCTS AND MATERIALS (AT THEIR HIGHEST VALUE), AND REGENERATING NATURE.

PM Narendra Modi
In his essay on Circular Economy at narendramodi.in, February 2024

As India enters the decade of action (2025–2035), the NCEF serves as both compass and catalyst for a new model of growth—regenerative, inclusive, and globally competitive. With Edition 3, CII aims to ensure that circularity becomes embedded across all sectors of the economy, not as an environmental obligation, but as a mainstream industrial strategy driving value creation, innovation, and resilience.

The NCEF is designed as a living document—one that evolves with policy, technology, and market developments. Each edition builds on new data, stakeholder insights, and international learnings, ensuring that the framework remains relevant and adaptive.

In the first two editions of the NCEF, the document was organized into two parts—Part I, which provided a comprehensive introduction to the circular economy, and Part II, which outlined the action plans for selected focus materials. Part I provided a comprehensive introduction—explaining the importance of circularity for India, outlining its core principles, and detailing the key strategies for shifting from a linear to a circular model. This foundation was critical in building a shared understanding among policymakers, industries, and stakeholders at a time when circularity was still an emerging concept in India's policy landscape.

With this foundation now well established and widely disseminated, NCEF Edition 3 takes a deliberate step forward. This edition does not revisit the conceptual narrative in depth; instead, it focuses on execution with defined proposed responsibilities for different stakeholders, reflecting the country's readiness to operationalize circularity at scale. By emphasizing material-specific action plans, measurable targets, and implementation mechanisms, NCEF–3 represents a natural progression—from defining what and why circularity matters to demonstrating how it will be implemented on the ground.

To maintain continuity, this chapter presents a concise synthesis of the essential elements from earlier editions. The following three sections: Understanding the Circular Economy (Section 1.2), Circular Economy Pathways: From Prevention to Responsible Disposal (Section 1.3), and Key Strategies for Implementation (Section 1.4) provide this structured recap. Together, they summarize the conceptual model, operational hierarchy, and strategic levers that form the foundation for the material-specific action plans presented in subsequent chapters, ensuring coherence and consistency.

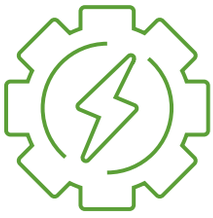
1.2. UNDERSTANDING THE CIRCULAR ECONOMY

A Circular Economy is an economic system that aims to reduce waste and pollution by keeping products and materials in use for as long as possible. It is a closed-loop system that minimizes the use of virgin resources and maximizes the reuse and recycling of materials. The Circular Economy takes a holistic approach to economic development, considering the environmental and social impacts of all economic activities. In a fully Circular Economy, waste is minimized by designing products and industrial processes so that resources are kept in use in a perpetual flow, and by ensuring that unavoidable waste or residues are recycled or recovered.

The Circular Economy is characterized by the following

REDUCE resource consumption and waste production to lessen environmental impact.

REUSE products and materials to minimize resource extraction.



REPAIR items instead of replacing them, promoting resourcefulness and sustainability.

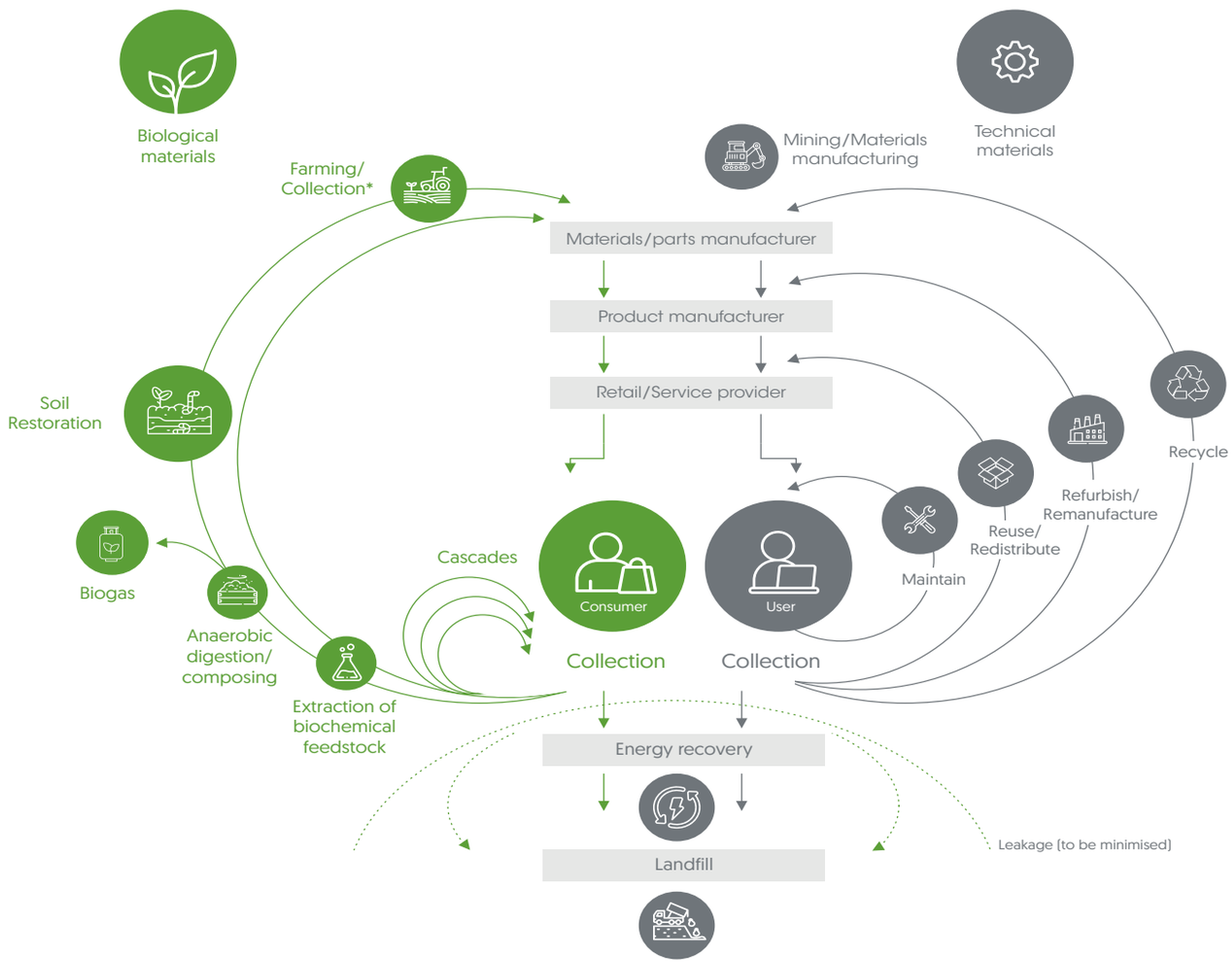
REMANUFACTURE by recreating products from discarded components, highlighting resource regeneration.

UPCYCLE waste materials into higher-value products, extending their lifecycle.

RECYCLE, converting materials into new products to keep resources in use and out of landfills.

The Ellen MacArthur Foundation model, presented in **Figure 1-2** promotes systemic change across entire supply chains by integrating circularity from the design stage, making it possible to avoid waste before it's even generated. The model comprises two cycles: a biological cycle, in which residues are returned to nature after use, and a technical cycle, where products, components or materials are designed and marketed to minimize wastage. The approach prioritizes durable product design, modular components, and regenerative practices, which support a resilient and restorative economy that functions harmoniously with nature.

Figure 1-2: The Ellen MacArthur Foundation Circular Economy Model



Source: Ellen MacArthur Foundation, "Towards the Circular Economy" (2013), p. 24

Translating circular principles into practice requires a systemic and collaborative approach across policy, industry, and society. Implementation begins with rethinking design and production systems to eliminate waste at the source, followed by the creation of enabling infrastructure, financing mechanisms, and market incentives that make circular practices economically viable. **Figure 1-3** below presents how to mainstream/implement circular economy.

Figure 1-3: Implementation of Circular Economy

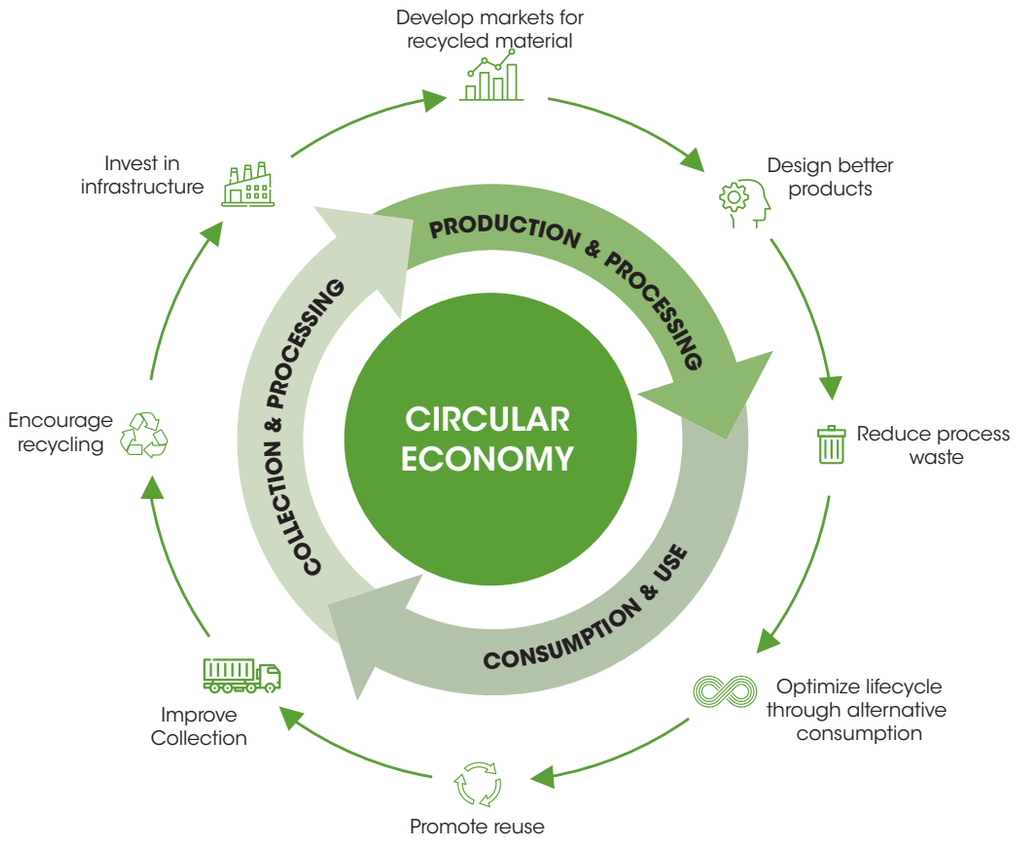


Image Credit: Circular Innovation Council

1.3. CIRCULAR ECONOMY PATHWAYS: FROM PREVENTION TO RESPONSIBLE DISPOSAL

NCEF lays out a coherent pathway for India's transition from a linear to a circular model of growth—one that conserves resources, reduces dependence on virgin materials, minimizes waste, and generates equitable social and economic value. Its implementation rests on four core principles: Prevention, Upcycling, Recycling, and Energy Recovery. Together, these principles provide the operational foundation for mainstreaming circularity across different industries and value chains. In addition to the above, as a last resort to manage non-recoverable waste, responsible disposal through scientific landfilling forms an integral part of circularity to prevent soil, air, and water contamination.

1. Prevention

Prevention is the foremost principle of circularity, focusing on avoiding waste generation at the source. It promotes optimal resource use through better product design, life extension, reuse, and repair. Designing for circularity means creating durable, modular, and repairable products that can be easily disassembled and upgraded. Strategic material selection—using recycled, renewable, or low-impact inputs—reduces environmental burdens, while modular design extends the life of components and facilitates future upgrades.

Policies such as Extended Producer Responsibility (EPR) and green public procurement can strengthen preventive approaches by incentivizing producers to design for longevity, repairability, and recyclability. Prevention therefore represents the most cost-effective and sustainable strategy for reducing environmental impact and improving material efficiency across sectors.

2. Upcycling

Upcycling involves transforming discarded or unused materials into products of higher value or utility, thereby preventing waste and creating new economic opportunities. Unlike conventional recycling, which often degrades material quality, upcycling maintains or enhances value through creativity, innovation, and design.

In the Indian context, upcycling holds enormous potential across diverse sectors: textiles (repurposing fabric scraps into garments and accessories), construction (using reclaimed wood, glass, or metal), crafts (turning discarded materials into artisanal products), and agriculture (converting crop residues or food waste into compost or bio-energy). Encouraging start-ups, designers, and MSMEs to participate in upcycling hubs can expand employment opportunities and reduce landfill pressure.

3. Recycling

Recycling is central to material recovery and resource efficiency. It enables materials to be reintroduced into production cycles, reducing the need for virgin extraction. Effective recycling requires well-functioning systems for collection, segregation, sorting, and processing supported by modern infrastructure and digital technologies.

Material recovery depends on organized supply chains and investment in advanced sorting and processing facilities. The use of AI, IoT, and blockchain can enhance transparency, traceability, and efficiency across recycling systems.

EPR mechanisms and recycled-content mandates can drive markets for secondary materials, while fiscal incentives and R&D support encourage innovation in recycling technologies. A single unified platform may be considered for handling EPR compliance across all the regulated materials, to simplify the process for industry and stakeholders and avoid complications arising from multiple portals.

Equally critical is consumer participation—through awareness, segregation at source, and local recycling hubs—which ensures a steady flow of clean materials into the system. A mature recycling ecosystem thus forms the backbone of India's circular economy, reducing waste, emissions, and import dependence.

4. Energy Recovery

Energy Recovery focuses on extracting usable energy from residual waste that cannot be economically reused or recycled. It plays a key role in minimizing landfill disposal while generating renewable energy. Technologies such as incineration, anaerobic digestion, gasification, and pyrolysis convert waste into electricity, heat, or biofuels, providing alternatives to fossil energy. Innovations like torrefaction and biochar production further enhance efficiency and carbon sequestration potential.

Robust waste segregation and pre-processing are essential to ensure feedstock quality, while strict emission standards, continuous monitoring, and flue-gas treatment systems safeguard environmental performance. Supportive policies—feed-in tariffs, viability-gap funding, and public-private partnerships—can help expand India's waste-to-energy infrastructure responsibly. When combined with effective recycling and upcycling, energy recovery ensures that only non-recoverable residues are finally disposed of, closing the material loop.

5. Landfilling

Even in a highly circular system, some materials inevitably reach their end of life and require safe disposal. Modern landfills (recognized as the last resort within the circular hierarchy) serve as engineered containment facilities designed to manage non-recoverable waste while preventing soil, air, and water contamination. Key features include impermeable liners, leachate and gas collection systems, and long-term environmental monitoring. In the Indian context, landfills should operate as common treatment facilities for residual fractions that cannot be prevented, reused, recycled, or recovered for energy. Expanding circular practices will progressively reduce the volume of waste reaching such sites, extending their operational life and mitigating environmental risks. Well-planned landfill management ensures that even the final stage of the waste hierarchy aligns with the broader goals of environmental protection and public health.

1.4. KEY STRATEGIES FOR IMPLEMENTATION OF NCEF

NCEF attempts to provide a structured pathway for India's transition from a linear "take-make-dispose" system to a regenerative economic model that conserves resources, reduces waste, and enhances competitiveness. Implementation of this framework depends on a coherent set of strategies that together form the circular economy implementation architecture—including policy reform, market incentives, innovation, partnerships, capacity building etc., as elaborated below:

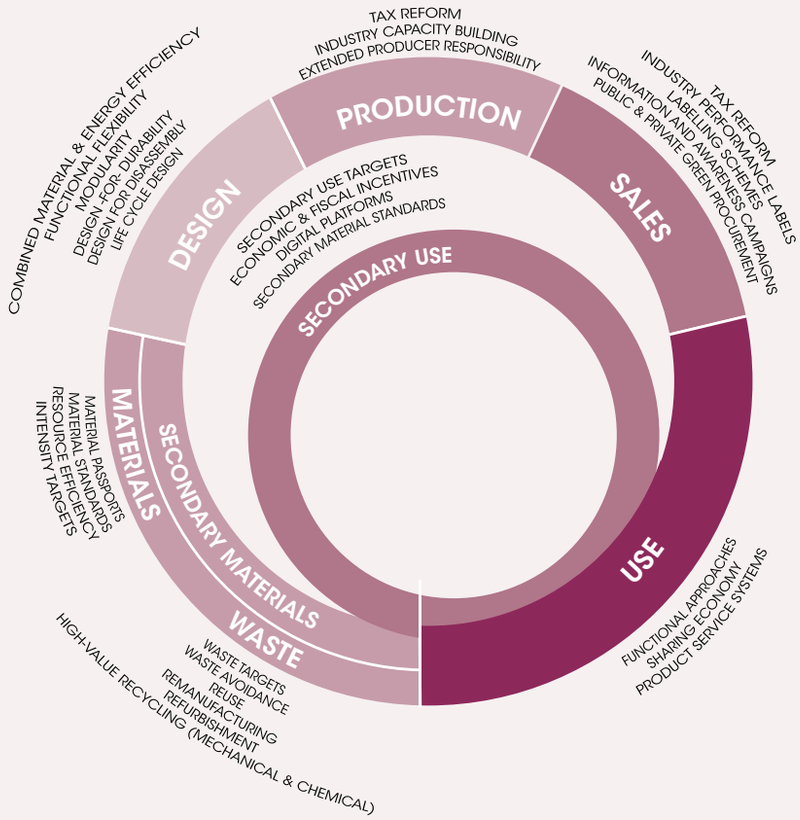
1. Policy and Regulatory Framework

A robust policy and regulatory ecosystem is the foundation of circular transition. Well-defined policies and standards enable industries, businesses, and communities to align their efforts toward resource efficiency and waste minimization. An effective framework integrates resource efficiency principles into national missions, industrial policies, and environmental regulations. It includes measures such as Extended Producer Responsibility (EPR), eco-design standards, product take-back systems, minimum recycled content etc.

Strong policy coherence—across sectors such as plastics, metals, construction materials, vehicles, and electronics—ensures that circularity is mainstreamed through every stage of the value chain, from design to disposal. Financial instruments, green procurement, and circularity criteria in public investments further reinforce adoption and accountability.

Figure 1-4 below presents the key policy interventions at each stage which can play a critical role in supporting the transition to a circular economy.

Figure 1-4: Policy Interventions to Support Circular Economy



Source: 'Policy Levers for a Low-Carbon Circular Economy' by Circle Economy, Nov 2017

2. Incentives for Circular Businesses

Economic incentives are vital to attract investment and foster innovation in circular solutions. These can include financial incentives—such as low-interest financing and non-financial incentives like fast-track clearances, recognition programs, and access to green procurement markets.

3. Public Awareness and Education

Widespread awareness and behavioural change are essential for circular economy adoption. Citizens, industries, local authorities et.al. must recognize waste as a resource and consumption as a shared responsibility.

Education programs and communication campaigns can promote segregation at source, responsible consumption, and repair and reuse practices. Embedding circular economy principles in school and university curricula nurtures long-term behavioural shifts and cultivates future professionals skilled in sustainable design and resource management.

4. Research, Development, and Innovation

Innovation drives circular transformation. Continuous research and development are needed to design products and processes that minimize material intensity, improve recyclability, and extend lifespan. Priority areas include eco-design, material substitution, advanced recycling technologies, and digital solutions such as artificial intelligence, blockchain, and the Internet of Things for traceability and efficiency.

Public-private collaboration in R&D can accelerate breakthroughs in new materials, reverse logistics, and business models such as leasing, product-as-a-service, and sharing platforms—helping industries move from linear throughput to regenerative cycles.

5. Public-Private Partnerships (PPPs)

PPPs play a critical role in mobilizing investment, expertise, and technology for circular projects. They enable shared risk, long-term financing, and effective management of large-scale infrastructure such as recycling facilities, waste-to-energy plants, or material recovery parks.

Collaborative governance between the public sector, private enterprises, and financial institutions strengthens accountability and ensures that circular initiatives deliver measurable economic and environmental outcomes. PPPs also help integrate informal sectors into formal systems, ensuring inclusivity and livelihood security.

6. Knowledge Network and Capacity Building

A national circular economy knowledge network enhances collaboration, data sharing, and best-practice dissemination among stakeholders. Such a platform can facilitate training programs, technical support for MSMEs, and cross-sector partnerships between academia, industry, and government.

Capacity building must target all actors in the value chain—producers, recyclers, regulators, and consumers—to strengthen implementation capabilities and foster continuous improvement. Knowledge exchange and skill development are essential for sustaining momentum in the circular transition.

7. Circular Economy Parks

Circular Economy Parks (CEPs)—or eco-industrial clusters—serve as physical ecosystems for implementing circularity at scale. They promote industrial symbiosis, shared resource management, and innovation in material recovery. These parks can operate as large-scale hubs integrating research, education, and recycling infrastructure, or as smaller cluster-specific zones focusing on sectors like automotive, textiles, or electronics. CEPs create economies of scale, reduce logistics costs, and provide demonstration models for circular practices, entrepreneurship, and green job creation.

8. Institutional Framework

Effective coordination requires a dedicated institutional mechanism that can align national, state, and local efforts. Establishing a central coordinating body or authority ensures policy consistency, standardization, and stakeholder engagement.

Such an institution can oversee implementation, data monitoring, and inter-ministerial coordination while also facilitating investment mobilization and research support. A structured governance system—with advisory boards, technical panels, and stakeholder committees—helps maintain accountability, transparency, and adaptive policymaking.

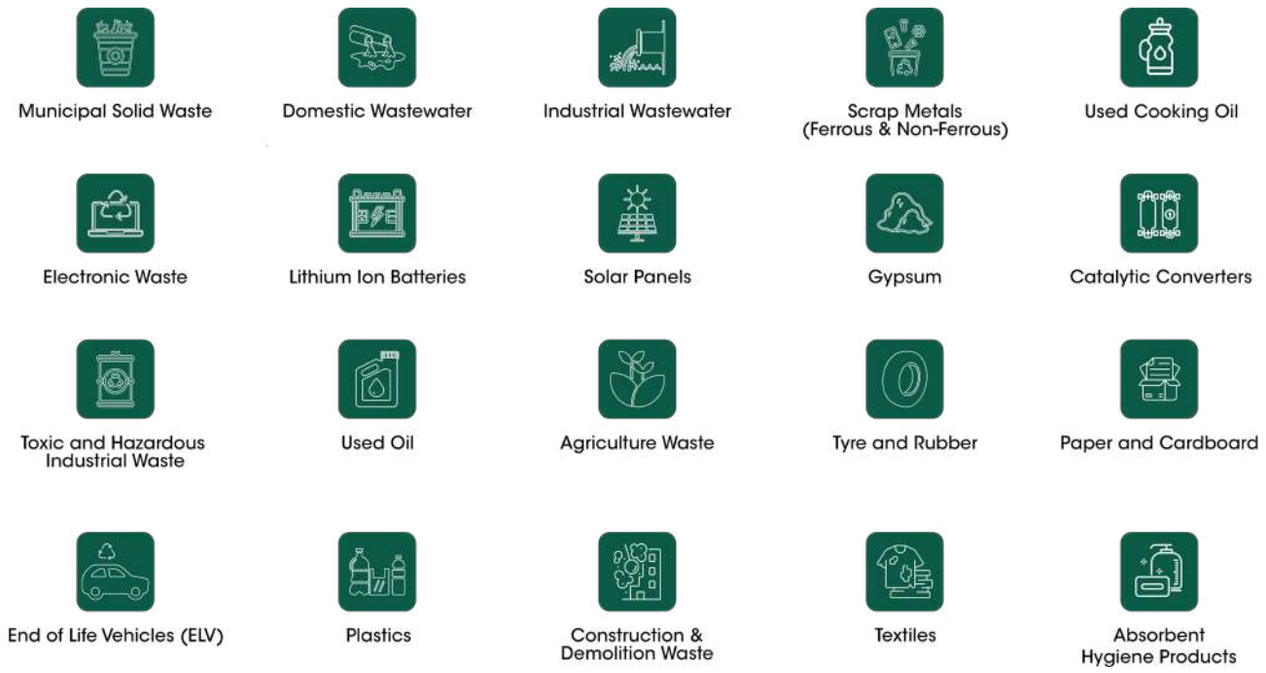
Key Strategies For Implementation Of NCEF

1.5. FOCUS MATERIALS UNDER NCEF EDITION 3

Building on the foundation of the previous edition, which covered sixteen priority materials, Edition 3 of the National Circular Economy Framework (NCEF) broadens its scope to include four additional materials—Used Cooking Oil, Catalytic Converters, Paper and Cardboard, and Absorbent Hygiene Products—bringing the total to twenty focus materials.

This expansion aligns with NITI Aayog's national priorities and reflects the evolving material landscape critical to India's economy and sustainability goals. The inclusion of these new materials strengthens the framework's coverage across both consumer-centric and industrial value chains, integrating waste streams from households, businesses, and large-scale manufacturing sectors.

Each material presents significant opportunities for resource recovery, import substitution, and green innovation, supporting India's transition toward a low-carbon, resource-resilient economy. Collectively, these twenty materials represent a comprehensive cross-section of India's production and consumption system—ranging from high-volume commodities such as plastics, metals, and construction waste to emerging resource streams like used oil, catalytic converters, and hygiene products—thereby offering a holistic blueprint for mainstreaming circularity across all sectors of the Indian economy.



1.6. STRUCTURE OF CIRCULAR ECONOMY ACTION PLANS FOR FOCUS MATERIALS

NCEF Edition 3 adopted a common structure comprising four sections (as presented below) that can be applied consistently across diverse material streams, while remaining flexible enough to accommodate the unique contexts of each sector. Each material chapter broadly follows this standardized structure, starting with a factual baseline and progressing toward an actionable implementation roadmap. A brief description of the four sections is provided below:

1. Material Landscape and Circularity Baseline (Where we are?)

Each chapter opens with a comprehensive description of the material's lifecycle, from extraction to end-of-life. It maps domestic and global value-chain linkages, assesses the material's economic importance, and identifies strategic dependencies or risks. Quantitative data describe market size, growth projections, trade flows, and price volatility. The section also documents the current degree of circular practice—how far design for durability, reuse, repair, and recycling have already penetrated the market—and summarises existing national and state-level policies, incentives, and best practices. The purpose of this opening section is to establish a clear factual baseline that future progress can be measured against.

2. Gaps and Challenges in Advancing Circularity (What is missing?)

This section identifies the barriers impeding circular adoption. These may include policy fragmentation, weak enforcement, fragmented feedstock supply chains, technological limitations, inadequate infrastructure, skills shortages, or market failures such as weak demand for secondary materials. Attention is also given to the role of the informal sector—often a major player in material recovery—and to the challenges of integrating it into formal systems without undermining livelihoods. Each material analysis concludes this section with lessons drawn from domestic and international case studies to ensure that recommendations in later sections are grounded in proven practice.

3. Vision and Targets for Circular Economy Transition (Where we want to go?)

This section articulates a clear, aspirational vision for each material stream—defining "what good looks like." It translates this vision into SMART targets (specific, measurable, achievable, relevant, and time-bound), typically set for 2030 with optional horizons to 2035, 2040, 2047 etc. Targets cover indicators such as reduction in virgin material use, improvement in collection and recycling rates, increased recycled-content share, landfill diversion, and design-for-durability metrics. Every target is accompanied by an explanation of its rationale and the baseline data from which it was derived. This ensures that goals are both ambitious and evidence-based.

4. Enablers and Implementation Framework (How we get there?)

This section translates strategy into action. It identifies policy interventions, market instruments, financing tools, infrastructure requirements, and capacity-building measures needed to achieve the stated targets. It covers instruments such as extended producer responsibility (EPR), product standards, bans or mandates where appropriate, and economic incentives like green bonds, blended-finance facilities, and circular procurement schemes. Infrastructure components include collection systems, circular economy parks, material recovery facilities, and digital traceability platforms. Each intervention is linked to a timeframe and accompanied by a stakeholder map that assigns responsibilities to central and state ministries, urban local bodies, industry associations, academia et.al. The section concludes with identification of implementation risks, proposed mitigation strategies, and key performance indicators for monitoring and accountability.

While the subsequent chapters (i.e., Chapters 2 to 21), each representing a Circular Economy Action Plan for a specific material, broadly follow the common four-section structure outlined above, the content within each section has been customized to reflect the distinct nature of the material, its value chain, and the insights of the respective expert groups guiding its development. This adaptive approach ensures that every action plan remains context-specific, technically sound, and practically implementable, while maintaining overall consistency across the framework. Together, these material chapters translate the principles and strategies of NCEF Edition 3 into targeted, actionable pathways for advancing India's circular economy agenda.

Chapter 2

CIRCULAR ECONOMY ACTION PLAN FOR MUNICIPAL SOLID WASTE

2.1. MATERIAL LANDSCAPE AND CIRCULARITY BASELINE

2.1.1. Overview of Municipal Solid Waste Generation & Disposal

India generates roughly 50 to 62 million MT of Municipal Solid Waste (MSW) per year, with urban inhabitants having a per capita waste footprint of 330–550 grams per day with metro cities generating about 600-700 grams per day. MSW generation is projected to surge significantly, reaching 165 million MT by 2030 and 436 million MT by 2050. As per the latest national level data under Swacch Survekshan, Door-to-Door (D2D) collection practice is reported across 94.6% of total wards while source segregation happens in around 88.29% upto some extent. Though the official figures indicate that over 90% of generated waste are being processed, only 15 states and union territories treat more than 50% of their waste. As per a CPCB report on 2021-22, 24% of the wastes in India are landfilled and 22% remain unaccounted for due to supply chain leakages.

As reported by States/UTs on Swachhattam portal, a total of 1,61,157 ton per day (TPD) of Municipal Solid Waste is generated in the urban areas of the country. Out of which 1,29,708 TPD is processed. i.e. against 16% waste processing in 2014, the current processing capacity has increased to 80.49% by setting up of waste processing facilities such as Material Recovery Facilities (MRFs), transfer stations, composting plants, Construction and Demolition (C&D) and waste to energy plants including waste to electricity, bio-methanation plants etc.

Organic waste makes up 40–60% of India's total MSW, containing 150–250 kg of organic carbon per tonne. Dry waste constitutes 33% to 35% of MSW and is regarded as the most valuable stream due to its high economic value recyclables. Key materials within the dry waste stream include plastics (46% of the dry fraction), paper and cardboard (7%), textiles (5%), and metals (1%). The recycling of dry waste through Material Recovery Facilities (MRFs) is estimated by MoHUA to increase annual recovery value by ₹11,836 crores by 2025.

2.1.2. Environmental & Social Footprint

Due to absence of source segregation, Organic waste decomposes in landfills producing methane, a potent greenhouse gas responsible for 20% of global GHG emissions, with MSW contributing up to 11% of the global total. Open waste burning is a significant source of air pollution. The waste sector accounted for about 18% of India's total PM2.5 emissions in 2020, projected to nearly double by 2050. Socially, the indispensable informal waste sector operates largely under hazardous and unregulated conditions, facing social stigma, low earnings, and health risks, often lacking recognition and social security.

2.1.3. Growth Projection

India's MSW generation is projected to reach 436 million MT by 2050. By 2030, GHG emissions from the MSW sector are expected to total 41.09 million tonnes annually. While India has a potential to generate 2,523 TPD of Bio-CNG from MSW, current production is only 46 TPD. Targets under the MoHUA's plan include generating 2 MMTPA of CBG by 2030. Recycling of critical raw materials helps conserve resources and minimizes the risk of price volatility. Recycling targets for specific dry waste streams are projected to reach 90% for plastics and paper & cardboard by 2030.

2.1.4. Current Level of Adoption of Circular Practices

India recovers slightly over 50% of its dry waste streams, equating to roughly 19% of its total MSW, which is comparable to the global average. Although the national baseline for source segregation is 88.29%, effective enforcement is inconsistent, with some surveyed cities reporting actual citizen compliance at only 32%. High segregation levels (over 90%) are crucial for technologies like Bio-CNG production. Strategies include promoting reduction and reuse aligned with Mission LiFE, composting, and bio-methanation for organic waste.

2.1.5. Overview of existing policies & incentives

The existing policies and Rules related to Solid Waste Management include The Solid Waste Management Rules, 2016 which mandate source segregation into three streams and position landfilling as the least preferred option. The national flagship program, Swachh Bharat Mission (SBM) Urban 2.0, aims to make Indian cities "garbage-free" by 2026, requiring scientific processing of 100% of waste. Policies like Mission LiFE promote waste reduction. Incentives focus on promoting scientific processing & market assistance, For instance, Central Financial Assistance (CFA) for setting up processing facilities, and Market Development Assistance (MDA) by Ministry of Chemicals and Fertilizers offering for the sale of Fermented Organic Manure (FOM).

To further strengthen monitoring, reporting and enforcement of rules covering both urban and rural areas and for improving quality of environment across the country, the MoEF&CC, has further come up with Draft Solid Waste Management Rules, 2025. Some prominent features which include mandate on 4-way segregation of wastes at source, well defined scope of Bulk Waste Generator waste processing, mandatory fuel substitution schedule which requires industries to use at least 6% RDF / Solid Combustible (SCF), centralised online portal for annual filing and monitoring. In parallel, the MoHUA is developing technical guidelines and design documents to help implementation of solid waste management projects in all States / UTs supplementary to the Draft SWM Rules, 2025

2.1.6. Selected Best practices for MSW management

Innovative solutions focus on decentralization and inclusion.

- Women SHG-run decentralised plants to achieve zero landfill in small cities - Ambikapur
- Integration of Informal waste pickers for D2D collection - SWaCH cooperative in Pune
- Dedicated MIS portal for Bulk Waste Generator (BWGs) to monitor compliance - Gurugam
- 100% Electric Fleet for Primary Collection and Road Sweeping – Lucknow
- Recycling of waste plastics from mixed MSW into Biodegradable bags - Hyderabad
- Deposit Refund Scheme for collection of non-biodegradable materials through automated collection machines – Panaji
- 16-way segregation linked to purchase model of recyclables – Panaji
- Solar-charged CCTV cameras for cost-effective monitoring around GVPs – Vijayawada

The Waste Wise Cities document prepared by the Center for Science and Environment and NITI Aayog has identified best practices and innovations in Solid Waste Management across Tier-1, Tier-2 and Tier-3 Indian cities that can be replicated elsewhere.

2.2. GAPS AND CHALLENGES IN ADVANCING CIRCULARITY

2.2.1. Policy Gaps & Enforcement Barriers

A critical challenge is the gap between policy mandates and on-the-ground implementation, often stemming from inadequate enforcement of municipal bye-laws. The efficacy of enforcement is compromised by the Municipal Local Bodies' (ULBs) frequent failure to fulfill their own duties, such as ensuring segregated collection and transportation. Legal instruments for collecting user charges or imposing fines often exist in bye-laws (100% of cities surveyed have penalty provisions), but strategic enforcement of these penalties remains limited.

Existing dry waste policies often fail to provide incentives for recycled products, as they are taxed at the same GST rates as virgin materials, inhibiting competitiveness. Furthermore, policies often lack mandatory language for crucial aspects like integrating the informal sector, resulting in weak and inconsistent implementation.

2.2.2. Material Specific Challenges

Operational facilities face issues from the heterogeneity of municipal solid waste (MSW) due to poor source segregation. Even after initial segregation, contamination by non-digestible materials like tender coconut, bagasse, fish bones, and inert materials hinders microbial digestion, causes mechanical failures, and necessitates costly facility upgrades. Specific materials face inherent hurdles, such as plastics, which degrade in quality and lifespan after only 2–3 recycling cycles. On the other hand, low-value complex materials, including multi-layered plastics and compound packaging like Tetra Pak, are difficult and costly to recycle due to their heterogeneous nature, often resulting in their loss or unscientific disposal

2.2.3. Dry and Wet Waste

Achieving optimal resource recovery is dependent on high-quality feedstock. Effective Bio-CNG production, for example, requires over 90% segregation of organic waste. However, contaminated feedstock and inconsistent supply affect plant performance, often stemming from inaccurate estimation of feedstock potential during the planning stage. The high and escalating rate of waste generation, coupled with challenges related to waste composition variability, makes predicting biogas yields and planning infrastructure difficult. Additionally, many cities still lack adequate processing facilities which arises due to fragmented land holdings and distributed demand for recycled water and compost create difficulties in aggregation, making the logistics and pricing for reuse less economically viable Informal sector dominance and competitive viability issues

The informal waste sector, indispensable for resource recovery, faces structural inequities and continuous threats to livelihood due to privatization of SWM services. Formalizing waste systems risks displacing informal workers who rely on access to waste for income. ULBs often lack clarity in mandates regarding integration and may fear being obligated to provide jobs or sustain livelihoods once waste pickers are formally registered. Furthermore, opposition from formal sanitation unions sometimes prevents ULBs from integrating informal waste pickers into the system.

2.2.4. Infrastructure & Technology Gaps

Infrastructure constraints account for nearly 20% of the root causes identified across the waste supply chain. Key deficits include the lack of land for setting up treatment facilities due to 'Not in My Backyard' (NIMBY) sentiment; inadequate infrastructure for handling legacy waste; and issues related to old/obsolete vehicles and facility maintenance. Operational challenges are exacerbated by unreliable power supply and poorly designed facilities. In comparing models, centralized, highly mechanized facilities often yield low material recovery rates and reduce job opportunities relative to smaller, decentralized, labour-intensive models.

2.2.5. Limited Monitoring and Tracking Compliance

Cities face a lack of reliable, updated baseline data on waste generation and composition, frequently relying on old guesstimates, hindering accurate planning and resource allocation. There is an absence of real-time monitoring mechanisms for crucial facilities like Bio-CNG plants, making it difficult to consistently track and evaluate performance. While systems like the Integrated Command and Control Centre (ICCC) exist, they are not universally leveraged to monitor SWM operations effectively. Awareness & skills deficits

A major bottleneck in achieving successful waste management system is the lack of public awareness and subsequent low participation in mandatory source segregation initiatives. This deficit extends to the market, where low levels of awareness and social stigma towards by-products, especially treated sludge, result in low market demand and sales. There is a significant need for capacity building and training across all stakeholders, including administrative officers who often lack awareness of the needs and crucial roles of informal waste workers. The reliance on generalized, infrequent notification methods (like newspapers) for updating bye-laws fails to reach a wide audience, negatively impacting citizen compliance.

2.2.6. Weak downstream markets (offtake, quality assurance, cost competitiveness etc.)

Downstream markets suffer from a lack of cost competitiveness, largely because recycled products face the same Goods and Services Tax (GST) as virgin materials, requiring tax rebates to ensure uptake. Offtake is weak, notably for Refuse Derived Fuel (RDF), which struggles to find buyers due to high production costs despite MoHUA advisories affirming viability. The absence of long-term mandatory buy-back agreements by government agencies or fertilizer companies for recovered products like biogas and compost severely limits financial viability and market stability. A robust supply chain and market for Bio-CNG is still developing in India, with limited distribution channels.

2.3. VISION AND TARGETS FOR CIRCULAR ECONOMY TRANSITION

2.3.1. Vision Statement (Visionary and Directional)

The vision for the circular economy transition in Municipal Solid Waste (MSW) is to transform India into a nation of "garbage-free" cities, aligned with the holistic goals of Swachh Bharat Mission (SBM) Urban 2.0. This entails a fundamental shift from a landfill-centric model to a resource-maximization hierarchy, prioritizing waste minimization, segregation at source, and scientific processing. The strategic focus is on achieving maximum material recovery of valuable dry waste fractions (such as plastics, paper, and metals) and robust energy recovery from the organic waste stream. By converting segregated waste into economic resources—such as recycled materials, Bio-Compressed Biogas (CBG), and Refuse-Derived Fuel (RDF)—this transition seeks to minimize environmental pollution, conserve natural resources, alleviate supply risks (like price volatility), and provide sustainable livelihoods through inclusive integration of the informal sector.

2.3.2. SMART Targets for Circular Economy Transition (2030)

The national solid waste management framework, guided by SBM 2.0 and circular economy principles, sets ambitious targets aimed at maximizing resource efficiency and achieving a minimal environmental footprint by 2030.

Table 2-1: Proposed Targets

Goal	Current Status	2030 Target
Door to Door collection rate (%)	The current coverage of wards with D2D collection is facilitated is 94.6%	100% Basis: This aligns with SBM 2.0 objectives
Households practicing source segregation (%)	The current baseline of wards practising source segregation is 88.29%	100% Basis: This aligns with SBM 2.0 objectives
Generation of Bio-CNG (CBG) per annum (MMTPA)	As of December 2024, while the government release mentions 125 plants, the SATAT portal says 77 plants have been commissioned, and 17,801 tonnes of gas was sold in 2024-25 — a far cry from 15 million tonnes	2 MMTPA Basis: This aligns with MoHUA's Circular Economy Framework for Bio-CNG
Setting up of minimum 200 TPD bio-methanization plants in all ULBs exceeding 1 million population	As on date, States/UTs have reported 895 functional community biogas plants with minimum capacity of 5 cum/day on GOBARdhan portal	75 Basis: This aligns with MoHUA and SATAT initiatives
Mandate for fertilizer units to utilize compost in their production process (% of compost)	Baseline data is not available for the same	12% Basis: This target addresses the need to establish market demand for the Fermented Organic Manure (FOM) by-product derived from wet waste processing.
Increase in recycling rate of MSW dry fraction (%)	At present, India recovers slightly over 50% of its dry waste streams or roughly only 19% of its MSW is recycled which is on par with the global average	85% Basis: This aligns with MoHUA through implementation of MRFs
Plastics recycling rate (%)	At present, the recovery rate is estimated to be 60% of daily generation	90% Basis: This is a projected recycling target for plastics
Replace coal with Refuse-Derived Fuel (RDF) in cement industries to increase Thermal Substitution Rate (TSR) (%)	Baseline data not available for the same	15% Basis: This target reflects the voluntary goals set by leading cement industries to minimize fossil fuel usage and utilize the combustible fraction of waste.
Remediation of legacy dumpsites (%)	As of 2025, only 25% of legacy dumpsites have completed remediation	100% Basis: This aligns with SBM 2.0 objectives

2.4. ENABLERS AND IMPLEMENTATION FRAMEWORK

2.4.1. Policy Interventions & Market-based Instruments

- Mandate the use of at least 25% recycled materials in non-food grade packaging.
- Mandate the use of mono-polymers in the production of packaging products (e.g., avoiding PET bottles with HDPE covers/caps) to enhance recycling.
- Develop a national policy for mainstreaming informal workers that mandates their formalization.
- ULBs must incorporate mandatory provisions for a sustainable procurement practice to move away from tipping fees for mixed waste toward contracts designed to pay for segregated collection, transportation, and treatment.

2.4.2. Financing Tools / Incentives

- Incentives for BWG compliance could include offering property tax or water tax rebates to high-performing entities.
- All user charges may be integrated within Property Tax or Utility Bills and kept in a separate escrow fund to be used only for waste management
- The Ministry of Chemicals & Fertilizers (MoCF) should extend Market Development Assistance (MDA) to compost produced from biomethanation and tag its sale with chemical fertilizers.
- Incentives must be promoted by the Ministry of New and Renewable Energy (MNRE) to attract the private sector and ensure Bio-CNG offtake.

2.4.3. Infrastructure

- Million Cities must allocate land, minimum 100 acres at multiple locations, on nominal long-term lease for developing Integrated Resource Recovery and Waste Management Facilities
- Suitable Transfer Stations should be planned (especially if distance to processing site exceeds 15 km) and equipped with infrastructure features like leachate collection systems, odor control, and noise barriers
- ULBs should invest in compartmentalized collection vehicles and transfer stations.
- Transfer stations must be equipped with features such as paved handling areas, leachate collection, odor/dust control, vehicle washing, and CCTV surveillance.

2.4.4. Investment Technology Development

- Integrated Command and Control Centres (ICCC) should utilize GPS and RFID technology for optimizing collection routes, tracking vehicle movement, and enhancing D2D collection efficiency.
- An app for providing integrated solution for citizens and ULB staff, facilitating household mapping, tracking of waste collectors, and e-payment of user charges to be developed and used by all ULBs
- New technologies such as IoT-enabled cameras, smog detectors, and sensors should be adopted for monitoring and managing fire hazards at treatment facilities and dumpsites.
- Research and development should be prioritized for cost-effective alternatives to imported components used in Bio-CNG plants.
- AI-driven sorting mechanisms can be integrated to enhance the efficiency of waste segregation.

2.4.5. Promotion of PPP

- Million-plus cities should be encouraged to adopt Bio-CNG technology through a Public-Private Partnership (PPP) model, mandating source segregation as a prerequisite.
- Concession period for PPPs for waste Collection & Transport (C&T), and Processing & Disposal (P&D) to be structured for a minimum of 15 years and 30 years respectively to ensure long-term sustainability and viability.
- Outcome-based financing models should be implemented to incentivize private partners based on performance of achievement of pre-defined KPIs (Key Performance Indicators)

2.4.6. Capacity Building & Skills

- A comprehensive training needs assessment (TNA) and skills gap analysis should be undertaken for personnel across all levels of the SWM supply chain.
- The informal sector, including rag pickers and kabadiwalas, must be formally organized into structured entities and integrated into the waste value chain, aided by advanced IT tools
- Training materials and plans should be developed in regional languages for effective knowledge dissemination among the workforce.
- ULBs should finalize a customized training calendar that includes scheduled training sessions covering machinery operations and troubleshooting techniques.

2.4.7. Awareness & Behaviour Change Campaigns

- Information, Education, and Communication (IEC) campaigns should be continuous and utilize all available media to achieve maximum segregation at the generator level.
- The policy of 3Ps (Plead, Persuade, and Penalize) must be consistently followed with citizens to establish permanent compliance with segregation rules across the MSWM cycle.
- ULBs should introduce creative initiatives, such as reusable steel cutlery in Bartan Bhandars, to actively reduce waste generation at the source
- Communication of bye-laws should include a rigorous drive using social media (WhatsApp, Facebook, etc.) and text messages, preferably in the local language, to reach a wide audience.
- Awareness should be raised among farmers about the benefits of Fermented Organic Manure (FOM) through targeted education and demonstration programmes.

2.4.8. Initiatives/Measures/Actions with prioritization

The targets, goals, and enabling strategies outlined earlier form the foundation for a comprehensive implementation road map (presented in **Table 2-2**). This roadmap will serve as a strategic guide to systematically achieve the defined objectives by translating high-level targets into concrete actions. The table below details specific initiatives and activities, mapped against the targeted outcomes, along with estimated timelines, key ownership, and responsible stakeholders. These actions encompass a range of critical areas, all aimed at ensuring a structured, coordinated, and impactful pathway toward sustainable waste management and circularity. **Table 2-3** presents the implementation risks and mitigation measures.

Table 2-2: Proposed Priority Actions to Achieve Circular Economy Targets

Target No. 1: Enhance Collection & waste segregation at source (Achieving 100% D2D Collection and 100% source segregation by 2030)				
Category	Proposed Measures	Action Item	Timeline for Achievement	Stakeholder for Implementation
Policy-related initiative	Penalty Enforcement	Enforce penalty provisions for non-compliant waste generators by strategically imposing fines and collecting user charges	Short Term	ULBs
Policy-related initiative	Implementation of bye-laws	Communicate bye-laws through rigorous drives using social media, text messages, and local language communications to reach a wide audience and increase compliance.	Short Term	ULBs
PPP	Modernize Collection Logistics	Leverage the Integrated Command and Control Centre (ICCC) to monitor SWM operations via GPS/ RFID in optimizing routes, and identifying Garbage Vulnerable Points (GVPs).	Short to Medium Term	ULBs, Smart City Mission, Service Providers
Policy-related initiative, PPP	Infrastructure for C&T operations	Provide adequate compartmentalized collection vehicles and Transfer Stations equipped with features like paved handling areas, leachate collection, and odor control	Medium Term	ULBs
Target No. 2: Improve wet waste management (Achieve 2 MMTPA Bio-CNG Generation per annum by 2030)				
Category	Proposed Measures	Action Item	Timeline for Achievement	Stakeholder for Implementation
Policy-related initiative, Economic Instrument	Scale Bio-CNG Infrastructure	Encourage million-plus population cities to adopt Bio-CNG technology through outcome-based (PPP).	Medium Term	ULBs, State, MNRE
Research & Development	Alternative to imported components	Prioritize research and development for cost-effective alternatives to imported components used in Bio-CNG plants	Medium Term	ULBs, Industry, Academia
Economic Instrument	Marketing assistance	Address demand for Fermented Organic Manure (FOM) by mandating fertilizer units to utilize compost in their production	Medium Term	MoCF, Fertilizer Industry
Target No. 3: Improve dry waste management (Achieve 85% dry waste recycling and 15% RDF Thermal Substitution Rate (TSR) by 2030)				
Category	Proposed Measures	Action Item	Timeline for Achievement	Stakeholder for Implementation
Policy-related initiative	Promote recycled packaging	Mandate the use of at least 25% recycled materials in non-food grade packaging.	Short Term	MoEFCC, Industry
Policy-related initiative	EPR for dry waste streams	EPR to be expanded to other significant dry waste streams - Textiles, Rubber, etc.,	Short Term	MoEFCC, CPCB

State Support	Formalisation of Informal Sector	Systematically enumerate and issue occupational ID cards to informal waste pickers, linking them to centralized databases and social welfare schemes.	Short Term	MoHUA, ULB
Policy-related initiative	Use of mono material in packaging	Mandate the use of mono-polymers in the production of packaging products to enhance recycling efficiency (e.g., avoiding multi-layer packaging where possible).	Short Term	MoEFCC
Target No. 4: Legacy waste remediation to reclaim land for setting up scientific facilities (Achieve 100% remediation of Legacy dumpsites by 2030 and prevent further dumping of fresh waste)				
Category	Proposed Measures	Action Item	Timeline for Achievement	Stakeholder for Implementation
State Support	Governance & Project acceleration	Establish a SPOC body to expedite project approvals, funding, and land allocation for remediation projects and land reclamation	Short Term	State, Central
PPP	Monitoring & accountability	Utilise ICCC and technology aided enforcement programs to monitor dumpsite remediation progress and mitigate illegal activities	Medium Term	ULB, Smart City Mission
PPP, State Support	Risk Mitigation	Plan Circular Economy Hubs that promote the concept of CIMBY (Circularity in My Backyard) to mitigate the NIMBY challenge associated with treatment facilities.	Medium Term	ULB, State

Table 2-3: Implementation Risks and Mitigation

Potential Risk	Mitigation Strategy
NIMBY (Not In My Back-Yard)	Plan Circular Economy Hubs that promote the concept of CIMBY (Circularity in My Backyard)
Low segregation at source.	Strengthen IEC activities and BCC campaigns; enforce source segregation mandates; incentivize compliance.
Poor offtake for Bio-CNG / Fermented Organic Manure (FOM).	Execute initial MoUs/long-term purchase agreements with buyers (e.g., OMCs, local industries, agricultural cooperatives); promote local market linkage and establish quality standards.
Delays in regulatory approvals and clearances.	Designate a nodal officer/single window clearance mechanism to fast-track mandatory clearances and permissions.

Monitoring and Accountability

- The Integrated Command and Control Centre (ICCC) should serve as a central office for real-time monitoring of operations, including vehicle movement, manpower, and grievance redressal.
- A technology-aided enforcement program, including fines and penalties, should be implemented focusing on non-compliance with segregation at source and littering.
- Performance monitoring of PPP projects must be based on Key Performance Indicators (KPIs) which link payment milestones to performance evaluation metrics.

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Chapter 3

CIRCULAR ECONOMY ACTION PLAN FOR DOMESTIC WASTEWATER

3.1. MATERIAL LANDSCAPE AND CIRCULARITY BASELINE

3.1.1. Wastewater Generation and Treatment Status

India generates approximately 72,368 MLD of wastewater in urban areas and 39,604 MLD in rural regions. Despite this substantial volume, only about 28% of urban wastewater undergoes treatment, while rural wastewater management remains largely decentralized and limited in formal infrastructure (NITI Aayog, 2022).

Untreated wastewater is a leading cause of river, lake, and groundwater pollution, posing both environmental and public health risks. The National Mission for Clean Ganga (NMCG) identifies untreated sewage as a key threat to riverine water quality, while NITI Aayog's Composite Water Management Index (CWMI) points to untreated wastewater as a major source of groundwater contamination and ecosystem degradation.

3.1.2. Economic and Sectoral Linkages

The wastewater sector plays a crucial role in supporting agriculture, industry, construction, resource recovery, and public health. Treated wastewater can serve as a vital substitute for freshwater in irrigation, helping conserve essential water resources and alleviate stress on aquifers. In industry, it can be reused for processes such as cooling in power plants and refineries, reducing dependency on freshwater and lowering operational costs. In construction, treated wastewater supports activities like concrete mixing, dust suppression, and landscaping, promoting environmental compliance. Additionally, wastewater treatment enables the recovery of biogas energy and nutrients like phosphorus and nitrogen, which can be used in fertilizer production, advancing circular economy objectives.

Importantly, effective wastewater management helps reduce waterborne diseases and limits human exposure to pathogens, safeguarding public health. Overall, wastewater should be seen not just as a waste stream, but as a valuable resource with the potential to contribute to water security, food production, and energy generation. Strengthening linkages across these sectors can amplify circularity benefits and enhance local resilience.

3.1.3. Policy and Regulatory Framework

India has progressively developed a robust policy ecosystem promoting wastewater management and circularity:

- **National Urban Sanitation Policy (NUSP, 2008):** Promotes decentralized sanitation systems and reuse of treated wastewater in cities.
- **National Water Policy (2012):** Encourages wastewater reuse for agriculture and industry to combat water scarcity.
- **Atal Mission for Rejuvenation and Urban Transformation (AMRUT, 2015, 2021):** Targets 100% wastewater treatment and recycling for non-potable uses.
- **Swachh Bharat Mission – Urban (SBM-U, 2014, 2021):** Focuses on decentralized wastewater management and reuse in landscaping and industry.
- **Swachh Bharat Mission – Gramin (SBM-G, 2014, 2021):** Promotes elimination of open defecation and decentralized management of greywater and domestic wastewater.
- **Jal Jeevan Mission (JJM, 2019):** Focuses on safe drinking water and promotes greywater management in rural households.
- **National Mission for Clean Ganga (NMCG, 2014):** Prioritizes wastewater treatment, pollution abatement, and resource recovery from sludge.
- **Faecal Sludge and Septage Management (FSSM) Policy (2017):** Supports decentralized faecal sludge treatment and reuse in non-sewered areas.

- The forthcoming Draft **Liquid Waste Management Rules (2024)**—expected to be enforced from October 2025—introduce detailed standards, reuse targets, and monitoring mechanisms, marking a significant step toward codifying circular practices.

Together, these policies signal a systemic transition from linear waste disposal toward a resource-centric approach, embedding reuse, recovery, and accountability into the nation's water governance architecture.

3.1.4. Incentive Mechanisms Driving Circularity

India's wastewater regulations and programs include several financial and policy incentives that promote adoption of circular economy principles:

- **Capital Subsidies and Grants:** Up to 50% capital grants under NUSP and Rs. 500 crore performance-based grants under AMRUT.
- **Subsidized Loans:** Provided under SBM-U 2.0 for decentralized wastewater reuse systems (up to Rs. 2 crore per city).
- **Tax Rebates:** Up to 30% rebate for industries and agricultural users reusing treated wastewater (National Water Policy).
- **Public-Private Partnerships (PPP):** Encouraged under AMRUT and NMCG with performance-linked funding models.
- **R&D and Innovation Support:** Up to 90% capital subsidy under JJM for rural wastewater technologies such as nutrient recovery and greywater recycling.
- **Differential Tariffs and Polluter-Pay Mechanisms:** Guided by CPCB, incentivizing compliance and sustainable reuse.

These incentive structures reflect a deliberate policy shift from compliance-driven regulation to performance-based transformation, aiming to catalyse investment, innovation, and private sector engagement in circular wastewater management.

3.1.5. Market Outlook and Circularity Gaps

India's wastewater management market is poised for significant growth, projected at a CAGR of 11.76% (2022–2029), reaching US$11.199 billion by 2029 (NITI Aayog, India Infrastructure, 2022).

This growth is underpinned by rapid urbanization, infrastructure expansion, and government missions such as SBM-U 2.0, which aims for 100% urban wastewater treatment by 2030. However, persistent gaps remain:

- Urban treatment capacities currently meet only 43.9% of actual needs.
- Many treatment plants are outdated or underutilized due to operational and maintenance challenges.
- Rural areas remain underserved, with most wastewater discharged untreated, leading to groundwater pollution and health risks.

Bridging these gaps requires integrated planning, technology-led innovations, and inclusive models that link infrastructure, financing, and community participation to achieve a sustainable and circular wastewater economy.

3.2. GAPS AND CHALLENGES IN ADVANCING CIRCULARITY

While India is increasingly embracing circular economy principles in wastewater management, with progress varying across regions and sectors, several challenges still hinder its full-scale adoption. From a policy and regulatory perspective, there are several state-level regulations, guidelines, and wastewater policies designed to promote water reuse, resource recovery, and decentralized treatment systems, but the lack of a unified regulatory framework results in inconsistent application and enforcement across regions.

Disparities across state and municipal levels are further compounded by variations in effluent treatment standards, water pricing mechanisms, and investment levels. From a regulatory perspective, India has developed an extensive framework promoting wastewater reuse, resource recovery, and decentralized systems, yet gaps remain in infrastructure, regulation, enforcement, public acceptance, and the service sector.

A primary challenge is the lack of uniform effluent standards and enforcement mechanisms, which limits consistent adoption of wastewater reuse and resource recovery mandates. Moreover, local governments often lack the necessary skills and capacity to plan and execute Public-Private Partnership (PPP) projects or manage advanced wastewater systems, slowing the adoption of innovative treatment and resource recovery technologies.

Infrastructural deficits at existing Sewage Treatment Plants (STPs) also pose significant challenges. For instance, out of over 1,469 treatment plants in India, with a total capacity of 31,841 MLD, they only cover approximately 43.9% of the total sewage needs, leaving major treatment gaps. Many plants remain outdated, inefficient, or underutilized, impeding effective wastewater management and leading to inconsistent treatment outcomes. Furthermore, while policies like SBM-U 2.0 and Faecal Sludge and Septage Management (FSSM) support decentralized systems, adoption remains low, especially in rural and smaller urban areas, increasing dependency on inefficient centralized systems. Additionally, limited focus on the quality and reliability of treated wastewater further constrains its widespread reuse.

The lack of infrastructure to support resource recovery, such as biogas generation and nutrient extraction, impedes progress in this critical area. Even in regions that have successfully implemented treatment systems, scaling is often restricted by lack of local markets and private investment, especially where decentralized systems are most needed. Despite policies encouraging resource recovery, the essential infrastructure to support biogas generation, nutrient extraction, and similar processes is lacking—particularly in rural areas. And the underdeveloped market for treated wastewater reuse has resulted in economic losses as resources remain underutilized and valuable nutrients are discharged into drains due to a lack of market demand or effective pricing strategies.

The high volume of greywater and fecal sludge from small businesses and informal residences adds to issues, requiring the incorporation of these sources in a more efficient system. Additional issues such as limited public awareness and low acceptance of treated wastewater hinder broader adoption, fueled by lack of trust and misinformation. The lack of data and monitoring, particularly regarding the performance of decentralized systems and the impact of local initiatives, also impedes data-driven decision-making. There is currently no standard for data collection across municipalities, and what information is collected is difficult to access by decision-makers.

3.3. VISION AND TARGETS FOR CIRCULAR ECONOMY TRANSITION

India's vision for a circular economy in wastewater management involves transforming wastewater from a burden into a valuable resource through reuse, recycling, and resource recovery, all while ensuring environmental sustainability, public health, and economic growth. By systematically addressing current inefficiencies and adopting integrated strategies, India aims to set new benchmarks in wastewater and fecal sludge management.

Achieving this vision necessitates concrete, time-bound targets underpinned by clear regulatory drivers, and innovative financing mechanisms.To achieve transformative change, we propose the following quantitative targets to guide the development of a sustainable and resilient circular wastewater economy by 2030:

Table 3-1 : Proposed Targets

S.No.	Proposed Target	Target by 2027	Target by 2030
1	Comprehensive Wastewater Treatment in Urban Areas (Draft Liquid Waste Management Rules, 2024; Reuse Targets , SBM-U 2.0, CPCB)	50% of urban wastewater treated, focus on large cities (over 1 million).	100% wastewater treatment coverage in all urban areas, integrating STPs and Faecal Sludge Treatment Plants
2	Minimum Reuse of Treated Wastewater by Bulk Users (Draft Rules Tables 1 & 2)	20% reuse for new bulk users; 10% for existing users.	50% reuse for new bulk users; 25% for existing bulk users
3	Decentralized Wastewater Treatment Systems for Bulk Users (Draft Rules Mandate)	New bulk users must install onsite decentralized treatment or purchase EUR certificates.	Full compliance: all obligated bulk users must have decentralized treatment or valid EUR certificates
4	Minimum Recovery of Treated Wastewater by Treatment Facilities (Draft Rules Table 3)	55% minimum recovery of treated wastewater for reuse.	At least 65% minimum recovery of treated wastewater, adjusted for sludge content
5	Sludge Treatment and Safe Management (Draft Rules Chapter II & III; SBM-U 2.0)	Mandatory reporting of sludge generated, treated, reused as organic manure/ biogas; safe disposal.	Full operationalization of sludge reuse, comprehensive reporting, and qualitative monitoring
6	Faecal Sludge and Septage Management (FSM) (Draft Rules Chapter III; SBM-G Phase II)	Mechanized desludging and transport to registered treatment facilities.	Universal FSM system coverage in rural and urban areas with safe treatment and reuse or disposal
7	Prohibition of Untreated Wastewater Discharges (Draft Rules, SBM-U)	No untreated discharge to land or water bodies; penalties and enforcement mandatory.	Complete enforcement and monitoring preventing untreated discharges
8	Monitoring, Reporting and Compliance on Centralized Portal (Draft Rules, EUR framework)	Partial implementation of monthly reporting, geo-tagging, EUR certificate issuance.	100% mandatory digital compliance with monthly/annual reporting, real-time monitoring, and penalties.

3.4. ENABLERS AND IMPLEMENTATION FRAMEWORK

To transition effectively to a circular economy in wastewater management, India must adopt a combination of regulatory reforms, market-based incentives, and strategic partnerships that drive innovation and infrastructure development.

3.4.1. Regulatory Reforms and Market Incentives

- **Mandate Water Reuse Targets** in a phased manner to progressively reduce freshwater demand.
- **Enforce Differential Tariffs** where treated wastewater is priced lower than freshwater for non-potable use, incentivizing sectors like construction, power, and agriculture to switch to recycled water.
- **Strengthen Compliance and Outcome-Based Monitoring** across all centralised and decentralised STPs for real-time data on discharge quality and resource recovery.
- **Uniform quality standards** should align treated wastewater with end-use requirements, following CPCB guidelines that categorize water quality based on suitability for industrial, agricultural, potable reuse, and ground or surface water recharge

3.4.2. Investment in Technological Innovation and Resource Recovery

- **Support Advanced Treatment Technologies** by prioritizing R&D funding for emerging wastewater treatment technologies, including membrane bioreactors, sludge-to-energy conversion systems, and nutrient recovery technologies
- **Implement Pilot Programs and Nature-Based Solutions** especially in peri-urban and rural areas, offering a cost-effective and sustainable alternative where conventional systems may be economically unfeasible.
- **Promote Resource Recovery Standards** capturing valuable resources such as phosphorus and nitrogen in wastewater treatment processes, with applications in agriculture.

3.4.3. Green Financing Mechanisms and Public-Private Partnerships (PPP)

- **Develop Green Bond Initiatives:** Introduce green bonds as a funding source for wastewater infrastructure projects, offering long-term returns for investors and providing capital for technology upgrades and expansion.
- **Expand PPP Models** with a focus on Viability gap funding (VGF) to attract private investment in smaller towns and underserved areas.
- **Standardize PPP Procurement Norms** across states to facilitate smoother and faster project approvals, enhancing private sector understanding and confidence in entering regional wastewater projects.
- **Encourage Low-Interest Loans for SMEs** working on decentralized wastewater solutions and resource recovery technologies, fostering innovation and sector growth.

3.4.4. Capacity Building for Local Governments and Inclusion of the Informal Sector

- **Provide Training** to local governments to manage both centralized and decentralized systems effectively.
- **Establish a Knowledge-Sharing Platform at national level** to enable local governments to learn from successful projects.
- **Formalize Informal Sector Roles** into formalized maintenance, waste collection, and sludge management roles, providing training and safety standards.

3.4.5. Smart Technologies for Monitoring, Compliance, and Data Management

- Expand Real-Time Monitoring Systems to treatment facilities similar to the IoT-based monitoring by NMCG.

- Predictive Analytics and Maintenance as a Service allows enhanced participation by private sector in pre-emptively address issues at facilities.
- Data-Driven Decision Platforms like the MoEFCC's ENVIS to integrate real-time reporting and making the treatment data available to improve policy alignment and public transparency.

3.4.6. Market Development, Urban Resilience, and Service Models

- **STP as a Service (SaaS)** business models where private operators finance, install, and operate decentralized treatment plants, charging clients based on the volume of wastewater treated. Bengaluru's PPP model for sewage treatment has shown SaaS's potential for scalability.
- **Develop a Market for Treated Wastewater** by facilitating buyer-seller linkages for treated wastewater, similar to the partnerships in Tamil Nadu, where treated water is sold to industrial parks at a fraction of freshwater costs.
- **Develop Private Sector Service Ecosystem for Decentralized Systems** offering spare parts, auxiliary services, and technical expertise thereby creating reliable service networks that enhance system longevity and encourages uptake.
- **Integrate Wastewater for Urban Resilience and Planning** by aligning with Sponge City and Eco-City principles.
- **Industry Forums with enhanced focus on Wastewater Reuse** to inform and drive policy, practice and adoption.
- **Industry-Academia Linkages for Innovation and Workforce Development** to support research, innovations, and building a skilled workforce.

3.4.7. Nutrient Recovery and Energy Generation

- **Mandate Nutrient Recovery Standards** in all STPs.
- **Set up Energy-Positive Wastewater Plants** by encouraging models like Denmark's Aarhus plant, which generates 192% of its energy needs.
- **Incentivise Bioenergy production in Treatment Facilities** from sludge.

3.4.8. Public Awareness and Demand Generation

- **Encourage Municipalities to Run Targeted Public Awareness Campaigns** to promote wastewater reuse.

In conclusion, transitioning to a circular economy model for wastewater management involves a broad range of actions at various levels and with numerous players.The implementation must be robust.This will enable measurable outcomes for the environment, industry, and urban populations. By focusing on these drivers, while maintaining a balance of what can or should come from the sector we are building a new vision to solve wastewater practices. We propose these methods to help further our process through data-based decision making and long-term stability of the initiative so that it will have lasting and meaningful impacts.

3.4.9. Implementation Roadmap

The targets, goals, and enabling strategies outlined earlier form the foundation for a comprehensive implementation road map (presented in **Table 3-2**). This roadmap will serve as a strategic guide to systematically achieve the defined objectives by translating high-level targets into concrete actions.The table below details specific initiatives and activities, mapped against the targeted outcomes, along with estimated timelines, key ownership, and responsible stakeholders. These actions encompass a range of critical areas, including policy reforms, economic instruments, PPP models, research and development, and capacity building—all aimed at ensuring a structured, coordinated, and impactful pathway toward sustainable waste management and circularity.

Table 3-2: Proposed Implementation Roadmap

S.No.	Proposed Target	Initiative	Action	Timeline	Responsible Entity
1	Comprehensive Wastewater Treatment in Urban Areas	Sewage Network Expansion	Expand and upgrade sewage collection networks in large cities.	2040	Urban Local Bodies (ULBs)
		STP & FSTP Development	Construct/upgrade municipal STPs and integrate Faecal Sludge Treatment Plants.	2030	ULBs, State Pollution Control Boards (SPCB)
		Real-Time Monitoring	Deploy IoT & predictive analytics to monitor treatment plants.	2027	SPCBs, MoHUA
		Mid-Term Assessment	Conduct 2027 evaluation of progress on treatment and nutrient recovery.	2027	MoHUA, MoEFCC
		Green Financing & PPP	Develop green bonds; expand PPP with viability gap funding for treatment infrastructure.	2027	MoHUA, Financial Institutions, Private Sector
		Public Awareness & Urban Resilience	Run campaigns to increase acceptance of wastewater reuse; link with sponge city concepts.	Continuous	ULBs, MoHUA
2	Minimum Reuse of Treated Wastewater by Bulk Users	Reuse Target Enforcement	Mandate phased water reuse targets for bulk users with monitoring via EUR certificates.	Immediate	MoHUA, Bulk Users
		Market Development	Promote reuse markets using dual plumbing and differential tariffs to incentivize reuse.	Immediate	MoHUA, Industry Associations
			Encourage entrepreneurship to develop last-mile solutions that connect reuse markets and improve access for small-scale and rural reuse vendors.	Immediate	ULBs, Start-up India
3	Decentralized Wastewater Treatment Systems for Bulk Users	Technical Support	Disseminate guidelines & conduct tech assistance for decentralized onsite treatment.	Continuous	MoHUA, ULBs
		Financing Support	Provide low-interest loans and incentives for decentralized system adoption.	Immediate	Financial Institutions, MoHUA
		Service Ecosystem Development	Encourage private service networks for parts, maintenance, and technical expertise.	Continuous	Private Sector, ULBs

S.No.	Proposed Target	Initiative	Action	Timeline	Responsible Entity
4	Minimum Recovery of Treated Wastewater by Treatment Facilities	Recovery Incentives	Implement subsidies/ carbon credits for higher water recovery and nutrient capture.	2027	MoHUA, SPCBs
		Outcome Monitoring	Real-time reporting of water/nutrient recovery on digital platforms.	Immediate	SPCBs, Treatment Operators
5	Sludge Treatment and Safe Management	Product Commercialization	Develop markets for biofertilizers, biogas from treated sludge; ensure quality standards.	Immediate	ULBs, STP Operators, Agriculture Sector
		Reporting & Quality Control	Enforce monthly/ annual sludge reporting and qualitative analyses.	Immediate	SPCBs, MoHUA
6	Faecal Sludge and Septage Management (FSM)	Mechanized Desludging Services	Implement operational desludging services with registered operators.	Immediate	Gram Panchayats, Registered Operators
		FSM Treatment & Reuse	Develop treatment plants; promote reuse of FSM byproducts.	2030	ULBs, FSM Operators
		Data Monitoring	Establish mobile platforms at village/ state level feeding into central monitoring.	Immediete	MoHUA, Gram Panchayats
7	Prohibition of Untreated Wastewater Discharges	Enforcement & Penalties	Strengthen enforcement with regular water quality sampling and legal penalties.	Immediate	SPCBs, MoEFCC, Judiciary
		Market-Based Instruments	Introduce tradable discharge credits and pollution compensation schemes.	2027	MoEFCC, SPCBs
8	Monitoring, Reporting and Compliance on Centralized Portal	Digital Reporting Systems	Operationalize online portals for monthly reporting, geo-tagging, EUR certificates.	Immediate	MoHUA
		Predictive Analytics & Transparency	Use IoT sensors and ENVIS-like platforms for real-time status and public disclosure.	Immediate	MoHUA, SPCBs
		Compliance Incentives & Penalties	Link data with performance-based incentives/penalties for adherence to treatment norms.	Immediate	MOHUA, SPCBs

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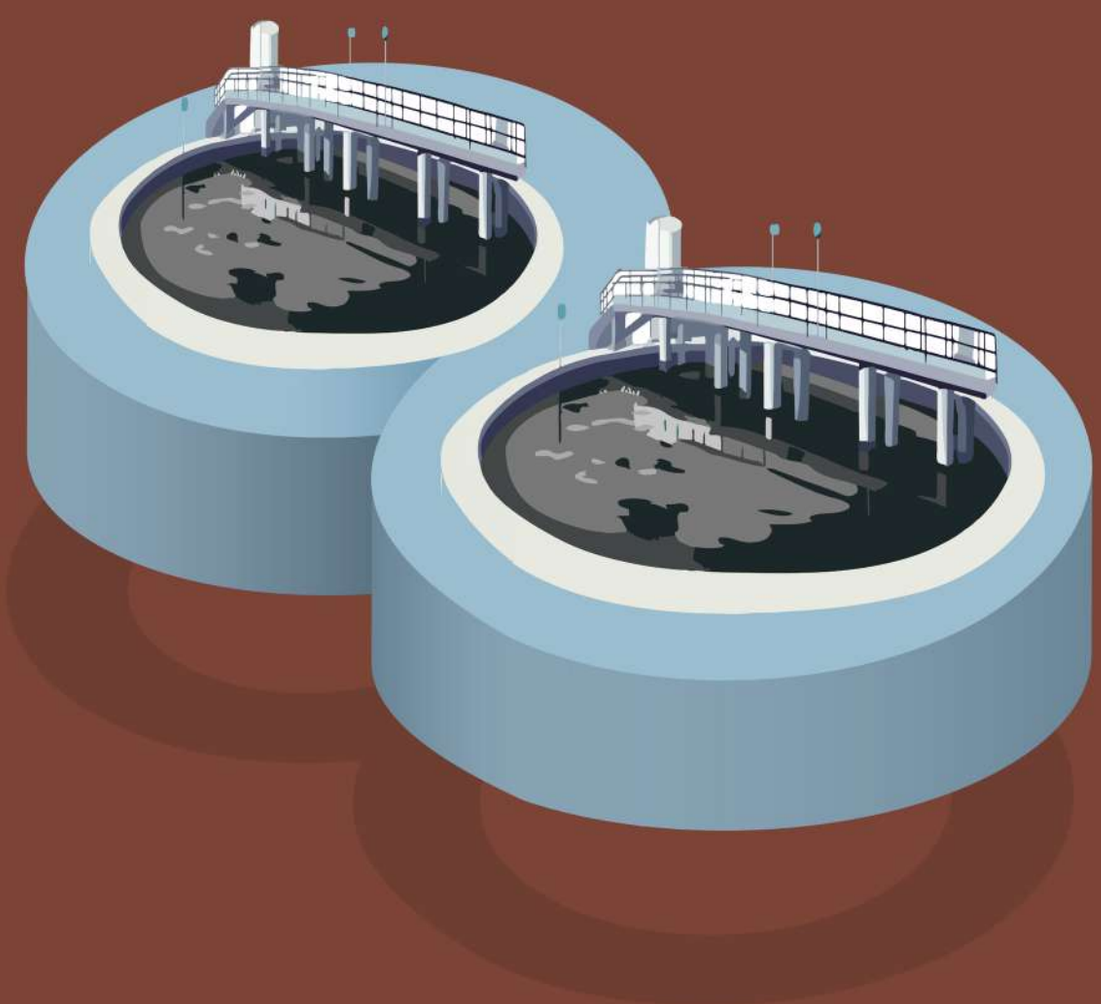
Chapter 4

CIRCULAR ECONOMY ACTION PLAN FOR INDUSTRIAL WASTEWATER



4.1. Material Landscape and Circularity Baseline

Water crisis stems from over-extraction of water resources, pollution, climate change, rapid urbanisation, and rising demand from agriculture, which consumes 90% of the nation's water. Water scarcity has already hit India, which accounts for 18% of the global population, with just 4% of global water reserves to depend on.

It is a matter of concern that the CPCB report in the year 2022 indicates that there are 311 polluted river stretches of different grades in 279 rivers in 30 States/Union Territories. Many industrial areas have to rely on groundwater, which is getting used up fast through over extraction. Elsewhere, bore wells are running dry or producing water of low quality. Groundwater in some industrial areas is polluted with illegal wastewater discharge. Apart from this, the surface water bodies are inadequate to meet the increasing demand for freshwater.

This crisis is on, and this situation threatens economic stability, food security, and public health, with 21 cities projected to run out of groundwater by 2030 and demand expected to exceed supply by 2030.

Scarcity in water resources makes it imperative that we reconsider our water sourcing options, and treated water, especially sewage water, is a reliable, underutilised source.

Water moves through a complex material value chain from extraction and use in domestic and industrial activities, to treatment and end-of-life disposal or reuse. This chain exhibits interconnected domestic and global dependencies, reflecting shared water sourcing, wastewater flows, and technology transfers for treatment solutions (Mohua.gov, GlobeNewswire)

In India and worldwide, water supports critical sectors such as agriculture, manufacturing, energy, and pharmaceuticals, where it serves strategic and operational functions. Industries rely on secure water supplies but face vulnerabilities from trade dependencies, water scarcity, and regulatory risks. As water becomes scarcer, industries seek to reduce exposure to physical water risks and market volatility (Imarcgroup)

The environmental and social footprints of industrial water use are substantial. Untreated or inadequately treated wastewater contaminates ecosystems, harms biodiversity, affects public health, and disproportionately impacts vulnerable communities near industrial clusters. This results in economic losses and social inequities, underscoring the urgency of sustainable water management practices.

As per CEEW analysis, India could have over 96,000 million litres of treated wastewater (TWW) available daily for reuse by 2050, based on the projected treatment capacity (80% of wastewater generation) and the compound annual growth rate observed between 2015–16 and 2020–21. This presents a significant assured market potential and economic opportunity for TWW reuse.

At current rates (MoHUA 2021), the market value of TWW in 2021 was estimated at INR 630 million (USD 8 million) per day, rising to INR 1.9 billion (USD 24 million) per day by 2050.

In agriculture, which consumes most freshwater, around 8,603 MCM of TWW was available in 2021, enough to irrigate 1.38 Mha of land—nearly nine times Delhi's area. This irrigation could generate INR 966 billion (USD 12 billion) in agricultural revenue. Since secondary-treated wastewater contains nutrients like N, P, and K, it could also save INR 50 million (USD 0.6 million) annually in fertiliser costs. By 2050, about 24,058 MCM of TWW could irrigate over 3 Mha of land, multiplying these benefits.

Realising this potential requires city-level reuse plans to direct TWW towards irrigation, industries, construction, landscaping, cooling, firefighting, and water body rejuvenation. Examples already exist: Chennai, Nagpur, and Surat sell secondary TWW to industries; Chennai channels revenue into water body restoration; Delhi uses tertiary TWW for groundwater recharge, cutting pumping energy; and Delhi, Gwalior, and Kanpur supply treated wastewater for peri-urban irrigation (ceew).

Market trends indicate rising demand for industrial water treatment and circular water use technologies, driven by regulatory tightening, water scarcity, and sustainability commitments. India's wastewater treatment market is expanding rapidly alongside global trends in resource recovery and digital monitoring. The Indian wastewater treatment market size reached USD 9.64 billion in 2024. Looking forward, IMARC Group expects the market to reach USD 18.63 billion by 2033, exhibiting a growth rate (CAGR) of 7.60 % during 2025-2033. Price volatility of water-related inputs and services further shapes industrial water strategies and investments. (imarcgroup, mordorintelligence)

Currently, circular practices in industrial water management, encompassing design for water efficiency, reuse, recycling, and resource recovery, are growing, but adoption is uneven. Many industries pilot innovative reuse frameworks, digital tools for onsite water monitoring, and collaborative water stewardship. However, infrastructural gaps, high capital costs, and regulatory complexity constrain wider adoption. (indiawaterportal)

India has made important advancements in managing industrial wastewater through major national initiatives such as the National Water Policy (NWP), the Control of Water Pollution (Grant, Refusal or Cancellation of Consent) Guidelines 2025, and the recently published draft Liquid Waste Management Rules 2024 outline Extended User Responsibility for recycling of treated wastewater. These frameworks aggressively enforce effluent discharge standards, ZLD (zero liquid discharge) regulations, and the use of cutting-edge wastewater treatment and recycling technologies. Cities have begun the implementation of decentralised wastewater treatment systems for non-potable water reuse for irrigation, landscaping, industrial cooling and water body rejuvenation.

Government initiatives support this with the reuse of wastewater and water recycling, such as the Atal Mission for Rejuvenation and Urban Transformation (AMRUT), aimed at the construction of wastewater treatment plants. This formed part of Atal Mission for Rejuvenation and Urban Transformation (AMRUT) 2.0.

Water-intensive industries, particularly textiles and food processing, are decreasing their use of freshwater and implementing closed-loop systems. It is this recycling and the reuse of water that businesses in these sectors are encouraged to adopt, as it increases their operational efficiency, reduces their net environmental footprint, and provides direct cost savings. Additionally, state pollution control boards support policies including providing financial incentives, technology promotion, and streamlined consent mechanisms to encourage industries to invest in wastewater recycling, reuse, and pollution prevention.

Emphasis has to be there for providing incentives for motivating treated wastewater reuse. Some of the forms of incentives

- Capital subsidies (Gujarat, Karnataka, Maharashtra, Tamil Nadu)
- Tax deductions (Karnataka, Maharashtra, Tamil Nadu)
- Lower tariffs (Gujarat)

Together, this supportive ecosystem strengthens India's drive towards circular economy principles in industrial water use and wastewater management.

Traditional chemical and biological wastewater treatment technologies are now being complemented by advanced options such as membrane filtration, reverse osmosis (RO), and advanced oxidation processes (AOP), which make wastewater safer for reuse in sectors like textiles, pharmaceuticals, and agriculture. Innovations are also emerging through pilot projects, start-ups, and industry collaborations that promote efficiency and circularity. At the same time, digital technologies powered by IoT, AI, and blockchain are enabling real-time monitoring, optimisation, and transparent data management. These tools support regulatory compliance, reduce costs, and advance sustainable water practices. With government incentives and regulatory push, the adoption of such solutions in India is set to expand rapidly.

All these trends underscore the critical link between sustainable water management and industrial resilience, signalling enhanced coordination among stakeholders to balance economic growth with environmental stewardship. (mospi.gov, shareindia.com)

4.2. Gaps and Challenges in Advancing Circularity

The importance and relevance of enabling circular solutions in managing wastewater have found wide acceptance. Initiatives towards achieving circularity face several challenges. Some of those are elaborated in the following paragraph:

1) **Fragmented Enforcement**- Enforcement of wastewater management policies is hampered by fragmented roles among various agencies.

    (i) Inconsistent regulations by the Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs) concerning effluent discharge, which result in widespread noncompliance by industries.
    (ii) Urban sanitation programmes such as AMRUT 2.0 and SBM 2.0, overseen by the Union Ministry of Housing and Urban Affairs, have no assigned agency for the enforcement of wastewater reuse regulations. While the CPCB and SPCBs monitor and regulate treatment of effluents, they do not have specific mandates for the reuse of effluents for particular sectors.
    (iii) Urban Local Bodies (ULBs) at the state level, who operate Sewage Treatment Plants (STPs), still primarily focus their efforts on the disposal of sewage rather than reuse.
    (iv) Wastewater reuse policies lack the enforcement that comes from fiscal compulsion, resulting in their widespread advisory nature, and large-scale adoption is made difficult as a result.
    (v) Finally, the governance essentials of transparency and responsive real-time monitoring systems are neither fully functional nor integrated

2) **Heterogeneous nature of industrial wastewater,** its volume and contaminant composition, which vary across sectors, processes, and geographical regions, makes the creation of generalised treatment methods and circular approaches to wastewater reuse exceptionally challenging. Treatment facilities struggle with disruptions and irregularities in the wastewater, and this inefficiency is due, in part, to the treatment systems themselves. Industrial wastewater quantity and quality also fluctuate due to seasonal variations affecting consistent treatment and reuse performance.

3) **Common Effluent Treatment Plants** (CETPs) handle inconsistent feedstock both in quantity and quality, especially, insufficient aggregation from many small-scale industries, fail to treat wastewater to an appropriate or relevant standard, using outdated technologies, ill-fitted to the contemporary pollutant load, or insufficient in scale. Industrial wastewater treatment is not a one-size-fits-all practice, but rather an often bespoke combination of various process solutions. Regional and seasonal factors should also be considered in the design and planning of wastewater infrastructure. Moreover, informal industrial units and micro-enterprises often bypass consolidation systems and, therefore, are a real limiting factor with regard to system scale and overall system treatment efficiency.

4) **Treatability of wastewater** - is one of the major challenges in circularity in wastewater, especially in sectors like pharma, pesticides, dye & dye-intermediates, paper & pulp, distillery and chemicals. For the small and medium (SME) enterprises generating such challenging wastewater, the capital and operational costs of advanced treatment technologies, like Zero Liquid Discharge (ZLD), are unbearable. Moreover, the available solutions and facilities for varying wastewater characteristics also render the re-use of wastewater economically unfeasible and environmentally unsustainable.

5) **Infrastructure to support** circular economy initiatives is also scarce. Only a few hubs exist to integrate water reuse, recovery, and resource valorisation at scale. Existing industrial clusters generally lack shared treatment and reuse infrastructure that could promote circular flows of water and materials.

6) **Lack of awareness and technical skills** - remains a significant barrier. Many plants suffer from inadequate staffing, with untrained operators compromising performance. Industries also often lack a clear understanding of the benefits and practical methods of wastewater reuse and circularity, slowing down adoption. (cleantechwater,ceew)

7) **Weak downstream markets** - further constrain progress. Markets for recycled water, biosolids, and other by-products struggle with issues of quality assurance, cost competitiveness, and buyer acceptance as the cost of the treated wastewater often exceeds that of freshwater sources, discouraging large-scale adoption by industries. Regulatory gaps and lingering perceptions about the quality of recycled products reduce economic incentives for reuse. Despite these challenges, several best practices offer valuable lessons.

8) **Integrated Wastewater Re-use Systems –** Few States have implemented integrated wastewater re-use systems. TN State has implemented Tertiary Treatment Reverse Osmosis (TTRO) plants to supply treated sewage water to industries, significantly reducing freshwater demand. Gujarat has also successfully implemented a treated wastewater reuse policy, while internationally, examples from Singapore and Japan highlight the importance of integrated technology, stringent regulation, and public acceptance in scaling wastewater circularity.(downtoearth, indiawaterportal). The perceived implementation challenges have been several. Given below is a Table with Policy initiatives made by various State Governments and the challenges faced in their implementation.

Table 4-1: Implementation Challenges

State	Policy Status	Implementation Challenges
Gujarat	Strong reuse policy (2018), targets 70% reuse by 2025, 100% by 2030.	No clear sectoral prioritisation, limited data on enforcement.
Haryana	Prioritises wastewater reuse for agriculture and canal networks.	Implementation remains challenging.
Karnataka	Major focus on lake rejuvenation for shallow aquifer recharge with treated wastewater.	Inconsistent implementation in smaller towns.
Rajasthan	Encourages industrial reuse in Udaipur and Beawar.	Absence of a long-term reuse strategy in non-industrial regions.
Maharashtra	Mandates industrial reuse in urban areas.	Limited to cities like Nagpur and Pune, weak adoption elsewhere.
Tamil Nadu	Reuse integrated into urban water planning.	Lack of financial incentives for STPs to prioritise reuse.
Delhi	DJB supplies treated wastewater for horticulture and lake recharge.	Institutional fragmentation between Delhi Jal Board, Delhi Development Authority and Central Pollution Control Board delays implementation.
West Bengal	Published Treated Used Water Reuse Policy in 2020.	No clear implementation strategy for large-scale adoption.
Madhya Pradesh	Encourages reuse in urban parks and industrial use.	No targets or enforcement mechanisms.
Chhattisgarh	Encourages municipal wastewater reuse.	No targets or enforcement mechanisms.
Jharkhand	Recognises treated wastewater as a resource.	Weak social acceptance of reuse for irrigation.

Source:https://www.downtoearth.org.in/water/policy-and-governance-roadblocks-are-the-biggest-challenges-to-treated-water-reuse

4.3. Vision and Targets for Circular Economy Transition

4.3.1. Circular Economy Vision for Industrial Wastewater

To create closed-loop water cycles in industries and industrial areas that ensure 100% of reuse of wastewater generated and reduce freshwater withdrawal by integrating resource efficiency, climate adaptation, along inclusive economic development.

Table 4-2: SMART goals

S.No.	Proposed Target	Target by 2030
1	The quantity of treated wastewater that will be reused in water-intensive industries (such as thermal power plants, pulp & paper, textile, iron & steel industries, etc.) as a percentage of their total freshwater consumption.	40%
2	The quantity of wastewater recovered in ETPs and CETPs as a percentage of their total wastewater handled.	80%
3	New industries to adopt Zero Liquid Discharge Systems or ensure that no liquid effluent is discharged outside their premises as a percentage of the total number of new industries being established.	80%
4	Percentage of new industrial clusters/parks established after the year 2024 having provision for ZLD-CETP as a percentage of the total number of industrial clusters/ parks that are being established.	80%
5	Reduction in raw water consumption by replacing it with treated water in industrial units	20%

4.4. Enablers and Implementation Framework

Factors that would aid towards achieving the vision would principally be:

1. Mandatory wastewater reuse targets for industries, municipal corporations, and housing societies.
2. Market entry support by the Government mandating the usage of treated water in specific sectors
3. Incentivising wastewater reuse by way of capital support, tax holidays, etc, as well as extended producer responsibility credits.
4. Developers of Industrial Parks/ clusters to include building infrastructure to recycle wastewater as part of their project, and include the associated costs as part of the land/infrastructure development cost
5. Developing infrastructure based on the best available, proven and appropriate technologies for the treatment and reuse of wastewater
6. Encouraging utilisation of treated water in multiple applications such as agriculture, horticulture, industrial cooling, toilet flushing, and for rejuvenation of waterbodies after ensuring quality requirements.
7. Regulatory controls that ensure robust monitoring, as far as possible, using digital tools, discharge norms, illegal withdrawal of groundwater, and sustainable handling of sludge

8. Community and stakeholder involvement
9. Extend financial and technical assistance to industries for upgrading wastewater treatment and recycling facilities.
10. Policy directives as elaborated in earlier paragraphs, which will enable desired interventions in the areas of water conservation, water replenishment and water restoration.These ultimately lead to water-positive strategies and net-zero impact strategies.
11. Business mode; that promotes a collaborative approach and responsibility-Projects to be implemented on a PPP model with the designer, developer having a long-term responsibility in the effective functioning of the project.
12. Effective sludge management by adopting processes for resource and energy recovery from sludge.

Table 4-3: Implementation Roadmap

Target No. 1: **Target Description: Achieve reuse of 40% treated wastewater in water intensive industries**			
Policy Related Initiatives			
Proposed Initiative/ Measure	Action Item	Timeline	Proposed Owner for Implementation
Introduce mandatory reuse quotas for industries	Frame sector specific guidelines, Integrate quotas into Consent to operate conditions	2025-2027	MOEFCC, CPCB, SPCB
Capital subsidies & tax benefits for reuse projects	Implement wastewater reuse incentive scheme that encourages industries to shift from freshwater to recycled sources; Link with CPCBs extended user responsibility program	2026-2030	MOEFCC, State and central government
ZLD compliant CETPs in all new industrial parks/ SEZ	Mandate by way of provisions in environmental clearances, financial closure, Consent to operate	2025-2028	MOEFCC, Industrial infrastructure development corporations, SPCB
Public Private Partnerships in Project Development			
Proposed Initiative/ Measure	Action Item	Timeline	Proposed Owner for Implementation
Set-up under PPP model wastewater reuse plants	Developer-led-design-build-operate models for reuse project contracts	2025-2030	Urban Local Bodies (ULB), Industrial Development Corporation's (IDC), SPCB
Research and Development			
Proposed Initiative/ Measure	Action Item	Timeline	Proposed Owner for Implementation
Develop pilot reuse projects and AI based monitoring systems	Fund AI/ IoT projects developed for monitoring and compliance	2025-2029	CPCB

Target No. 2 Target Description: Ensure 80% of new industries to adopt Zero Liquid Discharge (ZLD)			
Policy Related Initiatives			
Proposed Initiative/ Measure	Action Item	Timeline	Proposed Owner for Implementation
Mandate ZLD conditions in industry licences and regulatory approvals	Project proposals to include ZLD provisions	2025-2026	MoEFCC, CPCB, SPCBs
Capital subsidies & tax benefits and other financial incentives for ZLD infrastructure	Implement relevant schemes	2025-2028	MOEFCC, State and central government
Public Private Partnerships			
Proposed Initiative/ Measure	Action Item	Timeline	Proposed Owner for Implementation
Projects on PPP basis	Identify techno-commercially competent organisations for partnership. Government to support with speedy approvals and viability gap funding	2025-2029	IDC
Circular Economy Initiatives			
Proposed Initiative/ Measure	Action Item	Timeline	Proposed Owner for Implementation
Mandate integrated systems comprising energy and resource recovery from wastewater, sludge	Integrate energy and recovery measures into project proposals	2025-2030	CPCB,SPCB
Research and Development			
Proposed Initiative/ Measure	Action Item	Timeline	Proposed Owner for Implementation
Fund sludge valorisation and reuse trials	Pilot valorisation projects and co-processing of ZLD sludge with RDF	2026–2029	CPCB
Target No. 3 **Target Description: Provide ZLD-CETP in 80% of new industrial clusters**			
Policy Related Initiatives			
Proposed Initiative/ Measure	Action Item	Timeline	Proposed Owner for Implementation
CETP provision to be mandated in land development plans	Develop CETP along with park/cluster development. Provide pipeline network. Cost of developing CETP to be made part of land price	2025–2028	State Industries Dept, SPCB
Mandate in industry licences and regulatory approvals	Project proposals to include ZLD provisions	2025-2026	MOEFCC
Capital subsidies & tax benefits and other financial incentives for ZLD infrastructure	Implement relevant schemes	2025-2028	MOEFCC, state and central government

Public Private Partnerships			
Proposed Initiative/ Measure	Action Item	Timeline	Proposed Owner for Implementation
Integrated cluster wastewater projects	Bidding under hybrid annuity mode for new clusters	2025–2030	State Water Boards, CPCB
Circular Economy Parks			
Proposed Initiative/ Measure	Action Item	Timeline	Proposed Owner for Implementation
Multi-utility reuse corridors	Integrate common treatment, reuse, and pipeline distribution	2025–2028	Industrial Corridors SPCs
Research and Development			
Proposed Initiative/ Measure	Action Item	Timeline	Proposed Owner for Implementation
Smart water balance system prototype	Use digital tools for industrial water circularity	2027–2030	NITI Aayog, CPCB, IITs
Target No. 4 **Target Description: Achieve 20% reduction in freshwater consumption in industrial units through treated water substitution**			
Policy Related Initiatives			
Proposed Initiative/ Measure	Action Item	Timeline	Proposed Owner for Implementation
Sectoral freshwater reduction mandates	Implement progressive yearly freshwater use reduction targets	2025–2030	SPCBs, State Industries Dept
Economic Instruments			
Proposed Initiative/ Measure	Action Item	Timeline	Proposed Owner for Implementation
Penalty/rebate model based on freshwater use	Tax rebate for threshold use; surcharge above target	2026–2030	MoEFCC, CPCB
Public Private Partnerships			
Proposed Initiative/ Measure	Action Item	Timeline	Proposed Owner for Implementation
City-industry reuse supply projects	Partner ULBs and industries for treated sewage reuse	2025–2028	MoHUA, State Urban Utilities
Circular Economy Initiatives			
Proposed Initiative/ Measure	Action Item	Timeline	Proposed Owner for Implementation
Rainwater harvesting and industrial recycling hubs	Combine rainwater lines with treated wastewater networks	2025–2029	State SPCBs, Smart City Missions
Research and Development			
Proposed Initiative/ Measure	Action Item	Timeline	Proposed Owner for Implementation
Data-driven reuse planning tools	Develop models for demand forecasting in circular systems	2027–2030	DSIR, IITs, CEEW

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Chapter 5

CIRCULAR ECONOMY ACTION PLAN FOR SCRAP METAL

India is at an inflection point for scrap-metal circularity. Rapid steel expansion, rising demand for Electric Arc Furnace (EAF)-based (scrap-fed) production, and ambitious national targets mean scrap is now a strategic raw material. Domestic scrap supply today falls short of demand; imports surged in the early 2020s to fill the gap. The sector is dominated by a fragmented feedstock base and an extensive informal value chain that recovers much of the material but faces health, quality and traceability challenges. Policy initiatives (Steel Scrap Recycling Policy, Vehicle Scrappage Rules etc.), corporate pilots, and digital marketplaces are promising, but large gaps remain in aggregation, quality standardisation, financing, data transparency and formal integration of informal actors. This report provides a baseline, identifies gaps, proposes a clear 2030 target set (SMART), and presents an enablers-led implementation framework (policy, financing, infrastructure, skills, PPP and monitoring) with prioritized short-, medium- and long-term actions.

5.1. Material Landscape and Circularity Baseline

5.1.1. Overview of Material Value Chain

(a) **Primary Supply**

The metal value chain begins with Raw Material Extraction through mining of ores of iron, bauxite, copper, etc., Manufacturing processes which typically includes casting, forging, machining all of which are energy-intensive in nature and release substantial CO_2. Steelmaking is done through Blast Furnace-Basic Oxygen Furnace (BF-BOF) and Direct Reduced Iron (DRI)

(b) **Secondary Supply (Scrap)**

When the product reaches the End of Life, a large portion of scrap collection in India occurs through informal channels, which often lack proper environmental controls, leading to health hazards and pollution. Scrap metal originates from three sources – Industrial Scrap (New Scrap), Obsolete / Post-consumer scrap (Old Scrap) and Speciality Industrial Scrap. The scrap value chain usually follows the steps as below:

(i) Collection - Managed by household Kabadiwalas, waste-pickers, or formal collection centres

(ii) Segregation / Sorting – Often manual in the informal sector, while formal players use advanced sorting and separation systems

(iii) Processing – Includes shredding, baling, shearing, and sometimes de-coating or de-oiling to make scrap suitable for re-melting

(iv) Re-melting & Refining – Conducted by Electric Arc Furnaces (EAFs), Induction Furnaces, and Basic Oxygen Furnaces (BOFs) in secondary steel and foundry plants

(v) Manufacturing – Recycled metal is then used to make new products, completing the circular loop

5.1.2. Importance of Scrap metals

Scrap metal is crucial for several strategic sectors of the Indian economy:

- Steel and Construction: Scrap as a core feedstock for EAFs and for blending in BOF / DRI routes supports steel production by reducing reliance on iron ore
- Automotive: Recycled metals, ferrous and non-ferrous (Copper & Aluminium) reduce manufacturing costs & enhance energy efficiency. Vehicle Scrappage can also unlock steady feedstock
- Electronics and Electrical: Supplies essential Copper and Aluminum for components and wiring.

- Energy: Essential for renewable infrastructure, including wind turbines, solar panels, and Electric Vehicles (EVs).
- Defence and Aerospace: Critical recycled metals like Titanium and Aluminum lower costs and environmental impact in these sectors.

India produces nearly 25 million tonnes of scrap annually but imports an additional 5 to 7 million tonnes to meet the market demand. Imported scrap also becomes necessary as the domestic sector is fragmented and weak.

Table 5-1: Environmental Gains from Circular Use of Scrap

Utilisation	Savings
Recycling of 1 Ton of Scrap metal	Avoids 1.5 MT CO_2 emissions Saves 1.4 MT of iron ore (mining) Avoids 0.740 MT coal consumption Avoids 0.120 MT of limestone consumption Reduces raw material extraction impacts and landfill burdens
Usage in steel production	Lowers energy by 16-17% Lowers water consumption by 40% GHG emissions drop by 58%

Recycling and Reprocessing is more energy-efficient than primary production; for instance, recycling Aluminum saves up to 95% of the energy required for virgin production.The recycled materials re-enter the system as Secondary Raw Material, reducing demand for virgin resources, as metals like Steel and Aluminum can be recycled indefinitely without quality loss.

Conversely, negative impacts arise primarily from poor handling include:

- Scrap corrosion releases particulates and toxic compounds into the air
- Toxic metals (lead, mercury, cadmium) leach into soil, affecting fertility and entering the food chain.
- Leaching also contaminates groundwater, rivers, and lakes.
- Disposal in landfills leads to resource loss and contamination.
- Informal workers are prone to respiratory & neurological disorders) due to lack of protective gear.

5.1.3. Domestic – Global Linkages

India's scrap metal ecosystem functions within an interconnected domestic and international network. While domestic generation of scrap is steadily increasing, it remains insufficient to meet growing demand from the secondary steel and non-ferrous metal industries.

To bridge this gap, India imports large volumes of ferrous and non-ferrous scrap, primarily from the United States, United Kingdom, United Arab Emirates, and Europe.These imports are crucial for sustaining EAF-based steelmaking and ensuring material continuity for domestic industries.

Conversely, scrap exports occur where local processing capacity and price conditions make it viable. Trade dynamics are strongly influenced by global commodity prices, government trade policies, and shipping or logistics costs.Together, these domestic and global linkages make India a significant participant in the global scrap trade, connecting local recyclers and processors to international markets

5.1.4. Market Trends & Growth Projections

The scrap metal market is projected to expand at an 8.4% Compound Annual Growth Rate (CAGR) between 2020 and 2026, reaching $22 billion by 2026. Key drivers include urbanization, increasing demand for recycled materials, and government support. India's crude steel capacity is forecasted to grow to over 300 million tonnes by 2030. By FY30, scrap demand is projected to reach 65 million tonnes.

Scrap prices follow global ferrous and non-ferrous commodity cycles, impacted by China, South Korea, and Europe demand and regional logistics; sudden policy changes and tariffs can create volatility.

5.1.5. Supporting Practices and Policies

India aims to increase the share of scrap metal in steel production to 50% by 2047. Key government policies include:

i. National Steel Scrap Recycling Policy (2019) - Encourages scientific scrapping centers, Hub-and-Spoke models and formalised collection to improve scrap quality and availability.

ii. Vehicle Scrappage Policy (2021) - Recovery of valuable metals from end-of-life vehicles (ELVs) and provisions to integrate informal sector

iii. Draft EPR (Extended Producer Responsibility) for non-ferrous metals (Aluminum, Copper, Zinc), effective April 1, 2025 mandate minimum recycled content in products and sets recycling targets for producers.

iv. The concept of Urban Mining, recovering metals from discarded electronic goods, is also promoted.

v. State industrial policies, public procurement rules (localization), and recent national policy actions on green steel/classification may indirectly encourage recycled content and demand for scrap

5.1.6. Recent Innovations

Indian innovation to transition the scrap metal sector from fragmented and informal to a structured, regulated system includes the development of digital platforms to formalize trading, such as FerroHaat (a 24x7 marketplace by Tata Steel) and MetalMandi (an AI-driven platform designed to bring transparency and fair pricing to scrap trading).

5.2. Gaps and Challenges in Advancing Circularity

5.2.1. Policy Gaps and Trade Barriers

Policy progress is hampered by insufficient national data on scrap generation / flaws and weak regulatory enforcement. For international trade, exporters face barriers related to regulatory and customs complexity, including strict rules regarding safety, quality, pre-shipment inspection certificates (PSIC), and accurate HS codes. The upcoming European Union Waste Shipment Regulation will impose new compliance burdens on non-OECD countries importing scrap from the EU, potentially shifting advantages toward OECD members like Turkey.

5.2.2. Material Specific Challenges and Feedstock Availability

In the BAU scenario, the fragmented sector of domestic scrap generation is unlikely to meet rising demand. Consequently, India remains reliant on imports, with a projected supply gap requiring 20 to 30 million tonnes of imports annually by 2030. Relying on imports long-term is unsustainable, especially as other countries increasingly impose export restrictions on scrap. The slow implementation of End-of-Life Vehicles (ELV) rules on the ground hinders adoption of reverse logistics for dispersed ELVs while large assets (ships, infrastructure) remain underdeveloped.

Quality concerns, such as contamination or improper sorting, affect the final value of the scrap. Additionally, the demand for imported ferrous scrap faces recurrent threats from cheaper alternative metallics, such as Direct Reduced Iron (DRI) or Hot-Briquetted Iron (HBI), which steelmakers often opt for when imported scrap prices are high. Non-ferrous scrap (Copper, Aluminium) often commands higher value but needs specialised processing.

5.2.3. Informal Sector Dominance

Informal waste management sector handles about 60% of India's scrap metal but lack formal recognition, bargaining power, and safety nets. This sector is unregulated, relying on inefficient, manual methods for collection and sorting, which leads to contamination and difficulty in producing high-quality scrap for reuse. This hinders effective tracking and monitoring of materials. The lack of transparency in these markets often leads to inefficient pricing and exploitation of small collectors. Unsafe practices, such as burning insulated wires, release toxic fumes, damaging both the environment and worker health.

5.2.4. Infrastructure & Technology Gaps

India faces shortage of formalized scrap collection and processing infrastructure. As per Steel Scrap Recycling Policy, to meet growing metal demand, approximately 70 new scrap processing centers and 300 collection centers need to be established. Moreover, the Mills need consistent, certified scrap qualities to integrate more secondary feedstock. The existing infrastructure has inconsistent access to mechanised dismantling, sorting, demagnetising, shredding and de-contamination tech resulting in inefficient processing and impurities in recycled metals. High Capex requirements for recycling plants, coupled with thin profit margins, often deter private investment.

5.2.5. Awareness & Skill deficits

- Limited industry awareness on design for recyclability and low adoption of systematic EPR-like schemes for metal-intensive products.
- Skill gaps in formalised dismantling, quality testing and occupational safety.

5.2.6. Case Studies

International examples demonstrate proven paths toward advanced circularity:

- Formalization (China): China became the world's largest scrap recycler by formalizing its industry and integrating technology into transactions.
- Public-Private Partnerships (Netherlands): Collaborative models encourage industries to include recycled content in products, such as Tata Steel Netherlands incorporating 30% recycled content.
- EPR Policies (Japan): Japan's Extended Producer Responsibility mandates manufacturers to manage the end-of-life disposal of products, leading to a 98% recycling rate for automobiles.
- Advanced Recycling Technologies (Europe): The EU utilizes sensor-based sorting to improve the purity and recovery efficiency of recycled metals.
- EAF Steelmaking (U.S.): In the U.S., 70% of steel is produced via the Electric Arc Furnace (EAF) route, which is far less polluting, reducing energy consumption and carbon emissions by 75% compared to traditional production.
- Zero-Waste Plants (Sweden): The Swedish steel industry uses by-products like slag for construction, achieving high recycling rates.

5.3. Vision and Targets for Circular Economy Transition

5.3.1. Vision Statement

The goal is to transition the scrap metal sector from its current informal, fragmented state to a structured, regulated system that integrates the informal sector and establishes robust nationwide infrastructure. This approach will streamline scrap metal collection, processing, and recycling to reduce dependency on metal imports and foster efficient resource utilization. By adopting circular design principles, particularly in high-impact sectors like automotive, construction, and electronics, and leveraging Public-Private Partnerships (PPP), India aims to establish itself as a global leader in scrap metal recycling, supporting sustainable economic growth, environmental stewardship, and resource independence.

5.3.2. SMART Targets

The following targets are based on existing government policies, draft regulations (Hazardous and Other Wastes Rules, 2024), and industry projections derived from the sources.

Table 5-2: Targets

Goal/Target	Current Status	2030 Target
Share of Scrap in Steel Feedstock	The share of scrap used in steel production is approximately 20-22% in early 2020s. India's steel production via the Electric Arc Furnace (EAF) route is currently 28%.	**35%** *Basis: The government's long-term target is for scrap to form 50% of the total feedstock in steelmaking by 2047. The share of EAF-based steelmaking capacity is expected to reach 50% by 2030.*
Steel Scrap Recycling Rate (%)	The current steel scrap recycling rate is 30%.	**90%** *Basis: Target set to align with the current global average and national circularity goals. This can be supported by setting another target of achieving 30% average recycled content in domestic structured steel by 2030.*
Registered Vehicle Scrapping Facilities (RSVF) and Formal Scrapping Centers	India has limited coverage, with only a few dozen operational and more under planning. It requires approximately 70 new scrap processing centers and 300 collection centers.	**100%** *Basis: Aligns with the National Steel Scrap Recycling Policy (2019).*
Formalization of Informal Sector (%)	The informal sector handles a majority (likely at least 60%) of the country's scrap metal.	**80%** *Basis: Aligns with the National Steel Scrap Recycling Policy (2019).*
Recycling Target for Non-Ferrous Metals (EPR Obligation)	EPR obligation for non-ferrous producers starts at 10% in FY 2025-26.	**50%** *Basis: Extended Producer Responsibility (EPR) recycling obligations of the draft Hazardous and Other Wastes Rules, 2024.*
Minimum Recycled Content	Minimum requirement is 5% starting FY 2027-28 for all listed non-ferrous metals.	**Aluminium: 10% Copper: 20% Zinc: 25%** *Basis: Draft Hazardous and Other Wastes Rules, 2024*
Crude Steel Capacity	Current capacity has crossed 161 million metric tonnes per year (MMt/y).	**300 MMt/y** *Basis: Aligns with the National Steel Scrap Recycling Policy (2019).*

5.4. Enablers and Implementation Framework

5.4.1. Policy Interventions & Market Based Instruments

Policy interventions are necessary to transition the sector toward circularity and formalization.

i. **Developing National Scrap Data Potal:** Develop a national database to track scrap metal generation, collection, recycling rates, flows, prices and quality (aggregated from municipal, industrial, RSVF, customs datasets) to enable data-driven decision-making and policy adjustments.

ii. **Quality & grading standards:** Bureau of Indian Standards (BIS) or Ministry of Steel standards for scrap grades and certification labs to reduce uncertainty.

iii. **Market Indexation:** Promote indexation and transparent pricing methodologies for ferrous scrap. While the market currently relies on bilateral spot purchasing due to fluctuating finished steel demand, increasing uniform, long-term procurement based on transparent price indices will enhance market stability and accountability

iv. **EPR for Non-ferrous metals:** Expand and enforce EPR policies to mandate that industries take responsibility for the end-of-life management of their products and enforce regulatory mandates requiring the inclusion of recycled content in products to drive demand for scrap.

5.4.2. Financing Tools/Incentives

Financial mechanisms are crucial to overcome the high capital expenditure associated with recycling infrastructure.

i. **Green bonds & climate finance** for large circular infrastructure (shredders, remanufacturing lines, CE parks)

ii. **Blended finance & Viability Gap Funding (VGF)** for initial capex-intensive circular parks and RVSFs in underserved regions.

iii. **Incentives for Recycled Content:** Tax incentives, subsidies, and financial support for companies that adopt recycled materials and implement circular design principles.

iv. **Public Procurement:** Promotion of green steel by using public procurement policies to highlight its environmental benefits and encourage wider adoption.

v. **Working capital facilities & receivables financing** for aggregator networks to smooth cash flows and encourage formal grading & traceability.

5.4.3. Infrastructure

Addressing the infrastructure deficit is critical, given the need for approximately 70 new scrap processing centers and 300 collection centers.

i. **Processing Centers:** Establish new processing and collection centers utilizing a 'Hub-and-spoke' model to address regional infrastructure gaps and streamline collection, sorting, and metal recovery.

ii. **Circular Economy Parks:** Co-located shredders, metal processors, labs, reman facilities and testing labs near steel clusters and ports to reduce transport costs and support exports.

iii. **Regional RVSFs / Aggregation hubs:** State-led procurement of small RVSFs in partnership with industry – focus on industrial corridors.

iv. **Port Infrastructure:** Invest in improving port infrastructure (including customs clearance systems, radiation scanning, and container handling capacity) to reduce turnaround times and lower clearance risks for scrap consignments.

5.4.4. Investment Technology Development

Technological adoption is essential for improving scrap purity and processing efficiency.

i. **Advanced Processing Technology:** Invest in modern recycling technologies, such as automated sorting, shredding, and advanced alloy identification techniques (like spectroscopy analysis and XRF analysis).

ii. **Efficiency Tools:** Promote the adoption of data analytics and AI-powered sorting systems to increase process optimization and quality control.

iii. **Digital Traceability (Digital Product Passport):** QR / Blockchain tagging for high-value scrap consignments to improve chain-of-custody

iv. **Shredding & Baling standardisation:** Utilize equipment like baling machines to compress and package scrap materials to create mill-ready scrap bales.

v. **Decarbonization Technology:** Encourage investment in and expansion of the Electric Arc Furnace (EAF) and Induction Furnace (IF) routes for steelmaking, which utilize scrap as a prime feedstock

5.4.5. Promotion of PPP & industrial consortia

Public-Private Partnerships are essential for bridging investment and innovation gaps.

i. **Joint Funding:** Foster PPPs to jointly fund and develop CEPs and RVSF networks with off-take guarantees with industries.

ii. **Co-investment:** Incentivize private industries to co-invest in advanced recycling technologies, creating a circular economy based on shared responsibilities and collective benefits.

iii. **OEM-led takeback programmes** in automotive and appliances sectors with PRO arrangements.

5.4.6. Capacity & Awareness building

i. **Upskilling:** Government-led initiatives should focus on upskilling informal workers (aligned with NSDC / state skill missions) by providing training and access to modern recycling tools to operate advanced equipment and adopt safer practices, thereby enhancing both recycling efficiency and worker safety.

ii. **Formalisation Drives to register,** KYC and provide social safety nets via ULBs and welfare boards.

iii. **Citizens' campaigns** to segregate ferrous and non-ferrous scrap at source (RWAs, market associations).

iv. **Industry workshops** on design for recyclability and procurement of recycled content steel.

v. **Green Steel Promotion:** Actively promote Low-Carbon Emission Steel (green steel) as a premium product in the market, highlighting its environmental advantages to both consumers and industries.

5.4.7. Initiatives/Measures/Actions with Prioritization

The targets, goals, and enabling strategies outlined earlier form the foundation for a comprehensive implementation road map (presented in **Table 5-3**). This roadmap will serve as a strategic guide to systematically achieve the defined objectives by translating high-level targets into concrete actions. The table below details specific initiatives and activities, mapped against the targeted outcomes, along with estimated timelines, key ownership, and responsible stakeholders. These actions encompass a range of critical areas, all aimed at ensuring a structured, coordinated, and impactful pathway toward sustainable waste management and circularity.

Table 5-3: Proposed Priority Actions to Achieve Circular Economy Targets

Target No. 1: Enhance Steel Circularity *(Achieve 35% of Scrap in Steel Feedstock & 90% Steel Scrap recycling rate by 2030)*				
Category	**Proposed Measure**	**Action Item**	**Timeline**	**Stakeholder for Implementation**
PPP	Transition Steelmaking Capacity	Investment in new Electric Arc Furnace (EAF) and Induction Furnace (IF) capacity to meet the 300 MMt/y target by 2030 and reduce reliance on energy-intensive blast furnace routes.	Long term	Industry (Steel Manufacturers)
Economic Instrument	Incentives for transition	Provide Incentives for low-emission production (EAF / IF)	Long term	Ministry of Steel
PPP	Advance Technology and QC	Invest in modern recycling technologies (Ex: AI-powered sorting, shredding, and advanced alloy identification techniques)	Medium Term	Industry (Steel Manufacturers)
Standard Development	Quality & grading standards	Establishing standards for baling, scrap grades and certification labs to reduce uncertainty	Medium Term	BIS, Ministry of Steel
Research & Development	Producing high-quality shredded scrap	Producing quality shredded scrap with higher yield (≥90%) in furnaces compared to cheaper alternative metallics like HBI.	Short term	Industry, Academia
Target No. 2: Build Infrastructure for Formal Sector *(Establish 70 processing centers, 300 collection centers, & achieve 80% formalisation of informal sector)*				
Category	**Proposed Measure**	**Action Item**	**Timeline**	**Stakeholder for Implementation**
Circular Economy Parks, PPP	Establish new infrastructure (Hub & Spoke Model)	Identifying lands for establishing 70 processing & 300 collection centers with advanced technology (Ex; Shredders & automated sorters), CEPs, RSVFs with offtake guarantees	Medium - Long term	State and ULBs, Industry
Economic Instruments	Financial Viability	Provision of green bonds, VGF, Tax incentives, blended finance for capital intensive CEPs and RVSFs	Medium Term	State / ULBs, MDBs, Ministry of Finance
Capacity Building	Formalization of Informal Sector	Registration, upskilling, access to modern recycling tools, and provide social safety nets via welfare boards	Short - Medium term	Central / State Government, Industry (PPP)
State Support	Port Infrastructure	Invest in improving port infrastructure (including customs clearance systems, radiation scanning, and container handling capacity)	Short-Medium term	Central and State Government
PPP	Launch Digital Trading Platforms	Develop and scale AI-driven platforms to bring transparency, ensure fair pricing, and formalize transactions	Short term	Industry, CII / Metal Platforms

Target No. 3: Enforce Non-ferrous EPR *(Achieve 50% recycling target and mandated minimum recycled content for Non-Ferrous Metals)*				
Category	**Proposed Measure**	**Action Item**	**Timeline**	**Stakeholder for Implementation**
Policy-related initiatives, PPP	Achieving EPR Targets	Achieve specified recycled content and meet recycling quotas for non-ferrous producers. Establish robust compliance mechanisms including penalties for non-compliance	Medium term	MoEF&CC, Industry (Manufacturers)
Policy-related initiatives	Promote Urban Mining	Promote Urban Mining to recover valuable metals from e-waste	Short term	Central / State
PPP	Digital Traceability	Utilising QR / Blockchain tagging for consignment movement	Short term	Industry
Target No. 4: Increase Steel Production Capacity ***(Achieve 300 MMT / yr Crude Steel Capacity)***				
Category	**Proposed Measure**	**Action Item**	**Timeline**	**Stakeholder for Implementation**
Circular Economy Park	Authorized centres	Establish authorized scrapping facilities linked to the Vehicle Scrappage Policy	Short term	Industry (Automotive)
PPP	Data Management and Accountability	Develop a National Scrap Data Portal to track scrap metal generation, collection, flows and recycling rates to enable data-driven decision-making.	Short term	MoS / Central Govt
Economic instruments	Development of Indexes	Promote indexation and transparent pricing methodologies for ferrous scrap to enhance market stability and accountability.	Short term	MoS / Industry
Standard Development	Development of Standards & LCA studies	Establish regional test laboratories and conduct LCA and quality benchmarking studies	Short term	State, Academia, CSIR Labs

Note: MoS – Ministry of Steel, MoRTH – Ministry of Road, Transport & Highways

Table 5-4: Implementation Risks and mitigation

Implementation Challenge	Mitigation Strategy
Insufficient Domestic Supply (Supply Gap of 20-30 MMt)	i. Develop the full network of 70 processing and 300 collection centers. ii. Promote Urban Mining to recover valuable metals from e-waste.
Competition from Cheaper Alternative Metallics (DRI/HBI)	i. Focus on producing high-quality shredded scrap, which offers a higher yield (over 90%) in furnaces compared to HBI ii. Fund local testing labs and BIS grading for quality testing. iii. Promote EAF usage, which prefers scrap as feedstock.
Regulatory/Customs Complexity for Imports	i. Utilize digital trading platforms that standardize documentation (HS codes, PSIC) and track compliance. ii. Improve port infrastructure for faster clearance.
High Capital Expenditure in Recycling Plants	i. The government must provide financial support through low-interest loans, blended finance, VGF and public procurement guarantees to share the investment burden.
Dominance of Fragmented Informal Sector	i. Formalize the sector by integrating informal workers through training, providing access to modern tools, providing social security bundles and offering financial incentives, ensuring efficient and safe processing.

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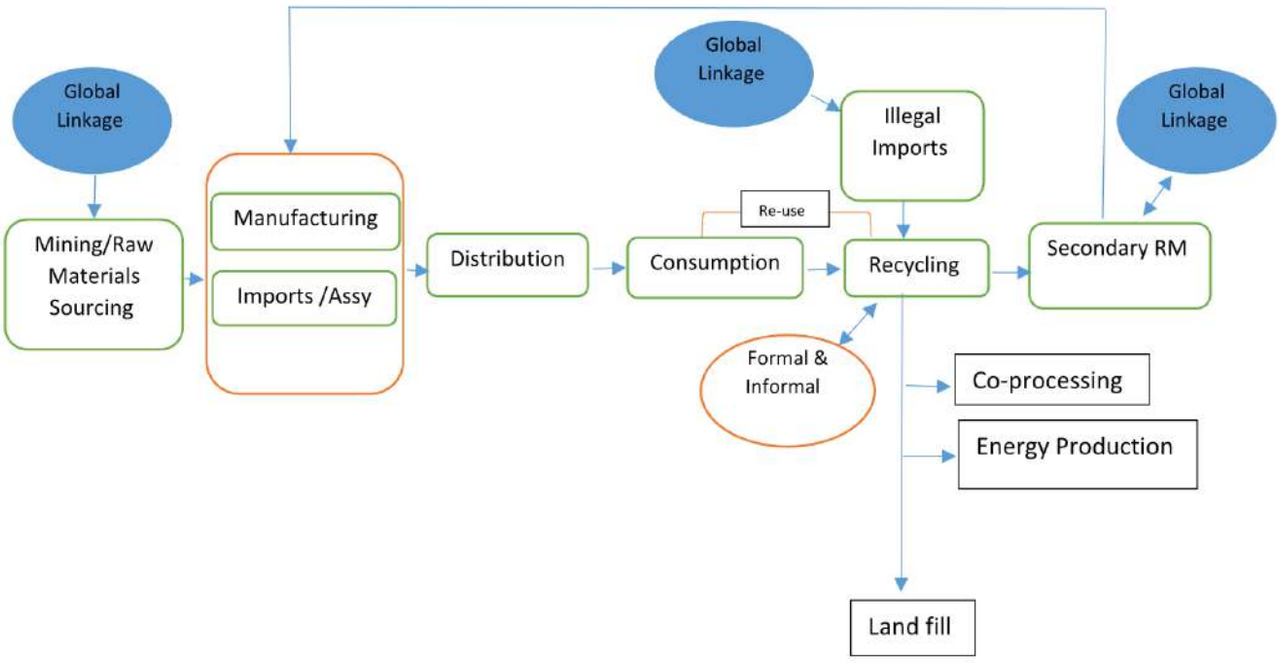
Chapter 6

CIRCULAR ECONOMY ACTION PLAN FOR E-WASTE

6.1. Material Landscape and Circularity Baseline

India stands as the third-largest generator of electronic waste globally, producing over 1.6 million tonnes annually, with projections expected to reach 5 million tonnes by 2030. This surge is fuelled by rapid digital adoption, urban growth, and increasingly shorter electronic product lifecycles. Despite the establishment of formal recycling frameworks, the informal sector processes most of the e-waste—over 85%—often through hazardous and environmentally damaging methods. This leads to significant pollution, health risks for workers, and loss of valuable recoverable materials such as gold, copper, and rare earth metals.

Fig 6-1: Stages of E-waste value chain in India



Majority of Indian recycling sector is still dependent on the informal sector process. The informal sector is also linked globally through imports of E-waste or re-usable electronic items that contributes to the E-waste pollution.

E-wastes were estimated to contain 31 billion kg of metals, 17 billion kg of plastics, and 14 billion kg of other materials (minerals, glass, composites, etc.,) [2]. Following are some key excerpts from Global E-waste Monitor, 2024:

- An estimated 19 billion kg of e-waste, mainly from metals like Iron which is present in high quantities and has high recycling rates in almost all e-waste management routes, were turned into secondary resources.
- Platinum-group metals and precious metals were among the most valuable metals but present in much lower quantities; nonetheless, an estimated thousand kg were turned into secondary resources through formal and informal recycling practices.

This is agreed well with the scientific community as the latest research is focussed on extraction of precious metals (Ag, Au, Pt, Pd, etc.,) and Rare Earth Elements (Ta, Ga, etc.,) particularly from Waste Printed Circuited Boards, contributing a mere (3-6%) of the E-wastes because these elements are often found in quantities 'larger than their natural ores' [5, 6].

6.2. Gaps and Challenges in Advancing Circularity.

The E-Waste (Management) Rules, 2022, introduced Extended Producer Responsibility (EPR) and mandate collection and recycling targets. However, enforcement challenges and fragmented implementation across states limit their effectiveness. To move towards a circular economy, India requires scaling up formal recycling infrastructure, integrating informal workers into regulated systems, enhancing eco-design and repair initiatives, and increasing public awareness about responsible e-waste management. Strengthening these areas will be vital for India to transform e-waste from a growing environmental liability into a valuable resource stream supporting sustainable development and economic resilience.

Table 6-1: Technological gaps

Sector	Contributions to Advance circularity	Gaps
Formal and Informal Sectors in India	• Most processes are limited to surface leaching, • Recovery of base metals, • Recovery of few precious metals - Gold, Silver, Palladium	• All other rare earth & Critical metals are not recovered, • Low Recovery efficiency technologies. • Low volumes handled due to inefficient sourcing.

Table 6-2: Material specific challenges

Materials in E-waste	Challenges in Recycling
Rare Earth Metals	Extremely difficult to extract due to low concentrations and complex bonding
	Recycling processes are energy-intensive and costly.
	Lack of scalable technology for REM recovery limits circularity
Batteries	Poor Labelling and Design make sorting & recycling Harder
Plastics	Mixed & Brominated plastics - Difficult to recycle
	Flame retardants in plastics pose toxicity risks during melting or incineration
	Limited markets for recycled e-plastics due to contamination and degradation.
Printed Circuit Boards (PCBs)	Composed of metals, fiberglass, and resins tightly fused together.
	Require advanced mechanical and chemical separation.
Mercury, Lead, and Other Hazardous Materials	Pose serious health and environmental risks if not properly handled
	Require controlled environments and trained personnel for safe disposal
Mixed Alloys and Solder	Solder contains lead or tin, which complicates metal recovery.
	Mixed alloys in connectors and casings are hard to separate and purify.
Glass and Ceramics	CRT glass contains lead and phosphors, making it hazardous.
	Ceramics in capacitors and insulators are non-recyclable and add bulk.

Table 6-3: Feedstock availability (subscale/fragmented) and feedstock aggregation (inefficient/economic viability)

Subscale and Fragmented Feedstock Availability	*Dispersed sources: E-waste is generated by households, businesses, and institutions in small, scattered quantities*
	low collection rates: In India, only about 22.7% of e-waste is formally collected
	Informal sector dominance: A large portion is handled by informal recyclers, who rarely channel waste into formal systems.
	Lack of reverse logistics: Few mechanisms exist for consumers to return used electronics, especially in rural areas.
Inefficient Feedstock Aggregation	*High transportation costs: Collecting small volumes from multiple locations is logistically expensive.*
	No centralized hubs: Absence of regional aggregation centres leads to inconsistent supply for recyclers.
	Poor traceability: Without digital tracking, recyclers struggle to forecast material flows and plan operations
	Limited incentives: Producers and consumers lack financial motivation to participate in take-back or aggregation schemes.
Economic Viability Challenges	*Economic Viability Challenges*
	Volatile material prices: Market fluctuations in recovered metals affect profitability.
	High upfront investment: Advanced recycling technologies require significant capital, which is risky without guaranteed feedstock.

Table 6-4: Informal sector dominance and competitive viability issues

Informal Sector Dominance	*Handles up to 90% of e-waste in countries like India*
	Operates through door-to-door collection, auctions, and imports.
	Informal workers dismantle, sort, and extract valuable materials using unsafe methods like acid leaching and open burning
	Extracted metals and refurbished electronics are sold in second-hand markets or exported, often bypassing formal channels & taxes
Competitive Viability Challenges for Formal Sector	*Higher operational costs: Formal recyclers must comply with environmental and labour regulations, increasing expenses.*
	Limited feedstock access: Informal collectors intercept e-waste before it reaches formal systems, reducing supply.
	Weak enforcement of EPR: Producers often fail to meet collection targets, and informal channels remain unregulated
Systemic Gaps	*Fragmented supply chains: Lack of centralized collection and tracking systems makes aggregation inefficient.*
	Poor consumer awareness: Many users prefer informal collectors for convenience or small cash incentives.
	Limited collaboration: Few models exist to integrate informal workers into formal systems, despite their reach and expertise.

Table 6-5: Lessons from best practices - Case Studies (both India and International)

Switzerland's National E-waste System	*Advanced Recycling Fee (ARF): As a core principle of Extended Producer Responsibility (EPR), Swiss consumers pay an Advance Recycling Fee when they purchase new electronics. This fee covers the cost of collection and processing at the end of the product's life.*
	Producer Responsibility Organizations (PROs): Not-for-profit PROs like SWICO and SENS, funded by manufacturers and importers, manage the take-back and recycling infrastructure.
	Efficient collection network: Consumers can return e-waste free of charge at any retailer or designated collection point. This widespread and convenient collection infrastructure has led to high recycling rates.
South Korea's RFID Tracking System	*Use of RFID tags to monitor e-waste from collection to recycling*
	Technology-driven traceability enhances transparency and compliance

6.3. Vision and Targets for Circular Economy Transition

6.3.1. Vision:

"By 2030, India envisions a circular and sustainable e-waste ecosystem where 100% of E-waste is scientifically collected, recycled, and repurposed—protecting human health, conserving resources, and driving a green digital economy. India aims to become a global leader in green electronics and e-waste innovation—where every discarded device is a resource, not waste, fuelling sustainable industries and livelihoods."

Table 6-6: Proposed Targets

S.no	Proposed Target	2030	2035	2040	Basis of Target
1	Efficient E-waste sourcing infrastructure against 100% E-waste generated	70%	85%	100%	In the 2023–24 financial year, India recycled only 43% of its e-waste, though this was an improvement from 22% in 2019–20. This leaves 57%—or approximately 990,000 metric tonnes—untreated
2	Efficient formal Recycling rate of collected E-waste	80%	90%	100%	In the 2023–24 financial year, India recycled only 43% of its e-waste, though this was an improvement from 22% in 2019–20. This leaves 57%—or approximately 990,000 metric tonnes—untreated
3	Reduction of Informal Recycling	40%	15%	0%	95% of e-waste is still handled by the unregulated informal sector. This often involves unsafe, crude extraction methods that release toxic pollutants and pose serious health risks to workers

4	Usage of Recovered secondary raw materials content vs virgin materials	30%	50%	100%	The "Circular Economy in Electronics and Electrical Sector" action plan outlines that India's electronics manufacturing is highly dependent on virgin raw materials, and that recycled inputs are not widely used due to quality and supply chain gaps, reinforcing the <15% reuse estimate
5	Achieve material recovery yield from E-waste processing	90%	100%	-	Only few metals are aimed for recovery in process
6	Percentage of Landfill from E-waste	>1%	-	-	Due to complex composition of E-waste majority of material is sent to Landfills
7	Design & Use of Recyclable friendly raw materials in new products	90%	100%	-	E-waste contains over 1,000 different substances, including metals, plastics, glass, and hazardous chemicals. Globally, around 20–30% of e-waste components are considered non-recyclable due to contamination, composite materials, or lack of viable recovery technologies

6.4. Enablers and Implementation Framework

The targets, goals, and enabling strategies outlined earlier form the foundation for a comprehensive implementation road map. This roadmap will serve as a strategic guide to systematically achieve the defined objectives by translating high-level targets into concrete actions. Table 6-7 presents the list of enablers to achieve the proposed targets while Table 6-8 presents the proposed priority actions to achieve the circular economy targets.

Table 6-7: Enablers to achieve the proposed targets

S.No	Headers	Framework Implementation
1	**Policy interventions & market-based instruments**	Stringent Enforcement of E-waste Rules, Including EPR obligation achievement
		Encourage Recycling friendly manufacturing of products
		Encourage & mandate Refurbishing Product usage in Government sectors
		Creating a mandate framework for circularity among recyclers – Eg . Level 1 , Level 2 & Level 3 , cluster wise recyclers can be categorized and should be encouraged to connect themselves rather than sending back their materials to informal market for little bit of higher price
2	**Market based instruments to accelerate E-waste circularity**	Incentivizing / Subsidizing technologies, addon schemes similar to Critical mineral incentive scheme 2025
		Reduction of GST from 18% to 5% thus reducing cashflow burden on recyclers

3	**Infrastructure**	Establishment of more Eco parks similar to proposed Delhi Eco Parks
		Formalizing Informal sector collection initiatives by training ,certifying, Licensing them
4	**Investment Technology Development**	Strengthening COE's similar to C-met & investing more technology development & subsequent implementation
		Investing ,Developing or subsidizing new startup technologies that develop collection mechanisms & traceability of E-waste flow
5	**Promotion PPP**	Urban Local bodies should be promoted for E-waste management through PPP model , similar to Solida & other waste management
6	**Awareness & behaviour change campaigns**	CPCB led by MoEF&CC should encourage & Mandate awareness programs categorically for: • Industries (MSME , medium & Large scale) • Consumer awareness sessions • Informal sectors etc

Table 6-8: Proposed priority actions to achieve the circular economy targets

Target No. 1: **Target Description: Efficient sourcing of E-waste**			
Policy Related Initiatives			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Mandate E-waste Disposal through a proper Due diligence in All government offices / schools/colleges & institution	A Separate Recycling / Sustainability wing should be framed in MoEF&CC that connects all Government offices , which Qualifies Recycler through a proper due diligence	2026	MoEF&CC/ CPCB
E-waste collection from residential communities should be mandated	Residential / Commercial / Community complexes should be brought under Bulk consumer Regulations	2026	MoEF&CC/ CPCB
Enforce Stringent action against Violators of E-waste rules	Cancel the licences of Default recyclers as well as producers if found faulty	2026	MoEF&CC/ CPCB
Medium & Small-scale companies should be brought under mandate consumer category	Change definition of Bulk consumer, this should be differed and Split into IT & non-IT definition, IT companies with minimum 05 Head count should be mandated under these rules and Minimum requirement for non-IT should be fixed as 100 items instead of 1000 Items.	2026	MoEF&CC/ CPCB
Mandate Annual Filings for Bulk Consumers & Audit them frequently	Recycling Wing should framed & carry out this activity transparently	2026	MoEF&CC/ CPCB

To ensure Effcient EPR sourcing from Recyclers	To ensure Current EPR Collection prices are implemented, so that Recycler can carry out their EPR without pricing issues	2026	MoEF&CC/ CPCB
Economic Instruments			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Incentivising & subsidizing technologies	Schemes Like NCMM should be made available to both Large & medium recyclers to encourage technologies	2025-2030	MoEF&CC
	Out of 10 Incubation startup encouraged & funded by Government should include at least 2 E-waste related (one for sourcing innovation & another fro Processign innovation)	2025-2030	MoEF&CC/ Ministry of Education
Support Recyclers to improve their cash flow	GST should be reduced from 18% to 5% - this will increase the cash flow of recyclers, that encourages them to source more	2026	Finance Ministry
Rewarding / Incentivising Source segregation in residential areas through ULB's	Reduce Swachha / Garbage collection taxes if E-waste is segregated separately, that encourages individuals to segregate e-waste	2026-2030	State Urban Ministry / State government
Public Private Partnerships			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
All Urban Local Bodies should be Mandated for E-waste Collections through PPP similar to Solid Waste Management , Atleast for 65 top E-waste geenrating cities in India	Top 20 E-waste generating Cities should be target for E-waste collection Mandate	2028	MoEF&CC/ CPCB
	Rest 45 Cities should be mandated gradually after first 20 Cities Implementation	2032	MoEF&CC/ CPCB
Target No. 2 **Target Description: Efficient formal Recycling rate of collected E-waste**			
Policy Related Initiatives			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Stringent Enforcement of E-waste Rules - Including processing capabilities	A separate Recycling / Sustainability wing or Dept should be framed in MoEF&CC that carries out Due dilgence & Penalises Defaulters	2026	MoEF&CC/CPCB
Create a circularity among Recyclers	Level 1 recyclers should be mandated to send his material to Level 3 Recyclers only categorically (recommended by PCB)	2028	MoEF&CC/CPCB

Fixation of EPR prices without deviation as recently proposed & ensure its implementation through producers	Enforcement of EPR Obligations	2026	MoEF&CC/CPCB
Circular Economy parks			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Multiplication Eco parks	MoEF&CC should Aim to establish at least 1 Eco park in top 10 E-waste generating cities and monitor it through Special established wing	2025-2030	MoEF&CC
Research & Development			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Subsidizing & Incentivize colleges that promote Engineering projects on E-waste processing	Encourage Top 10 IIT/ Engineering colleges to take up 1 project for Efficient E-waste processing & Fund them accordingly	2025-2030	Education Ministry / MoEF&CC
Establish COEs at state Level to Improve Processing technologies	Establish at least 1 COE/ R&D project per state in top 10 E-waste generating states that works on E-waste processing R&D categorically (Rare Earth -1 , Precious metal 1 COE , Sourcing efficiency mechanism 1 COE)	2025-2030	MoEF&CC
Target No. 3 Target Description: Reduction of Informal Recycling			
Policy Related Initiatives			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Integration of Informal Sector	A census should be conducted for Identification & registration of Informal collectors & processors	2026-2027	CPCB/ULB
	Informal Sector worker Should be trained & certified	2027-2028	CPCB/ULB
	A separate License should be given for their Collection process	2028	CPCB/ULB
	After Authorization , Mandate License holders either to use eco park or divert material to Efficient recycler only	2028-2030	CPCB/ULB
Economic Instruments			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Economical Support to Informal Sector	Increase the Minimum tax threshold for Informal Sector those who are trained & certified	2028-2030	MoEF&CC

Target No. 5 Target Description: Usage of Secondary Raw materials content Vs Virgin materials (30%)			
Policy Related Initiatives			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Encourage Manufacturers to Use More secondary Raw materials	A Minimum Threshold of Secondary raw material usage should be formatted & mandated	2026-2027	Meity /Electronics ministry /Commercial dept
	Reduce tax rebates for products which are 50-100% madeup of Recycled secondary raw materials	2027-2028	Meity /Electronics ministry /Commercial dept
Target No. 6 Target Description: Achieve Material recovery Yield from E-waste processing			
Policy Related Initiatives			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Subsidizing or Incentivizing E-waste processors as per their processing capacity	Categorize E-waste processing units based on their Processing capacity & incentivize as per their yields	2025-2030	MoEF&CC
Target No. 7 Target Description: Percentage of Landfill from E-waste			
Policy Related Initiatives			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Standardize E-waste process flow including Hazardous material disposal/Co-processing	Identify Best practices that are diverting from Landfill to Coprocessing & standardize them across all recyclers & mandate them to follow similar methods	2025-2030	CPCB
Target No. 8 Target Description: Design & Use of Recyclable friendly raw materials in new products			
Policy Related Initiatives			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Encourage Manufacturers to More recyclable friendly material usage for their Product manufacturing	Incentivize companies that use more recyclable friendly virgin materials in their products	2025-2030	CPCB
Establish a COE that works on Recyclable friendly product manufacturing	In collaboration with Meity, A COE can be setup to work of user-friendly recyclable material identification & implementation	2025-2030	Ministry of Electronics/ Meity

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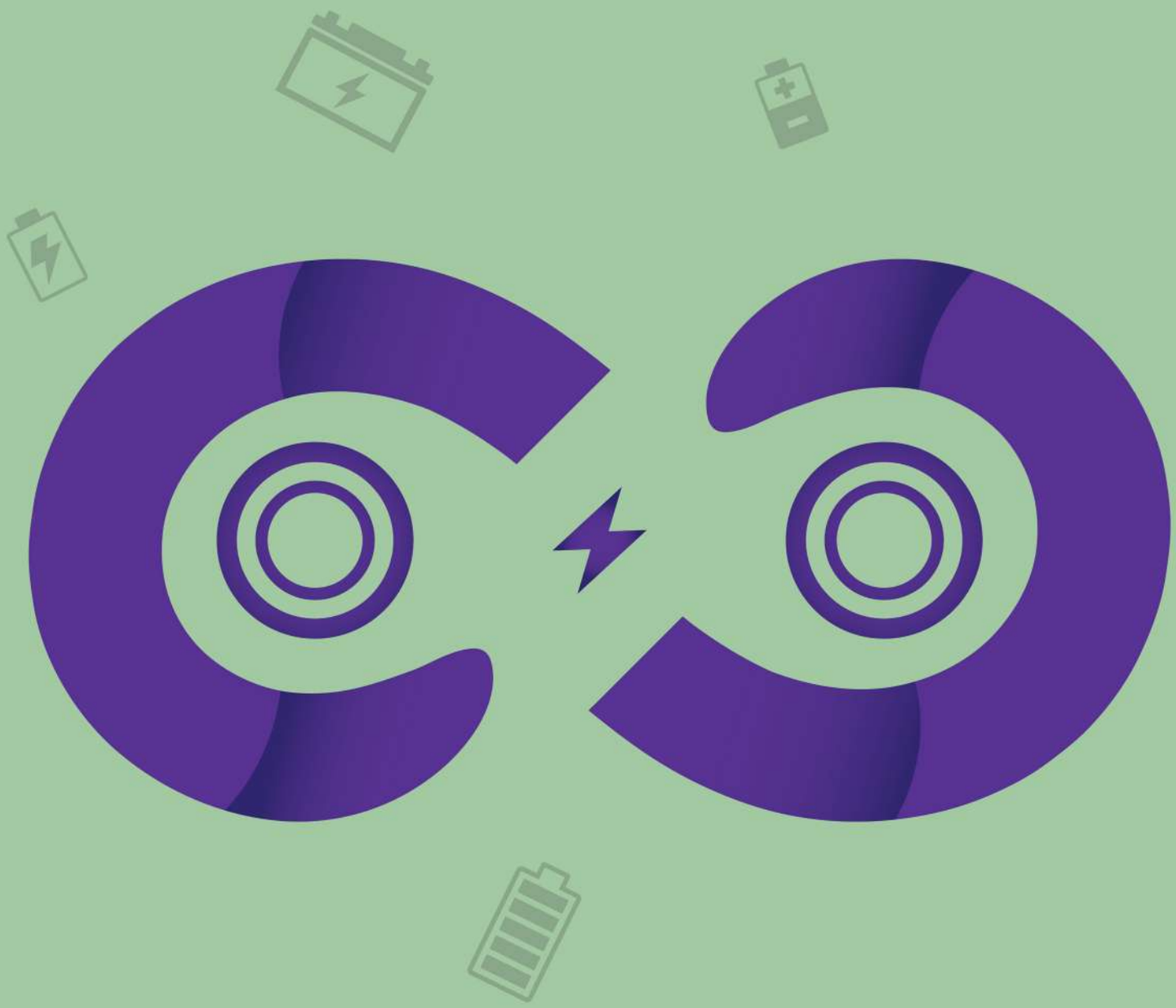
Chapter 7

CIRCULAR ECONOMY ACTION PLAN FOR BATTERIES



7.1. Material Landscape and Circularity Baseline

India's battery consumption, particularly lithium-ion (Li-ion), lead-acid, and zinc-alkaline types, has surged over the past decade due to the growth of electric vehicles (EVs), renewable energy storage, and consumer electronics. Lead-acid batteries dominate in automotive and industrial applications, while Li-ion batteries are rapidly expanding in EVs, laptops, and grid storage systems. Zinc-alkaline batteries, though small in tonnage, are produced in very large numbers for household electronics and portable devices. Their small size makes collection challenging, and recycling is often non-remunerative, leading to widespread informal disposal.

Government estimates indicate that India generates over 0.2 million tonnes of battery waste annually, with Li-ion waste projected to increase sharply as EV penetration accelerates. The battery value chain spans extraction and manufacturing, distribution and use, collection and aggregation, dismantling and pre-processing, recycling and recovery, and end-of-life disposal. Critical metals such as lithium, cobalt, nickel, manganese, and lead, along with bulk materials like plastics, steel, and aluminum, are embedded in batteries. While India has significant lead-acid recycling capacity, Li-ion recovery infrastructure is nascent, resulting in potential losses of strategic materials. Import dependence is high for lithium and cobalt, exposing India to price volatility and supply chain risks.

Formal collection and recycling remain limited. Informal operators dominate collection, offering immediate cash incentives to consumers, while formal recyclers struggle to secure sufficient feedstock. Lead-acid batteries are largely collected and recycled formally (~80–85%), but Li-ion batteries see less than 5% formal recovery due to technical and economic barriers. Zinc-alkaline batteries, despite their large numbers, have negligible formal recovery because of dispersed volumes and the lack of economic incentive for recyclers. Collection overall is fragmented across metros, tier-2, and tier-3 cities, and reverse logistics networks are underdeveloped. Transportation costs and dispersed volumes reduce the economic viability of large-scale recovery.

Current Recycling and Refurbishing Ecosystem: India's LIB recycling sector is predominantly based on mechanical processing, converting LIBs into black mass (BM), which is exported to other countries for further refining to obtain salts of lithium, nickel, magnesium, and cobalt for new battery manufacturing. The absence of cell manufacturers in India limits domestic recycling to BM production, which requires further refining to produce battery-grade material. Establishing a robust ecosystem for producing pre-CAM (pCAM) and cell manufacturing would support a truly circular LIB economy. Further, developments in AI are helping identify the state of health (SOH), state of charge (SOC), and depth of discharge (DOD) of EOL cells, enabling efficient segregation and reuse of these cells in second-life applications.

Safety and Informal Sector Challenges: Handling BM and other heavy metals poses significant health risks to those in the recycling sector. LIBs also present hazards such as thermal runaway, particularly if punctured or short-circuited, and carry electrical shock risks due to residual charges. The informal sector in India, often lacking proper safety protocols and scientific methods, is a prominent handler of new waste streams like LIBs. Currently, our country has low-skilled capacity to manage LIB waste, but the first wave of EOL EV batteries expected in 2-3 years will require trained manpower to safely handle this waste stream. India is taking big decisions on the manufacturing and recycling of LIB and rolling out incentives for faster adoption of EVs by individuals and organizations.

To address these challenges, the Battery Waste Management Rules, 2022 introduce a dedicated Extended Producer Responsibility (EPR) framework. Producers, importers, and brand owners must register on the CPCB online portal, meet annual collection and recycling targets, and channel battery waste only to authorized recyclers. EPR certificates and tracking mechanisms aim to improve accountability and traceability. However, enforcement remains uneven, particularly outside major cities, and monitoring of informal sector contributions is limited.

Technological gaps hinder advanced material recovery. Safe dismantling and recovery of Li-ion batteries require specialized processes, including hydrometallurgical extraction, AI-enabled sorting, and safe handling of flammable electrolytes. Lead-acid recycling is technologically mature but often employs outdated machinery, reducing yield and quality. Zinc-alkaline batteries pose another challenge: their small size makes manual segregation labor-intensive, and the recovery value of materials like zinc and manganese dioxide is often too low to incentivize investment in specialized facilities. Existing infrastructure is concentrated in northern, western, and southern India, leaving large regions underserved and increasing logistics costs. Integrated circular economy parks or urban mining hubs remain rare, with Delhi's E-Waste Eco Park (51,000 TPA) serving as a reference model for consolidation and industrial symbiosis.

Awareness and skill deficits further constrain circularity. Households often dispose of used batteries through informal channels, unaware of environmental risks, while informal workers typically lack formal training in safe handling. Skills for advanced battery processing, including rare-earth and lithium recovery, are scarce, and municipal staff often lack monitoring expertise. Downstream markets for recovered metals are also limited due to inconsistent quality, price volatility, and minimal adoption in domestic EV and energy storage manufacturing.

7.2. Gaps and Challenges in Advancing Circularity

Despite the Battery Waste Management Rules, 2022, India's battery recycling ecosystem faces significant gaps that limit circularity. Policy enforcement is inconsistent, particularly in tier-2 and tier-3 cities. Although producers and importers must meet collection and recycling targets via the CPCB portal, verification of reported data and on-site audits remain weak, while informal channels continue to bypass regulatory oversight. In 2023, only 10–18% of lithium-ion batteries were formally recycled in India, compared with 45% in China and 35% in the EU. Additionally, the absence of a comprehensive national battery waste inventory constrains the tracking of flows, compliance assessment, and infrastructure planning.

Material-specific challenges are pronounced for lithium-ion batteries. Unlike lead-acid batteries, which have matured recycling processes, Li-ion batteries are technically complex, containing lithium, cobalt, nickel, manganese, and organic electrolytes that pose safety risks during dismantling. Current authorized recyclers largely focus on lead-acid recovery, with Li-ion and other emerging chemistries under-served (1-5% end of life Li-ion battery recycled). Advanced recovery technologies, including hydrometallurgical extraction, AI-assisted sorting, and safe electrolyte handling, remain scarce and economically challenging to deploy at scale.

Feedstock availability and aggregation pose additional barriers. Informal collectors dominate battery collection, especially in small towns, offering immediate cash to consumers. This creates fragmented supply for formal recyclers, making it difficult to operate economically. Transportation costs for scattered waste further undermine viability, limiting investment in advanced facilities. The lack of regional aggregation hubs or circular economy parks exacerbates inefficiencies and prevents economies of scale.

Informal operators can offer higher prices to consumers by avoiding compliance costs and safety measures, while formal recyclers face higher labor, regulatory, and operational costs. This competitive imbalance results in unsafe practices such as open burning of battery casings, acid leaching of lead, and improper handling of Li-ion cells, which threaten worker safety and environmental quality. Informal workers also remain largely untrained and without legal protection.

Infrastructure and technology gaps hinder circularity. Most formal recycling units are concentrated in northern, western and southern India, leaving large areas underserved. Facilities often rely on outdated machinery, reducing recovery efficiency, product quality, and safety. High capital costs, uncertain feedstock supply, and weak downstream markets discourage investment in advanced recovery technologies. The scarcity of integrated platforms—circular economy parks or urban mining hubs—limits opportunities for industrial symbiosis and collaborative scaling of recovery operations. While China operates 500,000 MT/yr industrial parks for battery recycling, India has no such dedicated clusters; clustering and shared infrastructure are in pilot phase.

Awareness and skills deficits further constrain progress. Consumers are often unaware of safe disposal channels

or environmental risks, resulting in continued informal collection. Municipal staff and regulatory authorities frequently lack expertise in monitoring, enforcement, and safe battery handling. Informal workers are untrained in critical processes like safe Li-ion dismantling, rare-earth recovery, or hazardous material management, creating bottlenecks in the value chain.

Weak downstream markets for recovered metals limit the economic incentive to invest. Recovered lithium, cobalt, and nickel often lack consistent purity and certification, reducing trust among manufacturers. Price volatility, linked to global mining output and EV demand, further discourages uptake. Public procurement rarely prioritizes recycled metals, weakening demand-pull for quality recyclates.

Lessons from domestic and international best practices highlight potential solutions. International examples, such as Japan's battery recycling systems and South Korea's directives, show the importance of strict enforcement, traceability, and industrial clustering to achieve high recovery rates. Scaling formal platforms, enforcing EPR obligations, and integrating informal workers into regulated frameworks can significantly advance battery circularity in India.

7.3. Vision and Targets for Circular Economy Transition

To establish a safe, efficient, and fully circular battery ecosystem in India, where all battery waste is responsibly collected, recycled, and recovered, maximizing resource value, minimizing environmental and health risks, and integrating formal and informal stakeholders into a sustainable value chain by 2030.

Table 7-1: SMART Targets

S.No.	Proposed Target	2030 Target	Basis for Setting Target
1	Formal Collection of End-of-Life Batteries (% of total batteries collected formally)	80%	Current formal collection is only 10–18% for lithium-ion batteries (2023). EPR rules, expanding reverse logistics, and retail take-back programs make 80% achievable by 2030, bridging the gap with countries like China (45%) and the EU (35%).
2	Recycling & Recovery of Critical Metals (% of lithium, cobalt, nickel, and rare earths recovered from collected batteries)	60%	Currently, advanced recovery for lithium-ion and rare earths is limited; most formal recycling focuses on lead-acid. By deploying hydrometallurgical extraction, AI-enabled sorting, and circular economy parks, 60% recovery is feasible.
3	Worker Formalization & Safety Training (% of informal battery recyclers trained and integrated into formal sector)	70%	About 95% of battery collection and dismantling is informal. Structured training programs, certifications, and PPP-based integration can formalize a majority of workers by 2030.
4	Landfill Diversion of Hazardous Battery Waste (% of hazardous battery waste safely recycled or treated)	85%	Currently, substantial fractions of lithium-ion and lead-acid residues end up in landfills. Strengthened EPR enforcement, circular economy hubs, and safe processing facilities can achieve high diversion rates by 2030.

7.4. Enablers and Implementation Framework

India's Battery Waste Management Rules, 2022 form the regulatory foundation for circularity in the battery sector, mandating collection, recycling, and recovery targets for producers and importers. However, enforcement remains inconsistent, particularly in tier-2 and tier-3 cities, where informal channels bypass regulatory oversight. Strengthening compliance through the CPCB portal for real-time data verification, independent audits, and periodic site inspections is essential. Establishing uniform standards for recycled battery materials, safe dismantling of lithium-ion and lead-acid batteries, and certification of recovered metals will enhance market trust. Policies

promoting design for recyclability, durability, and safe end-of-life treatment, along with standardized secure data deletion protocols for batteries containing memory modules, will further advance circularity.

Financial instruments can catalyze large-scale adoption of formal recycling. Green bonds and blended finance can support the establishment of recycling facilities, circular economy parks, and advanced recovery technologies. Viability Gap Funding (VGF) can partially subsidize public-private partnership (PPP) battery parks to attract private sector investment. Public procurement policies favoring locally produced recycled-content batteries, combined with low-interest loans, capital subsidies, and output-based incentives, can accelerate adoption of hydrometallurgical recovery, AI-assisted sorting, and safe lithium-ion processing units.

Infrastructure development is critical to secure feedstock and improve recovery efficiency. Regional circular economy hubs for aggregation, dismantling, recovery, and safe disposal can consolidate operations and enable economies of scale. Expansion of reverse logistics networks, retail take-back points, and aggregator networks in smaller cities can reduce fragmentation and ensure stable feedstock supply. Deployment of advanced recovery technologies, including hydrometallurgical extraction and AI-enabled sorting, will improve recovery yields, quality, and operational safety.

Technology development and R&D support is vital to foster innovation. Universities, research institutions, and industry consortia can pilot rare-earth recovery, battery recycling, AI-assisted sorting, and safe hazardous material handling. International collaboration and technology transfer, drawing on models like Japan's Eco-Town and the EU WEEE directive hubs, can accelerate domestic capability.

Public-private partnerships should be leveraged for joint investment in collection infrastructure, workforce training, and circular economy parks. Coordinated programs can enable safe collection, dismantling, and material recovery at scale.

Capacity building is essential to formalize and train informal workers, who handle ~95% of battery waste, in safe dismantling, segregation, and hazardous material handling. ULB staff and regulators should receive targeted training on compliance and monitoring, while academia can contribute through pilot programs and curriculum development for emerging recovery technologies.

Consumer awareness and behavior change campaigns must complement infrastructure and policy. Deposit-refund schemes, retail take-back programs, and nationwide awareness campaigns can encourage safe disposal, while industry-led EPR initiatives and incentives for product returns reinforce engagement.

Implementation risks include informal sector non-compliance, fragmented supply, technology adoption barriers, and investment uncertainty. These can be mitigated by integrating informal workers into formal systems, strengthening feedstock aggregation, phasing technology deployment, and providing financial incentives for private sector participation.

Monitoring and accountability require maintaining a national battery waste inventory to track collection, recycling, and material recovery. Periodic audits and compliance reports from CPCB, state PCBs, industry PROs, and ULBs will ensure transparency, data integrity, and effective enforcement across the sector.

Table 7-2: Proposed Priority Actions to Achieve Circular Economy Targets

Target No. 1: 80% formal collection of battery waste by 2030			
Policy Related Initiatives			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Strengthen EPR compliance	Conduct independent audits of CPCB portal data and verify collection/recycling reports; on-site recycler audits	2025–2027	MoEFCC, CPCB, State PCBs
Mandatory design for recyclability	Enforce design standards for lithium-ion, zinc-alkaline and lead-acid batteries to improve end-of-life recovery	2025–2028	BIS, MoEFCC, Industry associations
Economic Instruments			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Financial support for collection	Provide low-interest loans and capital subsidies to formal aggregators and recyclers	2025–2030	MoEFCC, SIDBI
Public procurement incentives	Mandate recycled-content batteries in government electronics and EV procurement	2026–2030	MoEFCC, DoE, State Governments
Public Private Partnerships			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
PPP battery collection hubs	Establish 10 pilot PPP collection and aggregation hubs across metro and tier-2 cities	2025–2027	ULBs, Industry consortia
Joint awareness programs	Industry and NGOs to run consumer awareness campaigns promoting safe disposal and take-back	2025–2026	MoHUA, NGOs, Industry
Circular Economy Parks			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Regional battery recycling hubs	Establish hubs for aggregation, dismantling, recovery, and safe disposal	2025–2030	Central & State Governments, Industry
Feedstock logistics	Strengthen reverse logistics networks and retail take-back points in tier-2 and tier-3 cities	2025–2030	ULBs, Industry
Research and Development			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Advanced recovery technology pilots	Support hydrometallurgical recovery, AI-assisted sorting, and safe lithium-ion dismantling	2025–2030	DST, CSIR, Industry R&D labs
Battery lifecycle assessment	Conduct studies to optimize recovery efficiency, environmental footprint, and material yield	2025–2027	Academic institutions, Industry

Target No. 2 50% recovery of critical and precious metals (gold, lithium, cobalt, rare earths) by 2030			
Policy Related Initiatives			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Standards & certifications	Develop uniform standards for recovered metals and certification of recyclates	2025–2027	BIS, MoEFCC
Safe dismantling protocols	Mandate safe dismantling and handling standards for lithium-ion and lead-acid batteries	2025–2027	MoEFCC, State PCBs
Economic Instruments			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Subsidies for advanced recovery	Incentivize deployment of hydrometallurgical extraction, AI sorting	2025–2030	MoEFCC, SIDBI
Market development incentives	Support formal recyclers with output-based incentives for recovered metals	2025–2030	MoEFCC, Industry associations
Public Private Partnerships			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Circular economy recovery hubs	Pilot PPP urban mining hubs for critical metal recovery	2025–2028	Central & State Governments, Industry
Knowledge-sharing consortia	Facilitate joint research and technology transfer programs for rare-earth and lithium recovery	2025–2030	Academia, Industry, MoEFCC
Research and Development			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Pilot rare-earth and lithium recovery	Fund pilot plants for advanced metal extraction and AI-based sorting	2025–2030	DST, CSIR, Industry
Safety & efficiency studies	Evaluate environmental footprint, recovery efficiency, and occupational safety	2025–2027	Academic institutions, Industry

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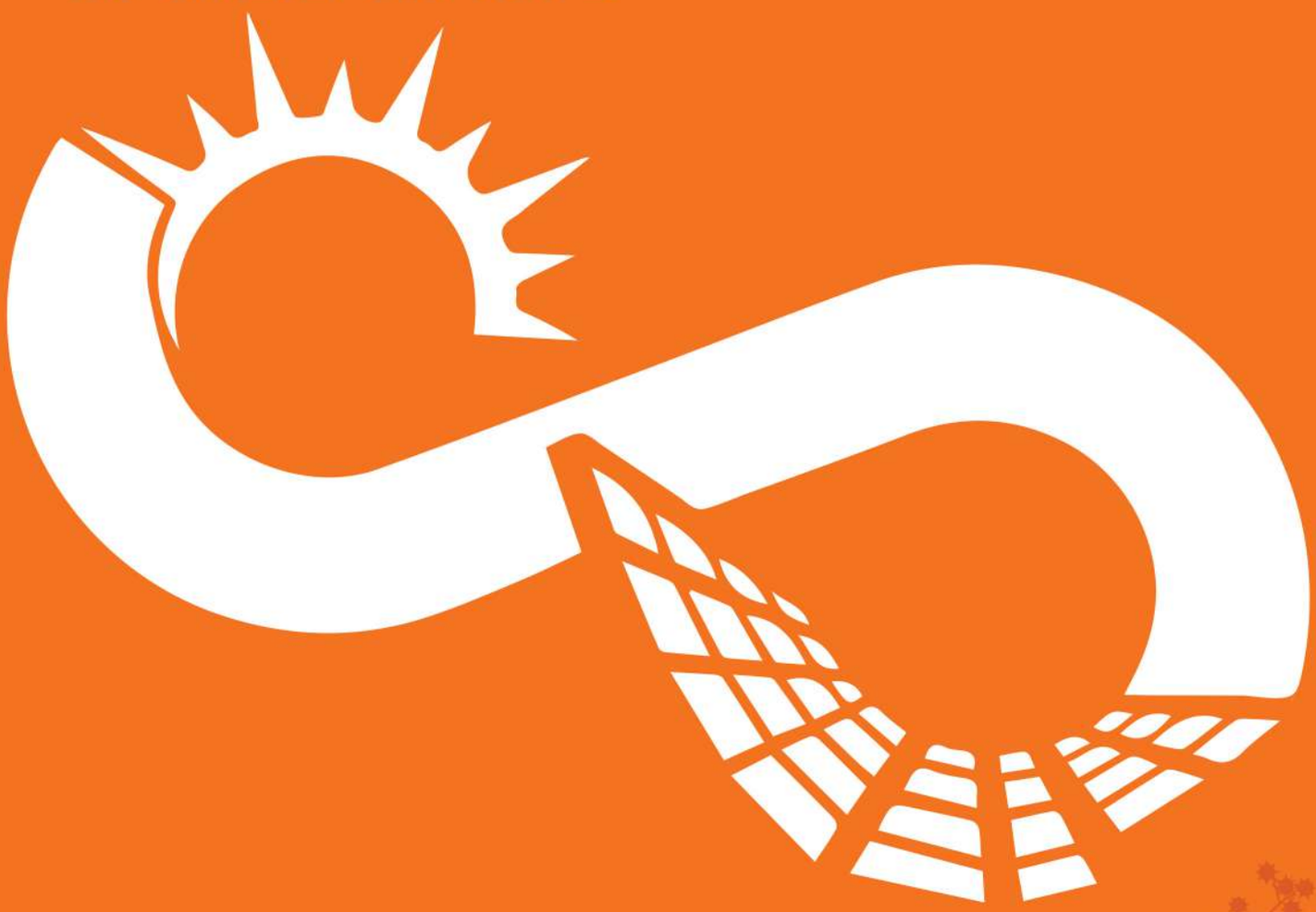
Chapter 8

CIRCULAR ECONOMY ACTION PLAN FOR SOLAR PANEL WASTE



8.1. Material Landscape and Circularity Baseline

8.1.1. Overview

India's solar industry has seen exponential growth in recent years, particularly since 2015. According to the 2022 report by the International Energy Agency (IEA), India is now among the top three solar power generators globally, following China and the USA. As of September 2025, India's installed solar capacity has reached 120 gigawatts (GW).

The National Electricity Plan released by the Central Electricity Authority (CEA) set a target of 500 GW of renewable energy capacity by 2030, with solar expected to contribute at least 50%. This ambitious plan is crucial for India to meet its net-zero commitment by 2070, made at the COP26 conference. Solar panels have a typical lifespan of 25 to 30 years. However, recent years have seen a rising volume of prematurely decommissioned photovoltaic (PV) panels due to improper handling, installation, and product defects. These factors suggest a significant increase in solar waste in the coming years.

The figure below illustrates a typical silicon photovoltaic (PV) cell, showcasing the essential components and structure that enable the conversion of sunlight into electrical energy.

Figure 8-1: Typical Silicon PV Cell

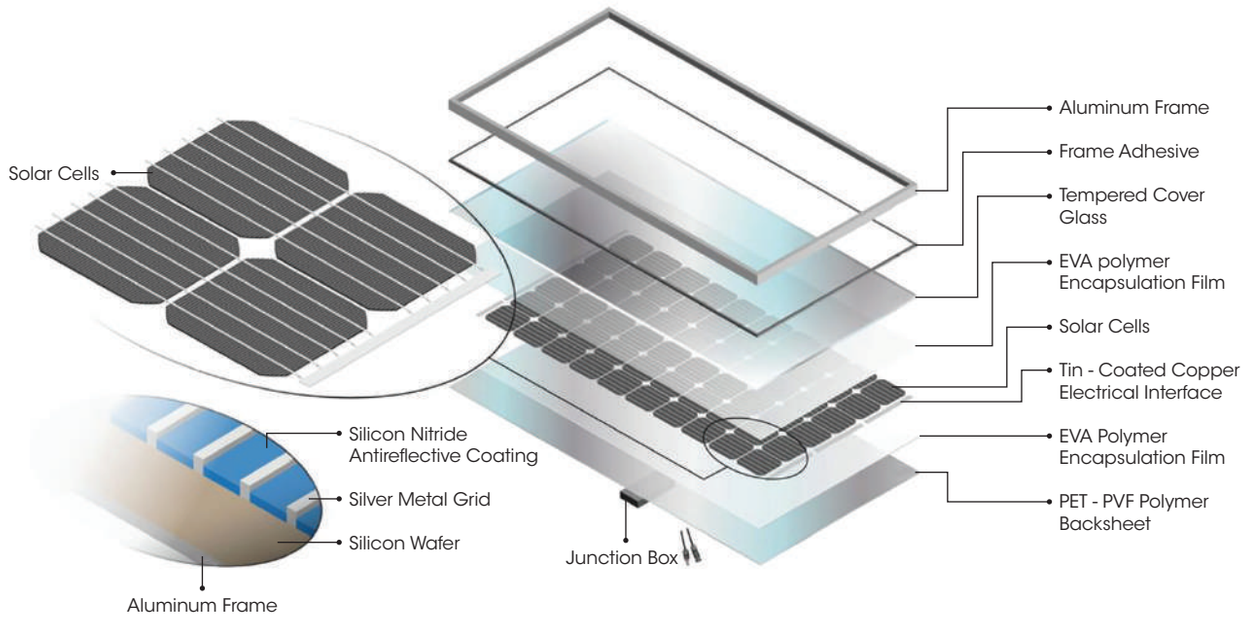


Image Source: Zhang, Bin, et al. "Aluminum saving and CO2 emission reduction from waste recycling of China's rooftop photovoltaics under carbon neutrality strategy." iScience 27.10 (2024).

Understanding the material composition of these cells is crucial for addressing end-of-life (EoL) management and promoting circularity in solar technology. A typical silicon PV cell is predominantly made up of glass (70%) and Aluminum (18%), with smaller amounts of polymer (9%), silicon (3%), and copper (1%). Silver makes up around 0.07% of the panel weight.

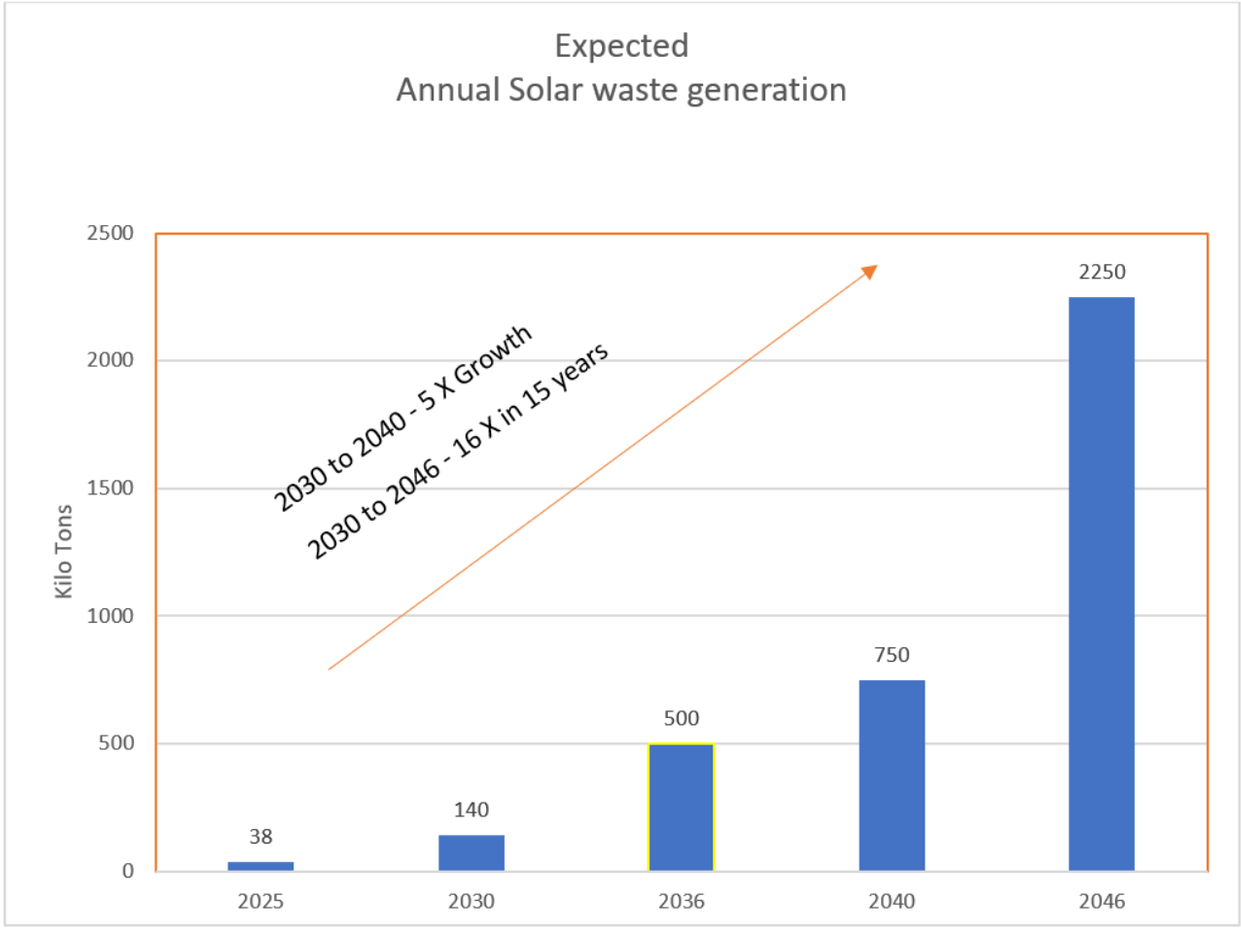
8.1.2. Importance of circularity in solar for the Indian economy

India consumed around **4 .5 million tons of Aluminum , 1.7 Million ton of Cu** and **7000 tons of silver** in 2024 . India remains a net importer of all these metals . India is the 3rd largest consumer of aluminium in the world.The solar industry is one of the largest consumer of silver.Silver consumption for making solar panels was estimated at **19% of total global demand in 2024**, representing 8000 tons.These reasons make it all the more important for India to recover precious and non ferrous metals.

Government of India has brought out the National Non-ferrous Metal Scrap Recycling Framework (2020) .This is an initiative by the Indian Ministry of Mines to formalize and organize the recycling ecosystem and reduce India's dependence on non ferrous metals and precious metals . It is important than The metals scrap recycling framework 2020 and the electronic waste management rules 2022 talked to each other so commonalities can be found and tackled .This Will provide an impetus to solar panel recycling.

8.1.3. Market trends and Growth projections

Understanding the projected scale of solar waste is crucial for effective circularity planning.The following diagram, illustrates the expected growth in solar waste over the coming years.



Source: " *Enabling a circular economy in India's Solar Industry" By Dr Akansha Tyagi & Team , CEEW*

This anticipated waste includes several sources: transportation and handling losses, operational waste, and annual end-of-life (EoL) waste from decommissioned panels.

Notably, the states with the highest solar panel installations—Rajasthan, Gujarat, Karnataka, Tamil Nadu, and Andhra Pradesh—are expected to contribute approximately 70% of India's solar waste by 2030. This information underscores the need for targeted waste management strategies in these regions to support a circular economy in India's solar sector.

8.1.4. Overview of existing policies and incentives

Solar panel recycling is currently governed under the Electronic Waste Management Rules (EWMR). There is no comprehensive policy specifically for the recycling of solar PV modules. The " Draft guidelines for Storage and Handling of Waste Solar Photo-Voltaic Modules or Panels or Cells" brought by CPCB in 2025 is a good start .

Solar panel recyling has common ground with other rules and frameworks like the National Non-ferrous Metal Scrap Recycling Framework (2020), Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016. Finding synergies between these three policies can make the solar panel recycling in India more effective and relevant to today's scenario.

8.1.5. Current levels and innovation

Today, waste PV modules (predominately from premature decommissioning) end up in the vast informal sector where it is crudely dismantled and processed for valuable fractions. This may endanger unskilled informal workers due to presence of toxic materials in solar panels like cadmium antimony and lead. There is wastage of critical secondary materials when extracted by the informal sector due to crude methods of extraction and this lead to the loss of critical secondary materials.

There is no large-scale investment in solar panel recycling in India by the private sector but some green shoots have emerged. Companies have Attero , Borosil and Dynamic Industries, Korea have started taking the first steps to establish recycling centres in India.

8.2. Gaps and Challenges in advancing circularity

Despite recent policy updates, the country faces hurdles in building a functional and cost-effective solar panel recycling ecosystem. Them being

8.2.1. Policy gaps

Absence of a Dedicated Solar Recycling Policy: Solar recycling is currently governed under the Electronic Waste Management Rules (EWMR) 2022, where it has been temporarily placed without a dedicated framework. As a result, there is no comprehensive policy specifically for the recycling of solar PV modules, and these modules are often treated as regular e-waste destined for disposal. Solar panels are exempt from recycling targets under EWMR, further limiting the incentive for organized recycling efforts. Additionally, while numerous incentives exist for new solar power investments, similar support for recycling infrastructure is lacking. A dedicated solar panel recycling policy is essential to promote circularity in this sector. The "Draft guidelines for Storage and Handling of Waste Solar Photo-Voltaic Modules or Panels or Cells" brought by CPCB in June 2025 is a good start and we hope this is Precursor to a comprehensive policy for solar panel recycling.

8.2.2. Infrastructure and skill gap

Insufficient Recycling Infrastructure and Knowledge: A significant barrier to effective solar PV recycling is the limited infrastructure and lack of technical expertise. Existing waste management facilities, including Treatment Storage and Disposal Facilities (TSDFs), are often not suited for solar reycling. Substantial portion of end-of-life (EoL) management, including recycling, is handled by the informal sector, which lacks the necessary skills and technology. Implementing targeted training, resources, and regulatory measures to promote environmentally sound practices is essential. Integrating the informal sector into formal recycling initiatives through supportive regulations can help expand recycling capacity and ensure adherence to sustainable standards.

8.2.3. Informal sector dominance

A significant portion of solar e-waste is handled by India's informal waste sector. Workers operate without proper safety equipment, putting them at risk of exposure to hazardous materials like lead and cadmium. scrap dealers often engage in unscientific disposal practices, including open burning or landfilling. This causes toxic substances to leach into the soil and groundwater, he low cost of informal, unregulated handling of waste can undercut the business case for formal recyclers who must invest in proper infrastructure and safe procedures.

8.2.4. Technology gap

There is no Indian company or research institution that has the technology over the full value chain, including chemical extraction of precious metals from Solar panels. We need to rely on foreign institutions for this technology. Recent collaboration of National Institute of Solar Energy (NISE) and the recycling company Attero to advance research and development in solar panel recycling is a step in the right direction.

8.3. Vision and Targets for Circular Economy Transition

The vision is to bring circularity into solar panel manufacturing in India by 2040 and hence contribute to the overall goal of Atma Nirman Bharat. Goals to bring this vision to reality has been detailed below

Table 8-1: Proposed Goals and Targets

<table>
<tr><th>Goal</th><th>2030</th><th>Assumptions</th></tr>
<tr><td>Dedicated Solar Waste Policy under EPR umbrella</td><td>A comprehensive solar waste management policy within an EPR framework to be established by 2026 to 2030.

The solar policy should also coordinate between various bodies like Ministry of Mines so that common ground with other existing policies like the "National Non-ferrous Metal Scrap Recycling Framework " can be found</td><td>The policy should treat producers, importers, end users and authorised recycling centres as the key stakeholders and incentivise them accordingly. The current informal sector should be encouraged to move into the formal category and practices like land filling should be discouraged.</td></tr>
<tr><td>Financial Incentives for Recycling</td><td>• 25% Capex incentive
• Waiver of import duty for recycling machinery</td><td>Capex incentive similar to the model of the "Scheme for Promotion of Manufacturing of Electronic Components and Semiconductors"</td></tr>
<tr><td>Establishment of collection centres and recycling units</td><td>Collection centre and recycling in major clusters of solar power generation. Top 4 states of Rajasthan , Gujarat , Karnataka and Tamil Nadu contribute to 75% of India's solar power generation</td><td>No of centres based on solar waste projections .0.12 Million tons and 0.6 Million tons of cumulative panel waste expected by 2025 and 2030.</td></tr>
<tr><td>Mandatory Recycled Content in Solar Panels</td><td><table><tr><th>Category</th><th>% Recycled Content</th></tr><tr><td>Category 1</td><td>30%</td></tr><tr><td>Category 2</td><td>10%</td></tr><tr><td>Category 3</td><td>0%</td></tr></table></td><td>Introduce mandatory recycled content requirements in solar PV panels, similar to those in plastics.
• Category 1: Items that can be recycled mechanically, such as glass, aluminium frames, copper cables etc
• Category 2: Items requiring more advanced recycling methods, like plastics, laminate glass, and silicone.
• Category 3: Precious metals, including silver. This can be a 2035 target since technology is still lab scale.</td></tr>
</table>

8.4. Enablers and Implementation Framework

Transitioning toward a circular economy for solar panels will require a coordinated framework that integrates policy, technology, finance, and capacity-building measures. While India has made significant progress in solar deployment, managing end-of-life (EoL) solar waste demands targeted interventions across the entire value chain. The following section outlines key enablers and an implementation framework necessary to support circularity, resource recovery, and responsible recycling in the solar panel ecosystem. Listed below are the key enablers:

Figure 8-2: Key Enablers

(a) **Policy Advocacy and Support:** Develop comprehensive policies and regulations specifically addressing solar waste management, including guidelines for collection, transportation, recycling, and disposal. Ensure that these policies are in line with international best practices and standards. Based on India's current policy framework, the EPR mechanism will be most suited for assigning accountability to stakeholders in the EoL value chain.

(b) **Research and Development:** Promote research and development initiatives focused on maximum extraction with minimum energy and environmental effects. Government to Government programs, University collaborations, International collaborations to be encouraged. Central Government ministry help required in fostering G2G programs, especially on licensing best available technology globally for recycling and bringing them to India.

(c) **Encourage Circularity of Materials in Solar Panels**: Solar panel design, materials, and manufacturing processes should be encouraged with an emphasis on recyclability and minimizing waste generation (example: usage of antimony free glass). Another key aspect will be the creation of markets for secondary raw materials generated from panels, with incentives for companies using them.

(d) **Financial Support and Incentives:** Introduce financial incentives such as tax benefits, subsidies, and grants to encourage the adoption of sustainable practices in the solar industry, including the proper management of solar waste. Provide support to recycling companies through incentives and subsidies to promote their growth and viability.

(e) **Monitoring and Enforcement:** Establish a monitoring and enforcement guideline to ensure compliance with regulations and guidelines for solar waste management. Regular audits and inspections should be conducted to verify that manufacturers, recyclers, and other stakeholders adhere to the prescribed standards.

(f) **Certification and Labelling:** Establish certification standards and labelling mechanisms for solar products that promote recyclability and environmentally responsible manufacturing processes. This can incentivize manufacturers to design products with easier recyclability and provide consumers with information to make sustainable choices.

To operationalize the proposed vision and targets, a set of actionable initiatives has been identified to guide implementation. These priority actions focus on policy reforms, economic incentives, infrastructure creation, and mandatory recycling measures that will enable India to build a sustainable, self-reliant, and circular solar waste management system. The table below summarizes these proposed measures, their timelines, and responsible implementing agencies.

Table 8-2: Proposed Priority Actions to Achieve Circular Economy Targets

Target	Proposed Initiative/ Measure	Action item and timeline	Timeline	Proposed Owner
Dedicated Solar Waste Policy	Policy related Initiative - Dedicated Solar waste recycling rules under EPR policy	A dedicated solar waste recycling guidelines needs to be formed for full life cycle of solar panel	2027	CPCB
Establishment of collection centres (CC) and recycling centres (RC)	Economic incentive - Subsidies for setting up recycling facilities Policy related initiative - Mapping of solar clusters Policy related initiative -White paper on quantum of solar waste expected in coming years	1)Financial incentives like CAPEX subsidy, interest subvention etc 2) Solar clusters across the country should be mapped to determine ideal location for collection and recycling centres 3) Though various data exists on quantum of solar waste expected in coming years, GoI should release a white paper on this matter.	2027	MOEF&CC
Mandatory Recycling in Solar Panels	Policy related initiative – Mandatory recycled content in future solar panels. Policy related initiative – Penalty on landfilling / unscientific disposal	1) Similar to plastic recycling , there should be a mandate for increased use of recycled content and recycling of solar panels through the Extended Producer Responsibility (EPR) rules. 2) There should be a penalty for landfilling and unscientific disposal of solar waste , to prevent harming the environment and the people handling them .	2027	CPCB

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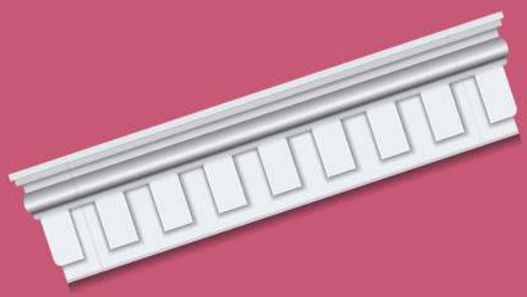
4. Enabling a Circular Economy in India's Solar Industry - Dr. Akansha Tyagi & Team, CEEW. https://www.ceew.in

Chapter 9

CIRCULAR ECONOMY ACTION PLAN FOR GYPSUM



9.1. Material Landscape and Circularity Baseline

Gypsum, primarily Calcium Sulfate ($CaSO_4$), is a highly versatile raw material. The traditional value chain begins with the extraction of natural gypsum, but in India, local production is limited due to deep-seated reserves that are not feasible for mining. India produces only around 2.50% of the world's 150 million tonnes of natural gypsum. This constraint has resulted in a significant dependence on global linkages, with India relying heavily on imports, primarily from Oman, Iran, Thailand, Pakistan, Bhutan, and East Asia.

The end-of-life value chain is dominated by three main waste types, which are by-products of industrial processes: phosphogypsum (PG), generated from phosphoric acid production; flue gas desulfurization gypsum (FGDG), generated from sulfur removal in coal-fired power plants; and red gypsum (RG), a waste product from titanium dioxide production. While generally classified as non-hazardous, the effective management, recycling, and repurposing of these wastes are crucial for achieving circular economy goals and reducing landfill dependence.

9.1.1. Importance of Gypsum for key sectors

- Gypsum is essential for the economy, particularly in the construction sector, where it contributes 11.5% to the global construction chemicals market. Approximately 4–5% of gypsum is added during clinker grinding to control cement hardening.
- Gypsum is recognized as a critical mineral for the pharmaceutical sector by the Ministry of Mines
- Gypsum is used in medicine (orthopedic casts, dental plasters)
- Gypsum is also utilized in agriculture for treating saline and alkaline soils and enhancing soil structure.

The limited availability of domestic gypsum leads to supply constraints and a high trade dependency, with imports representing nearly 35% of the total gypsum consumed by the Indian cement industry. This dependence is projected to grow, potentially requiring the cumulative import of nearly 180 million tonnes by FY 2037-2038

9.1.2. Environmental & social footprint

1. Natural gypsum mining is associated with health hazards for miners, including pulmonary impairment, musculoskeletal symptoms, hypertension, and diabetes.
2. Landfilling plasterboard can generate greenhouse gases such as CH_4, CO_2, and H_2S.

A major challenge posed by synthetic gypsum is the presence of impurities. For instance, Phosphogypsum contains heavy metals and radioactive elements from the rock matrix. In the US, the EPA classifies PG as TENORM (Technologically Enhanced Naturally Occurring Radioactive Material). However, the use of recycled gypsum waste results in environmental benefits when transported short distances (equal to or less than 30 km) compared to natural gypsum production.

9.1.3. Market trends & growth projections (India/global benchmarks, trade flows, price volatility):

The global market for gypsum-based products is set to expand at a Compound Annual Growth Rate (CAGR) of 3.7% to 6.2%, reaching a size between USD 9.15 and 13.76 billion by 2033. In India, the industry's cumulative demand for gypsum is expected to reach approximately 380 million tons by FY 2037-2038 (CAGR of 5.15%). Due to the domestic shortage, the reliance on imported gypsum is high. To bridge this gap, India is exploring alternate chemical sources. FGD gypsum generation is projected to increase significantly due to government mandates, potentially reaching 9.94 million tonnes per annum (MTPA) at 55% Plant Load Factor (PLF).

9.1.4. Current level of adoption of circular practices (design, reuse, repair, recycling, recovery)

Gypsum products are inherently suitable for closed-loop recycling due to the reversible hydration reaction of calcium sulphate. In India, the cement industry is already exploring alternate sources and has the potential to use about 16 MMT of Phosphogypsum annually. Furthermore, the Indian Road Congress (IRC) has approved the use of neutralized phosphogypsum stockpile for road construction. Globally, utilization rates for synthetic gypsum are high in some countries, with Japan achieving over 90% utilization of FGD gypsum, primarily in cement and gypsum board manufacturing. However, adoption faces hurdles, including the high transport freight cost of gypsum and the variation in quality and high moisture content of synthetic gypsum, which often requires pre-treatment.

9.1.5. Overview of existing policies & incentives (national/state level)

Gypsum has been identified as a priority area for the circular economy by NITI Aayog. Nationally, the government has imposed new duties on imports of certain gypsum products from countries like China, Oman, and Iran to

encourage local sourcing. A key enabler is the mandate for all thermal power plants in India to install FGD units by December 2026.

To promote synthetic gypsum use, the following developments were made:

i. Phosphogypsum has been excluded from Schedule I of the hazardous waste category for agricultural purposes.

ii. State governments, including Telangana, Uttar Pradesh, and Tamil Nadu, provide financial assistance covering 50% of the cost of gypsum material and transportation for farmers.

iii. Furthermore, the Central Pollution Control Board (CPCB) and the Atomic Energy Regulatory Board (AERB) have issued guidelines for the safe management and utilization of phosphogypsum and FGD gypsum in construction and agriculture.

9.2. Gaps and Challenges in Advancing Circularity

9.2.1. Policy gaps & enforcement barriers

A major challenge is the low adoption rate in installing Flue Gas Desulphurisation (FGD) units in thermal power plants, a critical step for generating a steady stream of synthetic gypsum. This low adoption is primarily attributed to the high capital expenditure required. To bridge this gap, recommendations include promoting investments in FGD installation to ensure a consistent supply of synthetic gypsum at a competitive price. Furthermore, current tariff levels of industrial by-products may need revision to lower freight slabs to streamline the movement of gypsum to end-user industries, addressing policy barriers related to logistics and cost.

9.2.2. Material specific challenges

Synthetic gypsum derived from industrial waste presents several material-specific hurdles. Wide ranging impurities in phosphogypsum (PG) and FGD gypsum, along with high moisture content, often render the material unfit for direct use in applications like cement manufacturing, necessitating pre-treatment.

Phosphogypsum, in particular, contains undesirable trace radioactive elements, fluorine (which causes ring formation in kilns), and P_2O_5. Additionally, there is significant variation in the quality of synthetic gypsum depending on its source and application. Operationally, gypsum is by nature a sticky material, posing difficulties during loading, unloading, and transportation.

While the projected annual generation of FGD gypsum is expected to increase significantly (estimated at 9.94 MTPA at 55% Plant Load Factor) due to government mandates, current availability is hampered by the slow adoption of FGD units. Even when available, the high transport freight cost of gypsum severely impacts the economic viability of feedstock aggregation, making it difficult to efficiently move the material to end-user industries. The environmental benefits of using recycled gypsum waste are only realized when transport distances are equal to or less than 30 km.

9.2.3. Competitive viability issues

The circularity efforts face stiff competition from sourcing natural gypsum, which is often still widely available and cost-effective. Synthetic gypsum manufacturers are challenged to innovate and clearly demonstrate the environmental and economic benefits of their recycled products to overcome this market competition.

9.2.4. Infrastructure & technology gaps

Advanced technology is essential to address quality issues. Synthetic gypsum requires pre-treatment to ensure quality and stability for use in the cement industry. While scientific communities have developed various purification processes for phosphogypsum - such as direct flotation, wet chemical conversion, and TBP (TriButyl Phosphate) and sulphuric acid-based conversion - widespread adoption requires investment. Manufacturers need to heavily invest in advanced quality control measures to manage the variation in synthetic gypsum quality.

9.2.5. Limited availability of platforms

The importance of infrastructure related to location and efficient transportation is high, as recycling facilities must be situated strategically. The need to reduce transport distances to less than 30 km to achieve environmental

benefits underscores the necessity for regional recycling infrastructure. The target is to set up 4 regional recycling facilities for gypsum by 2028.

9.2.6. Weak downstream markets

Downstream market adoption is weak due to quality concerns and cost competitiveness. The requirement for pre-treatment adds costs, and manufacturers must comply with standards. Best practices suggest implementing clear waste acceptance criteria and clear recycled gypsum quality criteria to boost market confidence and quality assurance

9.2.7. Lessons from best practices

- **Removing Impurities (Japan):** The Japanese company Onoda Cement demonstrates effective pre-treatment by using calcination to dehydrate phosphogypsum. This calcined material is then neutralized with lime water, converting impurities into insoluble or inactive calcium salts, thereby addressing the challenges of moisture and impurities.
- **Logistical innovations (India):** UltraTech Cement Limited utilized coastal waterways to transport a 57,000 MT consignment of legacy phosphogypsum from Paradeep port (Odisha) to Gujarat. This strategy addresses the difficulty posed by the high volume and sticky nature of the material.
- **Repurposing Legacy wastes (India):** Paradeep Phosphates successfully repurposes its legacy Phosphogypsum waste, generated at over 5000 MT/day, for use in road construction, cement production, and Zypmite production, ensuring efficient utilization of this industrial by-product.

9.3. Vision and Targets for Circular Economy Transition

9.3.1. Vision statement

The vision for the gypsum sector is to maximize the value of all industrial gypsum by-products, including phosphogypsum (PG), flue gas desulfurization gypsum (FGDG), and red gypsum (RG), in critical sectors such as construction, road infrastructure, and agriculture. This transition will be supported by advanced purification technologies, stringent quality controls, and localized infrastructure to overcome material-specific impurities and high transport costs. Ultimately, a truly circular gypsum economy will mitigate the environmental impacts associated with landfilling (such as methane emissions) and the social and health hazards linked to natural gypsum mining, while meeting the cumulative national demand projected to reach nearly 380 million tons by FY 2037-2038.

9.3.2. SMART targets

This is crucial as the cement industry has the potential to use approximately 16 million metric tons (MMT) of phosphogypsum annually alone. Simultaneously, reducing reliance on imported gypsum is essential, as imports currently make up nearly 35% of the total gypsum consumed by the cement industry. Furthermore, addressing the significant existing legacy stockpile of phosphogypsum, estimated at 70 MMT, through approved applications like road construction is a priority. Finally, enhanced recycling and safe disposal are necessary to manage 100% of all generated gypsum waste streams, aligning with CPCB guidelines.

Table 9-1: Specific Goals and Target

Goal	Current status	2030 Target
Replace the natural gypsum with synthetic gypsum in cement production	Current adoption in cement production is around 4%.	10% Basis: Total demand is 12–15 MTPA, which FGD gypsum alone could cover.
Reduce reliance on imported gypsum in the cement market (%)	Imports currently represent nearly 35% of the total gypsum consumed by the Indian cement industry.	25% Additional target: 20% (by 2035)
Enhance recycling of synthetic gypsum waste (Phosphogypsum, FGD gypsum, and red gypsum)	The absence of tracking and monitoring has resulted in lack of data	100% Basis: Aligns with CPCB guidelines for the usage of PG and FGD gypsum. Additional Target: Achieve a 25% recycling rate of construction gypsum waste by 2035.
Use of stockpiled phosphogypsum in road construction and agriculture (%)	Right now, the usage is being explored and legacy wastes are stockpiled	10% Basis: Approval by Indian Road Congress (IRC) on use of PG for road construction.
Develop regional recycling infrastructure and enforce quality standards (number) to ensure 100% compliance with national standards for gypsum-based construction materials.	Regional facilities at present do not exist	4% Basis: Recycling facilities must be strategically located, as environmental benefits are achieved only when transport distances ≤ 30 km.

9.4. Enablers and Implementation Framework.

9.4.1. Policy interventions & market-based instruments

Policy interventions are crucial for accelerating the transition towards a circular economy for gypsum, focusing on shifting market incentives and enforcing safety standards.

i. Encourage local sourcing: Imports constitute nearly 35% of the total gypsum consumed by the Indian cement industry. The government has already imposed new duties on imports of certain gypsum products from countries like China, Oman, and Iran.

ii. FGD Units for all thermal power plants: A key mandatory intervention is the directive for all thermal power plants to install Flue Gas Desulphurisation (FGD) units by December 2026. This is expected to significantly increase the supply of synthetic FGD gypsum, which can cover the entire projected demand of 12–15 MTPA from the cement industry alone.

iii. Promotion in Agricultural uses: Furthermore, the government has facilitated the use of waste gypsum by excluding Phosphogypsum (PG) from Schedule I of the hazardous waste category for agricultural purposes.

iv. Setting Standards: For quality assurance and market confidence, best practices recommend implementing clear waste acceptance criteria and clear recycled gypsum quality criteria.

9.4.2. Financing Tools/Incentives

Financial measures are essential to overcome the high capital expenditure barrier associated with using synthetic gypsum and installing necessary environmental controls.

i. Promote Investments in FGD installation in power plants: This will generate a steady stream of synthetic gypsum at a competitive price. Additionally, central ministries are encouraged to make FGD gypsum available to farmers at competitive rates.

ii. Financial support for end-use: State governments, including Telangana, Uttar Pradesh, and Tamil Nadu, currently provide financial assistance to farmers, covering 50% of the cost of gypsum material and transportation for use in treating saline and alkaline soils.

iii. To promote inter-industry upcycling possibilities over direct disposal (such as usage of gypsum in cement industry), government may consider providing transport subsidy to enable material to reach the correct partner industry.

iv. A policy change to revise current tariff levels of industrial by-products to lower freight slabs is also recommended to streamline movement to end-user industries.

9.4.3. Infrastructure

Infrastructure development must prioritize logistics and proximity, given that recycled Gypsum Waste only results in environmental benefits when transported equal or less than 30 km compared to natural gypsum production.

i. Regional recycling facilities: A specific target is to set up 4 regional recycling facilities for gypsum by 2028.

ii. Utilisation of Coastal waterways: Coastal waterways and other logistical solutions can address the challenge of high transport freight costs and the bulk nature of the material. Recently, UltraTech Cement Limited shipped a consignment from Paradeep port (Odisha) to Gujarat demonstrating its efficiency

9.4.4. Investment Technology Development

Investment in purification and pre-treatment technologies is paramount due to the wide ranging impurities and high moisture content in synthetic gypsum.

i. Industrial-Academia Collaboration: Industries shall promote and utilise the recent innovations in scientific community for phosphogypsum purification, including direct flotation, wet chemical conversion, and TBP and sulphuric acid-based conversion.

9.4.5. Capacity & Awareness building

The Central Pollution Control Board (CPCB) and the Atomic Energy Regulatory Board (AERB) have issued detailed guidelines for the safe management and utilization of phosphogypsum and FGD gypsum in building materials, construction, and agriculture. Capacity building is required to implement the on-site segregation of gypsum waste and ensure compliance with clear quality criteria. Awareness efforts should focus on:

i. Demonstrating the environmental and economic benefits of synthetic gypsum

ii. Promoting the approval of neutralized phosphogypsum for road construction by the Indian Road Congress (IRC)

iii. Highlighting the successful utilization of legacy PG waste (Ex; Paradeep Phosphates) for changing industry behavior and boosting market acceptance.

9.4.6. Initiatives/Measures/Actions with prioritization

The targets, goals, and enabling strategies outlined earlier form the foundation for a comprehensive implementation road map (presented in Table 9-2). This roadmap will serve as a strategic guide to systematically achieve the defined objectives by translating high-level targets into concrete actions. The table below details specific initiatives and activities, mapped against the targeted outcomes, along with estimated timelines, key ownership, and responsible stakeholders. These actions encompass a range of critical areas, all aimed at ensuring a structured, coordinated, and impactful pathway toward sustainable waste management and circularity.

Table 9-2: Proposed Priority Actions to Achieve Circular Economy Targets

Target No. 1: Utilisation of Stockpiled Phosphogypsum (PG) (Achieve 10% use of stockpiled PG in road construction and agriculture by 2030)				
Category	**Proposed Measure**	**Action Item**	**Timeline**	**Stakeholder for Implementation**
Policy-related initiatives	(PG) in road construction	Mandate and enforce the use of neutralized (PG) in National Highway (NHAI) road construction projects.	Short – Medium Term	MoRTH, NHAI
Economic Instrument	(PG) in agriculture	Promote use of neutralized (PG) in agriculture by providing financial assistance (50% cost / transport subsidy) to farmers	Short – Medium Term	State / FSSAI / Chemical Min
Target No. 2: Reducing dependence on Imported Gypsum and Supply Chain Stability (Use synthetic gypsum in cement production (10%) and reduce reliance on imported gypsum (25%) by 2030)				
Category	**Proposed Measure**	**Action Item**	**Timeline**	**Stakeholder for Implementation**
Policy-related initiatives / PPP	FGD Installations in Power Plants	Promote Investments in FGD Installation in power plants to ensure a steady, competitive supply of FGD gypsum	Short Term	Industry (Power)
Economic Instruments	Overcoming Freight Logistics	Revise Tariff levels of industrial by-products to lower freight slabs for movement of synthetic gypsum to end-users	Short Term	MoRTH, MoR, Industries
Research & Development	Feasibility studies	Conduct a detailed techno-economic analysis on synthetic gypsum sourcing and its utilization across sectors.	Short Term	NITI Aayog, Think Tanks, Academia
Target No. 3: Enhanced Recycling and Safe disposal of Gypsum Waste Streams (Establish guidelines to manage 100% synthetic gypsum and achieve 25% recycling rate of construction gypsum waste by 2035)				
Category	**Proposed Measure**	**Action Item**	**Timeline**	**Stakeholder for Implementation**
Research & Development	Quality Control Investment	Invest in Pre-treatment Technology (Ex: Calcination, Floatation) & QC measures to manage impurities / moisture	Short – Medium Term	Industry (Cement, Fertilisers), Academia
Policy Related Instruments	Capacity Building	Capacity building for on-site segregation of gypsum waste & ensure compliance with clear quality criteria.	Short – Medium Term	CPCB and AERB (Issuing guidelines); Central, State (Tracking national targets).
Target No. 4: Develop Regional Recycling Infrastructure and Enforce Quality Standards (Set up 4 regional recycling facilities for gypsum by 2028 and ensure 100% compliance with national standards for gypsum-based construction materials)				
Category	**Proposed Measure**	**Action Item**	**Timeline**	**Stakeholder for Implementation**
PPP	Regional Facilities Development	Set up 4 regional recycling facilities for gypsum by 2028, ensuring proximity to end-users (transport ≤ 30 km).	Medium Term	State / ULBs, Industry.

Table 9-3: Implementation Risks and Mitigation

Implementation Challenges	Mitigation Strategy
The slow progress of adoption of FGD Units is primarily due to high capital expenditure.	Promotion of investments to adopt FGD technology and strictly enforcing the government's mandate for installation by December 2026.
Synthetic Gyspum may contain traces of fluorine, P2O5, and radioactive elements raising quality & impurity concerns	ι. Install advanced quality control measures ιι. Utilize scientific purification processes like calcination, neutralisation, or floatation
Logistical Difficulties due to high transport freight cost and sticky nature	i. Revision of Tariffs to lower freight slabs, utilizing coastal waterways for bulk transport. ii. Regular cleaning of loading equipment also to be considered

9.4.6. Monitoring and Accountability

The Central Pollution Control Board (CPCB) and the Atomic Energy Regulatory Board (AERB) are key bodies responsible for oversight, specifically issuing and monitoring adherence to guidelines for the safe management and utilization of phosphogypsum and FGD gypsum in construction and agriculture.

Accountability rests with Central and State Ministries to track the fulfillment of national targets, such as the increase in synthetic gypsum replacement (targeting 10% by 2030) and the installation rate of FGD units. Industry must be accountable for investing in pre-treatment, adhering to quality standards, and reporting utilization rates of industrial by-products in alignment with CPCB/AERB directives.

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Chapter 10

CIRCULAR ECONOMY ACTION PLAN FOR TOXIC AND HAZARDOUS INDUSTRIAL WASTE

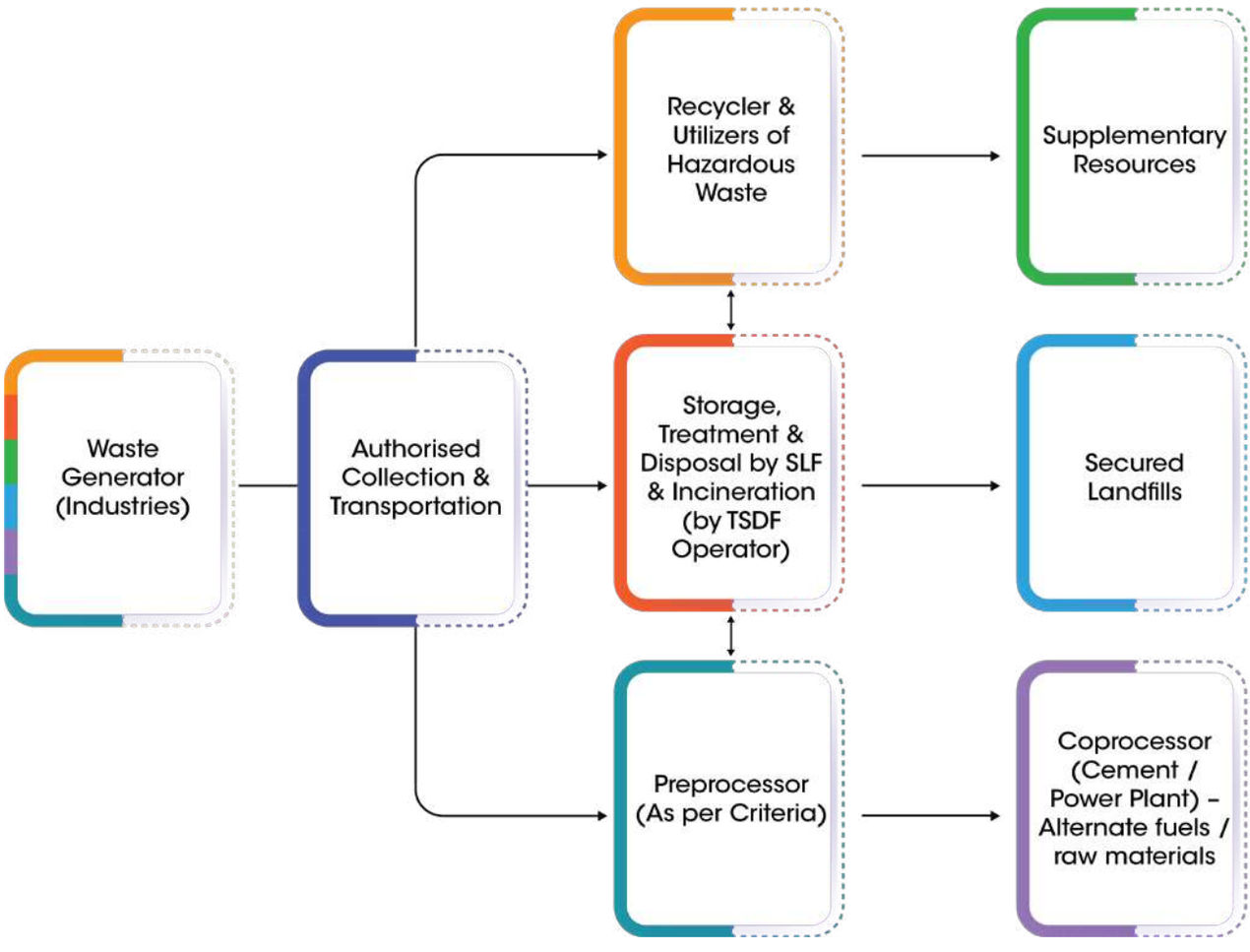
10.1. Material Landscape and Circularity Baseline

Industries generating hazardous waste are primarily required to take all necessary measures to ensure that such waste is managed in a manner that protects human health and the environment from any adverse effects. Hazardous waste requires specialized handling and treatment due to the presence of a heterogeneous mixture of chemicals and toxic substances.

Hazardous waste management rules have been in place since 1989, and the framework has been amended from time to time, mainly to facilitate the recycling or utilization of certain hazardous wastes, including their transboundary movement in line with the Basel Convention. The existing Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 provide a comprehensive approach for the management and handling of industrial hazardous and other wastes. Continued reforms are expected to further promote resource efficiency and the principles of a circular economy.

Figure 10-1 presents the typical flow of hazardous waste management, from its generation to final disposal. It highlights the key stakeholders involved in the process, including waste generators (industries), transporters, treatment, storage, and disposal facilities (TSDFs), pre-processors, recyclers, and coprocessors.

Figure 10-1 : Typical Flow of Hazardous Waste Management



Non-utilizable or non-recyclable hazardous waste needs to be disposed through a Common Hazardous Waste Treatment, Storage and Disposal Facility (TSDF) or can be disposed of through captive treatment facility installed by the individual waste generators. However, disposal at common TSDFs is beneficial as compared to the captive facility because of the reasons such as reduced capital investment, reduced cost of treatment and post-closure monitoring.

As per the inventory report of the CPCB, about 84,000 industries have been authorized under the Rules for generating hazardous waste. Recycling and utilization of hazardous waste account for about 55% (10.06 million MT) of the total hazardous waste generated (18.5 million tons). Co-processing in cement kilns alone utilizes about 2.85 million tons of incinerable hazardous waste. About 3.78 million MT of waste has been disposed through secured landfilling (3.4 MMT) and incineration. There has been a significant increase in recycling/utilization of hazardous waste from 7.5 MMT in the year 2022 to 10.06MMT in the year 2024.

While we strive to achieve a higher degree of utilization, recycling and co-processing of hazardous waste, there is a need to focus on research, innovation and the adoption of environmentally sound, safe and sustainable technologies for the handling, treatment and utilization of hazardous wastes – a critical environmental challenge with far-reaching implications for public health and ecosystems.

10.1.1 Current and Projected Growth Rate

Hazardous waste management is currently undergoing a transformation, incorporating new technologies to minimize waste generation and convert wastes into presupplementary resource materials or for energy recovery, enhancing overall efficiency and stability. Both government and non-government organizations are actively working to treat hazardous waste responsibly, with a greater emphasis on reuse and recycling to promote a circular economy.

Effective management of hazardous waste offers numerous benefits and plays a vital role in supporting the circular economy. There has been a steady growth in industries related to hazardous waste management, and the following operations are significantly contributing to circular economy objectives:

1. **Recycling Facilities :** Authorised for recycling of commonly recycled hazardous wastes namely, lead scrap, non-ferrous metals scrap, spent catalysts, paint sludge, used oil, waste oil, e-waste etc.

2. **Facilities for Utilization of Hazardous waste** : Captive or standalone utilization facilities for various types of hazardous wastes such as discarded chemical containers, spent solvents, spent acids, ETP sludges, etc., produce secondary raw materials to manufacture new products.

3. **Pre-processing (Utilization in Cement Kilns)**: This involves preparing/converting hazardous wastes into a homogeneous material, meeting pre-defined characteristics suitable for subsequent co-processing in cement kilns.

4. **Disposal**: After exhausting the above options, the wastes that cannot be utilized or recycled are being sent to authorised TSDFs for scientific disposal, which may involve secure landfilling and/or incineration.

This approach significantly contributes to the economy by creating job opportunities, promoting reusability and recyclability, and fostering a sustainable future for all.

As per the inventory there has been a significant increase in the utilization of hazardous waste compared to the 2022-2023 levels as shown below:

S.No	Method of utilization	FY 2022-23 Million MT	FY 2023-24 Million MT	% Increment
1	Commonly recycled hazardous wastes	2.35	2.34	No change
2	Co-processing in Cement Kilns	2.31	2.85	23%
3	Captive utilization	2.26	2.9	28%
4	Non-captive utilization other than co-processing	1.69	1.97	16%
5	Total Quantity of HW Recycled/ Utilized	8.61	10.06	17%

According to annual inventories, hazardous waste generation has been steadily increasing. The generation in 2023-24 was 18.5 million metric tons, which is 11% more than the previous year. This hazardous waste poses significant environmental and health risks and improper handling or disposal can lead to the contamination of air, water, and soil, the emission of greenhouse gases, and harm to wildlife and ecosystems. Scientific management of waste following environmentally sound management practices, will help in achieving resource conservation and minimizing the associated risks.

Generation of hazardous waste has steadily been on the rise from 6 million metric tons in 2010 to 18.5 million metric tonnes in 2023. The hazardous waste management sector is projected to grow at a compound annual growth rate (CAGR) of 5.6% from 2024 to 2036.

10.1.2 Current level of Adoption of Circular Economy Principles

The Government of India has continued its policy framework that promotes the Circular Economy and resource efficiency. Its impetus started with re-notification of all the waste management Rules in the year 2016, primarily to promote recycling and utilization of wastes. Further amendments to the waste management Rules since 2022 have provided for the implementation of extended producer responsibility (EPR) schemes to incentivize the recycling industry and promote the business ecosystem around the circular economy in the country.

The EPR schemes have been implemented for following waste streams:

- Plastic packaging wastes
- E-Waste
- Waste Batteries
- Waste Tyres
- Used Oils
- End-of-Life vehicles
- Non-ferrous metals
- Construction and Demolition Wastes

Incentivisation of Recyclers through the EPR scheme, in the form of recycling credits, has resulted in a greater number of registered facilities and increased volumes of collection and recycling. The same is evident from plastic waste recycling, where the number of registered plastic waste processing facilities on EPR portal has increased from about 1400 in 2022 to 2960 facilities in 2025.

Recycling industries handling wastes such as battery scrap, non-ferrous metal scraps, metal dross, used oils, spent catalysts, paint sludges and e-waste have been pre-existing; however, their sustainability has increased with support from CE initiatives such as EPR. About 2.34 million tonnes of such hazardous wastes were recycled during the year 2023-24.

In addition, utilization of any hazardous waste as supplementary resource or for energy recovery has been facilitated under Rule 6 and 9 of the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016. Prominent hazardous wastes utilized include contaminated containers, spent solvents, spent sulphuric acid, and carbon residues. The CPCB has so far developed 118 SOPs for utilization of above 78 types of hazardous waste. The trend in the utilization of hazardous wastes is given below:

Type of utilization	Trend
Non-Captive Utilization by 1231 industries	1.91 (↑16%)
Captive utilization by 1312 facilities	2.9 million MT (↑13%)
Utilization by co-processing in 111 Cement Kilns	2.85 million MT (↑23%)

There has been a gradual increase in the volume of pre-processing of hazardous wastes to make it suitable for co-processing in cement kilns, which is an important industrial sector. Alternate Fuel and Raw Material (AFR) is being produced in pre-processing operations, particularly at common hazardous waste TSDFs in the country. AFR plays a crucial role in the circular economy, serving as an alternate fuel in cement kilns as well as an alternate raw material.

The above-mentioned activities are few examples of how circularity is currently embedded in the overall hazardous and toxic waste management sector. However, it faces its own set of challenges, ranging from the presence of an unorganised sector, limited commercial viability for the organised sector, and the absence of incentives to enable the end user to adopt such circular materials.

10.1.3 Overview of existing policies and incentives promoting circular economy

India has established a specific set of policies, rules and regulations to promote a circular economy in waste management. The existing waste management Rules include various policies that align with circular economy principles. The Hazardous Waste Management Rules, 2016 advocate the principles of management hierarchy comprising of waste minimization/avoidance, recycling, utilization, co-processing prior to ultimate disposal in secured landfills or incineration. Major initiatives have been taken since the year 2022, implementing the principles of circular economy through EPR schemes. The following principles that are engraved in green acts and rules promotes circularity in waste management:

- **Reduction of Waste Generation**: The Rules emphasize minimizing the production of toxic and hazardous waste within production systems.
- **Proper Segregation**: The Rules mandate the proper segregation of hazardous waste from non-hazardous or non-toxic waste to ensure effective management, as hazardous waste requires different treatment methods.
- **Recovery, Recycling and Utilization**: The Rules encourage increased recycling and reuse of hazardous materials, which not only supports pre-processing but also helps reduce reliance on fossil fuels and raw materials.
- **Regulatory Compliance and Monitoring**: The regulations provide clear guidelines for compliance and monitoring systems to ensure that the handling of hazardous waste does not adversely affect the environment and health.
- **Extended Producer Responsibility (EPR):** This is an environmental protection strategy that makes producers responsible for the life-cycle of their products placed on market. Such responsibility may include retrieval, recycling and disposal of their end-of-life products with minimal environmental consequences. EPR thus enhances sustainability of the waste management. EPR scheme is implemented for the hazardous

and other wastes such as used oils, e-waste, waste tyres, non-ferrous metals, waste batteries and plastic waste.

10.1.4 Lessons from international best practices

Global policies such as resource efficient Europe and the waste-specific regulations of EU on the circular economy have been studied as the guiding policies and frameworks that can be tailored to suit the country's requirement. The EU also has RoHS that restricts the use of certain hazardous chemicals in the manufacturing process of electronics and electrical equipment. The US has TSCA (Toxic Substances Control Act) and California has its own legal frame work called Prop 69 which includes a list of 800 chemicals and requires companies to publish a list of chemicals that are known to cause cancer, birth defects and other reproductive problems. Some other practices include:

- Life Cycle Assessment (LCA): Implementing LCA helps industries evaluate the environmental impacts of their products from creation to disposal, encouraging them to make decisions that enhance circularity and reduce hazardous waste generation.
- Green Chemistry: Promoting the principles of green chemistry encourages the design of chemical products and processes that minimize or eliminate hazardous substances, leading to less hazardous waste generation.
- Research and Innovation: Investing in research and development for safer waste management technologies and methods is crucial. Countries that support innovation in this field often see advancements in circular waste practices.
- Implementation and enforcement of effective regulation: to minimize the use of hazardous chemicals, both virgin and recycled, in the manufacturing process. The EU has enforced REACH (Registration, Evaluation, Authorization and Restriction of Chemicals) a comprehensive set of legal frame work addressing chemicals in use and requiring companies marketing chemicals to present a set of test data.

10.2 Gaps & Challenges in Advancing Circularity

10.2.1 Policy gaps and regulatory barriers

The waste management sector faces challenges in adopting uniform practices and developing common infrastructure across states for the handling of hazardous waste. Treatment procedures for some of the wastes are limited in guidelines and there is no clear guidance from the Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCB). Additionally, there is non-uniformity among the States in implementing the hazardous waste management Rules, including the issues related to transboundary movement across the States. Social and political factors can also hinder effective hazardous waste management. Many of these problems stem from a lack of financial resources, well-trained staff, and sufficient manpower.

While there is a framework under the Rules to promote circularity in hazardous waste material, there is no obligation mandating waste generators (similar to EPR systems) to recycle or utilize the hazardous waste. One example is the practice of pre-processing wastes as alternative fuels and raw material for co-processing in cement industries. Cement industries are receiving waste from multiple channels including biomass, RDF and plastic wastes for co-processing including the pre-processed industrial hazardous waste from standalone pre-processors. It has been observed that most of the standalone pre-processors do not have adequate infrastructure, trained staff and does not practice SOPs to ensure environmentally safe production of pre-processed hazardous wastes. To address this, it is essential to institute mandatory requirements for minimum infrastructure, qualified manpower, and baseline environmental assessments for pre-processing facilities, to ensure only competent and compliant entities operate in this space. SPCBs/CPCB may closely monitor the pre-processing operations to minimize the environmental and health risks such as soil and groundwater contamination.

Over the past decade, implementation of Zero Liquid Discharge conditions in consent to discharge of wastewater in industries like pharma, dye-intermediate, pesticide, textile, chemicals, tanneries, Paper & pulp and other industries by States across the country has resulted in generation of evaporation salts, which are categorized as hazardous wastes. MEE slats are highly hygroscopic and improper management of same would result into high risk of contaminating soil and water bodies. This policy has converted the issue of wastewater discharge into hazardous waste handling and disposal. There is limited scope for utilization of such mixed salts and the disposal of the same is a complex process for the TSDFs. The existing guidelines of CPCB/SPCBs does not provide adequate

options for managing the salts including recovery of the same. At present some of the facilities are storing large volumes of salts on site posing severe risk of environmental impacts.

10.2.2 Challenges posed by informal sectors

Hazardous wastes such as used batteries, e-waste, insect repellent bottles, CFL bulbs, used oils, and waste oils etc. are commonly collected by the informal sector. These informal operators have a limited understanding of hazardous waste types and treatment processes. As a result, the toxicity and hazards associated with certain waste types may go unrecognized, leading to improper handling and treatment. Workers in the informal sector lack proper knowledge and training in waste handling and are often paid less. This allows them to manage waste at lower costs than formal sectors, prompting some industries or consumers to opt for disposal through informal channels. Unfortunately, these practices can harm the environment and contribute to ineffective waste management.

10.2.3 Commonly recycled hazardous wastes

The main challenge being traceability and leakage of material to the informal sector.The Operation of the informal sector in the area affects the viable operations of authorised and environmentally compliant recyclers. With negative impacts on environment, operations of informal sector do not fit the definition of circular economy.

10.2.4 Utilization of Hazardous wastes

Present regulation does not stipulate the obligation of sending utilizable hazardous wastes to the facilities authorized for utilization under Rule 9. This may leave occupiers with the option to either send such waste for disposal or to a utilizer based on cost considerations rather than considering the circularity of material. The same applies to wastes that are suitable for co-processing in cement kilns for resource or energy recovery.

10.3 Vision and Targets

Circular economy framework for industrial hazardous wastes would need a different approach compared to other wastes such as household solid wastes, e-waste, wate tyres, waste batteries etc. due to inherent toxic and hazardous characteristics. Hazardous wastes are required to be stored, transported, handled, treated, processed and disposed of in accordance with laid down protocols and guidelines to minimise risks to environment and health of people associated with them.

The existing framework identifies recyclable and utilizable hazardous wastes and authorises the occupiers to manage according to their applications for authorization, which is subsequently issued by SPCBs. However, there are no obligations on occupiers (generators) to manage a particular stream of hazardous waste material according to resource recovery potential.

In present context, circularity in hazardous wastes exists on the ground in the following ways:

(a) Recycling of commonly recycled hazardous wastes such as spent catalysts, used oils, non-ferrous metals scraps and drosses, paint sludges, e-waste and waste batteries.

(b) Utilization of about 78 types of hazardous waste as per 118 SOPs developed by CPCB.

(c) Co-processing of hazardous waste in cement manufacturing, enabling energy recovery as a supplementary benefit.

However, considering the limitations and situation on ground, action may be needed on the following fronts:

1. **Strengthen Existing Rules & Regulations**: The existing regulations may be strengthened further to incorporate circularity approaches at the core of regulations rather than leaving the options with the generators or utilizers. The existing guidelines may be strengthened to address the loopholes and discourage shortcut methods being adopted in management of hazardous wastes such as standalone pre-processors.
2. **Incentivize Waste Generators**: Encourage industries to view circularity in production and waste minimization as a value-added activity, rather than a burden.
3. **Enhance Traceability**: Improve tracking of waste materials throughout their lifecycle.
4. **Engage with the Informal Sector**: Foster collaboration with informal waste handlers to improve overall management practices.
5. **Promote Research**: Invest in research to find alternatives to traditional waste management practices.
6. **Transform Operations of TSDFs:** Hazardous waste management may shift gradually from the option of secured landfilling and incineration to the production of alternate fuels and raw material (AFRs). The existing TSDF infrastructure, while continuing to support disposal services for the residues and recyclables, may be converted into centralised resource recovery centres, with infrastructure facilities compliant with CPCB's SOPs and guidelines for utilization, recycling and pre-processing of hazardous wastes.
7. **EPR Scheme for Hazardous Wastes**: The EPR regulation has been implemented for hazardous wastes such as waste oils, e-waste and waste batteries to makes the Producer to take-up responsibility for the life-cycle of their products placed on market. At present there is no obligation on the occupiers or generator to manage the hazardous waste in a specific manner, often it is the generator who decides the disposal pathway and applies for authorization. An EPR like scheme may be envisaged for the generators of specific hazardous wastes to mandate retrieval, recycling or utilization through authorised TSDFs or utilizers. Such scheme would enhance sustainability of the waste management. To begin with government may consider mandating utilization of hazardous waste following the SOPs under Rule 9 already prepared by CPCB.
8. **Management of MEE Salts** : Considering the challenges posed in collection, storage and disposal of MEE salts from wastewater treatment, CPCB/CSPCBs may therefore consider developing comprehensive guidelines on management of the same. Options for management of salts may include the recovery of salts, construction of specialised secured landfills (such as rigid landfills), stabilization or encapsulations methods and any other alternate treatment disposal options through TSDFs. To support salt recovery facilities, industries may be encouraged to utilize recovered salts as a part of resource recovery and circular economy initiatives, and appropriate incentives or recognition mechanisms may be introduced to promote and strengthen facilities engaged in salt recovery.
9. **Centralized Tracking system :** To optimize resource consumptions and utilization in process industry, It is required to maintain data pertaining to consumption of material, products and generation of wastes. The existing annual reporting system may be centralized for online annual reporting of such data. The national hazardous waste tracking system developed by CPCB/NIC needs to be adopted uniformly across the SPCBs to track end to end movement of hazardous wastes including the inter State movement.

Goals & Targets

It is a challenge to increase 2030 utilization and recycling targets for hazardous wastes due to inherent quality/ characteristics of the hazardous waste, which negatively impact on day to day operations such as storage, collection, transportation, treatment and processing.

Therefore, there is a need to assign utilization/ recycling targets for the waste generators as well. A brief guideline is provided as under:

Table : Proposed Target

S. No.	Proposed Target	Target by 2030
1	**Captive Utilization of Hazardous and Other Wastes:** Utilization of hazardous waste by the waste generator, over and above their current numbers (% improvement). *[Basis for target: CPCB has prepared 115+ SOPs for utilization of different types of hazardous waste during the period 2016 to 2024]*	5%
2	**Utilization of hazardous waste as a supplementary resource**: Diversion of hazardous waste to authorized utilizers by the waste generator for utilization based on CBCP's SOPs, as a percentage of total waste. *[Basis for target: CPCB has prepared 115+ SOPs for utilization of different types of hazardous waste during the period 2016 to 2024]*	10%
3	**Thermal Substitution Rate (TSR) Target** for cement industries through utilization of Hazardous Waste as AFR. *[Basis for target: Voluntary targets set by leading cement industries to achieve about 25-30% TSR by 2030]*	15%

10.4 Enablers and Implementation Framework

The above mentioned eight action points can be achieved through the following measures:

10.4.1. Policy Enhancement & Mandates:

- Ensure effective regulation and enforcement to minimize the use of hazardous chemicals—both virgin and recycled—in manufacturing processes.
- Define "essential use" of hazardous chemicals as necessary for health, safety, or societal functioning, in line with the Montreal Protocol, rather than for profit.
- Use REACH as a baseline to identify substances of very high concern and promote their substitution with safer alternatives.
- Regulate groups of substances collectively rather than individually.
- Require industries to commit to transparency regarding hazardous chemicals in their supply chains, both upstream and downstream.
- Establish guidelines for output materials provided by pre-processors to co-processors, specifying minimum quality and safety parameters.
- Formulate guidelines/SOPs for establishing authorized utilizers across the states. Promote captive utilization by providing incentives (financial/fiscal) to industries investing in captive utilization infrastructure

.10.4.2 Market Reorientation:

- Shift market dynamics towards resource conservation by incentivizing waste-reduction practices and penalizing those that generate excess waste. Clear price signals can encourage circular economy aligned business models.
- Incentivize the design of products with reduced hazardous content to facilitate recycling.
- Implement the "No Data, No Market" principle, encouraging companies to disclose comprehensive lists of chemicals used in manufacturing.
- Exempt import duties on waste recycling technology and equipment.
- Extend tax incentives for industries achieving hazardous waste reduction through improved processes or new technologies.
- Develop an Extended Producer Responsibility (EPR) scheme for toxic and hazardous industrial waste.
- Offer Central and State subsidies for establishing Eco Parks and common hazardous waste management and recycling facilities.
- Provide incentives for industries to transition from Red to Orange, and eventually Green categories as per CPCB classifications.

10.4.3 Enhance Traceability:

- Traceability of waste has become a major challenge for the Hazardous Waste Management Industry. With multiple value add partners being identified it is becoming more and more difficult to keep a track of where the waste was generated and what was its final end use. The idea of setting up of common waste management facilities was to minimize & control the footprint of the waste being generated, in terms of its end use. With multiple partners being created in the value chain this tracking has become very diluted and therefore the following needs to be encouraged.
- Establish common facilities or eco-parks that manage the entire value chain of certain products, from raw material production to recycling and final disposal, to improve quality control and traceability.
- Upgrade common hazardous waste handling facilities with comprehensive waste management capabilities, including utilization, recycling, recovery, and final disposal, prioritizing circular practices to minimize environmental harm. Encourage common facilities (authorized utilizers) in all states ensuring accessibility for all industries.
- Implement a national centralized tracking system that monitors the entire production and disposal process, inventorying materials used, products manufactured, wastes generated, and value chain partners.

10.4.4 Integrate the Informal Sector:

The informal sector poses a huge risk to the circular economy principles at large as the practices undertaken harm the environment at large as well as lead to a lot of resource wastage since the activities undertaken are by and large more revenue centric rather than circularity or environment centric by:

- Encouraging the lower-tier informal sector to formalize their operations through incentives.
- Promoting partnerships between the informal sector and the authorised TSDFs/Recyclers in formal sector, allowing informal entities to supply materials for the formal sector.
- The government should act as an enforcement body, with a stringent action plan, to support the transition of the informal sector when necessary.

10.4.5 Research & Development:

- Focus on identifying cleaner manufacturing processes, starting with industries having high waste generation potential.
- Prioritize circular economy initiatives at the government level, allocating significant resources and promoting coordinated research across departments and ministries.
- Incorporate circular economy topics into relevant academic curricula to foster research and innovation in reducing hazardous waste.
- Conduct extensive research on the limitations and long-term impacts of using hazardous waste as an alternative resource in cement industries or other utilization, focusing on the materials utilized

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Chapter 11

CIRCULAR ECONOMY ACTION PLAN FOR USED OIL

11.1. Material Landscape and Circularity Baseline

11.1.1. Overview of the Material Value Chain and Its Importance

The material value chain begins with the refining of crude oil or the synthesis of lubricating oils. Finished lubricants—typically consisting of about 90% base oil and 10% additives—play a crucial role in minimizing friction across key sectors, including automotive, industrial, mining, power, and marine operations.

Used oil is primarily generated by the automotive sector – including Original Equipment Manufacturer (OEM) service centers, independent garages, and by institutional and industrial consumers.

In FY 2023–24, India imported approximately 232.5 million tonnes of crude oil, which was refined into fuels such as petrol and diesel. Of this volume, only about 1–2% is refined into base oils. Domestic base oil consumption reached 4.1 million tonnes per year, up from 3.7 million tonnes in FY 2022–23.
Used oil recycling holds strategic significance for India, as it reduces dependence on imported virgin base oil, which currently meet 60–80% of national demand. Re-refining also conserves energy, requiring only about one-third of the energy needed to produce virgin base oil from crude oil.

11.1.2. Environmental Footprint and Market Dynamics

Improper handling and disposal of used oil pose severe environmental and health hazards. Just one litre of used oil can contaminate up to one million litres of fresh water. Used oil often contains toxic substances such as polycyclic aromatic hydrocarbons (PAHs) and heavy metals including lead and iron, making it highly hazardous. When burned, it releases significant pollutants such as NO_x, SO_2, and heavy metal emissions.

The Indian lubricant market is among the largest globally, currently estimated at around 3.08 million metric tonnes (MMT). Consumption of finished lubricants is expected to grow steadily, reaching 4.8–5.6 MMT by FY 2029. Consequently, the recoverable volume of used oil is estimated at 1.4 MMT annually and is projected to rise to 1.7–2.2 MMT by FY 2031.

However, India faces an inverted cost dynamic—recycled oil is typically 5–10% more expensive than comparable virgin base oils, largely due to inefficient collection systems, limited logistics networks, and higher operational costs.

11.1.3. Circularity Baseline and Policy Landscape

India's current level of circularity in used oil management remains low, with only 15–20% of generated used oil reaching authorized recycling channels. Re-refining is the most preferred circular practice, as it restores used oil into high-quality base stocks. However, many Indian recyclers—predominantly micro, small, and medium enterprises (MSMEs)—continue to use outdated and environmentally unsound technologies such as acid-clay treatment or basic vacuum distillation. As a result, most facilities operate at less than 30% of their installed capacity.

The regulatory environment is undergoing rapid transformation with the introduction of Extended Producer Responsibility (EPR) for used oil under the *Hazardous and Other Wastes (Management and Transboundary Movement) Second Amendment Rules, 2023*, effective April 1, 2024. This policy mandates producers to meet progressive recycling targets—starting at 5% in FY 2025 and reaching 50% by FY 2031.

EPR compliance will be certificate-based, with re-refining receiving the highest weightage (1.0) compared to other disposal methods, thereby encouraging environmentally responsible recycling.

11.1.4. Best Practices and Innovations

International experiences demonstrate that strong centralized legislation and well-designed financial mechanisms are critical to effective used oil management. Countries such as South Korea and Italy have implemented models where dedicated environmental handling fees on virgin lubricant producers fund recycling operations and support compliance.

To achieve India's ambitious EPR targets, systemic reforms and technological modernization are essential. Key recommended actions include:

1. Mandatory Digital Tracking – Implementing a digital monitoring system for used oil movement to replace manual documentation (e.g., Form 10).
2. Formalized Collection Networks – Structuring organized collection systems, beginning with bulk generators and progressively integrating independent garages and informal collectors.
3. Technological Upgradation – Transitioning from obsolete technologies to advanced processes such as hydro-processing (e.g., HyLube, CEP Process) to produce high-quality API Group II/III base oils.
4. Industry Consortia and Coordination – Establishing a National Used Oil Management Association to centralize governance, ensure compliance, and promote industry collaboration.
5. Incentivizing RRBO Adoption – Encouraging lubricant manufacturers and OEMs to incorporate Re-Refined Base Oils (RRBO) through measures such as voluntary commitments, fiscal incentives, or reduced GST rates.

11.2. Gaps and Challenges in Advancing Circularity

11.2.1. Policy Gaps and Enforcement Barriers

A major policy gap in India's used oil management system lies in the limited tracking and accountability mechanisms across the supply chain. At present, Extended Producer Responsibility (EPR) compliance depends largely on a manual, paper-based manifest system (Form 10) for tracking hazardous waste movement—an approach prone to errors, manipulation, and non-compliance.

Moreover, bulk generators are often exempt from mandatory registration on the Central Pollution Control Board (CPCB) EPR portal, which restricts the ability to track lubricant inputs versus used oil outputs in a formal and verifiable manner.

Legislative ambiguity also creates barriers to effective operations. The industry continues to face long-standing challenges in disposing of hazardous residues, such as spent clay and bottom residue generated during the re-refining process. Stakeholders have also urged regulatory amendments to restrict the co-processing of used oil as an alternative fuel in cement, power, and steel industries, arguing that re-refining should take precedence due to its higher circularity value.

Additionally, logistical constraints—including the need for state-specific No Objection Certificates (NOCs) and restrictions on inter-state transport of used oil—further escalate costs and reduce the efficiency of collection and recycling operations.

11.2.2. Feedstock Availability and Informal Sector Dominance

India's used oil supply chain is highly fragmented and dominated by informal operators, significantly constraining the availability of feedstock for authorized re-refiners.

- **Informal Dominance and Price Escalation:**
  The unorganized automotive repair sector—comprising independent garages and roadside mechanics—accounts for 35–45% of the total used oil generated, yet remains largely outside the formal collection system. Informal collectors (kabadiwalas) operate through cash-based, undocumented transactions that enable tax evasion (estimated at 20–30% of additional income), thereby inflating used oil prices and undermining legitimate recyclers.

- **Competitive Disadvantage:**
  Due to high collection costs and inefficiencies in the formal supply chain, Re-Refined Base Oil (RRBO) often costs 5–10% more than comparable virgin base oil. This cost disparity incentivizes generators to divert used oil into unregulated markets, where it is frequently sold for diesel adulteration or furnace oil blending, offering higher financial returns.
- **Underutilization of Capacity:**
  The chronic shortage of feedstock has led to widespread underutilization of re-refining facilities, with most authorized units operating at less than 30% of their installed capacity.

11.2.3. Infrastructure and Technology Gaps

India's re-refining infrastructure suffers from technological obsolescence, limited scale, and inadequate quality assurance mechanisms.

- **Outdated Technology:**
  Many recyclers continue to use the environmentally harmful acid-clay treatment process to produce low-quality Group I base oils. This method generates large volumes of hazardous acid sludge and is banned in most developed countries due to its ecological impact.
- **High Cost of Upgradation:**
  Transitioning to modern technologies such as hydro-processing or solvent extraction—required to produce high-quality API Group II/III base oils demanded by the modern lubricant market—requires significant capital investment. For instance, setting up a 50 KTPA hydrogenation facility can cost INR 700–900 crore, a prohibitive expense for MSME re-refiners lacking assured feedstock and guaranteed market off-take.
- **Quality and Testing Deficits:**
  Most recyclers lack in-house testing laboratories capable of verifying RRBO quality against Bureau of Indian Standards (BIS) specifications. Dependence on costly third-party laboratories located in metro cities further exacerbates challenges in maintaining consistent quality assurance.

11.2.4. Weak Downstream Markets and Limited Platforms

The downstream market for Re-Refined Base Oil (RRBO) remains weak due to quality inconsistencies, limited policy incentives, and inadequate awareness.

- **Degraded RRBO Quality:**
  Poor segregation at the collection stage leads to contamination and variability in feedstock, resulting in RRBO products with inconsistent color, elevated trace metal content, and variable specifications—factors that deter lubricant manufacturers from adopting re-refined products.
- **Limited EPR Incentive Alignment:**
  The current EPR framework is certificate-based, focusing solely on recycling credit trading without mandating or incentivizing the use of RRBO in new lubricant formulations. This lack of alignment limits market demand and discourages producers from integrating RRBO into their supply chains.
- **Awareness and Institutional Platforms:**
  Public and consumer awareness about the value of used oil as a recyclable resource remains low, reinforcing its perception as a cheap, non-standard product. To improve governance, coordination, and industry collaboration, it has been recommended to establish a National Used Oil Management Association, modeled after successful centralized bodies in other countries.

11.2.5. Lessons from Global Best Practices

International experience offers several proven strategies to overcome the challenges of policy, collection, and technology in used oil management:

- **Centralized Oversight and Mandates:**
  Countries such as Italy (CONOU), South Korea (KLOIA), and France (CYCLEVIA) operate under centralized Producer Responsibility Organizations (PROs) that manage the entire value chain. This model ensures high collection efficiency—Italy, for example, achieves 98% recycling of collected used oil—and mandates the incorporation of re-refined base oils in motor lubricants.

- **Sustainable Financing Mechanisms:**
  Canada and several U.S. states, such as California, impose Environmental Handling Charges (EHCs) on virgin lubricant sales. These funds are used to support collection, transport, and infrastructure development, making the system financially self-sustaining.
- **Digital Traceability Systems:**
  Nations like Spain (SIGAUS) and France (CYCLEVIA) employ advanced digital traceability platforms that enable end-to-end tracking—from generation and transport to final treatment—ensuring transparency, compliance, and quality assurance across the entire lifecycle of used oil.

11.3. Vision and Targets for Circular Economy Transition

11.3.1. Vision Statement:

By 2030, India will transform its used oil management system into a fully circular ecosystem, where all high-value used oil is collected and re-refined into base oil or recycled into high-quality products, reducing reliance on virgin base oils, minimising hazardous waste disposal and creating a vibrant ecosystem of collection, aggregation and recycling with formalised value-chains.

Table 11-1: SMART Targets

S.no.	Proposed Target	2030	Basis for Target
1	Collection of used oil: ≥ 90 % of estimated generated used oil (unit: % of generation)	90%	Current recycling is ~15% of used oil generated in India. A near-doubling is ambitious but achievable if EPR and aggregation improve.
2	Re-refining / recycling rate: ≥ 70 % of collected used oil processed into re-refined base oil or equivalent (unit: % of collected)	70%	With improved technology and licensed capacity, shifting from low re-refining share to majority.
3	Recycled content in lubricants: ≥ 30 % of base oil supply (unit: % recycled content)	30%	Given the growing base oil market (India base oil market expected to grow from ~3.59 bn L in 2024 to ~4.42 bn L by 2030) a target of 30% recycled content signals circularity.

These targets provide a directional yet measurable roadmap to 2030.

11.4 Enablers and Implementation Framework

To realise the vision and targets above, a layered set of enabling actions across policy, infrastructure, financing, capacity building and stakeholder alignment is required.

11.4.1 Policy & Market-Based Instruments

- Introduce mandatory EPR recycling certificates for used oil producers/importers under Ministry of Environment, Forest and Climate Change (MoEF & CC) rules; ensure increasing annual targets from e.g., 5% in FY2025 to 50% by FY2031.
- Deploy feed-in incentives or mandated recycled content standards for base oils and lubricants, thereby creating demand for re-refined oil and improving offtake markets.

- Ban or restrict disposal routes and levy high environmental-compensation fees for unauthorised disposal of used oil.

11.4.2 Financing Tools / Incentives

- Use blended finance / viability gap funding to support state-level or regional circular economy parks for used oil collection, sorting and processing.
- Launch green bonds specific to hazardous waste recycling infrastructure, with used oil recycling as eligible project category.
- Establish preferential procurement mandates from government fleets / defence / large industry for lubricants with > 30 % recycled content.

11.4.3 Infrastructure & Technology Development

- Set up Regional Circular Economy Parks / hubs for used oil – aggregation centres linked to licensed re-refining units, ideally colocated with industrial estates to minimise transport cost.
- Invest in advanced technology demonstration units (e.g., hydro-processing, solvent decontamination) to improve yield and quality of re-refined base oil.
- Develop traceability platforms (blockchain or digital) to monitor feedstock flows from generators → collection agent → recycler → re-refiner → product offtake.

11.4.4 PPP, Capacity Building & Awareness

- Promote Public-Private Partnerships between major lubricant producers, dealership networks, fleet owners (trucks/buses), workshops and authorised recyclers to formalise collection networks.
- Conduct capacity building programmes for collection agents, aggregators and recyclers on safe handling, storage, transportation and quality sorting (based on CPCB guideline for collection agents).
- Launch behaviour-change campaigns targeted at automotive workshops, small fleet operators and industrial users to promote hand-over of used oil to authorised channels, emphasising cost savings, environmental benefits, regulatory risk reduction.
-

11.4.5 Implementation Timeline & Stakeholder Roles

(a) **Target No. 1: Collection of used oil ≥ 90%**

- *Policy initiatives*: MoEF & CC issues notification mandating collection quotas by FY2026; CPCB monitors via portal.
- *Economic instruments*: Introduce recycling-certificate trading by FY2025; levy disposal penalty by FY2025.
- *Circular economy parks*: Identify 5 regional hubs by FY2026; operational by FY2028.
- *R&D*: Pilot digital traceability platform by FY2025; scale by FY2027.

(b) **Target No. 2: Re-refining rate ≥ 70%**

- *Policy initiatives*: Mandate minimum recycled content in base oil by FY2028.
- *Economic instruments*: Capital subsidy or VGF for re-refining units by FY2026.
- *PPP*: Large lubricant producers partner with one re-fining unit per region by FY2027.

- *R&D*: Demonstrate advanced de-contamination technology by FY2026; commercial scale FY2028.

11.4.6 Implementation Risks & Mitigation

Table 11-2: Implementation Risks and Mitigation Measures

S.No.	Risk Description	Potential Impact	Mitigation Measures
1	Informal collection continues to dominate, leading to feedstock leakage from formal channels.	Reduced feedstock availability for authorized recyclers and loss of material traceability.	Strengthen enforcement mechanisms, provide financial and regulatory incentives for formal collection agents, and implement digital tracking systems for used oil movement.
2	Re-refined base oil fails to meet quality norms.	Market rejection and reduced confidence in re-refined base oil (RRBO) products.	Adopt international quality standards, establish accreditation systems for re-refiners, and mandate third-party quality certification.
3	Insufficient offtake or demand for recycled content in lubricants.	Weak market pull for re-refined products, resulting in underutilized recycling capacity.	Introduce mandatory recycled content quotas, government procurement mandates, and prioritize RRBO adoption in public sector fleets.

11.4.7 Monitoring and Accountability

- CPCB to publish annual reports of EPR registration, tonnes used oil collected, re-refined output, recycled content achieved.
- State SPCBs to monitor collection agents & recyclers via digital portal.

Key performance indicators (KPIs) aligned with the SMART targets above: collection rate, re-refining rate, recycled-content share

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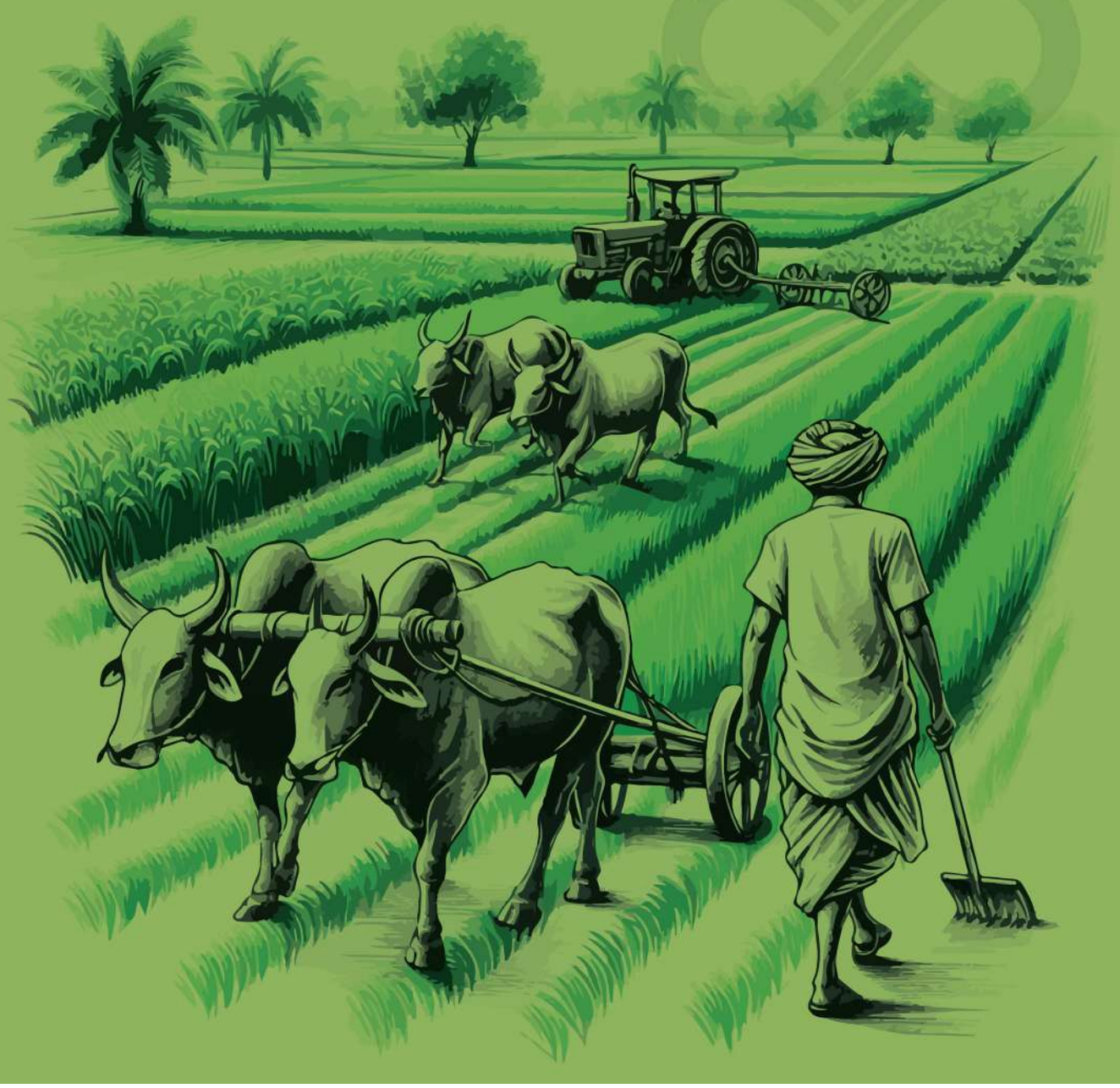
Chapter 12

CIRCULAR ECONOMY ACTION PLAN FOR AGRICULTURE WASTE



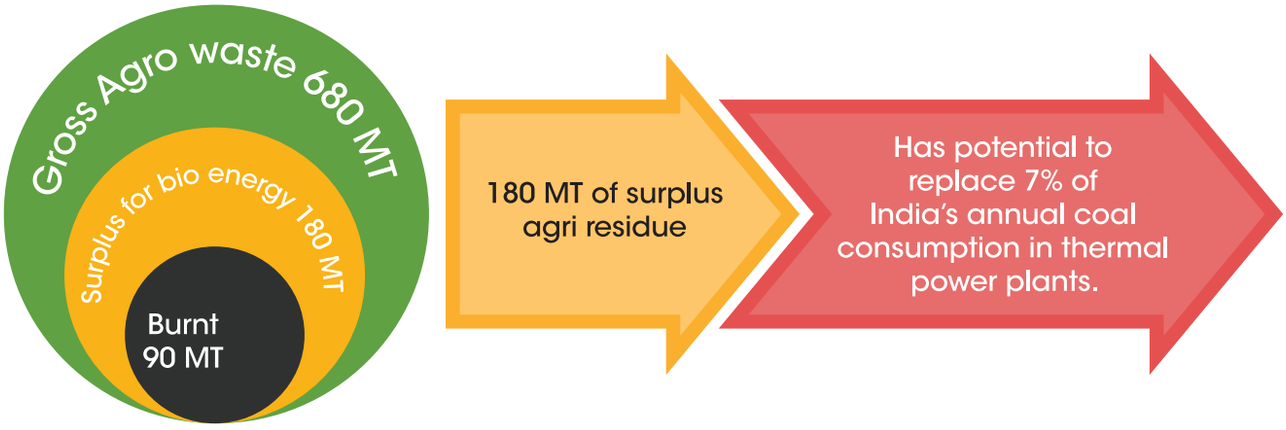
12.1 Material Landscape and Circularity Baseline

12.1.1. Overview

The agricultural waste sector plays a vital role in the global economy, driven by the need for sustainable management of biomass and the increasing demand for renewable energy sources. Agricultural waste encompasses a wide array of by-products from farming activities, such as crop residues, animal manure, and food processing waste. As the global population grows, the emphasis on sustainable practices and circular economy principles has led to innovative approaches in managing agricultural waste.

A 2018 study, "Estimation of surplus crop residue in India for biofuel production," conducted by the Indian Agricultural Research Institute (IARI) and the Technology Information Forecasting and Assessment Council (TIFAC), estimated that India generates approximately 680 million tonnes (MT) of gross annual crop residue.

Close to 70 percent of this residue is used in the agrarian economy as cattle fodder, soil mulch, manure, and thatching. However, a significant portion—around 180 million tonnes (MT)—remains unused. More than half of this unused agri-residue is set on fire annually to clear fields, primarily in North India, which worsens air pollution and poses health risks (TIFAC, 2018).



Recent data from the Indian Council of Agricultural Research (ICAR) in 2023 estimates that India now produces approximately 750 million tonnes (MT) of crop residues annually, reflecting an increase driven by rising agricultural productivity and crop diversification (ICAR, 2023). Additionally, satellite imagery and environmental reports from the Central Pollution Control Board (CPCB) in 2024 indicate a 15% rise in residue burning episodes over the past five years, further contributing to degraded air quality during winter months (CPCB, 2024).

12.1.2 Importance of circularity Agri-waste for the Indian economy

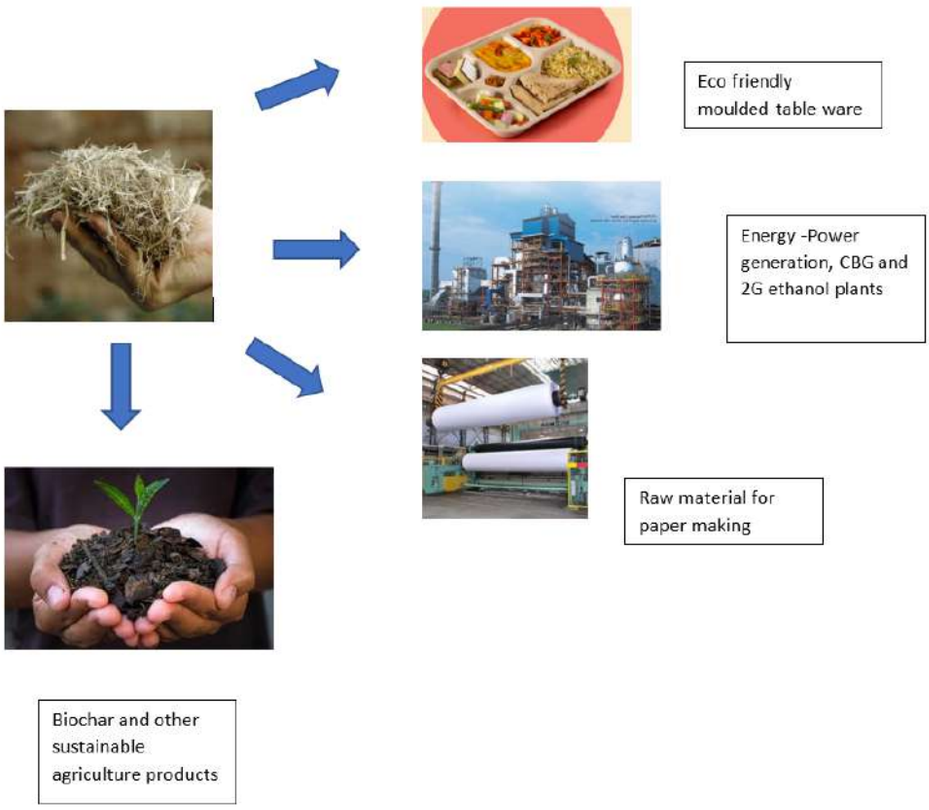
- **Energy Sector**: Agricultural waste serves as a crucial feedstock for bioenergy production, which is essential for achieving energy security and sustainability goals. The first 2G ethanol (ethanol from agriwaste) in India was commissioned in 2022 by IOCL Panipat, and 3 more plants are under advanced stages of construction. As of June 2025, 71 thermal power plants have adopted co firing of biomass, saving an estimated 34 lakh tonnes of CO_2 emission. India has the Potential for 20,000 Tons per day of CBG from Agri residue[2].

- **Agricultural Sustainability:** Organic fertilizers derived from agricultural waste improve soil health, enhance crop yields, and support sustainable farming practices by reducing dependence on chemical fertilizers.

- **Paper and Pulp Industry**: Bagasse, a by-product of sugarcane processing, is widely used for pulp and paper production. Wheat straw can also be combined with woodchips to manufacture paper. Several publicly listed Indian companies are successfully producing paper and pulp from agricultural residues, which now account for approximately 22% of the nation's paper production.

- **Environment friendly Disposable products**: Many well-known Indian cos like Yash Packaging and ITC paper have started making disposable tableware from bagasse which is exported and marketed as an eco-friendly alternative to single-use plastics. This shift supports sustainable consumption and reduces plastic waste.

- **Biochar:** Agricultural waste can be transformed into biochar via pyrolysis—a process that heats biomass in the absence of oxygen. Biochar is highly stable carbon that, when applied to soil, enhances fertility, water retention, and microbial activity while also sequestering carbon to mitigate climate change. India is increasingly exploring biochar's potential through pilot projects and research initiatives, recognizing its dual benefits for soil health and environmental sustainability (Indian Council of Scientific Research, 2024).



12.1.3 Overview of existing policies and incentives

Government of India and various State Governments has given several incentives to improve circularity of agri residue in the last 5 years. With the Global Biofuel alliance unveiled in the G20 meet in Delhi in February 2023, we can expect further impetus from GoI in promoting usage of agri residue.

Table 12-1: Policies and Incentives

Route	Policy and incentives
CBG / Biogas route	• **Ministry of New and Renewable Energy (MNRE) –** Provides Central Financial Assistance (CFA) for the construction of Compressed Biogas (CBG) plants. • **Sustainable Alternative Towards Affordable Transportation (SATAT) Scheme –** Sets the minimum purchase price for CBG and offers additional incentives to support the production of CBG. • **State-Specific Incentives –** Certain states, like Uttar Pradesh (UP) and Bihar, are pioneering state-level incentives. For example, the UP government offers 100% stamp duty exemption and an incentive of INR 75 lakhs per ton of CBG produced. • **Ministry of Petroleum and Natural Gas (MoPNG) –** Proposes mandatory blending of Piped Natural Gas (PNG) with CBG from Fiscal Year 2025 onwards to promote cleaner energy. • **MoPNG –** Provides financial assistance from the GoI for developing CBG pipeline infrastructure to improve distribution networks. • **MoPNG –** Offers financial aid for the purchase of Biomass Aggregation Machinery (BAM), up to INR 90 lakhs, to support the efficient collection of biomass. • **Ministry of Finance –** Facilitates priority sector lending by Public Sector Undertaking (PSU) banks, offers a 3% interest subvention through the Ministry of Agriculture (MoA), and provides excise duty (ED) exemption for GST paid on the CBG portion within Compressed Natural Gas (CNG) blends.

Biomass Pellet route	• **Ministry of Power –** Mandatory 5 % co-firing in power plants under **SAMARTH** mission. • **MNRE -** Subsidy for purchase of briquette and torrefaction machines. Maximum subsidy of INR 45 Lakh for briquette machine and INR 1.5 Cr for torrefaction pellet machine. • **MNRE –** Subsidy for biomass aggregation machinery (BAM)
2G ethanol route	• **PM JI-VAN YOJANA-** Promotion of 2G ethanol based on ligno cellulostic feedstock. The target is 12 commercial plants and 10 demo plants by 2029. Financial incentive of up to INR 150 crore for commercial plants and INR 15 crore for demo plants
Stubble management route	• Machinery purchase: Provides 50% financial assistance to farmers for purchasing crop residue management machinery. • Custom Hiring Centres (CHCs): Offers 80% financial assistance to groups like farmer cooperatives, FPOs, and rural youth for establishing CHCs, allowing individual farmers to rent the machinery. • State Government Incentives: Haryana and Punjab Government giving incentives like cash incentive of 1000 INR per acre for farmers not burning stubble, transportation incentive of INR 500 per acre, 4000 INR per acre incentive for direct seeding of rice.

12.2 Gaps / Challenges in advancing circularity

The widespread adoption of agri waste faces several significant challenges that need to be addressed. The major ones discussed below:

- **Collection window:** Biomass aggregators face challenge in collecting paddy and wheat straw in North India. Typically, the window for collection of agri residues before the onset of stubble burning season is only 2-3 weeks. Farmers burn stubble to plant the next crop (Kharif Rabi rotation) after 3 weeks.
- **Sourcing challenge:** Industry buys from biomass aggregators who buy from farmers. Industry expects biomass at agreed quantity and rates which may be difficult for aggregators to commit.
- **Storage issues:** There are various issues associated with the storage of agri residue including biodegradation, high moisture content, fire hazards during hot weather conditions and lack of storage facilities.
- **Machinery issues:** No well-known domestic machinery manufacturers in the agri waste conversion space. Most of the existing players are small scale players who have challenges scaling up their product and operations.
- **Focus on bio-fuel:** The Government's policy and incentives for agri residue, though well meaning, seems to mainly focus on conversion of agri residue to biofuel. Biofuel however is not truly circular. Value added products like paper, bio solvents, moulded tableware would be more circular than biofuel.
- **Poor Offtake:** CBG gas produced in rural areas has poor offtake due to low demand in rural areas and lack of PNG pipelines for direct injection in rural areas.

Despite the recognition of the benefits, widespread adoption of agri-waste management and circular practices faces several critical challenges that need strategic interventions:

- **Collection Window Constraints:** Biomass aggregators encounter difficulties in collecting crop residues such as paddy and wheat straw in North India. The collection window is typically only 2-3 weeks before the start of the stubble burning season, yet farmers burn residues to prepare fields for the subsequent Kharif or Rabi crops, often within a 3-week period. This limited window hampers efficient biomass collection and incentivizes stubble burning.

- **Sourcing and Contracting Challenges:** Industry players rely on biomass aggregators to procure raw materials from farmers. However, aggregators find it challenging to secure agreed-upon quantities and rates from farmers, especially with fluctuating market prices and inconsistent supply, often leading to supply gaps or unmet commitments.

- **Storage and Logistics Issues:** Agri-residue storage presents multiple hurdles, including biodegradation, high moisture content, fire hazards during hot weather, and a lack of adequate storage facilities, all of which impact the quality and safety of biomass stockpiles.

- **Machinery and Technology Limitations:** The sector lacks well-established, large-scale domestic machinery manufacturers for agri-waste conversion. Most players are small-scale enterprises that face difficulties scaling their operations and technologies, hindering mass adoption.

- **Policy Focus and Circularity:** Current policies, incentives, and initiatives are predominantly geared towards converting agri-residue into biofuel, which is less circular because it often results in energy-focused outputs rather than value-added, circular products like paper, bio-solvents, or biodegradable tableware. Promoting these higher-value, circular products could generate greater sustainable value.

- **Low Offtake and Market Demand:** The offtake of biogas or bio-based products like CBG in rural areas remains limited due to low demand and inadequate infrastructure, such as lack of extensive PNG pipeline networks, which restricts the economic viability and scale-up potential in rural settings.

- **Varying State Policies and Incentives:** India's decentralized governance results in inconsistent policies, incentives, and support mechanisms across states. This patchwork can create disparities in the adoption of waste management practices, with some states more proactive than others, leading to uneven progress and missed opportunities for scalable circular solutions.

- **Carbon Credit Market Opportunities and Challenges:** The emergence of carbon markets offers new financial incentives for agri-waste-based projects through carbon trading and credits, particularly in the context of carbon sequestration via biochar and sustainable biomass utilization. However, integrating these into the existing ecosystem is still in nascent stages, with challenges related to measurement, verification, and market access, especially for small-scale farmers and aggregators.

12.3 Vision and Targets for circular economy transition

By 2030, we aim to make a significant change in the handling of agricultural waste in the country .This involves creating practical systems for their reuse, which will improve resource efficiency, reduce environmental impact, and offer new economic opportunities within the agricultural sector.

Table 12-2: Proposed Targets

S.No.	Target Description (along with basis for setting the target)	2030 Target
1	**SAMARTH target for Co-firing biomass in Power Plants across India** *[Current SAMARTH Targets is a broad 7% Co -firing in power plants nationwide by 2026. States that have more stubble burning incidents should have higher co firing targets so that average is at 7%]* *[Smog issues are more in winters in Northern India , hence a higher target for Northern States.]*	10% for power plants in Punjab, Haryana, UP & Bihar 3% for Rest of India.

2	**Offtake of CBG gas in rural areas.** *[No guaranteed offtake for CBG produced is creating difficulties for CBG plant developers, especially in rural areas using paddy / wheat stubble as feedstock. GoI should promote CBG usage in rural areas like Government transportation.]*	25% of public transport buses plying on rural highway with a CBG plant should use CBG as fuel.
3	**Promote Alternatives Beyond Biofuel** *[Establish a technical body under the Ministry of Agriculture by 2026 to identify alternative uses for agricultural waste beyond fuel, like focusing on programs like 2G ethanol.]*	7 % of available agri residue should be utilised for non- fuel applications.
4	**Agri residue supply chain** *[Establish a Supply chain for agri residue to ensure round the year availability. This includes efficient collection , storage in proper godowns and dispatch to end user with the help of IT systems]*	One (1) Godown in a radius of 10 km in major wheat / paddy growing regions.

12.4 Enablers and Implementation Roadmap

12.4.1 Policy Advocacy and Support

Establish a comprehensive **Agricultural Waste Management Policy** either integrated with existing Solid Waste Management rules or as a standalone policy. This can provide consistent guidelines, tax benefits, and regulatory support, crucial for scaling up the adoption of sustainable practices across India, the third-largest producer of paddy, wheat, and sugar.

12.4.2 Research and Development (R&D)

Encourage **domestic R&D** and foster collaborations with international research institutes to address technological bottlenecks. Focus on preventing storage-related degradation, managing high silica and alkali content, and innovating processing techniques.

12.4.3 Circularity of Materials

Expand beyond biofuel applications by promoting alternative uses of agri-waste in:

- **Eco-friendly packaging** materials
- Soil enhancement and carbon sequestration through **biochar**
- Production of **bioplastics, bio-solvents,** and other specialty chemicals
- Increasing utilization in the **paper industry** for sustainable pulp production

12.4.4 Market Development and Access

Develop robust markets through **demand-driven incentives** for industrial adoption and create government-backed **platforms** to facilitate trade and better market access for agri-waste-derived products.

12.4.5 Financial Incentives and Subsidies

Implement targeted **financial incentives**, such as tax relief, interest subsidies, and grants, to encourage sustainable waste management practices and lower the economic barriers for small and medium enterprises.

12.4.6 Public Awareness and Education

Launch widespread educational campaigns to increase awareness about the environmental benefits and economic potential of agri-waste products, thereby fostering acceptance among consumers and industries.

12.4.7 Infrastructure Development

Invest in enhancing **rural infrastructure**, including roads, storage facilities, and logistics, to support efficient collection, processing, and distribution of agricultural waste.

12.4.8 Collaborative Frameworks and Partnerships

Establish frameworks for cooperation among government bodies, private sectors, NGOs, and farming communities. International partnerships can bring in expertise, funding, and best practices.

12.4.9 Innovation Hubs and Incubators

Set up specialized hubs and incubators to provide **resources, mentoring, and funding** for startups and entrepreneurs developing new agri-waste technologies, facilitating innovation and commercialization.

12.4.10 Initiatives/Measures/Actions with Prioritization

The successful realization of our mission to recycle agri waste requires concrete, measurable steps. The targets and enablers outlined earlier form the foundation for a comprehensive implementation road map (presented in **Table 12-3)**. This roadmap will serve as a strategic guide to systematically achieve the defined objectives by translating high-level targets into concrete actions. The table below details specific initiatives and activities, mapped against the targeted outcomes, along with estimated timelines, key ownership, and responsible stakeholders.

Table 12-3: Proposed Priority Actions to Achieve Circular Economy Targets

Target	Proposed Initiative/ Measure	Action item	Timeline	Proposed Owner
SAMARTH target for Co-firing biomass in power plants	Proposed Agricultural waste management policy -Variable target across states for co firing biomass.	Based on stubble burning data – States with higher stubble burning incidents should be given higher co-firing target for biomass . No single co firing target PAN India	2027	Ministry of Power
Offtake of CBG gas in rural areas	Infrastructure development -Incentivize use of CBG/CNG in rural areas to address the issue of low demand for CBG/CNG in rural areas.	Ministry of transport and highways should incentivise usage of CNG vehicles in rural areas so that CBG demand in rural areas pick up	2027	Ministry of Transport and Highways
Promote Alternatives to Biofuel	R&D and circularity of agri-waste – look at more circular options for agri-waste	Work with industries that are already using Agri waste as a feedstock to explore circular options like value added products, bio polymers etc	2027	CII
Agri residue supply chain	Infrastructure development – establish agri- residue supply chain	Bring out a white paper on establishing a supply chain for agri-residue for round the year availability.	2027	CII

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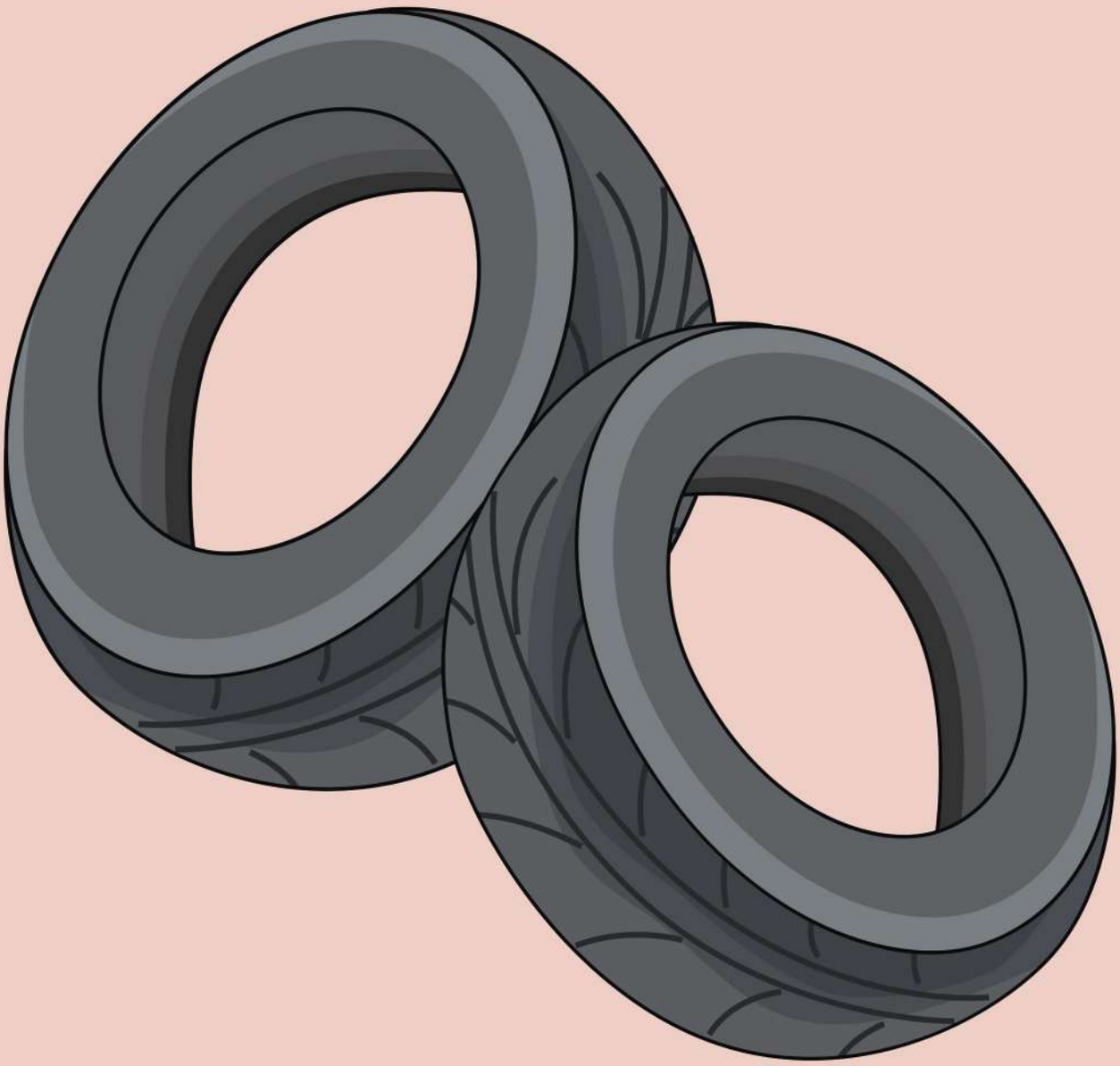
Chapter 13

CIRCULAR ECONOMY ACTION PLAN FOR TYRE & RUBBER



13.1 Material Landscape and Circularity Baseline

13.1.1 Overview of Material Value Chain

Tires are highly engineered composites consisting of 10–40% natural rubber, 20–60% synthetic rubber, 15–30% carbon black/silica, 10–15% steel, and 3–8% textile fibers. India's tire industry is critical for the automotive sector. Annually, India produces approximately 240 million new tires, and about 2.1 million MT of end-of-life tires (ELTs) are generated domestically. Additionally, India imports about 1.4 million MT of waste tires annually, resulting in approximately 3.5 million MT of ELT available for material recovery.The value chain ends traditionally with disposal, but sustainable management prioritizes waste prevention, reuse, material recycling, and energy recovery. Despite a 2022 ban on importing tires for pyrolysis, the import of waste or scrap tires surged five-fold from 2.64 lakh metric tonnes (MT) in FY21 to 13.98 lakh MT in FY24.

13.1.2 Importance of Material for Key Sectors of the Economy

1. **Resource Inputs:** Recycled materials substitute virgin resources, such as reclaim rubber and recovered carbon black (rCB). Pyrolysis yields oil and char that serve as substitutes for naphtha in chemical processes and pet coke in cement kilns, respectively.
2. **Economic Independence:** Oil derived from tire pyrolysis, when used in refineries, can help reduce India's dependence on imported crude oil, strengthening energy security and supporting the Atmanirbhar Bharat initiative.
3. **Key Sector Applications:** Recycled materials are used widely across sectors: reclaim rubber in tubes, conveyor belts, and automotive parts; crumb rubber in road surfacing (e.g., Crumb Rubber Modified Bitumen/CRMB), sports turfs, and matting; and recovered steel reintegrated into production cycles.

13.1.3 Environmental & Social Footprint

1. **Environmental Benefits:** Recycling tires significantly reduces greenhouse gas (GHG) emissions. Processing 1 tonne of tires reduces CO2 emissions by 700 kg. Retreading a truck or bus tire saves 15 gallons of oil compared to the 22 gallons required for a new tire.

2. **Environmental Hazards:** Tires are durable and non-biodegradable. Improper disposal results in fire hazards (tires can burn for months, releasing toxic compounds like benzene and polycyclic aromatic hydrocarbons). Contamination risks include leaching of heavy metals and chemical residues into soil and water.

3. **Social Impact:** End-of-life tire collection traditionally supports economically disadvantaged communities. The sector currently supports over 250,000 jobs in India, generating around ₹65 billion in wages. Discarded tires pose health risks by accumulating water, creating breeding grounds for disease-carrying mosquitoes (e.g., Aedes aegypti larvae).

13.1.4 Market Trends & Growth Projections

Indian tire recycling market is poised for substantial growth, currently valued at around ₹3,500–4,000 crore, and expected to expand to ₹9,000–12,000 crore by FY30. In 2024, the market was valued at USD 2.25 billion, projected to reach USD 3.05 billion by 2033, growing at a CAGR of 3.51%. Globally, Europe demonstrates leadership, collecting and treating 97% of ELTs, while the Asia-Pacific region is the fastest-growing market. Pyrolysis oil, a byproduct of recycling, is often cheaper than conventional furnace oil (around two-thirds the price). Growing environmental awareness, coupled with government initiatives promoting sustainable waste management and brand owners focusing on higher substitution rates, are driving this market expansion.

The international tire industry is experiencing significant development and institutional validation, evidenced by major U.S. infrastructure funds investing heavily in European waste tire pyrolysis projects.This shift aligns with the EU's ambitious net-zero targets and new regulations phasing out tire incineration and landfill, leading global tire and petrochemical leaders like Continental, BASF, and Michelin to sign long-term off-take agreements for recovered materials like carbon black and pyrolysis oil. Innovative applications worldwide are also driving change, including a Czech company recycling old tires into noise barriers, a New York company creating luxury furniture from

recycled rubber, and TCT (Tire Conversion Technologies) engineering high-performance products for construction and landscaping.

13.1.5 Current Level of Adoption of Circular Practices

While modern tire recycling in India encompasses formal practices such as Retreading, mechanical shredding for crumb rubber, and advanced recovery via pyrolysis and Devulcanization, the sector's current adoption level is heavily undermined by the prevalence of illegal outlets operating outside environmental norms. India, which is reported to be importing over 30% of the world's waste tires, sees millions of these used tires—often exported from nations like the UK—diverted not for sustainable processing, but to be burned in unregulated, makeshift pyrolysis plants. These poorly managed pyrolysis units, which leverage low oversight and cheap equipment, operate without adequate safeguards, leading to severe environmental and health risks by releasing toxic emissions such as dioxins, benzene, heavy metals, and untreated effluents into the air, soil, and water. In a direct response to this regulatory failure and public health hazard, the Indian government has initiated crackdowns, including banning waste tire imports specifically for pyrolysis and shutting down 270 illegal plants nationwide. A key recent example of enforcement is the action taken by the Punjab Pollution Control Board (PPCB), which launched synchronized inspections on 17 tire pyrolysis oil (TPO) units, resulting in the identification and targeting of 11 non-compliant facilities for issues such as improper char disposal and inadequate air pollution devices.

13.1.6 Overview of Existing Policies & Incentives

1. **Extended Producer Responsibility (EPR):** Mandated by the government, EPR requires tire manufacturers and importers to manage ELTs for proper recycling. EPR targets for new tire manufacturers rise to 100% of the quantity manufactured / imported in year after 2024-2025.

2. **Regulation & Compliance:** The Central Pollution Control Board (CPCB) enforces Standard Operating Procedures (SOPs) for pyrolysis units. The Directorate General of Foreign Trade (DGFT) limits waste tire import quantity to only 40% of the average trade volume.

3. **State-Level Action:** Gujarat has recently approved continuous pyrolysis plants, mandating a minimum capacity of 60 tonnes per day (TPD) to accelerate industrial-scale, compliant recycling and move away from outdated batch systems.

4. **Incentives:** Export incentives like the Duty Drawback Scheme offer tax refunds for exporters of recycled tire products.

13.2. Gaps and Challenges in Advancing Circularity

13.2.1. Policy Gaps & Enforcement Barriers

A significant challenge stems from regulatory weaknesses and conflicting policies, particularly concerning international trade and domestic standards. Despite India outlawing the import of waste tires for pyrolysis in 2022, the trade remains thriving. The unchecked import of waste or scrap tires surged five-fold from FY21 to FY24, contradicting the goals of the Extended Producer Responsibility (EPR) scheme which aims for responsible domestic End-of-Life Tire (ELT) management. These illegal imports burden India's waste management infrastructure and create a supply gap for quality domestic feedstock in advanced recycling facilities. Furthermore, UK exporters continue to ship millions of used tires to India for what is often illegal burning.

1. **Inconsistent Regulation:** There is a lack of standardized norms and policies across states for setting up new recycling units, including inconsistency in pollution norms between the State Pollution Control Boards (SPCBs) and the Central Pollution Control Board (CPCB).

2. **Feedsock Supply Restriction:** The Directorate General of Foreign Trade (DGFT) limits the import quantity of waste tires to only 40% of the average trade volume, which has inadvertently constrained the supply for advanced recycling units that rely on consistent feedstock.

3. **Patched Enforcement:** Enforcement remains patchy despite the ban on importing tires for pyrolysis. Illegal operators often release toxic smoke at night to avoid detection.

13.2.2. Material Specific Challenges

The intrinsic characteristics of tires pose fundamental technical challenges for achieving high-value circularity:

- **Heterogeneous Composition:** Tyres are highly engineered composites with a heterogeneous composition, typically consisting of natural and synthetic rubbers, carbon black or silica (15–30%), reinforcing steel (10–15%) for structural support, and textile fibers. This complex blend, which is extensively designed to be indestructible in nature, creates significant technical difficulty in recycling and poses a major barrier to producing consistent, high-quality upcycled materials, requiring advanced sorting technologies and specialized processing methods.

- **Product Design Constraints:** Current tire designs still limit the mandated or desired incorporation of recycled materials. Even with recycling, materials are often inferior; recycled content tires (up to 5% by weight) may suffer from reduced tread life and lower traction compared to new tires. Pyrolysis typically yields low-grade carbon black that cannot be reintroduced into new tire manufacturing.

13.2.3. Feedstock Availability and Aggregation

The collection system is underdeveloped and fragmented, leading to economic inefficiency:

- **Lack of Reverse Logistics:** A robust reverse logistics system is absent for efficiently sourcing raw materials, restricting the flow of ELTs into formal recycling streams.

- **Fragmentation:** The collection network is informal and fragmented, resulting in underutilized or improperly disposed tires and reducing the potential for efficient material recovery.

- **Economic Viability:** Due to the lack of a structured and cost-effective domestic procurement method, major recyclers often resort to importing waste tires.

13.2.4. Informal Sector Dominance and Competitive Viability Issues

The Indian tire recycling landscape is heavily influenced by informal practices, which undermine organized industry growth and sustainability efforts:

- **Unregulated Operations:** Many operators still work in the unorganized sector with outdated setups. Informal recycling practices still dominate the market.

- **Financial Exclusion:** Waste collectors, who are essential to the supply chain, often operate in the informal sector and lack financial inclusion, limiting their ability to contribute to an organized economy.

- **Undercutting Legitimate Businesses:** The proliferation of illegal burning in pyrolysis plants undercuts legitimate operators, rendering their businesses non-viable. It is often cheaper to purchase imported tires than source domestic waste tires.

13.2.5. Infrastructure & Technology Gaps

Technological constraints lead to low quality and high environmental risk:

- Outdated Technology: Many Indian companies rely on less effective, traditional recycling methods due to a lack of advanced technological infrastructure.

- Pyrolysis Compliance Failure: Over 53.90% of tire pyrolysis facilities fail to achieve mandated government criteria, often using old equipment, resulting in pollution and ineffective operations.

- Safety and Pollution Risks: Poorly managed pyrolysis plants release toxic gases, untreated effluents, and unsafe solid waste, posing serious health risks. Accidents, like explosions, are common.
- High Costs: Advanced technologies like pyrolysis and devulcanization face high capital investment costs, limiting their commercial scalability beyond pilot projects.

13.2.6. Awareness & Skills Deficits

- **Skills Shortage:** The shift to advanced recycling technologies like continuous pyrolysis is slowed by a shortage of trained personnel. The cost of a skilled workforce for advanced machinery is high due to limited availability.
- **Public Perception:** Prejudice exists against retreaded tires and products made from recycled material, which are often viewed as inferior.

13.2.7. Weak Downstream Markets

- **Low Circularity Integration:** Despite India's high recycling rate, the integration of reclaim rubber or recovered carbon black back into new tire manufacturing is low, at about 5%, meaning most materials are currently downcycled.
- **Quality and Trust Issues:** Market acceptance is limited, as industries are hesitant to adopt recycled content due to concerns over quality and performance consistency. The lack of standardized guidelines for circular products further complicates scaling efforts.
- **Cost Competitiveness:** Furthermore, the profitability of upcycled products is often undermined by competition with cheaper virgin materials and fluctuating oil prices, a challenge exacerbated by the lack of standardized guidelines for circular products, which further complicates scaling efforts in the industry.

13.2.8. Lessons from Best Practices

- **Reverse Logistics & Branding: Bridgestone** demonstrates successful reverse logistics by partnering 99% of its retail shops with processing companies for tire collection. **Continental** promotes sustainability by using a "Contains Recycled Materials" logo on tire sidewalls.
- **Innovative Applications:** Globally, companies like TCT (USA/Europe) transform end-of-life truck tires into high-performance site products (e.g., ground protection pads, anti-slip feet) used by partners like Walmart, creating a closed-loop system that replaces virgin plastics and concrete. In Nigeria, tires are upcycled into consumer goods such as mats, paving bricks, and flip-flops.
- **Domestic Infrastructure Shift:** India's Gujarat model signals a critical shift by approving continuous pyrolysis plants, which must operate at a minimum of 60 tonnes per day (TPD), moving the industry toward large-scale, automated, and environmentally compliant operations.
- **Technology & Infrastructure:** Continuous advancements are expanding capacity for sustainable ELT processing, including devulcanization, pyrolysis, and recovered carbon black (rCB) technologies. Investments in large-scale advanced recycling plants are being promoted through proposed strategies like Production-Linked Incentive (PLI) schemes and viable gap funding.
- **Product Innovation:** Globally, innovative uses for recycled rubber include civil engineering applications, sports surfaces, noise barriers (Czech company), and luxury furniture. In India, startups like Paaduks convert discarded tires into eco-friendly footwear.

13. 3. Vision and Targets for Circular Economy Transition

13.3.1. Vision Statement

The visionary goal for India's tire industry is to achieve a robust, circular economy by 2035. This transition aims to transform every End-of-Life Tire (ELT) into a valuable resource that actively contributes to sustained economic growth, environmental sustainability, and societal well-being. Key strategies supporting this vision include:

- **Material Efficiency & Circular Design:** Establishing industry standards that mandate minimum recycled content and enhance recyclability and durability.
- **Green Public Procurement:** Mandating the use of recycled materials in public infrastructure like roads (e.g., Crumb Rubber Modified Bitumen / CRMB) to create a strong, stable market for circular products.
- **Advanced Recovery & Recycling:** Implementing incentives like Production-Linked Incentive (PLI) schemes and viable gap funding to accelerate the establishment of large-scale advanced recycling plants (e.g., continuous pyrolysis and devulcanization).

Table 13-1: SMART Targets

S. No.	Goal / Target	Current Status	2030 Target
1	Increase recycled content in new tires (%)	Currently, only ~5% of recycled End-of-Life Tires (ELTs) are used in new tire production, with most material being downcycled.	**10%** *Basis: This goal supports Waste Tyres EPR*
2	Establish a nationwide ELT reverse logistics system.	The current nationwide status is marked by the absence of a robust reverse logistics system, as the collection network remains fragmented, informal, and without an organized structure either privately or governmentally	**90%** *Basis: This is line with strengthening the collection network based on lessons from global Extended Producer Responsibility (EPR) programs*
3	Incentivize the creation of advanced recycling facilities.	This promotes high-value material recovery, such as creating reclaim rubber and recovered carbon black for tire production and pyrolysis oil for refineries. This move is essential for achieving global scale and relevance.	**50%** *Basis: This goals supports required recycling infrastructure for achieving Waste Tyres EPR compliance*
4	Promote recycled tire-derived materials in government procurement.	Government guidelines (IRC, MoRTH) endorse the use of Crumb Rubber Modified Bitumen (CRMB) in road construction	i. **25%** recycled tire-derived materials in Government procured rubber products ii. **15%** recycled tyre content in road construction *Basis: This push to Mandate Green Public Procurement (GPP) policies is viewed as a necessary strategy to ensure the use of recycled tire-derived materials in public works, thereby creating a strong and stable market for circular products*

5	Launch a national training program for advanced tyre recycling (No. of personnel)	The informal sector significantly dominates the collection and processing methods. A major challenge lies in the unregulated nature of downstream processing, particularly pyrolysis, where over 53.90% of tire pyrolysis facilities fail to achieve mandated government criteria, often relying on old equipment that results in pollution and ineffective operations	5000 trained personnel *Basis: This goal addresses the skills gap by creating a specialized workforce required for advanced recycling operations like continuous pyrolysis and devulcanization, which is crucial for industry innovation and growth.*

13.4. Enablers and Implementation Framework

13.4.1. Policy Interventions & Market Based Instruments

- The government must implement and enforce national standards and pollution norms uniformly across all states to simplify recycling operations.
- There is a need to fast-track the standardization (BIS) of materials and processes to ensure consistent quality across the industry.
- The government should standardize HSN codes for waste and recycled materials to ensure accurate data collection and streamline industry practices.
- PPPs, combined with government incentives, can help bridge financial gaps and improve the overall competitiveness of the tire upcycling industry.

13.4.2. Financing Tools

- Implement Production-Linked Incentive (PLI) schemes and viable gap funding (VGF) to accelerate the establishment of large-scale, advanced recycling plants.
- Mandate Green Public Procurement (GPP) policies to ensure the use of recycled tire-derived materials in public works like road construction, creating a strong market.
- Facilitate the generation of verified green credits for recycling and emission reduction efforts to provide additional financial returns and climate impact.
- Leverage existing export incentives, such as the Duty Drawback Scheme, which provides tax refunds for exporters of recycled tire products.

13.4.3. Infrastructure

- A robust reverse logistics system must be established to ensure the efficient sourcing and consistent flow of End-of-Life Tires (ELTs) into formal recycling streams.
- Improve logistics by optimizing collection routes and expanding consumer collection points through standardized regional collection systems.

13.4.4. Investment Technology Development

- Investments should focus on advanced sorting technologies and standardized mechanical and chemical processing methods to overcome material heterogeneity.
- Accelerate the deployment of indigenous high-value recovery methods like Devulcanization and Continuous pyrolysis through targeted funding.

13.4.5. Capacity Building & Skills

- Launch a national training program focused on advanced recycling and circular economy skills to address the current shortage of trained personnel.
- The training programs should be developed in collaboration with the National Skill Development Corporation (NSDC) and academic institutions to strengthen the recycling workforce.

13.4.6. Awareness & Behaviour Change Campaigns

- Foster public awareness through eco-labelling initiatives and consumer incentives to encourage demand for recycled tire products.
- Mandate recycled content labelling on all tires, similar to global best practices, to increase consumer awareness and demand.

13.4.7 Initiatives/Measures/Actions with prioritization

The targets, goals, and enabling strategies outlined earlier form the foundation for a comprehensive implementation road map (presented in **Table 13-2**). This roadmap will serve as a strategic guide to systematically achieve the defined objectives by translating high-level targets into concrete actions. The table below details specific initiatives and activities, mapped against the targeted outcomes, along with estimated timelines, key ownership, and responsible stakeholders. **Table 13-3** presents the implementation risks and mitigation measures.

Table 13-2: Proposed Priority Actions to Achieve Circular Economy Targets

Target No. 1: Increase recycled content in new tires (10% by 2030) Policy Implementation for Circular Design and Quality Assurance				
Category	**Proposed Initiative**	**Actionable Item**	**Time**	**Proposed Owner**
Policy-related initiative	Environmental compliance	Implement and enforce uniform national standards for pollution norms and quality, coupled with stringent audits for EPR compliance.	Short Term	MoEFCC, CPCB, SPCB
Policy-related initiative	Quality Assurance	Fast-track the standardization (BIS) of materials and processes to ensure consistent quality across the industry	Short Term	BIS
Target 2: Develop Infrastructure & Logistics (10 Circular Economy Parks nationwide by 2030; 90% ELT collection rate by 2026)				
Category	**Proposed Initiative**	**Actionable Item**	**Time**	**Proposed Owner**
PPP	Develop Infrastructure	Strengthen reverse logistics systems and aggregate ELTs efficiently through Circular Economy Parks to ensure consistent feedstock supply	Medium Term	Industry
PPP, State Support	Optimise logistic systems	Improve logistics by optimizing collection routes & expanding consumer collection points via regional collection systems.	Medium Term	ULBs, Industry
Target No. 3: Incentivize Advanced Recycling & Technology (50 advanced recycling facilities for high-value recovery by 2027)				
Category	**Proposed Initiative**	**Actionable Item**	**Time**	**Proposed Owner**
Economic Instrument	Advanced recycling facilities	Implement Production-Linked Incentive (PLI) schemes and viable gap funding (VGF) to establish 50 advanced recycling facilities	Medium Term	MoF, MoC, Industry
Economic Instrument	Developing support infrastructure	Accelerate deployment of indigenous high-value recovery methods like Devulcanization / Continuous pyrolysis through targeted funding	Medium Term	MoF, MoC, Industry
Target 4: Strengthen Downstream Markets & Skills (Mandate GPP by 2026; Train 5,000 personnel by 2028)				
Category	**Proposed Initiative**	**Actionable Item**	**Time**	**Proposed Owner**
Policy-related initative	Strengthen downstream markets	Mandate the use of recycled materials in government-procured rubber products & road construction (e.g., CRMB)	Short Term	State, MoRTH, Industry
Capacity Building	Capacity Building	Launch a dedicated program to train 5,000 personnel in advanced recycling technologies and operations.	Medium Term	Academia, NSDC, Industry
Standard Development	Strengthen downstream markets	Promote standardized performance metrics, use third-party certification, and secure industrial partnerships for stable off-take	Medium Term	Industry, Academia

Table 13-3: Implementation Risks and Mitigation

Risk	Mitigation
High capital cost and market hesitancy regarding product quality limit commercial scalability	Promote standardized performance metrics, use third-party certification, and secure industrial partnerships for stable off-take.
Environmental and health concerns related to thermal processes, such as toxic emissions from pyrolysis	Require strict emission control systems and environmental monitoring for all thermal processes.
Inconsistent or insufficient domestic feedstock supply due to a fragmented collection network	Strengthen reverse logistics systems and aggregate ELTs efficiently through Circular Economy Parks.
Competition from cheaper virgin materials undermines the profitability of recycled content.	Implement policies that reward circular economy outcomes and provide subsidies/tax breaks for recycled products.

13.4.7. Monitoring and Accountability

- Utilize traceable digital platforms to update data on all tire waste collected, aggregated, segregated, and recycled in real-time.

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Chapter 14

CIRCULAR ECONOMY ACTION PLAN FOR END-OF-LIFE VEHICLES (ELV)

14.1. Material Landscape and Circularity Baseline

14.1.1. Overview of Vehicle Scrappage and Recycling Ecosystem in India

India's automotive industry continues to be a cornerstone of economic growth, contributing **7.1% to the national GDP in FY 2023–24** and generating significant employment. The sector achieved strong growth in **FY 2024–25**, with total sales rising to **2.56 crore units**, up **7.3% year-on-year**. **Passenger Vehicle** sales reached **43 lakh units**, while **Two-Wheeler** sales climbed to **1.96 crore units**, reflecting sustained consumer demand for personal mobility. Although **Commercial Vehicles** witnessed a marginal decline, overall volumes indicate a healthy replacement cycle.

This expanding vehicle base will inevitably drive **End-of-Life Vehicle (ELV)** generation, unlocking substantial opportunities in **vehicle recycling, material recovery, and circular economy initiatives**, all of which align with India's **Vehicle Scrappage Policy** and broader **sustainability goals**.

14.1.2. ELV Material and Value Chain

The ELV material value chain spans the entire automotive lifecycle — from **primary metal and polymer production** to **vehicle manufacturing, use, and end-of-life processing** — with deep domestic and global linkages. **Vehicle deregistration and formal scrappage flows** are being institutionalized through the **VAHAN/RVSF portal** and **MoRTH guidelines**, enabling authorized **Registered Vehicle Scrapping Facilities (RVSFs)** to issue **digital Certificates of Deposit (CoD)** and update national records, thus establishing a **traceable and accountable ELV feedstock system**.

ELVs are materially rich. **Ferrous fractions (steels)** constitute over **60%** of total mass and are the primary value driver for recyclers. **Non-ferrous metals** such as **aluminium and copper** account for around **10%**, while **plastics, rubber (tyres)**, **batteries**, and **fluids (used oil)** contribute approximately **15%**, requiring specialized recycling routes for safe and efficient recovery.

14.1.3. Growth in Formal Vehicle Recycling

The sharp rise in **Certificate of Deposit (CoD)** generation highlights rapid progress in India's formal scrappage ecosystem. Beginning with only **four vehicles in August 2022**, monthly CoD numbers surged to over **10,000 vehicles by April 2025**, representing a **2,500-fold increase in less than three years**. This trend reflects the scaling-up of **registered scrappage facilities**, growing **deregistration of unfit vehicles**, and stronger **coordination between OEMs, recyclers, and government systems**.

Despite this growth, a large share of ELV dismantling still takes place in the **unorganized sector**. However, the data clearly shows a gradual shift toward **organized, compliant recycling practices**. To unlock the full economic and environmental potential of vehicle recycling, **stronger collaboration among policymakers, OEMs, recyclers, and consumers** is needed, supported by **targeted policy incentives, awareness programs, and infrastructure development**.

14.1.4. Steel Recycling Linkage

ELV scrappage plays a pivotal role in supporting India's **steel recycling ecosystem**. Under the **Steel Scrap Recycling Policy (2019)**, every **tonne of recycled steel scrap** saves approximately **1.1 tonnes of iron ore**, **630 kg of coking coal**, and **55 kg of limestone**, while reducing **energy use by 16–17%** and **CO_2 emissions by up to 58%** compared to traditional steelmaking routes.

India produced **151.14 million tonnes of crude steel** and **145.31 million tonnes of finished steel** in **FY 2024–25 (provisional)**, with **consumption reaching 150.23 million tonnes** — a 50% rise from FY 2020–21 levels. The current scrap supply includes **25 million tonnes (MT)** from the **domestic unorganized sector** and **7 MT from imports**. There is considerable potential to **replace imported scrap** through **organized ELV recycling**, generating high-quality domestic scrap and strengthening material self-reliance.

Achieving the **National Steel Policy 2030** target of **70–80 MT of domestic scrap availability** will depend on expanding **RVSF capacity**, **streamlining collection networks**, and promoting **green steel initiatives** that enhance both environmental and economic sustainability.

14.1.5. Infrastructure Evolution and Challenges

India's scrappage infrastructure is currently **fragmented**, with formal **RVSFs** and authorized recyclers coexisting alongside a large **informal dismantling sector**. While informal players contribute significantly to material recovery, they often lack **traceability**, **environmental safeguards**, and **geographic uniformity**. National-level **regulatory measures and facility standards** are being introduced to **formalize operations**, **enforce compliance**, and **strengthen environmental accountability**.

The growing issuance of CoDs, the establishment of new RVSFs, and the expansion of **state-level scrappage policies** mark a positive shift toward a more transparent and sustainable recycling ecosystem.

14.1.6. Overview of Vehicle Scrappage Policy – A Three-Way Framework

Current adoption of circular practices remains **nascent but accelerating**. Integrated pilot facilities, e-waste clusters, and new RVSF registrations are increasing steadily. Policy and incentive frameworks under **MoRTH**, **state governments**, and **EPR (Extended Producer Responsibility)** mechanisms are evolving to promote **formal collection**, **standardized processing**, and **private-sector investment**.

Government End: Policy, Regulation & Economic Efficiency

- Aims to reduce vehicular pollution, enhance road safety, and improve energy efficiency by retiring old, polluting vehicles.
- Implements **mandatory fitness testing**, **Automated Testing Stations (ATS)**, and **RVSFs**, integrated with **VAHAN** and the **National Single Window System** for digital traceability.
- Supports the **Steel Scrap Recycling Policy (2019)**, reducing dependence on imported scrap and targeting **70–80 MT of domestic availability by 2030**.
- Drives the **formalization of the recycling industry**, improving resource circularity and reducing emissions.

Recycler End: Organized Recycling & Resource Recovery

- **RVSFs**, authorized by MoRTH, manage **eco-friendly dismantling**, **depollution**, and **segregation** of vehicle components.
- Generate **Certificates of Deposit (CoD)** and enable traceable deregistration.
- Recover **ferrous and non-ferrous metals**, **plastics**, **rubber**, and **e-waste**, feeding industrial supply chains and supporting **green steel production**.
- Benefit from state incentives and growing ELV inflows, with the potential ELV pool expected to exceed **2 crore vehicles by 2035**.

Consumer End: Incentives & Participation

- Vehicle owners scrapping old vehicles receive multiple benefits:
    - **Road Tax Rebate:** Up to 25% for private and 15% for commercial vehicles.
    - **Registration Fee Waiver** for new vehicles.
    - **OEM Discount:** 5% on new vehicle purchase with a valid **Certificate of Deposit (CoD)**.

Consumers gain from **lower maintenance and fuel costs**, enhanced **safety**, and participation in **clean mobility** initiatives.

14.2. Gaps & Challenges in Advancing ELV Circularity in India

The End-of-Life Vehicle (ELV) circularity ecosystem in India shows significant promise but remains constrained by systemic gaps across policy, markets, infrastructure, and human capital. The following is a concise, evidence-based summary of key barriers and lessons from practice:

14.2.1. Policy Gaps & Enforcement Barriers

- **Incomplete regulatory harmonization:** While MoRTH's Vehicle Scrappage Policy and RVSF standards exist, coordination with environmental regulations (CPCB/SPCB), Extended Producer Responsibility (EPR) frameworks, and state-level policies is uneven, creating compliance gray areas.

- **Weak enforcement and monitoring:** Limited inspection capacity and fragmented reporting reduce regulatory effectiveness.

- **Incentive misalignment:** Existing incentives are often project-specific or short-term and are insufficient to de-risk large capital-intensive investments in advanced recycling.

14.2.2. Material-Specific Challenges

- **Heterogeneous material streams:** ELVs contain mixed polymers, composite materials, and electronic components, each requiring specialized processing routes (mechanical vs chemical recycling; hydrometallurgy vs pyrometallurgy for batteries).
- **Contamination and quality variability:** Oils, fluids, dirt, and mixed scrap reduce recovery yields and necessitate intensive pre-treatment, increasing processing costs.

14.2.3. Feedstock Scale & Aggregation Economics

- **Fragmented supply:** Small, dispersed generators and informal collectors make it challenging to aggregate consistent, high-quality feedstock at scale.
- **Logistics cost sensitivity:** Transport and handling costs for low-value fractions, such as plastics and shredded foam, often exceed the material margin unless centralized clustering or subsidies are implemented.

14.2.4. Informal Sector Dominance & Viability Gap

- **Informal competitive advantage:** Low-cost informal dismantling competes with formal RVSFs by avoiding environmental and labor safeguards, undercutting formal players' economics.
- **Social transition risk:** Rapid formalization without livelihood provisions may provoke social pushback; inclusive transition mechanisms are essential.

14.2.5. Infrastructure & Technology Shortfalls

- **Limited capital investment:** High capital expenditure for chemical recycling, battery metallurgy, or used-oil re-refining deters private investment without concessional finance or blended instruments.
- **Technology maturity and local adaptation:** Many advanced recycling methods require adaptation for Indian feedstock profiles; proven pilots are limited and scaling risks remain.

14.2.6. Limited Availability of Integrated Platforms

- **Few eco-parks or cluster models:** Scalable models co-locating MRFs, recyclers, and downstream processors remain nascent, impeding economies of scale, shared services (e.g., effluent treatment), and centralized compliance.

14.2.7. Awareness & Skills Deficits

- **Low stakeholder awareness:** Consumers and small generators often lack knowledge on segregation or formal collection pathways, reducing capture rates.
- **Skill gaps:** Safe dismantling, battery handling, chemical recycling operations, and digital traceability require trained technicians, yet capacity-building initiatives remain limited.

14.2.8. Weak Downstream Markets & Value Realization

- **Offtake uncertainty:** Processors face irregular demand for recycled feedstocks and price volatility relative to virgin materials, hindering long-term contracts and investment.
- **Quality assurance shortfall:** The absence of standardized quality certification for secondary materials reduces buyer confidence and price realization.

14.3. Vision and SMART Targets for ELV Circularity in India

14.3.1. Vision Statement

"To establish a resource-secure, low-emission, and socially inclusive End-of-Life Vehicle (ELV) recycling ecosystem in India — maximizing material recovery, minimizing waste leakage, and promoting green jobs through formalized and technology-driven circular systems by 2040."

14.3.2. SMART Targets for 2030 (and Beyond)

Table 14-1 : Proposed Targets

Goal Area	Target (2030)	Basis & Rationale	Extended Target (2040/2047)
Formal ELV Collection and Recycling	60% of ELVs generated annually channeled through authorized RVSFs	Current baseline (2024): <10–15% formal collection; aligns with Vehicle Scrappage Policy and projected capacity expansion	90% formal collection by 2047
Material Recovery Efficiency	Metals: 90%; Plastics: 70%; Tyres: 80%	Benchmarks from EU/Japan; current Indian RVSFs: metals ~70%, plastics <40%	Near-zero landfill waste (<5%) by 2047
Reduction in Virgin Material Demand	15% reduction in virgin steel, aluminium, and plastics in new vehicles	Based on domestic material flow analysis; global average recycled steel ~35%, India ~20%	30% reduction by 2047
Design for Durability & Reparability	50% of OEMs integrate DfR guidelines into new models	Baseline: <10% OEMs report recyclability metrics; aligns with EU End-of-Life Directive benchmarks	100% integration by 2047
Circular Infrastructure Development	10 Integrated Recycling Parks (PPP-based) in high-vehicle-density zones	Present: <3 functional clusters	20 parks pan-India by 2047

Goal Area	Target (2030)	Basis & Rationale	Extended Target (2040/2047)
Informal Sector Transition & Skill Development	Formalize 100,000 informal workers through training & aggregator models	Covers ~25% of informal workforce	100% inclusion and skill certification by 2047
Environmental Performance	Reduce GHG emissions from informal ELV dismantling by 60%	Lifecycle emissions: 1 tonne recycled steel saves ~1.5 tonnes CO_2	Carbon-neutral ELV recycling by 2047
Digital Traceability & Data Integration	100% ELVs tracked via VAHAN-RVSF digital manifest	Baseline: partial pilot implementation	Full AI-driven material flow tracking by 2047
Public Awareness & Participation	State-level campaigns across all 28 states + 8 UTs; 70% consumer awareness	Baseline: <20% awareness	95% awareness by 2047

14.3.3. Basis for Target Setting

- **Policy Alignment:** National Vehicle Scrappage Policy (2021), EPR Guidelines (2022), India@2047 Vision, National Resource Efficiency Policy (draft).
- **Benchmarking:** EU ELV Directive (95% recovery), Japan's JARC system (98% recovery efficiency).
- **Feasibility:** Based on RVSF processing capacity expansion trends and private-sector investment models (DBOOT, PPP).
- **Data Sources:** MoRTH, CPCB, ICCT, TERI, NITI Aayog, BEE circular economy baseline studies (2023–24).

14.4. Enablers & Implementation Framework — ELV Circularity in India

Advancing ELV circularity in India requires a structured ecosystem of policy, finance, infrastructure, technology, and stakeholder engagement. The following section outlines key enablers and an actionable implementation framework.

14.4.1. Policy Interventions & Market Instruments

- **Regulatory clarity & enforcement:** Strengthen alignment between MoRTH scrappage rules, CPCB/SPCB standards, and EPR frameworks for vehicles and automotive components, including batteries.
- **Mandatory digital manifests & traceability:** Require VAHAN–RVSF integration and digital manifests for all RVSFs and recyclers to ensure transparency and traceability.
- **Procurement & standards:** Encourage public procurement preference for certified secondary materials and set recycled-content targets for government vehicle fleets.
- **Mandates & targets:** Establish phased targets for formal collection, recycling rates, recycled content in new vehicles, and battery recovery.
- **Market instruments:** Introduce tradable scrap-credit or recycling-credit schemes, similar to renewable energy certificates, to generate revenue for high-quality recycling and incentivize formalization.

14.4.2. Financing Tools & Incentives

- **Capital subsidies / Viability Gap Funding (VGF):** Targeted CAPEX support (15–25%) for early-stage chemical recycling, battery metallurgy, and other advanced recycling technologies.
- **Blended finance:** Combine concessional debt (SIDBI/DFIs), equity, and grants to de-risk first movers.
- **Green bonds & sustainability-linked loans:** Mobilize financing for large integrated parks and technology upgrades.
- **Public procurement guarantees:** Anchor offtake for secondary materials through state procurement and PSU tie-ups.
- **Tax incentives (non-GST):** Duty concessions for critical recycling equipment imports and accelerated depreciation for recycling capex.

14.4.3. Infrastructure & Circular Economy Parks

- **Cluster model:** Co-locate material recovery facilities (MRFs), plastics (mechanical & chemical), tyre, used-oil refinery, textile, e-waste, and battery recycling units to share utilities such as effluent treatment plants, power, roads, and weighbridges.
- **Common services:** Shared effluent treatment, hazardous waste management, testing labs, and material quality certification centers.
- **Logistics hubs:** Regional aggregation centers and transport corridors to reduce collection and transport costs.

14.4.4. Investment in Technology & R&D

- **Technology pilots:** Support pilot projects for chemical recycling, battery hydrometallurgy, and tyre-to-crumb/pyrolysis technologies.
- **Local adaptation:** Invest in adaptive R&D to suit Indian feedstock variability and mixed-polymer waste.
- **Standards & quality assurance:** Develop material quality standards for recycled polymers, metals, and battery outputs to improve market confidence.

14.4.5. Promotion of PPPs & Business Models

- **DBOOT / PPP model:** Implement Design-Build-Own-Operate-Transfer (DBOOT) PPPs for park development, with government providing land and enabling infrastructure and private partners responsible for construction and operation.
- **Aggregator models:** Support professional recycling organizations (PROs) and aggregators to formalize collectors and aggregate feedstock efficiently.
- **Co-investment vehicles:** Establish state-led special purpose vehicles (SPVs) to combine industry and government equity for park development.

14.4.6. Capacity Building & Skills

- **Training & certification:** Develop ASDC/NSDC-aligned modules for dismantling, battery handling, chemical recycling operations, safety, and digital manifest management.
- **Upskilling informal workforce:** Incentivize collector registration, provide safety kits, and deliver training through aggregator programs.

14.4.7. Awareness & Behaviour Change

- **State-led campaigns:** Conduct urban local body (ULB) and state campaigns to promote source segregation and ELV hand-in drives.
- **Incentive schemes for consumers:** Offer vouchers or discounts for scrapping old vehicles, linked to RVSF certificates.

- **Industry engagement:** Encourage OEM-led take-back programs and educate consumers on vehicle reparability and residual value.

14.4.8. Implementation Roadmap

The targets, goals, and enabling strategies outlined earlier form the foundation for a comprehensive implementation road map.This roadmap will serve as a strategic guide to systematically achieve the defined objectives by translating high-level targets into concrete actions. The table below details specific initiatives and activities, mapped against the targeted outcomes, along with estimated timelines, key ownership, and responsible stakeholders.These actions encompass a range of critical areas, including policy reforms, economic instruments, PPP models, research and development, and capacity building—all aimed at ensuring a structured, coordinated, and impactful pathway toward sustainable waste management and circularity.

Table 14-2 : Priority Actions to Achieve Targets

Action	Timeframe	Priority	Lead	Support	Key Outcome / KPI
Establish 1st Integrated Recycling Park (pilot)	0–18 months	High	State Govt (Industry Dept) / SPV	Private Consortium (DBOOT), MoEFCC	Park commissioned; TPA capacity; jobs created
Mandate digital manifest (VAHAN–RVSF integration)	0–12 months	High	MoRTH	CPCB, State Transport	100% manifests; traceability KPI
CAPEX subsidy & VGF scheme launch	0–12 months	High	State Finance Dept	SIDBI / DFIs	% Capex disbursed; private leverage ratio
Aggregator & collector formalization program	0–24 months	High	ULBs	NGOs, Industry PROs	No. collectors registered; feedstock uplift (t/month)
Pilot Li-ion recycling module	6–24 months	Medium	Private Partner	R&D Grants, MoEFCC	Pilot throughput; recovery rates (%)
Establish QA & certification lab	6–18 months	Medium	State / Industry Body	Academia	Material quality standards & certificates issued
Scale to 5 parks across state	18–60 months	Long	State Govt	Private Investors	Park count; statewide capacity (TPA)
OEM DfR adoption roadmap	12–36 months	Medium	Industry (OEMs)	BIS, MoRTH	% models with DfR metrics

Table 14-3: Stakeholder Roles & Responsibilities

Stakeholder	Role
Central Ministries (MoRTH, MoEFCC, DPIIT)	Policy mandates, national standards, funding windows, VAHAN integration

Stakeholder	Role
State Govt / Industrial Dept	Land allotment, CAPEX incentives, PPP facilitation, awareness campaigns
ULBs / SPCBs	Local collection networks, enforcement, operating permits
Industry (OEMs, Recyclers, PROs)	Investment, technology deployment, EPR compliance, DfR adoption
Financial Institutions / DFIs	Blended finance, concessional loans, green bonds
Academia & R&D	Technology adaptation, testing labs, skill curriculum development
NGOs / Community Groups	Collector mobilization, training, social safeguards

Table 14-4: Implementation Risks & Mitigation

Risk	Likelihood	Impact	Mitigation
Feedstock aggregation failure	Medium	High	Support aggregator incentives, guarantee minimum offtake, ULB collection tie-ups
Informal sector resistance	High	Medium	Inclusive transition plan with guaranteed income via PROs, skilling, phased enforcement
Technology commercial failure	Medium	High	Pilot + scale approach; blended finance; performance-based subsidies
Regulatory delays	Medium	High	Early engagement with MoRTH/CPCB; state-level policy fast-track cells
Price volatility of recyclates	High	Medium	Long-term offtake contracts, state procurement anchors, recycling-credit mechanism

14.4.9. Monitoring & Accountability

Governance Structure:

- **State Steering Committee:** Strategic decisions; includes Industry Dept, SPCB, MoRTH, and industry representatives.
- **Project Implementation Unit (PIU):** Day-to-day execution and finance management.
- **Independent Third-Party Auditor / Certification Body:** Conduct environmental and quality audits.

Key Performance Indicators (KPIs) & Dashboard:

- Feedstock intake (t/month by stream)
- % ELVs formalized (VAHAN manifest coverage)
- Material recovery rates (%) by stream
- Jobs created (direct/indirect)
- CAPEX disbursed vs invested; private leverage ratio
- GHG avoided (tCO_2e/year)
- Number of collectors formalized; training certificates issued

Reporting Frequency:

- **PIU:** Monthly operational report
- **State Steering Committee:** Quarterly review & corrective action
- **Public Disclosure:** Annual sustainability & KPI report

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Chapter 15

CIRCULAR ECONOMY ACTION PLAN FOR PLASTIC

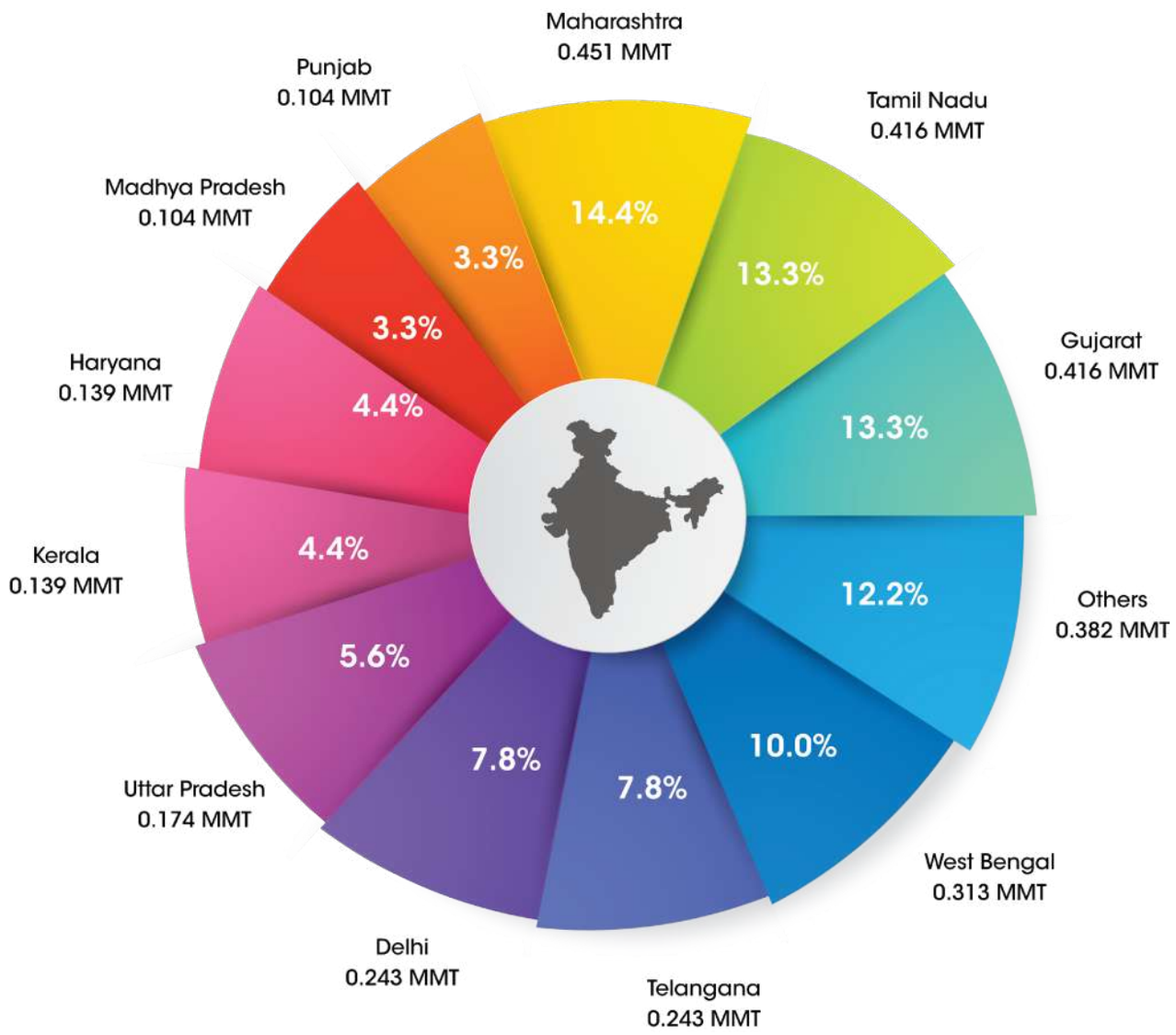
15.1. Material Landscape and Circularity Baseline

Plastics are a cornerstone of India's modern economy, with applications spanning packaging, textiles, automotive, consumer goods, construction, and healthcare. Domestic polymer demand has grown steadily from ~16 million tonnes in 2016 to ~20 million tonnes in 2022 and is projected to surpass 32 million tonnes by 2035. Most plastics are derived from crude oil and natural gas derivatives such as ethylene and propylene, with domestic production supplemented by imports of around 1.2 million tonnes annually. This dependence on imported crude exposes the sector to global price fluctuations. Downstream converters produce a wide array of products, including packaging, textiles, automotive components, films, and pipes, with packaging being the largest and fastest-growing segment and the primary focus of Extended Producer Responsibility (EPR) and recycling targets.

The plastics value chain spans multiple stages, each with distinct features and domestic and global linkages. Raw material extraction relies on naphtha, ethylene, and propylene, linking India to volatile global crude markets. The production stage is dominated by major players such as Reliance, IOCL, GAIL, and Haldia Petrochemicals. Conversion and end-use stages supply diverse sectors—packaging accounts for ~60% of demand, textiles (especially polyester) contribute ~8 million tonnes annually, automotive uses plastics to reduce vehicle weight and emissions, and healthcare relies on plastics for medical devices, PPE, and syringes. According to the CPCB Annual Report 2019-2020, India generates ~3.5 million tonnes of plastic waste annually(across 36 States and Union Territories)of which ~30 to 60% is recycled, mostly via the informal sector, while the remainder is mismanaged or incinerated sub-optimally.

- The top three states—**Maharashtra**, **Tamil Nadu**, and **Gujarat**—collectively account for **37%** of India's total plastic waste generation.
- **Delhi** and **Telangana** each contribute **7%**, highlighting significant urban plastic waste challenges.
- The **Others** category, encompassing various smaller states and Union Territories, accounts for **11%** of the total generation.

State-wise Plastic Waste Generation in India (2019–20)



The table below to explain the stages, key features, and global and domestic linkages of the plastics value chain.:

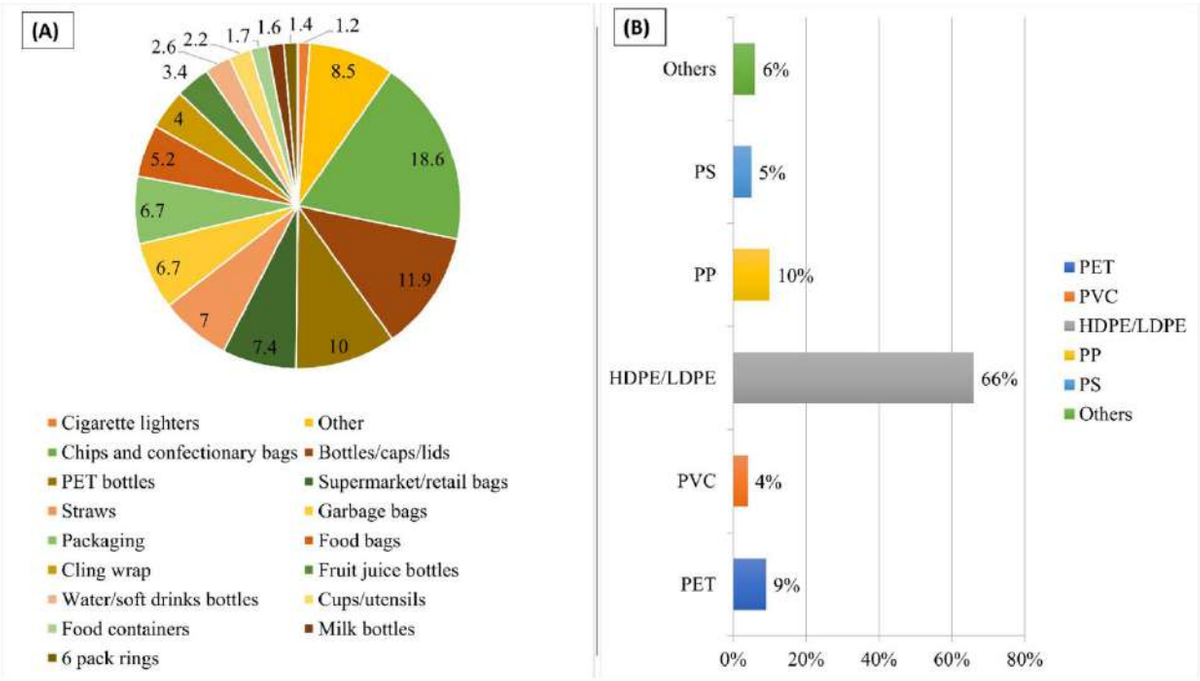
Table 15-1: Stages, Key Features, and Global and Domestic LInkages of the Plastics Value Chain

Stage	Key Features	Domestic & Global Linkages
Raw Material Extraction	Feedstock: Naphtha, ethylene, propylene (crude oil/gas derived)	High dependence on imported crude oil → price volatility
Production	Major players: Reliance, IOCL, GAIL, Haldia Petrochemicals	Resin imports ~1.2 MT annually

Stage	Key Features	Domestic & Global Linkages
Conversion & Use	Packaging (~60%), Textiles (polyester), Automotive, FMCG, Healthcare	Packaging is the largest and fastest-growing demand segment
End-of-life	~3.5 MT waste generated annually; ~30 to 60% recycled, ~5% CoProcessed, ~ 40% mismanaged	Informal sector handles ~90% recycling; global recyclate trade influences pricing

Plastics are strategically important across sectors: in FMCG, over 70% of products use plastic packaging due to durability and cost; in textiles, India is a global leader in polyester exports; in automotive, plastics enhance fuel efficiency; and in healthcare, they are critical for medical safety and efficiency. Trade dependencies, particularly the import of ~1.2 million tonnes of polymers, and reliance on global crude and petrochemical markets, expose the sector to supply shocks and price volatility.

The environmental and social footprint of plastics in India is significant. About 80% of waste collection is managed by informal workers, including kabadiwalas, aggregators, and sorters, who face minimal formal protection and health risks such as respiratory issues. Poorly segregated feedstock reduces recyclate quality and leads to leakage into landfills and water bodies, while regional disparities in recycling infrastructure—fewer units in Eastern and Central India—necessitate long-distance transport, increasing logistics costs and emissions.



(**A**) Sources of PW (as percentages)

(**B**) percentage composition of PW in India

Source: Aryan, Y., Yadav, P. and Samadder, S.R., 2019. Life Cycle Assessment of the existing and proposed plastic waste management options in India: A case study. Journal of Cleaner Production, 211, pp.1268-1283. From a market perspective, installed mechanical recycling capacity stands at ~4.78 million tonnes per year across ~2,309 units, with polyolefins dominating by number of units and PET having larger per-unit capacities. Of this ~4.78 million tonnes capacity, resin-wise distributed as

- Polyolefins (PP, PE, HDPE, LDPE): ~2.2 MTPA
- PET (Polyethylene Terephthalate): ~1.8 MTPA

Closed-loop recycling remains limited (<5% of capacity), though projections indicate that by 2025–26, ~34% of operations will need to meet high-quality standards to comply with EPR mandates. Demand for recyclate is increasing due to regulatory frameworks like the India Plastics Pact and voluntary commitments, though uptake is constrained by feedstock quality and price competition with virgin resin.

India is gradually adopting circular practices. Initiatives include design for durability, product reuse, and repair; the informal sector is critical in collection and sorting but largely unrecognized in formal frameworks. Policies and incentives such as the India Plastics Pact, the Wealth to Waste mission, amendments to the Plastic Waste Management Rules (2022), and national campaigns like Swachh Bharat Abhiyan aim to increase recycled content, eliminate single-use plastics, and drive quality recyclate demand.

TERI's guidance identifies three key objectives: (1) adoption of sustainable material solutions through bio-based or recycled polymers, circular design, and incentivized use of sustainable materials; (2) improving supply of high-quality secondary plastics by integrating informal workers, expanding infrastructure, and capacity building; and (3) promoting alternative uses for difficult-to-recycle plastics via R&D, industry collaboration, and business support programs.

Best practices and innovations complement these efforts. Design innovations reduce material use and extend product life, while reuse and return programs enable customers to return packaging for cleaning, refilling, or repurposing, reducing single-use plastics and environmental impact. Advanced sorting and recycling technologies, including AI, near-infrared spectroscopy, computer vision, and robotics, enhance material recovery, improve recyclate quality, and expand reuse opportunities. These combined approaches position India's plastics sector on a trajectory toward achieving 2030 circularity targets, though significant gaps in infrastructure, formalization, and consumer awareness remain.

15.2. Gaps and Challenges in Advancing Circularity

Source segregation remains low and highly variable, with households exhibiting uneven practices and many urban local bodies (ULBs) still lacking robust Material Recovery Facilities (MRFs). Poor segregation increases contamination, reduces recyclability, and constrains the uptake of recycled content.

The **informal sector** continues to dominate collection and initial recycling, providing livelihoods for thousands of workers. However, these operations are largely unregulated, with minimal protections, no formal contracts, and limited quality assurance, making integration into formal EPR frameworks difficult and exposing workers to health hazards such as respiratory and dermatological risks.

Recyclate quality and standards remain another major challenge (and often face compatibility issues with existing packaging applications). The absence of enforced, reliable standards for food- and medical-grade recycled polymers limits substitution for virgin resin, reducing market demand and discouraging investment in high-quality recycling facilities. **Technological gaps** further constrain circularity. While mechanical recycling works well for PET and HDPE, mixed or contaminated packaging streams remain inadequately processed. India's chemical recycling capacity is limited, both in scale and economic viability, and outdated or inefficient mechanical recycling technologies reduce recovery efficiency.

Policy and regulatory challenges persist. Although EPR registration is largely on track via the CPCB portal, enforcement and verification vary across states, and overlaps or ambiguities in state-level rules and bans create confusion for industry stakeholders. Lack of standards for traceability further weakens the EPR system, thereby fostering generation and transfer of dubious EPR credits. Incentives for recycled content adoption and circular investments are limited, and weak public procurement mandates reduce demand for high-quality recyclates.

Other structural gaps include **fragmented value chain coordination**, insufficient R&D for sustainable polymers and recycling technologies, and **regional infrastructure disparities**, with the majority of recycling units

concentrated in western and southern India. Transporting waste from underserved regions increases logistics costs and environmental footprint. Additionally, **consumer awareness** on segregation, reuse, and return schemes remains low, limiting participation and reducing recovery rates. Market acceptance also remains low as vendors prefer to supply virgin plastics due to its lower cost.

Delay in implementation of proposed mandatory use of recycled content in food contact packaging applications for rPET. As per the June 2025 gazette notification((G.S.R. 365(E), dated 3 June 2025), In the case of rPET food-contact plastic packaging applications, any shortfall in meeting the mandatory recycled plastic content target for FY 2025–26 may be carried forward for a period of three subsequent years (beyond 2026–27), in addition to the targets applicable for those years. Lack of clarity of in implementation of food grade rPP and rHDPE in India. **rPP and rHDPE:** No current approvals or guidelines from FSSAI; timelines for potential implementation are not specified.Finally, there is inadequate attention to the **environmental and climate impacts** of plastics across their life cycle. Policies often emphasize volumes recycled rather than environmental outcomes such as greenhouse gas emissions, microplastics leakage, or energy intensity. Addressing these challenges will require coordinated action across government, industry, civil society, and consumers to strengthen infrastructure, formalize informal recycling, enforce standards, incentivize innovation, and raise awareness. Clear guidelines to avoid double counting of PIBO responsibilities need to be published to ensure fair compliance.

15.3. Vision and Targets for Circular Economy Transition

Vision Statement

By 2030, India will achieve a circular plastics economy in which all plastic packaging is collected and recycled or reused for the same purpose, and recycled content in rigid packaging is substantially increased. This vision is linked to the implementation roadmap through strengthened EPR compliance, expansion of MRFs(Material Recovery Facility) and CE (Circular Economy) hubs, fiscal incentives, and targeted R&D and quality certification initiatives

Table 15-2: SMART Targets

S. No.	Proposed Target	2030 (Mandatory)	Basis (aligned with implementation roadmap)
1	Collection of plastic packaging waste	100%	Baseline: ~3.0 Mt in 2022–23; current formal collection ~60%. Achievable via strengthened EPR compliance including independent audits of PRO data, standardized segregation at source, green financing for MRFs, deposit refund schemes, city CE hubs, consumer awareness campaigns, and informal sector integration into collection chains.
2	Recycled content in rigid plastic (Cat 1) & Flexible packaging(Cat-2)	Category1(Rigid Plastics) 60% Category2 (Flexible Packaging) 20% by 2028-29 and Category3 (Multilayer Plastics) 10%	Baseline: <10% today overall. Achievable via mandatory recycled-content standards (PET/HDPE/PP) as per PWM, quality certification for recyclate, fiscal incentives and market development grants, and support for scaling high-quality food-grade recyclate. Informal sector integration also contributes to reliable feedstock.
3	Plastic Circular Economy Hubs (collection + MRF)	100% Collection target	Pilots of 25 PPP MRFs across metro and tier-2 cities, with logistics connectivity for collection from neighbouring districts. Supports 100% collection target and provides infrastructure for high-quality recycling.

4	R&D and Pilots	Creating automated sorting facilities using AI/ NIR Technology to increase quality & quantity of sorting process.	Includes funding for 10 sorting and decontamination pilot plants, and life-cycle assessment studies to monitor environmental footprint and recyclate quality. Supports both collection efficiency and uptake of recycled content.
5	Mismanaged Plastics	By 2035 Zero Mismanaged Plastic	Every piece of plastic placed on the market is either reused, collected and recycled (or safely treated/managed), or eliminated at source (no unnecessary single-use) so nothing leaks to open dumps, waterways, soil, or oceans.

15.4. Enablers and Implementation Framework

15.4.1. Policy Interventions & Market-Based Instruments

Effective policy frameworks are essential to drive the circular plastics economy. Key interventions include strengthened EPR compliance, with independent audits of Producer Responsibility Organizations (PROs) to ensure accurate reporting and adherence to targets. Standardized segregation at source for households and businesses will improve feedstock quality for recycling. Mandatory recycled-content standards for PET and HDPE aim to increase demand for high-quality recyclate, while nation-wide standardized deposit refund schemes incentivize the return of bottles and cans. These measures collectively support improved collection rates, reduced contamination, and stronger market pull for recycled plastics.

15.4.2. Financing Tools & Incentives

Financial instruments are critical for scaling collection, recycling, and reuse. Green financing for Material Recovery Facilities (MRFs) through blended finance helps build or upgrade infrastructure. Fiscal incentives for recyclate use, including output subsidies and tax benefits, encourage both producers and buyers to adopt recycled materials. Special incentives and financial assistance may be provided to industries adopting advanced or chemical recycling and integrating recycled content in packaging. Special incentives and financial assistance may be provided to industries adopting advanced or chemical recycling and integrating recycled content in packaging. Public procurement policies that favor products with recycled content create demand pull, while Viability Gap Funding (VGF) supports the establishment of circular economy (CE) hubs and regional CE parks. Together, these instruments reduce financial barriers and accelerate investment in circular practices.

15.4.3. Infrastructure

Robust infrastructure across the value chain underpins an efficient circular system. CE hubs and circular economy parks serve as integrated centers for collection, sorting, recycling, and R&D. Expansion of MRFs and parcelizer facilities improves processing efficiency and reduces contamination. Ensuring logistics connectivity allows collection from underserved regions, particularly in Eastern and Central India where collection is already less, reducing the environmental footprint of transporting waste over long distances. These facilities also provide formal platforms for integrating informal sector workers into structured value chains.

15.4.4. Investment & Technology Development

Investment in technology is essential to improve recyclate quality and recovery efficiency. Pilot sorting and decontamination plants enhance automated processing of mixed plastics. Advanced technologies including AI-assisted sorting, near-infrared spectroscopy, computer vision, and robotics enable precise separation of

complex waste streams, ensuring higher purity of recycled material. R&D efforts focus on durable, reusable, and biodegradable alternatives and life-cycle assessment studies to track environmental impacts and recyclate performance, supporting the design of circular products.

15.4.5. Promotion of Public-Private Partnerships (PPP)

PPP models are prioritized to leverage private sector expertise, investment, and operational efficiency. Pilots of 25 city CE hubs/MRFs demonstrate scalable collaboration between ULBs, industry, and academia. Partnerships also support R&D in material innovation, waste processing technologies, and formal training programs. VGF-supported CE parks provide co-investment platforms where private and public actors can jointly operate collection, recycling, and R&D centers.

15.4.6. Capacity Building & Skills Development

Human capital development is critical for effective circularity. Programs target the informal sector to improve health, safety, and recycling efficiency. Training ULB staff in segregation, monitoring, and MRF operations ensures consistent and high-quality collection. Additionally, industry-focused workshops and knowledge-sharing programs support design for recyclability, reuse, and sustainable material adoption, building long-term capability across the value chain.

15.4.7. Awareness & Behaviour Change Campaigns

Consumer and industry engagement is essential to drive source segregation, reuse, and return initiatives. Awareness campaigns encourage participation in deposit-return schemes, reuse programs, and proper disposal practices. Industry campaigns promote adoption of sustainable material solutions and responsible procurement. Incentivization through discounts, rewards, and recognition programs can increase engagement and ensure active participation in circular initiatives.

15.4.8. Prioritization of Initiatives

Initiatives are categorized based on impact and feasibility:

- **Short-term (2025–2027):** Inclusion of PROs in the EPR system, independent audits of recyclers, standardized segregation guidelines, pilot awareness campaigns, and initial MRF expansions.
- **Medium-term (2028–2030):** Scaling deposit refund schemes, expanding MRF capacity, consumer engagement, and fiscal incentives for recyclate adoption.
- **Long-term (post-2030):** Operational CE hubs and circular economy parks, deployment of advanced sorting and chemical recycling technologies, and full adoption of high-quality recycled content.

15.4.9. Implementation Risks & Mitigation

- **Low EPR compliance:** Mitigated through audits, penalties, and public dashboards.
- **Feedstock contamination:** Addressed via standardized segregation and CE hubs with quality-controlled sorting.
- **Informal sector exclusion:** Mitigated by formal integration, skill development, and incentives.
- **Technology gaps:** Addressed through pilot R&D projects, advanced sorting, and decontamination technologies.
- **Weak downstream demand:** Tackled by mandatory recycled-content standards, fiscal incentives, and government procurement policies.

15.4.10. Monitoring and Accountability

Progress is tracked via key performance indicators (KPIs) such as collection rates, recycling rates, recycled content adoption, CE hub operationalization, and R&D outcomes. Public dashboards, regular audits, and annual stakeholder reporting ensure transparency and accountability. Periodic evaluations provide feedback for continuous improvement and adaptive policymaking.

Table 15-3: Proposed Priority Actions to Achieve Circular Economy Targets

Target No. 1: **100% collection of plastic packaging waste by 2030**			
Policy Related Initiatives			
Proposed Initiative/ Measure	Action Item	Timeline	Proposed Owner for Implementation
Strengthen EPR compliance, traceability & disclosure	Conduct independent audits of data uploaded by recyclers and waste management agencies to ensure accuracy and compliance	2025–2027	MoEFCC, CPCB, State PCBs
Standardize segregation at source across India	Issue guidelines for municipalities and ULBs, Also share learnings from best ULB's in terms of handling their solid/ dry/plastic waste. **To implement 7 point frame work in a phased manner and build implementation Road map.** 1. Policy & Regulation, 2. Awareness & Behavior, 3. Infrastructure & Logistics, 4. Capacity Building & Training, 5.Technology & Monitoring, 6. EPR & Industry Engagement, 7. Monitoring, Evaluation & Scaling	2025–2027	MoEFCC, MoHUA, State Governments, ULBs
Economic Instruments			
Proposed Initiative/ Measure	Action Item	Timeline	Proposed Owner for Implementation
Green financing for MRFs & Recycling Infrastructure	Blended finance facility for MRFinfrastructure	2025–2028	MoF, SIDBI, MoHUA
Deposit refund schemes	Implement bottle/can return incentives (buy back scheme)	2026–2029	State Governments & Producers
Public Private Partnerships			
Proposed Initiative/ Measure	Action Item	Timeline	Proposed Owner for Implementation
City CE hubs (collection + MRF)	Pilot 25 PPP MRFs across metro and tier-2 cities	2025–2027	ULBs + Industry consortia
Consumer awareness campaigns	Joint campaigns to improve segregation at source and reduce littering; ; empanel NGOs to tag along with collection vehicles ensuring segregation at source.	2025–2026	MoHUA & NGOs/Industry, ULBs
Circular Economy Parks			

Proposed Initiative/ Measure	Action Item	Timeline	Proposed Owner for Implementation
Hub connectivity	Ensure logistics access for collection from neighbouring districts	2025–2026	Ministry of Road Transport & Highways
Research and Development			
Proposed Initiative/ Measure	Action Item	Timeline	Proposed Owner for Implementation
Sorting & decontamination pilots	Fund 10 pilot plants for automated sorting(AI +NIR) and washing Process	2025–2028	DST, CSIR
Life-cycle assessment studies	Track environmental footprint and recyclate quality	2025–2027	Academic institutions
Eliminate & redesign (reduce supply of problematic plastics)	**Design rules**: mandatory design-for-recycling standards and bans on non-recyclable multilayer films, colorants or additives that inhibit recycling.	2030-2032	MoEFCC, CPCB & Brands
Target No. 2 **50% Recycled Content in Rigid Packaging by 2030**			
Policy Related Initiatives			
Proposed Initiative/ Measure	Action Item	Timeline	Proposed Owner for Implementation
Mandatory recycled-content standards	BIS standards notification for PET/HDPE recycled content for FMCG, consumer durables, automotive and industrial applications	2026	BIS, MoEFCC, FSSAI
Quality certification for recyclate	Establish certification process for recycled pellets	2026–2027	BIS, MoEFCC
Regulations for rPP and rHDPE Food grade	FSSAI to provide guidelines for acceptance of recycled PP and HDPE as food contact material.	2026–2027	FSSAI MoEFCC
Economic Instruments			
Proposed Initiative/ Measure	Action Item	Timeline	Proposed Owner for Implementation
Fiscal incentives for recycled resin use and market development grants	1 Output subsidy for certified recyclate; tax benefits for buyers 2.Support recyclers for scale-up of food-grade and high-quality recyclate	2026–2030	MoEFCC, SIDBI
Public Private Partnerships			
Proposed Initiative/ Measure	Action Item	Timeline	Proposed Owner for Implementation
Material innovation	Develop biodegradable and recyclable alternatives	2025–2030	CSIR, Industry R&D Labs

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Chapter 16

CIRCULAR ECONOMY ACTION PLAN FOR CONSTRUCTION AND DEMOLITION WASTE

16.1. Material Landscape and Circularity Baseline

India's civil construction sector is witnessing robust growth driven by infrastructure investments. To meet future demands, India will need to develop 15 square kilometres of land every day until 2050, in addition to redeveloping old infrastructure. This sector is undergoing massive expansion, projected to become the world's third-largest market by 2025 with an estimated value of US$1.4 trillion. It is projected to reaching US$ 2.13 trillion by 2030. This rapid growth is fuelled by significant government initiatives, including an infrastructure budget of ₹11.21 lakh crore for 2025-26, driving nationwide development and employment. India's construction and cement sectors are at a pivotal juncture, being poised for accelerated growth driven by sustained infrastructure investments and government initiatives.

This upward trajectory is reflected in the 8% rise of cement production in early 2025 and an anticipated 7-8% increase in demand in FY26, particularly from the real estate sector. This rapid expansion saw cement volumes - anticipated to reach 480-485 million metric tonnes in FY26 – up from 453 million metric tonnes in FY25. The requirement of sand and coarse aggregate for utilising this cement in concrete mixes moves in conjunction and is now approximately 1 billion and 4 billion metric tonnes respectively.

Aggregate minerals, which include raw materials such as sand, gravel, and stone, are the building blocks of our cities and an integral part of the Indian economy. From being used to make the concrete that shapes our buildings to being the foundation of our roads, aggregates are necessary to maintain our quality of life. Crushed stone is a versatile material that has a variety of uses in road and building construction, landscaping, and other industries. It is typically made from various types of rock that have been broken down into different sizes. Most of this is now extracted from river beds or mined from rock formations.

But just how much can we keep relying on this sand and aggregate from mined sources year on year? According to projections India will keep consuming them at an accelerating rate of 8% each year till year 2047.

The construction industry has also become a primary energy consumer and a significant contributor to environmental degradation during mining for the material. The environmental impact of construction is thus observed in two key areas: air pollution and resource depletion. Construction and demolition waste accounts for approximately 30 per cent of all global solid waste, placing significant pressure on natural resources and the environment.
The construction industry embracing sustainability is in line with India's net-zero goals. The shift towards greener technologies and alternative materials is no longer optional but essential. The Government is preparing a national mission to incentivize sustainable raw material production, leveraging recycling and adoption of green materials which would contribute towards decarbonisation in the sector.

16.2. Gaps and Challenges in Advancing Circularity

Construction and demolition waste recovery rates vary widely across Indian cities, ranging from complete absence, to inadequate, to just sufficient systems. However, a major chunk of construction and demolition waste is still disposed of in unauthorised lands as filling material despite this waste having recyclable potential. This practice not only squanders resources but also exacerbates environmental pollution.
Implementing circular economy in construction offers a key solution to mitigating the adverse impacts of this waste. The approach should focus on reducing waste generation at sites, reusing materials, and recycling into alternate raw materials. This approach conserves resources and minimizes greenhouse gas emissions. However, circular economy adoption faces barriers such as high cost of transportation to processing sites, lack of local laws with legislative support, and low awareness about the value of reusability of the recycled aggregates.
Demolition Market: - **Dominance of the informal sector**

While a specific market size for India's demolition services is not estimated, the market is significant and growing due to rapid vertical growth and replacement of urban infrastructure. The informal sector continues to dominate

demolition, sorting, transportation and disposal to open lands and abandoned quarries. It is providing livelihoods to thousands of workers. However, these operations are largely unregulated, with minimal protections, few formal contracts, and limited quality assurance, making integration into formal EPR frameworks difficult and exposing workers to health hazards such as respiratory and dermatological risks. The sector's growth is fuelled by rapid urbanization, redevelopment projects, and infrastructure expansion, including roads, bridges, and flyovers

Manual deconstruction is primarily carried out by a large, informal workforce that relies on practical knowledge and teamwork for safety. While this group has a high material recovery rate due to profit-sharing incentives, it is unregulated and often lacks proper health and safety measures.

Formal large demolitions for large, complex structures are performed by specialized contractors, often with relying only on expertise. Utilising precision or controlled implosion techniques is rare. The same contractor is usually responsible for managing the waste generated. The informal system typically salvages instant valuable materials like tor steel and resells it, while using the rubble for scattered land-filling. This formal system must be brought into the gambit and made to comply waste management rules.

Source segregation in construction sites remains low due to poor planning and an overall industry culture that prioritizes speed over sustainability. Each of the fractions is generated in large volumes and comprises a wide variety of materials, from concrete and masonry to wood, metals, and hazardous substances. These complexities, combined with inadequate site management and regulatory enforcement, create significant barriers to effective waste segregation and recycling.

16.3. Vision and Targets for Circular Economy Transition

Vision Statement

India builds a regenerative construction ecosystem for each million plus city, where every demolished structure becomes a resource for the next — achieving zero waste, minimising resource depletion, and maximising material circularity in the built environment.

The transition towards a circular economy in construction envisions a future where cities become self-sustaining ecosystems — mining their own urban fabric before turning to the earth for fresh resources. By prioritizing the recovery and reuse of construction and demolition (C&D) materials, cities can effectively close the loop between construction, use, and recovery. This shift transforms C&D waste from an environmental liability into a renewable urban resource stream that fuels sustainable growth, reduces the carbon footprint of construction activities, and safeguards the planet's finite natural reserves

By 2030, India will establish a fully circular Construction and Demolition (C&D) waste economy**,** wherein all material fractions generated from demolition, renovation, and new construction are systematically collected, processed, and recycled for high-value and large-scale utilisation across the construction sector.

Table 16-1 Proposed Targets

	Proposed Target	2030	2035
1	**Owner Pay Principle :** The owner shall bear the responsibility and associated costs of managing all fractions of this waste to the extent necessary as to prevent any potential environmental or public health impacts arising from its generation or disposal. *{Aligns with Environment (Construction and Demolition) Waste Management Rules, 2025}*	100%	

	Proposed Target	2030	2035
2	**Recycling mandates:** Create a legislative-driven mandate for substitution of mined aggregates in specified low grade concretes and bound concrete recycled products of similar physical parameters *{In line in IGBC-CII 'Net Zero Waste Rating System for Buildings and Built environment and IS 383: 2016}*	25%	100%
3	**Establishment of Intermediate Waste Storage Facility / Collection Points** Provide a controlled, barricaded provisional storage facility in every zone of a million plus population city for aggregation of fraction wise C&D waste before it is transported to recycling facilities. Facilities should be located near high-generation zones to minimize transportation distances. *{Aligns with Environment (Construction and Demolition) Waste Management Rules, 2025}*	50%	100%

16.4. Enablers and Implementation Framework

16.4.1. Policy Interventions & Market-Based Instruments

The Ministry of Environment, Forest and Climate Change has notified the Environment (Construction and Demolition) Waste Management Rules, 2025, replacing the 2016 Rules. The new Rules, address C&D waste with a broader and more complex framework, emphasizing integrated waste management, utilization, and extended producer responsibility, supported by online monitoring and compliance
The real challenge lies in effective implementation, which can only be achieved if local-level bylaws of individual states and local governments are strengthened, waste collection points are established, and a robust market for recycled materials is developed

16.4.2. Financing Tools & Incentives

Municipalities may provide grants to private enterprises in the form of land parcel within the urban limits on favourable contract terms for the establishment of C&D waste recycling infrastructure. For instance, a recent Indian government initiative offered a capital expenditure (CAPEX) subsidy for recycling critical minerals from waste. Issuing green bonds by municipal corporations which could provide access to a growing pool of environmentally and socially conscious investors, including institutional players.

16.4.3. Infrastructure

While the number of C&D plants established is currently around 34 spread over 27 cities, it has to grow multi-fold to establish a network for C&D waste management across the country. They should be in the form of circularity parks where other minor C&D fractions (glass, plywood, metal sheet, glass wool etc.,) can also be segregated and sent for processing to the respective plants. Viability gap funding has to be explored especially for plants in cities with lesser quantity of generation.

16.4.4. Investment & Technology Development

Governments and private companies are focusing on new technologies to automate sorting, improve material

recovery, and close the loop on construction resources, creating a circular economy.

16.4.5. Promotion of Public-Private Partnerships (PPP)
Collaborations between government bodies and private firms are crucial for scaling C&D waste recycling efforts.

16.4.6. Awareness & Behaviour Change Campaigns
Campaigns and strategies must target multiple stakeholders, including construction workers, managers, developers, and local authorities, to address common barriers like low knowledge, weak regulations, and lack of financial incentives.

16.4.7. Prioritization of Initiatives
Initiatives are categorized based on impact and feasibility:

- **Short-term (2025–2027)**
- **Medium-term (2028–2030)**
- **Long-term (post-2030)**

16.4.8. Implementation Roadmap
The targets, goals, and enabling strategies outlined earlier form the foundation for a comprehensive implementation road map (presented in **Table 16-2**). This roadmap will serve as a strategic guide to systematically achieve the defined objectives by translating high-level targets into concrete actions. The table below details specific initiatives and activities, mapped against the targeted outcomes, along with estimated timelines, key ownership, and responsible stakeholders. These actions encompass a range of critical areas, all aimed at ensuring a structured, coordinated, and impactful pathway toward sustainable waste management and circularity.

Table 16-2 Proposed Priority Actions to Achieve Circular Economy Targets

Target No. 1: **Target Description:** ***Owner/Generator pay principle for 100% of the waste in million + population cities***			
Policy Related Initiatives			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Segregation at source by the Generator/owner	1. Conduct audits of construction and demolition sites to ensure compliance.	2026	CPCB, State PCBs
	2. Issuance of guidelines by local governance	2026	MoHUA, State Governments, ULBs
	3. Implement cement bags, grout bags, and return incentives schemes, so that they are not mixed with C&D waste.	2026	CPCB, State PCBs
Economic Instruments			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Green Financing for IWSFs in every ULB of a million+	Blended finance facility for the IWSF	2028	MoF, SIDBI, MoHUA
Public-Private Partnerships			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Setting up IWSF and processing plants	1. Provide land within the ULB limit to set up IWSF and processing facilities.	2026	ULBs, State Government
	2. Token lease to be charged for these.	2026	ULBs

Stakeholder awareness	Joint campaigns with CII, builders association, NGOs	2026	ULBs
Circular Economy Parks			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Hub Connectivity	Ensure logistic access of all zones within the ULB	2026	ULBs
Research and Development			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Recycling other fractions of C&DW	Glass, Wood, Mineral Wool for reuse and recycling		DST, CSIR
	Clay and Loam		DST, CSIR
Target No. 2 **Target Description: *Recycling Mandates***			
Policy Related Initiatives			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Mandatory Recycled Content Standards	BIS standard notification for usage of loam in construction	2027	BIS,DST, CSIR, MoEFCC
Quality Certification	Establish certification process for recycled aggregate	2026	BIS
Research & Development			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
	1. Usage as sub base in city road construction		IRC, NCCBM
	2. Usage of loam in urban landscapes		IRC, NCCBM
Target No. 3 **Target Description: Establishing support infrastructure around C&D Recycling Plant**			
Policy Related Initiatives			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
IWSF	Provide land for establishment of IWSF in urban lands	2028	ULBs, State Govt.
Economic Instruments			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
	Land given on token lease for establishing these Collection Points	2027	ULBs, State Govt.
Public Private Partnerships			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation

On site Recycling	In partnership with large builders and Large infra companies	2027	ULBs, State Govt.

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Chapter 17

CIRCULAR ECONOMY ACTION PLAN FOR TEXTILES

17.1. Material Landscape and Circularity Baseline

India is projected to generate nearly 8 million tonnes of post-consumer textile waste by 2025. Post-consumer textile waste mainly originates from household sources and consists of old garments or textiles that the owner no longer needs as it was. It is to be emphasised that much of this is reused, repurposed or downcycled prior to becoming post-consumer waste. Most of the post-consumer textile waste gets mixed with municipal solid waste and ultimately disposed of in landfills; a fraction may get converted into RDF or as feed to waste-to-energy plants.

Textile waste is also generated at the pre-consumer stage, which includes cutting off and discarding pieces during the production process, the quantity of which is estimated to be 7,50,000 tons. Most of this pre-consumer industrial waste textile waste is recycled into new raw material within the same factory or in allied units for the automotive, furniture, mattress, coarse yarn, home furnishings, paper and other industries. A small fraction (of about 10%) of pre-consumer waste gets mixed up with municipal solid waste.

Textile wastes position the country as the world's third-largest producer of dry textile waste and accounting for over 8.5% of the global total. The growth of the Indian textile waste industry has been fuelled by the rapid growth of the fast fashion industry, the growth of urban areas, and the expansion of textile production. The textile industry has grown rapidly in the last two decades. (source: Fashion for good, idronline, pmfias, netzeroindia)

The largest segment for recycled textiles in India continues to be cotton, but due to the rise of blended fabrics in the domestic and export supply chains, polyester is the fastest-growing segment. Over 900 small and medium-sized recycling units are in India, and around 4 million informal workers are involved in sorting, manual processing, and the recovery process. The textile waste is either reused or recycled, but only a small fraction of it, due to lack of traceability, collection systems, and quality assurance and poor systems, re-enters the global supply chains. Poor-quality textile waste is one of the issues affecting textile recycling. Pilot systems for automated sorting using AI and spectral imaging tools by entrepreneurs like 'Fashion for Good', 'Circle Economy', etc., in certain cities are improving recovery in feedstock and quality. (source: IMARC Group, Grandview Research, reports.fashionforgood, downtoearth)

In large metropolitan areas, discarded clothing constitutes as much as 10% of all municipal solid waste, which puts tremendous strain on available landfill space. The workers who perform the bulk of the manual sorting and recovery tasks within the recycling industry face sizable risks and have no social protections. (source: reports.fashionforgood)

In India, the circularity rate for textiles, which includes both reuse and recycling, falls within the range of 34–59%. Despite this relatively promising figure, industry experts point out that less than 20% of the total textile output is actually converted into high-quality recycled yarn or fabric. This gap highlights the challenges in moving beyond basic recycling to more advanced and value-retaining processes. (reports.fashionforgood,downtoearth)

The informal sector, including a few communities, is actively involved in the collection of used clothes by exchanging plastic, steel utensils, and selling them to petty traders after sorting and cleaning them to supply the second-hand market or selling these clothes directly to the buyers. The process of recycling from the collection of waste cloth to the selling of second-hand cloth in the market is mentioned in the following

International markets demonstrate stronger performance due to stricter regulatory frameworks and better systems. Policies such as Extended Producer Responsibility (EPR), landfill bans, requirements for recycled content in procurement, and integrated traceability measures have enabled significantly higher rates of closed-loop recycling. These measures ensure that materials are not only reused but also maintained in the production cycle at a higher value. (source: reports.fashionforgood)

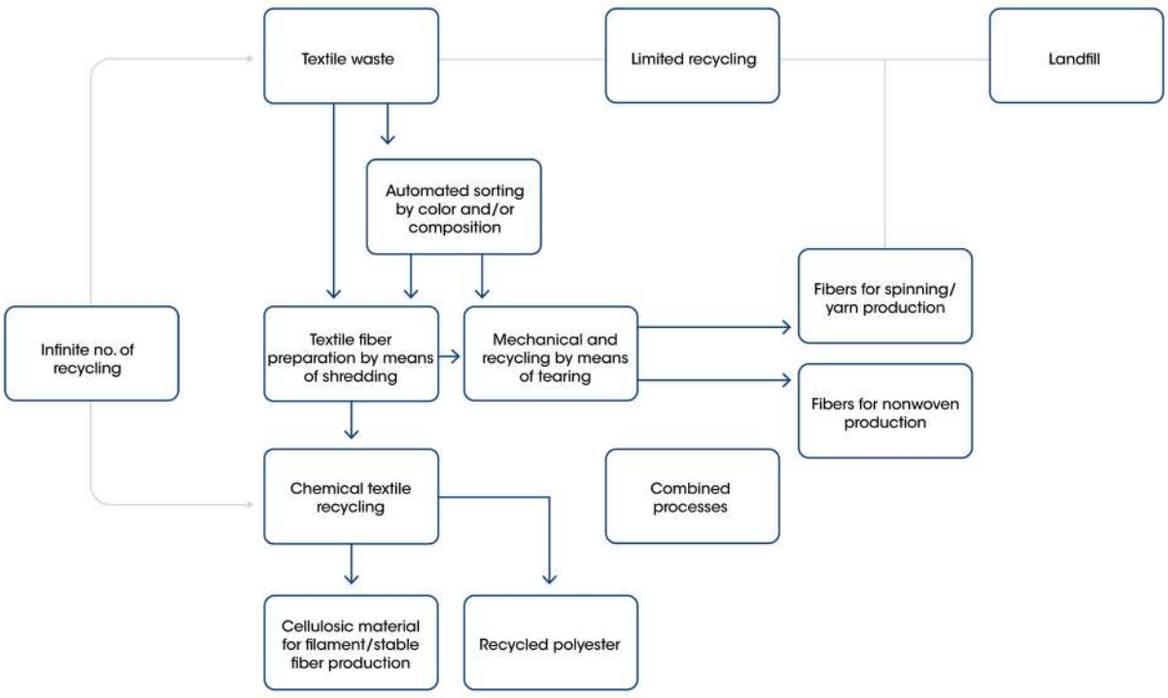
17.2. Gaps and Challenges in Advancing Circularity

Despite growing momentum in India's textile sector, several structural and systemic barriers continue to hinder the country's transition toward circularity. These challenges span across regulatory frameworks, market readiness, infrastructure, and social as well as technical dimensions. (source: pib.gov, circularity in textile waste)

One of the issues that affects circularity is the lack of collection channels and recycling opportunities, was causes recyclable textiles to reach the municipal solid waste. The other factor is the non-recyclability of textiles due to heterogeneous material. The biggest technical challenges in textile recycling come from complex fabrics that use a mix of different fibres, making true textile-to-textile recycling difficult to achieve. Getting to 100% recycling isn't realistic because garments are rarely made from a single material. For example, a cotton shirt might include nylon or polyester threads, and parts like buttons, zippers, and labels need to be removed by hand before recycling can even begin. This manual sorting process adds both time and cost to the operation.

Even fabrics labelled as "pure cotton" often contain viscose or regenerated cellulose fibres (man-made fibre) made from wood pulp, which behave differently during recycling and reduce the amount of usable fibre that can be recovered. These technical hurdles limit how effectively textiles can be recycled in a closed loop and impact the quality of the recycled material.

A good example from the industry is ANDRITZ, a global technology company that develops comprehensive textile recycling systems combining mechanical and chemical processes for fibre recovery and blending. Their advanced shredding, sorting, and reprocessing technologies highlight what's possible at an industrial scale. Still, even these systems struggle with mixed-fibre materials and maintaining fibre quality. This shows the importance of setting fibre composition standards, designing products for recyclability, and advancing chemical recycling methods to make circular textile production more scalable.



At the policy level, India currently lacks a mandatory landfill ban, an Extended Producer or users Responsibility framework, and procurement standards for recycled content in textiles. While the Ministry of Textiles launched an ESG Taskforce in 2025 to address governance and transparency gaps, systemic reforms are still evolving. On the market side, recycled textiles remain in a nascent stage. Less than 20% of the collected material is converted into high-quality input, and recycled products account for under 10% of the domestic supply chain, underscoring the limited demand and integration of circular solutions. (source: fashion for good)

The social dimension also poses pressing challenges. More than four million workers who manage textile waste in India, often under unsafe conditions and without access to training in emerging recycling technologies. Their health, safety, and livelihoods remain precarious. Additionally, low consumer awareness and weak participation in responsible textile use limit effective waste segregation and collection. On the technical front, while promising innovations such as AI-based sorting, automation, and digital traceability have entered pilot stages, they are yet to be scaled to a national level. (source: downtoearth, imarcgroup)

Encouragingly, the Ministry of Textiles has initiated measures to address some of these gaps. A nationwide mapping of textile waste was undertaken, and the Startup Grand Challenge (2024–2025) awarded nine projects focusing on traceability and end-of-life management solutions. (pib.gov). However, without systemic reforms—such as mandatory EPR, stronger infrastructure, consistent stakeholder engagement, and large-scale skilling initiatives for workers—progress toward circularity will remain suboptimal. (source: BCG global)

17.3. Vision and Targets for Circular Economy Transition

To establish a resource-efficient, low-carbon, and inclusive textile circular economy in India, minimising landfill and environmental impacts while maximising resource recovery, social equity, and value retention through advanced recycling and product life-extension strategies. The vision is to transform textile waste into a valuable resource, integrating both pre-consumer and post-consumer streams, emphasising fabric-to-fibre and fabric-to-raw material recycling, and creating sustainable livelihoods by formalising the recycling sector.

Table 17-1: SMART Targets

S.no.	Proposed Target	2030 Target
1	Policy or Regulatory framework through MoEF&CC	Within 1 year
2	Reduce landfill disposal of textile waste (%)	At least 50% reduction
3	Share of total textile waste collected and processed (%)	30%
4	Share of high-quality recycled output (yarn/fabric, %)	20%
5	Share of recycled content in new textiles (%)	10-15%

17.4. Enablers and Implementation Framework

17.4.1. Policy and Regulatory Enablers:

- Implement Extended Producer or User Responsibility (EPR) for textiles, mandating segregation, collection, recycling, and minimum use of recycled fibre in new textile products.
- National ban on Importing unsorted textile waste.
- Incentivize formal sector participation and process standardization via Ministry of Textiles guidelines.

17.4.2. Financing and Investment Tools:

- Offer green bonds, viability gap funding, and blended finance to recycling units, particularly for technology upgrades and MRF infrastructure.
- Incentivise collection channels.
- Procurement incentives for use of recycled materials in public and B2B supply chains.

17.4.3. Infrastructure and Technology:

- Establish Material Recovery Facilities (MRFs) with pre-processing, color/material sorting, and fabric-to-yarn conversion plants.
- Support adoption and scale-up of mechanical and chemical recycling, as well as AI-based sorting and digital traceability platforms.
- Promote circular economy parks as industry clusters for shared resources and R&D.

17.4.4. Industry and Social Enablers:

- Public-private partnerships with textile manufacturers, recyclers, gated communities, and other sector organizations for collection, processing, and product development.
- Structured capacity building programs for workers to transition into skilled roles in sorting, quality control, and technology operation.
- Consumer awareness and behavioural change campaigns, with pilots emphasizing gated communities and high-waste districts.

Table 17-2: Implementation Priorities

Enabler	Action Item	Timeline	Stakeholder
EPR mandate	Policy notification and compliance tools	2025-2027	Ministry of Textiles, CPCB
MRF deployment – linked to ULBs /SBM	Set up and scale in urban centers	2025-2030	ULBs, Private Recyclers, NGOs
Circular Economy Parks	Identify and build in key regions	2026-2030	Invest India, State Govts., Industry
Consumer engagement	Rolling outreach in gated communities	2025-2030	Brand partners, RWAs, media

Table 17-3: Implementation Roadmap

Target No. 1:			
Target Description: Establish a national policy and regulatory framework for textile circularity within 1 year			
Policy Related Initiatives			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Launch Textile Circularity Framework (TCF), integrating EPR, design-for-recyclability, and reuse norms	Notification of compliance guidelines under Ministry of Textiles; integrate with CPCB waste categories	2025–2026	Ministry of Textiles, CPCB, BIS
Economic Instruments			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Develop Green Finance Framework to support recycling & processing infrastructure	Introduce capital subsidies and green bond eligibility for textile circular projects	2025–2029	MoEFCC, NITI Aayog
Public Private Partnerships			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Create Collection-to-Recycling Partnerships under Swachh Bharat Mission Urban II	Engage ULBs, producer associations and recyclers for waste-to-resource networks	2025–2030	State Urban Local Bodies, Private Textile Firms

Circular			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Establish Textile Circular Parks with integrated MRF and fiber recovery units	Identify pilot parks in Gujarat, Tamil Nadu, Maharashtra, Haryana	2026–2030	Invest India, State Govts, MSME Ministry
Research and Development			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Foster R&D for blended-fabrics recycling and chemical processing	Support pilot projects by IITs and textile institutes for mixed-fibre recycling	2025–2028	DST, CSIR-NAL, Textile Research Associations
Target No. 2 **Target Description: Achieve 50% reduction in textile landfill disposal**			
Policy Related Initiatives			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Enforce the national landfill diversion standard for textile waste	Introduce landfill bans for unsorted textile waste through municipal bylaws	2025–2029	MoEFCC, CPCB, ULBs
Economic Instruments			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Introduce Landfill Tax for Non-Recyclers	Use revenue for funding informal-to-formal transition programs	2025–2030	State Pollution Control Boards
Public Private Partnerships			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Waste-to-Fibre Supply Chain Integration Projects	Channel post-consumer waste to processing industries through PPPs	2026–2030	Textile Manufacturers' Associations, Recyclers
Circular Economy Initiatives			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Expand urban textile aggregation centres linked to MRFs	Set up district-level collection points with traceable logistics	2025–2028	State Textile Boards, ULBs

Research and Development			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Pilot AI-enabled pre-sorting and spectral imaging tools	Conduct pilots using Fashion for Good & Circle Economy type models	2025–2027	CPCB, Start-ups, Technical Institutes
Target No. 3 **Target Description: Increase the collection and processing of total textile waste to 50%**			
Policy Related Initiatives			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Launch segregation-at-source rules for textile-rich municipalities	Amend municipal bylaws to classify and separately collect textile waste	2025–2029	ULBs, PSCBs
Economic Infrastructure			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Implement EPR Credit System	Reward producers/ brands achieving >30% fibre recovery	2026–2030	MoEFCC, CPCB
Public Private Partnerships			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Develop brand–ULB partnerships on collection and reuse	Tie-ups between textile brands and city ULBs to co-manage collection drives	2025–2028	Brand partners, Municipal Corporations
Circular Economy Initiatives			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Situate multi-fabric sorting and recovery facilities near production clusters	Integrate AI sorting with MRFs and dye recovery units	2026–2030	Invest India, State Industries Dept
Research and Development			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Conduct material flow mapping for textiles	Create digital databases linking production, collection, and recycling	2025–2027	NITI Aayog, CPCB

Target No. 4			
Target Description: Ensure20% of total waste processed leads to high-quality recycled yarn/fabric			
Policy Related Initiatives			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Introduce National Recycled Textiles Standard (NRTS)	Establish BIS standards defining purity and output recovery benchmarks	2026–2030	BIS, Ministry of Textiles
Economic Instruments			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Offer R&D-linked fiscal incentives for conversion efficiency	Tax benefits for innovation in fiber recovery and blending	2025–2030	MoEFCC
Public Private Partnerships			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Standalone chemical, mechanical units and co-developed chemical + mechanical hybrid units	Joint funding between state govts and private innovators	2025–2029	DPIIT, Textile Industry
Circular Economy Initiatives			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Add fiber reprocessing lines in CE Parks	Support mechanical shredding, re-threading, and dye recovery modules	2026–2030	MSME Ministry, CPCB
Research and Development			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Advance mixed fibre chemical recycling	Fund pilot hubs leveraging ANDRITZ, Birla Cellulose systems	2025–2028	DST, CSIR-NCL, Private Innovators
Target No. 5 **Target Description:** Achieve10–15% recycled content in new textiles by 2030			
Policy Related Initiatives			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation

Enact minimum recycled content procurement policy	Introduce government and B2B procurement mandates	2026–2030	Ministry of Textiles, DGGI
Economic Infrastructure			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Launch Green Textile Certification Scheme	Provide price incentives and preferential market access	2026–2030	BIS, QCI
Public Private Partnerships			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Create brand–retailer collaborations to scale recycled textiles	MOU-based sourcing pledges by top apparel brands	2026–2030	Industry Associations (AEPC, CMAI)
Circular Economy Initiatives			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Include "Closed-loop" product design labs	Support R&D for recyclable design and recycled-fibre blends	2026–2030	NIFT, State Textile Hubs
Research and Development			
Proposed Initiative/Measure	Action Item	Timeline	Proposed Owner for Implementation
Develop textile fibre certification databases	Use of smart technologies to track and confirm where the fibres come from.	2025–2030	BIS, WIPO, Start-ups

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Chapter 18

CIRCULAR ECONOMY ACTION PLAN FOR USED COOKING OIL

18.1. Material Landscape and Circularity Baseline

18.1.1 Material Value Chain and Current Challenges

Used cooking oil (UCO) in India originates mainly from commercial kitchens, food processing units, HoReCa (hotel, restaurant, catering), and households. The material value chain extends from production of raw cooking oils through refining and cold pressed methods(vegetable and seed oils like sunflower, palm, etc.), their use in cooking/frying, collection of UCO, and transformation into value-added products like biodiesel, oleochemicals (eg. Soaps and Detergents), animal feed ingredients and newly, Sustainable Aviation Fuel (SAF). Currently, UCO is collected by specialized firms under initiatives like the FSSAI's RUCO (Repurpose Used Cooking Oil) program, linking supply chains from food businesses to biodiesel and oleochemical industries across India. Repeated frying in UCO generates total polar compounds which are toxic and linked to health issues like hypertension, atherosclerosis, liver diseases and Alzheimers [1,2]. UCO reuse has been reported to be considerably high at 60% in a 2019 report by RUCO [2] highlighting dismal collection and recycling efforts. However, latest data shows 2024-2025 collection of ~22 Million litres of UCO that is 42% higher than the previous year [3].

18.1.2 Strategic Importance

UCO plays a strategic role in India's biofuel sector, supporting national target of 5% Biodiesel blending in Diesel by 2030 under the National Policy on Biofuels 2018[4]. It reduces fossil fuel dependency and crude oil imports, enhancing energy security. The growing foodservice sector ensures steady feedstock supply, creating circular livelihoods in collection and recycling. India's heavy reliance on edible oil imports (55- 60% of consumption)[5] creates upstream supply risks and trade vulnerabilities. The biodiesel and emerging SAF market based on UCO helps mitigate crude oil price volatilities while supporting decarbonization goals. Notably, Indian Oil Corporation's Panipat refinery became India's first certified SAF producer in August 2025 with 35,000 tonnes per year capacity which will help meet India's 1% SAF blending mandate for international flights by 2027[6]. Globally UCO output is rising 2% annually, driving biodiesel and renewable diesel supply. Europe imports significant UCO volumes from Asia[7] whereas India, despite its high edible oil use, remains a minor exporter.

18.1.3 Environment and Social Footprint

Dimension of UCO disposal	Impacts from non-compliant improper disposal	Impact from compliant proper disposal
Environmental Footprint	Improper disposal clogs drains and degrades rivers, groundwater and soil. Ex: 1 ltr of UCO potentially polluting 0.5 million liters of water [8]	Biodiesel from UCO emits near-zero carbon, cuts footprint by 70–75%, supports RUCO for cleaner environment.[2,9]
Social Footprint	Reuse forms carcinogenic Total Polar Compounds (TPC) [> 25%] which in turn causes lifestyle diseases due to its reentrance in the food chain	Recycling into biodiesel prevents food adulteration, creates jobs and supports 5% blending by 2030.

18.1.4 Overview of Existing Policies and Incentives

Key policies and initiatives include:

- FSSAI Regulations on UCO total polar compound concentration not exceeding 25% and mandate safe disposal and record keeping for food business operators using >50L oil/day[2]
- RUCO initiative by FSSAI in 2018 promotes collection and conversion of UCO into biodiesel
- National Biofuel Policy released in 2018 setting a 2030 target to achieve 5% biodiesel blending in High Speed Diesel[4]
- Indian government aims for 1% Sustainable Aviation Fuel (SAF) blending by 2027 and 2% by 2028[6]

18.1.5 Best practices and Innovations

Although different applications for UCO are technically possible, biodiesel is considered to be the be the

promising application out of all. Biodiesel can be produced either through a simpler transesterification process which is typically blended with conventional diesel and through a more capital and energy intensive Hydrotreating process which creates a drop-in renewable diesel that can directly replace conventional diesel.[7] Successful pilots and startups like kB Energy in Tamil Nadu demonstrate door-to-door UCO collection and partnership models with biodiesel producers, incentivizing clean collection and preventing illegal reuse [10]. Indizel from My Eco Energy stands to be the only renewable diesel supplier in India compliant with Indian and European fuel standards[11]. Other biodiesel companies operating in India include Muenzer Bharat[12], Aris Bioenergy[13] and Ecoil [14].

18.2 Gaps and Challenges in Advancing Circularity

18.2.1 Policy Gaps and Enforcement Barriers

While FSSAI's RUCO initiative and CPCB's EPR guidelines provide regulatory frameworks, enforcement remains weak. Many states lack appointed aggregators, creating regulatory vacuums . Food business operators (FBOs) face limited compliance monitoring, with barely 1-2% aware of UCO disposal obligations to authorized agencies. The absence of standardized federal definitions for UCO quality and certification standards across programs diminishes enforcement capabilities [15].

18.2.2 Material-Specific Challenges and Feedstock Availability

India's UCO supply chain is highly fragmented and subscale. An estimated 3-4 million tonnes of UCO is generated annually, yet formal collection reaches barely 30% . Munzer Bharat, India's largest UCO-based biodiesel producer with 10-tonne daily capacity, collects only 5-6 tonnes monthly despite Mumbai's 300-tonne potential, rendering operations economically unviable . Quality inconsistencies due to contamination with water, food particles, or mineral oils increase cleaning costs and processing complexity. [16]

18.2.3 Informal Sector Dominance and Competitive Viability

Around 60 % of India's used cooking oil re-enters the food chain through informal networks that offer higher prices to restaurants than authorized biodiesel buyers. This diversion poses public-health risks and undermines feedstock availability for formal biofuel producers. Additional volumes are sold to soap manufacturers or small recyclers, fragmenting the market and limiting economies of scale[16,17]. Collection and processing infrastructure for UCO-based SAF at large scale remains limited and unorganised [18].

18.2.4 Lessons from Best Practices

Internationally, Austria collects 1 kg UCO per capita through the Öli system with reusable containers and mandatory municipal recycling points achieving collection rate of 80% . Belgium's Valorfrit achieves 64% collection rates (0.73 kg/capita) through €1 million annual promotional campaigns featuring the "Oil Ghost" mascot and lottery incentives. The Netherlands engages youth through sports clubs receiving funding for UCO collected. [19]

18.3. Vision and Targets for Circular Economy Transition

18.3.1 Vision statement

The vision for circular economy transition for UCO management is to establish robust collection infrastructure capturing 80% of generated UCO, eliminating illegal food chain re-entry, and establishing a thriving ecosystem of biodiesel and sustainable aviation fuel production. This transformation will position India as a global leader in UCO valorization, delivering energy security, environmental sustainability, public health protection, and inclusive economic opportunities across the value chain—from household awareness to advanced biofuel innovation.

18.3.2 Smart Targets

Table 18-1 : Proposed Targets

S.no.	Proposed Target	2030	Basis for target
1	UCO Collection Rate (% of UCO generated)	30%	Current formal collection is <10% . European best practices (Belgium: 64%, Austria: >80%) demonstrate feasibility
2	Biodiesel Blending:	5%	National Policy on Biofuels 2018 mandates 5% biodiesel blending by 2030
3	SAF Production from UCO:	5%	India targets 1% SAF blending by 2027 and 5% by 2030 for international flights
4	Elimination of Illegal Food Chain Re-entry: (% of UCO generated)	<30% of collected UCO re-enters food supply	60% of UCO illegally re-enters food chain according to RUCO booklet
5	Infrastructure Development	60 new processing facilities; 5,000 new registered collection centers	Considering 222 Cr Litres annual UCO generation(RUCO),30% collection rate, 15 TPD plants. countrywide expansion to 7000+cities and existing RUCO NFPs and aggregators

18.4. Enablers and Implementation Framework

18.4.1 Policy Interventions & Market-Based Instruments

- Mandate 5% biodiesel blending in diesel by 2030 through National Policy on Biofuels 2018 amendments, with binding purchase obligations from Oil Marketing Companies (OMCs) for biodiesel produced from UCO
- Establish quality standards through Bureau of Indian Standards for UCO-derived biodiesel and SAF, to regularise and simplify for new entrants to establish related businesses
- Implement sector-specific bans: prohibit direct disposal of UCO into drains/sewage; mandate FBOs to register with authorized aggregators under RUCO framework with monitoring through FSSAI
- Implement household UCO collection in in urban centers with high population density

18.4.2 Financing Tools & Incentives

- Mobilize green financing through blended finance mechanisms combining government budgets, development finance institutions, and commercial lending for biodiesel and SAF processing infrastructure
- Introduce Viability Gap Funding (VGF) for 50% of capex for small-scale (<50,000 liters/day capacity) biodiesel units in tier-2/3 cities to ensure geographic distribution
- Leverage public procurement mandates requiring government offices, PSUs, and transport fleets to source 10% of fuel requirements as UCO-based biodiesel by 2027

18.4.3 Infrastructure Development

- Establish regional hubs for UCO collection aggregators and develop transport/pipeline infrastructure for collected UCO transport from hubs to fuel processing units in large scale

18.4.4 Technology & Innovation Investment

- Fund R&D through BIRAC/DSIR schemes for advanced UCO purification technologies, feedstock quality testing system to identify overused and unsuitable oil, and integrated biodiesel-SAF production units
- Support digital traceability platforms linking RUCO registration with blockchain-based supply chain tracking to ensure 100% formal collection transparency

18.4.5 Capacity Building & Skills

- Establish vocational training centers in partnership with polytechnics across 20 states for UCO aggregation, quality testing, and biodiesel production operations.Train 50,000 collection agents by 2028

18.4.6 Awareness & Behaviour Change

- Launch state and country wide integrated campaign modeled on Belgium's "Oil Ghost" mascot approach, targeting FBOs through quarterly FSSAI compliance audits linked to incentives
- Deploy WhatsApp-based notifications for household UCO collection in urban zones; partner with food delivery platforms for reverse logistics collection

18.4.7 Implementation Risks & Mitigation

- Risk: Illegal food chain diversion persisting. Mitigation: Strengthen FSSAI enforcement with surprise audits, impose penalties and incentivize reporting through whistleblower protections
- Risk: Aggregator non-compliance and data gaps. Mitigation: Institute third-party certification audits

18.4.8 Monitoring & Accountability

- Establish quarterly performance reviews through CPCB-FSSAI-MoP&NG coordination committee tracking collection rates, biodiesel production volumes, and food-chain diversion reduction against 2030 targets
- Publish annual circularity scorecards per state with transparent data on UCO volumes, illegal diversion incidents, and penalties imposed, accessible via public dashboard

18.4.9 Implementation Roadmap

Proposed Target	Action	Timeline	Owners
UCO Collection Rate: 30% of UCO generated	Public Awareness: Launch RUCO 2.0 campaign targeting FBOs to register and implement UCO collection	2026–2030	FSSAI, State Health Departments, ULBs
	Infrastructure: Establish 5,000 registered collection centers in partnership with municipal corporations and existing RUCO NFPs; integrate with municipal solid waste management systems	2026–2028	FSSAI, ULBs, Municipal Corporations, RUCO NFPs
	Capacity Building: Train 50,000 collection agents across 20 states on UCO handling, quality checks,; partner with ULB waste management departments	2026–2027	NITI Aayog, FSSAI, ULBs
Biodiesel Blending: 5%	Policy: Mandate 5% blending by Oil Marketing Companies (OMCs); establish BIS quality standards for UCO-derived biodiesel	2025–2026	MoP&NG, BIS, OMCs
	Economic Instrument: Introduce Viability Gap Funding (VGF) covering 50% capex for 60 new biodiesel processing facilities; prioritize locations near ULB waste management zones	2026–2028	NABARD, PFC, State Development Agencies, ULBs
	Infrastructure: Develop tenders 60 biodiesel processing facilities (targeting 15 TPD capacity) in UCO-surplus regions;	2026–2029	MNRE, Private Sector, State Agencies, ULBs
	Technology: Deploy digital traceability platform linking UCO supply to biodiesel production; integrate with municipal waste tracking systems	2026–2030	MoP&NG, OMCs, IT Service Providers, ULBs
	Public Procurement: Mandate government fleets (BSNL, Railways, PSUs) and public transport (city buses, municipal vehicles) source 5% of fuel as biodiesel by 2027; escalate to 10% by 2030	2027–2030	Ministry of Transportation, DoPT, PSU CEOs, ULBs, State Transport Authorities
SAF Production from UCO: 5%	Policy: Finalize National Policy on SAF with 1% blending mandate for international flights (2027) and 5% by 2030	2026	Ministry of Civil Aviation, MoP&NG
	Economic Instrument: Mobilize green financing and commercial lending for SAF plants	2026–2028	NaBFID, SIDBI
	Infrastructure: Develop tenders for SAF production plants with dedicated UCO supply contracts; scale-up Indian Oil Panipat refinery; coordinate UCO sourcing with ULBs	2026–2029	IOC, Refineries, Major Biodiesel Producers, ULBs

Proposed Target	Action	Timeline	Owners
	Technology R&D: Fund advanced SAF conversion technologies (HEFA, SPK pathways) through DSIR/BIRAC schemes	2026–2029	DSIR, BIRAC, IITs, Research Institutes
	Monitoring: Establish annual SAF production tracking dashboard; link airline incentives to SAF procurement targets	2027–2030	DGCA, Ministry of Civil Aviation, Airlines
<30% of Collected UCO Re-enters Food Supply	Policy: Strengthen FSSAI enforcement; impose heavy penalties per violation and criminal prosecution for repeat offenders; coordinate with ULB food safety wings	2026–2030	FSSAI, State Police, Legal Authorities, ULBs
	Public Awareness: Deploy nationwide "Food Safety First" campaign highlighting health risks; partner with restaurant associations and ULB health departments for compliance messaging	2026–2030	FSSAI, NGOs, Restaurant Associations, ULBs
	Economic Instrument: Introduce whistleblower rewards; incentivize aggregators for diversion prevention; coordinate with ULB complaint mechanisms	2026–2030	FSSAI, State Health Departments, ULBs
	Monitoring: Conduct surprise audits of 500+ food businesses quarterly; publish monthly diversion incidents and enforcement actions; link with ULB health inspectorates	2026–2030	FSSAI, State Food Safety Commissioners, ULBs
New Infrastructure Development: 60 Processing Facilities; 5,000 Collection Centers	Policy: Amend industrial licensing guidelines; fast-track environmental clearances for UCO biodiesel and SAF plants; streamline ULB approvals	2026–2028	MoEFCC, MNRE, State Departments, ULBs
	Infrastructure: Implement regional hubs for UCO collection aggregators and develop transport/pipeline infrastructure for collected UCO transport from hubs to fuel processing units	2026–2028	State Governments, NITI Aayog, Private Developers, ULBs
	Technology: Implement GIS-based UCO hotspot mapping for optimal facility siting; deploy IoT-enabled collection vehicle tracking; integrate with municipal asset management systems	2026–2027	NITI Aayog, Tech Companies, State Departments, ULBs

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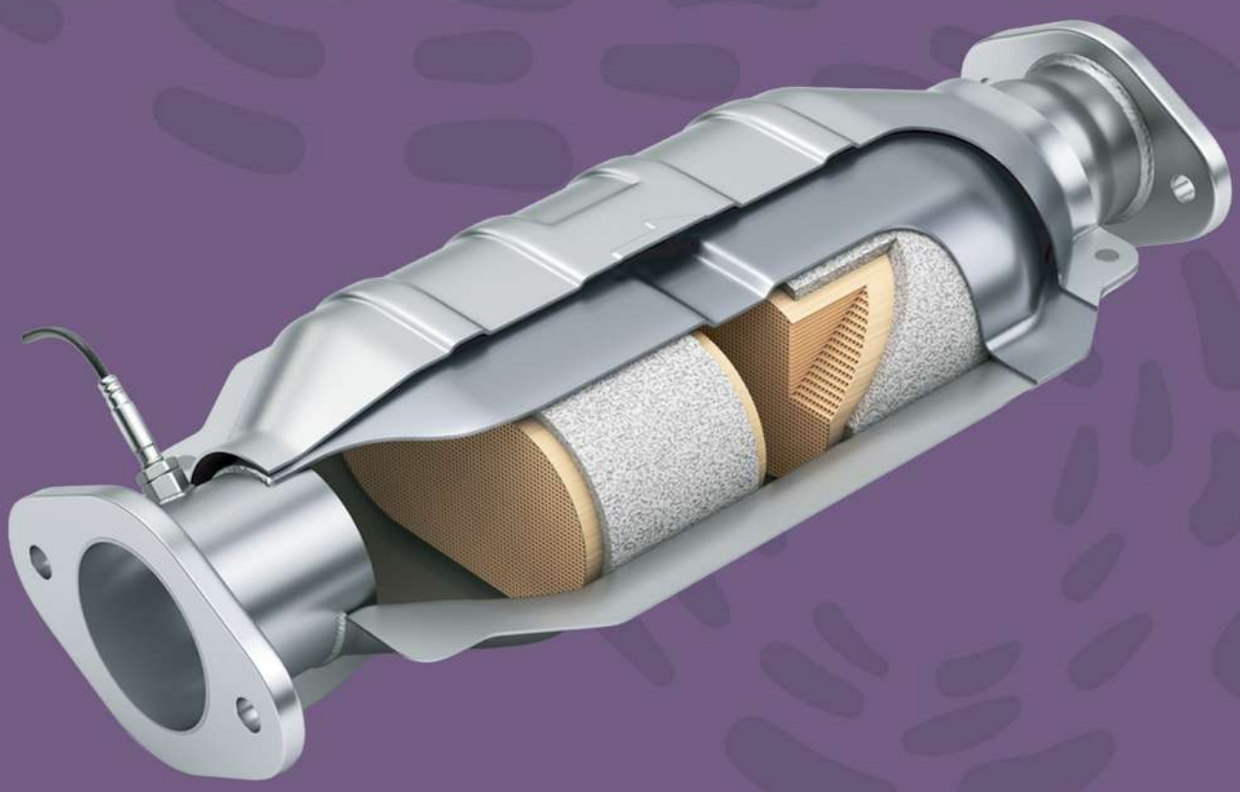
Chapter 19

CIRCULAR ECONOMY ACTION PLAN FOR CATALYTIC CONVERTERS



19.1. Material Landscape and Circularity Baseline

Catalytic converters, used in vehicles and industrial emission systems, contain platinum-group metals (PGMs: platinum, palladium, and rhodium) that catalyze the conversion of harmful exhaust pollutants—such as carbon monoxide, nitrogen oxides, and unburned hydrocarbons—into less harmful substances like carbon dioxide, nitrogen, and water vapor.

PGMs are critical to sectors like transport (automotive emissions control), refineries/chemicals (industrial catalysts), and emerging areas (fuel-cell vehicles, defense equipment). India has virtually no PGM mines (negligible resources) and meets ~99% of its PGM need via imports. This heavy import dependence exposes the country to global price volatility and supply disruptions, which in turn have a direct impact on industrial production costs as well as on the country's foreign exchange outflow.

- **Value Chain & Sectors:** Cars, motorcycles, and trucks now universally employ three-way converters to comply with stringent Bharat Stage VI norms. India's automotive sector produces millions of cars annually, each with a converter containing PGMs. Industrial converters in refineries and power plants similarly utilize PGMs to treat emissions or synthesize chemicals. PGMs are also used in aerospace and medical catalysts, adding significant strategic value.

- **Market Trends:** India's catalytic converter market is growing ~10% annually, driven by rising vehicle output and leapfrogging to BS-VI standards. Palladium currently makes up >50% of converter metal content, but platinum demand is rebounding via hybrids and emerging fuel cells. Despite EV trends, hybrids and hydrogen tech will sustain PGM use in coming years.

- **Trade & Strategic Risks:** With ~99% PGM import dependence, India is vulnerable to geopolitical shifts. PGMs are "critical minerals" under India's National Critical Minerals Mission. In 2025 the government launched a ₹1,500 Cr Critical Minerals Recycling Incentive Scheme (under the Mission) to subsidize recovery from waste (including EOL converters). Vehicle scrappage policy further mandates formal recycling.

- **Circularity & Recycling Baseline:** Currently converters are not designed for reuse/repair; they are replaced or scrapped at end-of-life. Collection is improving via Registered Vehicle Scrapping Facilities (RVSFs) and informal scrap networks. At these facilities, vehicles are dismantled (tyres, batteries removed) and catalytic converters are removed for processing. These spent converters have ceramic honeycomb substrates impregnated with Pt, Pd and Rh. Recyclers decant the substrate and smelt it to extract PGMs. For example, Hindustan Platinum now refines recycled PGMs to >99.95% purity and manufactures new platinum catalysts for fuel cells and medical use.

- **Policies and Industry Initiatives:** The legal framework for End-of-Life Vehicles (ELVs) identifies catalytic converters for capture and recycling. Central and state incentives support scrap recycling (e.g. capital subsidies, EPR mandates). The Critical Minerals Recycling Scheme (Ministry of Mines) offers up to 50% capex and 25% opex support for facilities recovering PGMs from converters and other waste. Major OEMs have embraced scrappage and formed consortia to recover and refine metals. These trends and initiatives form India's circular baseline for catalytic converters, moving from resource dependence to increased material recovery.

19.2. Gaps and Challenges in Advancing Circularity

Despite emerging policy attention and nascent industry capacity, India's transition to a fully circular value chain for catalytic converters remains constrained by multiple, interlinked gaps:

19.2.1. Policy and Regulatory Gaps

- Lack of mandatory producer-side obligations specifically for catalytic converters: current EPR and scrappage mechanisms are unevenly applied across vehicle components and do not uniformly mandate recovery tar-

gets or certified channels for Catalytic Converter retrieval and processing.
- Fragmented regulatory responsibilities across ministries and agencies (transport, environment, mines, commerce) create overlapping rules and weak enforcement incentives.
- Limited standardisation for design-for-recycling or end-of-life handling: there are few mandatory requirements on materials labelling, converter modularity or disassembly-friendly designs.

19.2.2 Material-specific Technical Challenges
- Heterogeneity in converter designs (substrate type, PGM loading and washcoat chemistry) complicates standardized recycling routes and impacts recovery yields.
- Small, dispersed PGM quantities per vehicle require aggregation and pre-processing capacity to achieve economically viable feedstock for refineries.
- Ceramics-based substrates and blended formulations complicate separation and can generate refractory residues that require specialized treatment.

19.2.3 Feedstock Availability & Aggregation Constraints
- Low formal collection rates: much of the end-of-life vehicle (ELV) fleet and independent dismantlers operate informally, causing leakage of converters to unregulated channels.
- Fragmented supply chains and geographic dispersion of spent converters raise logistics and aggregation costs, undermining economies of scale necessary for domestic smelters/refiners.

19.2.4 Informal Sector Dominance and Governance Issues
- Informal dismantlers often offer faster cash returns for scrap, undercutting formal channels; this undermines traceability, safe handling, and standards compliance.
- Informal handling presents occupational and environmental hazards (uncontrolled cutting, acid leaching), increasing negative social and environmental externalities.

19.2.5 Infrastructure, Technology and Capacity Gaps
- Limited domestic throughput refining capacity for PGMs; available facilities often rely on older hydrometallurgical or pyrometallurgical processes with variable recovery and environmental footprints.
- Insufficient pre-processing facilities (decanning, ceramic grinding, concentration) strategically located near major ELV sources.
- Lack of validated, low-cost recycling technologies suitable for India's scale and heterogenous material streams.

19.2.6 Market & Economics — Weak Downstream Markets
- Price volatility of PGMs creates investment uncertainty for capital-intensive recycling plants.
- Lack of guaranteed offtake arrangements, quality standards and pricing transparency discourages formal players; recovered PGMs often face certification and purity-acceptance hurdles.

19.2.7. Limited Platforms for Aggregation and Innovation

- Few circular-economy parks or integrated eco-parks that co-locate dismantling, pre-processing, refining and ancillary services; absence of such platforms increases transaction costs and slows technology adoption.

19.3. Vision and Targets for Circular Economy Transition

Vision: To establish a self-reliant, resource-efficient and environmentally responsible catalytic converter value chain that minimizes primary PGM import dependence, promotes domestic recovery and reuse of platinum group metals (PGMs), ensures formalization of end-of-life converter recycling, and contributes to India's clean mobility and emission control commitments. India should achieve a closed-loop catalytic converter recycling ecosystem, recovering PGMs within the country.

Strategic Objectives:

A Enhance Domestic Resource Security:

- Recover a significant share of PGMs from end-of-life catalytic converters, reducing import dependency for platinum, palladium, and rhodium by at least 25% by 2030 and 50% by 2040.
- Develop domestic refining and recovery capacity capable of processing at least 70% of collected catalytic converters.

B Formalize Collection and Recycling:

- Achieve 90% traceable collection of catalytic converters from scrapped vehicles and industrial sources through registered dismantlers, authorized TSDFs, and vehicle service centres as well as scrappage facilities.
- Integrate informal collectors into the formal system through certification, training, and incentive mechanisms.

C Environmental Protection and Safe Processing:

- Ensure 100% environmentally compliant treatment of converter waste through CPCB and SPCB approved recycling/refining facilities.
- Eliminate uncontrolled converter dismantling or acid-leaching practices by 2030.

D India as a Regional Hub

- Promote India as a regional hub for PGM recycling and catalytic converter recovery technologies, serving South and Southeast Asia.

E Innovation and Technology Development:

- Support R&D in hydrometallurgical and bio-metallurgical PGM recovery to increase recovery efficiency to >98% by 2030.
- Foster partnerships between academia (CSIR, IITs), public laboratories, and private refiners to pilot low-emission recycling technologies and substitute materials (e.g., base-metal catalysts).

F Circular Design and Extended Producer Responsibility:

- Encourage OEMs to adopt design-for-disassembly principles, modular converter housings, and identifiable substrate labelling.
- Introduce EPR obligations for automobile and industrial equipment manufacturers to ensure retrieval and channelization of end-of-life converters through authorised recyclers.

Table 19-1: Proposed Targets

Goal	Target (2030)	Basis for Target
PGM Recovery	≥50% domestic processing and ≥25% import substitution	Based on projected EOL vehicle volumes (~8 million vehicles/year by 2030) and new refining capacity under the Critical Minerals Recycling Scheme. Currently, less than 10% of EOL converters are processed domestically.
Formal Collection	≥90% formal collection coverage	Scaled through ELV policy, RVSF network expansion, and integration of informal handlers.
Refining Efficiency	≥98% recovery yield	Achievable through hydrometallurgical and bioleaching process innovation.

19.4 Enablers and Implementation Roadmap

This section outlines the implementation roadmap for advancing circularity in catalytic converters, based on the identified vision and targets. The roadmap provides a structured plan of action through policy measures,

economic instruments, public–private partnerships (PPP), circular economy parks (CEPs), and research & development (R&D). Each target area integrates strategic interventions to support India's transition to a closed-loop system for platinum group metals (PGMs) and catalytic converter recycling.

Table 19-2: Proposed Actions for Achieving the Circular Economy Targets

Target: PGM Recovery (≥50% domestic processing and ≥25% import substitution)		
Action Items/Initiatives	**Timeline**	**Proposed owner**
Strengthen domestic capacity for PGM recovery through establishment of dedicated refining and processing facilities, reducing import dependence and enhancing resource security. Encourage PPP models for setting up integrated PGM refining clusters between government, OEMs, and private recyclers. Fund R&D for hydrometallurgical, pyrometallurgical, and bioleaching methods with >98% recovery yield.	Before 2030	MoEF&CC, CPCB, Industry Associations, and State PCBs.
Target: Formal Collection and Traceability (≥90% formal collection coverage)		
Action Items/Initiatives	**Timeline**	**Proposed owner**
Ensure end-to-end traceability of catalytic converters through national digital tracking and formal collection systems. Develop traceability and aggregation systems in collaboration with automobile and auto parts OEMs, service centres, recyclers, and logistics partners. Develop blockchain or AI-based traceability tools for converter lifecycle management.	Before 2030	MoRTH, CPCB, MoEF&CC, State SPCBs, OEMs, NIC – Implementation Partners
Target: Refining Efficiency (≥98% recovery yield)		
Action Items/Initiatives	**Timeline**	**Proposed owner**
Promote technology-driven solutions and innovation for efficient, low-emission recovery of PGMs from spent catalytic converters. Establish technology demonstration centers under CPCB and CSIR to promote best available techniques. Encourage OEM–startup partnerships for localized converter recycling and technology transfer.	Before 2030	CSIR, MoEFCC, DST, IITs etc.

Chapter 20

CIRCULAR ECONOMY ACTION PLAN FOR PAPER & CARDBOARD

India's paper and packaging sector plays a pivotal role in driving sustainable industrial growth, serving as a key input for fast-moving consumer goods, agriculture, and logistics. While global pulp production is dominated by virgin wood, India's raw material base is more diverse, relying on recycled fibre, wood, and agro-residues. However, as a fibre-deficient nation, India continues to import a substantial portion of its recycled pulp, primarily from the US, Middle East, and Europe. The domestic wastepaper value chain remains largely informal, with small collectors and traders forming the backbone of collection and recovery systems. This unorganised structure, coupled with contamination and low segregation, limits material recovery and traceability. Despite these challenges, paper and paperboard continue to underpin India's growing packaging industry — the fifth-largest in the economy — reflecting the nation's shift toward sustainable, fibre-based alternatives to plastics.

Growing policy momentum and technological innovation are reshaping the industry's circularity landscape. Government initiatives such as the **Extended Producer Responsibility (EPR) framework**, the **Green Credit Programme**, and the **National Mission on Sustainable Packaging** are encouraging the use of recycled content, formalising supply chains, and promoting cleaner production practices. At the same time, Indian mills are investing in sustainable technologies — including total chlorine-free bleaching, bio-polymer coatings, and smart packaging solutions like RFID and QR-enabled traceability — to reduce their environmental footprint. Achieving full circularity will require coordinated action across policy, technology, and behavioural change: strengthening wastepaper recovery infrastructure, integrating the informal sector, ensuring quality standards, and encouraging responsible consumption. With a clear vision of self-reliance in fibre sourcing and efficient resource use, India's pulp and paper sector is well-positioned to become a global model of low-carbon and circular material management.

20.1. Material Landscape and Circularity Baseline

20.1.1. Overview of material chain at domestic & global levels

Globally, paper pulp production relies heavily on wood, accounting for about 90% of the material. In India, raw material inputs are diversified, consisting of 74–76% recycled fibre, 18–20% wood, and 6–8% agro-residue. The entire wastepaper value chain in India is largely unorganised, involving direct collectors (from households, offices, printing presses), small shops for initial sorting, and zonal segregation centres (semi-wholesalers) where material is baled and sent to ultimate users, often funded by large traders.

As a fibre-deficient country, India relies on imports to supplement its raw material demands, sourcing 40% of its required recycled fibre, primarily from the USA, Canada, Middle East, and Europe. As per 2024-25 trade data, India imported 2778 Thousand Tonnes of Paper, Paperboard and Newsprint while exporting 1529 thousand tonnes.

There has been a spurt in the import of wastepaper in the country post the tightening of import norms by China during 2017-19, the imports jumped from 4 million tonnes and stabilised to around 6.3 million tonnes 2020.

As per an estimate, recovery of wastepaper in India is around 28%. This rate is much lower as compared to global recovery rate of 58%**.**

Compared to India, many developed nations have highly effective, organized wastepaper collection and recycling systems.

1. Europe, for instance, leads in implementing EPR directives for packaging waste, backed by industry organisations like PRO EUROPE.
2. Japan has achieved a high recovery rate (around 80%) by implementing laws promoting the sorted collection and recycling of containers and packaging waste, effectively minimising waste sent to landfills.
3. In contrast, the US system is decentralised, with waste management regulations varying by state and municipality.

20.1.2. Importance of Material for key sectors of the economy

Paper and paperboard are essential, particularly as food packaging materials, valued for their low cost, light weight, availability, printability, and strength. The packaging industry is recognised as the fifth-largest sector of the Indian economy. India's domestic paper market relies heavily on packaging paper and paperboard, which accounted for 15.54 million tonnes in 2024–25. A major risk is India's dependency on imports for recovered paper and rising imports of speciality paper and high-grade board. Surging imports, rather than strengthening the collection and recycling network, significantly hurt the economic viability and capacity utilisation of domestic paper manufacturers.

20.1.3. Environmental & social footprint

The shift toward recycling paper significantly reduces the environmental impact compared to using virgin fibres. Recycled paper production uses 50% less water and reduces air pollution by 74% compared to virgin production. Recycling one ton of newspaper saves approximately one ton of wood. Conversely, losing the recyclable wastewater to landfills contributes to waste management costs, carbon footprint and deforestation. Paper production is historically responsible for about 35% of clear-felled trees globally. Socially, the Indian paper industry directly employs 500,000 people and indirectly supports about 1.5 million others. Additionally, promoting farm forestry increases green cover and creates employment opportunities in rural communities.

20.1.4. Market trends & growth projections

India is the world's fastest-growing paper market. As per the imports and exports trade data, the estimated domestic market size is 23.84 Million Metric Tonnes. Packaging Paper and Paperboard represents the largest category by size (15.539 Million Tonnes). Paper consumption in India is projected to grow by 6–7% in the next five years, reaching 30 million tonnes per annum by 2026–2027 while specific grades, such as Tissue paper, are anticipated to experience the highest growth rate at 12.88%, while high-BF Kraft Paper is expected to grow by 9.63%

India's per capita paper consumption is low at about 16 kg, significantly behind the global average of 57 kg. The Indian packaging industry is projected to grow at an 11.00% CAGR between 2024 and 2029. Cardboard prices in the US have experienced volatility, dropping sharply due to China's import ban in 2018, but recovering by 2021 due to booming e-commerce and exports to Asian countries, including India. Imports of paper and paperboard into India increased by 3.5% in the first half of FY25.

20.1.5. Current level of adoption of circular practices

India's adoption of circular practices is hindered by a low waste paper recovery rate of only 25–28% of total consumption, contrasting sharply with the global recovery rate of 58%. The US recycling rate for paper and cardboard in 2019 was 38%, though rates are much higher in parts of Europe (e.g., Belgium 92.9%, Finland 100%). India's recycling system is largely unorganized, leading to significant infrastructure gaps, contamination, and segregation issues in the recycled material. The practice of paper recycling itself promotes the circular economy principle, reducing reliance on virgin fibres and supporting sustainable paper production.

20.1.6. Overview of existing policies & incentives

Policy interventions in India include initiatives like "Make in India" and GST reforms to support advanced packaging infrastructure. There are proposals for mandatory recycling targets, Extended Producer Responsibility (EPR) programs for manufacturers and distributors, and Green Certification Standards. To protect domestic manufacturers, the Indian government imposed a Minimum Import Price (MIP) on virgin multi-layer paper board (VPB). The Ministry of Environment, Forest & Climate Change came up with the Draft EPR Rules for Paper Packaging, effective from April 1, 2026, for Producers, Importers, and Brand Owners (PIBOs) that mandate recycling obligations to reach 100% by 2028-29 and the use of recycled content in new paper packaging to 70% by 2029-30.

20.1.7. Recent innovations

The Indian paper industry is committed to reducing its carbon footprint through clean technology, including integrated mills reducing water usage from 200 cubic meters to under 50 cubic meters per tonne of paper. About 40 paper mills are expected to join India's Carbon Credit Trading Scheme (CCTS). In 2024, the Council of Scientific and Industrial Research (CSIR) launched the National Mission on Sustainable Packaging Solutions to focus on developing sustainable materials and advanced recycling methods. Innovations include the increasing use of smart packaging solutions such as RFID, NFC, and QR codes to improve product authentication and supply chain efficiency. For landfilled waste, conversion processes like gasification and pyrolysis offer potential innovations for recovering energy, fuels, and chemicals.

Furthermore, recently, some of the recent technological advancements, as reported by Central Pulp & Paper Research Institute (CPPRI), include a pilot-scale Ozone Treatment System, which facilitates Total Chlorine Free (TCF) bleaching, and the successful preparation of Dissolving Grade Pulp from Whole Jute for diverse industrial applications. Some projects are also underway, focusing on the bio-polymeric approach to improve barrier properties in packaging paper, and the establishment of a Pulp and Paper Mill-based Bio-Refinery Laboratory to produce bio-energy and bio-products.

20.2. Gaps and Challenges in Advancing Circularity

20.2.1. Policy gaps & enforcement barriers

Advancing circularity in India is significantly hindered by the lack of specific legislation or policy concerning wastepaper. While a legal framework for municipal solid waste exists, it often fails to adequately address the specific management and recovery of recyclables like paper. The Extended Producer Responsibility (EPR) framework is yet to be published and implemented. Furthermore, the lack of sufficient restrictions on imported finished paper allows foreign supply to meet domestic demand, thereby reducing the pressure to increase the domestic recovery rate of wastepaper.

India is a net importer of Pulp and Paper; import of wastepaper is therefore needed – however, at the same time, it is necessary to mandate the recovery of domestic wastepaper. Unregulated import of waste paper hurts the viability of domestic recycling.

20.2.2. Material-specific challenges

A primary challenge lies in the lower fibre quality of domestically available wastepaper compared to imported stock, necessitating imports to meet specific fibre strength requirements. Mixed material or Contamination in wastepaper is a severe issue, as recycled fibre contains a wide array of non-paper components, including inks, adhesives, waxes, plastic liners and stickies, which seriously degrade the quality of the end-products. Repeated recycling cycles lead to shortening of fibre length and accumulation of unintended chemical substances and contaminants, such as heavy metals originating from printing inks. Furthermore, specific heavy metals like Lead (Pb) and Cadmium (Cd) have been detected in recycled papers at concentrations significantly exceeding the EU standards for food packaging. Materials used for official documentation are often stored for long periods, becoming brittle and unusable as raw material by the time they re-enter the supply chain. The import of inferior-grade wastepaper (mixed with MSW/RDF) by some traders is another issue.

20.2.3. Feedstock availability

The overall availability of wastepaper in India is insufficient to meet the demand of the paper industry due to a persistently low wastepaper recovery rate, estimated at only 25–28% of total consumption. The inefficiency of the aggregation system leads to significant diversion of collected wastepaper into secondary applications (estimated at 9 million tonnes, or 43% of total domestic consumption), such as packaging fruits, use by roadside eateries, and moulded products. This diversion, which mainly occurs at the initial, low-cost stages of the supply chain, prevents

large volumes of material from reaching industrial recyclers. Consequently, India is forced to import 40% of its required recycled fibre.

20.2.4. Informal sector dominance and competitive viability issues

The wastepaper recycling market is profoundly unorganised; the unorganised nature of the supply chain, which includes rag pickers and door-to-door collectors, results in a lack of formal data regarding the quantity and flow of wastepaper, especially concerning secondary applications. This systematic unsystematic collection requires re-orientation into a formalised, organised mechanism. Competitive viability for domestic manufacturers is undermined by surging imports, particularly from China, Chile, and Indonesia, which have hurt the economic feasibility and capacity utilisation of domestic mills.

20.2.5. Infrastructure & technology gaps

1. **Infrastructure:** The low recovered paper percentage demonstrates weak institutional mechanisms and considerable leakages in the recycling process. The current collection system is widely unsystematic, unregulated and unsustainable.
2. **Technology & Efficiency:** Many paper mills suffer from technology obsolescence, leading to inferior quality recycled products and reduced economies of scale. The vital process of sorting recovered paper remains predominantly manual, labour-intensive, slow, and expensive, which lowers efficiency given the material's heterogeneity and contamination levels.
3. **Quality & Safety:** The quality of incoming raw material is currently judged primarily by physical appearance, lacking actual analysis of critical parameters like fibre quality or tensile strength.

While the Union Government has undertaken initiatives to promote a circular economy by notifying rules for 8 specific waste streams (plastic packaging, waste batteries, waste tyres, e-waste, non-ferrous metals, C&D waste, used oils and ELVs), a similar notification for wastepaper is not yet to finalised to facilitate transitioning the country from a linear to a circular economy.

20.2.6. Awareness & Skills Deficits

Low public awareness and poor source segregation hinder circularity in India's paper and packaging sector. Paper waste is often mixed with other waste, reducing recyclability. Successful local models, like Panaji's 16-way segregation system, show that community participation and clear systems can greatly improve recycling outcomes. To replicate this nationally, the Government, ULBs, and e-commerce platforms should run **"Waste to Wealth"** campaigns promoting paper waste segregation, organising paper-specific collection drives, using digital media for behavioural change, and involving informal workers as recycling ambassadors. **Segregation at source must be seen as a civic duty, not a choice.**

20.2.7. Downstream Markets

The domestic waste paper recycling industry struggles with quality assurance, as there are no guidelines specifying the optimum blend of virgin and recycled paper required to achieve specific quality standards. Furthermore, the domestic paper market is vulnerable to unregulated imports of speciality papers and paper boards, which impacts the economic viability of local manufacturers.

20.3. Vision and Targets for Circular Economy Transition

20.3.1. Vision statement

The visionary goal for the Pulp and Paper sector is to achieve self-reliance (Aatmanirbhar) in raw material sourcing and transition fully to a circular economy model, ensuring responsible consumption and sustainable resource management. This transition involves establishing **a** technology-enabled, quality-assured collaborative supply chain that effectively formalises the recovery process, allowing the industry to significantly improve the national recovery rate and reduce its environmental load. Achieving this means maximising domestic wastepaper circularity to reduce dependence on imported recycled fibre.

20.3.2. Policy and Institutional Structure under EPR

The proposed EPR regime mandates registration of manufacturers, importers, and brand owners (PIBOs) with CPCB. Targets will include:

- Specific recycling and recovery quotas (up to 100% by 2028 for certain packaging streams).
- Integration of informal collectors through Public–Private Partnerships (PPP).
- Cluster-based supply chains linking ULBs (urban local bodies), recyclers, and formal waste-processing agencies.
- The Green Credit Programme, under MoEFCC, may extend credits to mills based on recycled paper content and efficiency - monetising sustainability performance within the national carbon market.

20.3.3. SMART targets

The goals for the circular economy transition are set based on current utilisation rates, global best practices and policy recommendations such as those related to EPR schemes.

Table 20-1: SMART targets

Target Area	Existing Goal	Revised SMART Target Recommendation
Virgin Fibre Use	Reduce to ≤20% by 2030	Limit new fibre use to 15% by 2030 via certified chain-of-custody sourcing
Recycling Integration	100% formal supply chain for recycling under EPR by 2028	Achieve 80% integration for recycling by 2028.
GHG Emissions	≤50 Mn tonnes by 2030	Curb carbon footprint per tonne of paper by 20% over 2025 baseline
Awareness Campaigns	General awareness on recycling	Implement nationwide "PaperCycle India" campaign with measurable reach >100 million citizens

20.4 Enablers and Implementation Framework

20.4.1. Policy interventions & market-based instruments

- Restrictions on imported finished paper should be achieved by increasing the customs duty.
- OM No. 13-1/2004 – HSMD dt. 24th March, 2005, as revised on 10th Feb, 2006; issued by MoEF&CC to ensure that at all the ports of entry, only properly segregated paper, paperboard and paper product wastes enter the country without being contaminated with Municipal waste. Further, OM No. 13-1/2004 – HSMD dtd. 11th May 2010 issued by MoEF&CC stipulates limits for non-paper recyclable material in wastepaper consignments imported from other countries (superseding OM dtd. 10th Feb 2006).
- Green Certification Standards should be established for paper products, enabling consumers to choose environmentally friendly options.
- Guidelines specifying the optimum blend of virgin and recycled paper should be introduced to achieve specific paper quality standards.
- Wastepaper should be considered among the focus areas by NITI Aayog for accelerating the country's transition to a circular economy.

20.4.2. Financing tools / Incentives

- The pulp and paper industry should be included under the Green Credit Programme to promote sustainable wastepaper management practices. Green Credits may be generated based on the quantity of wastepaper utilised in the manufacturing process and their scale of operation.
- The government should allocate funding for research and development initiatives aimed at improving paper recycling technologies and processes.
- Taxation policies may promote Incentivisation for recycling paper products while synchronising imports of recycled paper and products to protect the domestic paper recycling industry. An appropriate recycling promotion fee for each tonne shall be levied on wastepaper that is imported into the country.
- While allowing import of wastepaper to meet the shortage of paper and pulp, the Government may consider levying an appropriate charge on imported wastepaper to promote domestic wastepaper collection. A Paper Recycling Promotion Society may be formed as a public-private partnership with representation from the Ministry, the mills, the wastepaper trade and other stakeholders to administer the amount received and utilise the funds.

20.4.3. R&D and Product Innovation

- Research should focus on defining optimal blend ratios for virgin and recycled fibre, balancing structural integrity and printing quality. CPPRI's pilot programs are expected to drive the development of quality standards for recycled pulp, including parameters for tensile strength, brightness, and contaminant tolerance.
- JK Paper Ltd, a sector leader, reports that 100% of its raw material is from renewable farm-forestry and that its plants achieve carbon-positive and wood-positive status. The company has introduced biodegradable paper-based alternatives to plastics (cup-stock board, carry bags, straws), while ensuring zero landfill discharge and using up to 45-55% renewable energy across its operations.

20.4.4. Investment Technology Development

- The adoption of automated or AI-based sorting systems would improve economic viability by replacing slow, manual, and labour-intensive sorting.
- A competent research organisation like CPPRI should undertake R&D on how to quality check raw material to optimise the use of virgin and recycled wastepaper.
- May consider mandating the formal players, such as actual users, preferably under PPP mode, in wastepaper management.

20.4.5. Capacity building & Formalisation

- There is an urgent need to integrate the informal sector with the formalised collection and recycling mechanism to improve the circularity of wastepaper.
- Contractors, scrap dealers, aggregators, and recyclers may register under the proposed EPR scheme along with their associated kabadiwallahs and rag pickers.
- Formal agencies working at different levels in the supply chain need to be clustered as suppliers to registered formal wastepaper recycling agencies.

20.4.6. Awareness & behaviour change campaigns

Panaji, Goa, sets a strong example with its **16-way waste segregation system**, where households separate waste into 16 categories, including paper and cardboard. This model highlights how **community participation, municipal support, and continuous awareness drives** can make segregation effective.
To scale this nationwide, **awareness and behaviour change campaigns** under initiatives like **"Waste to Wealth"** should:

- Educate citizens on the value of paper segregation and recycling.
- Conduct paper-specific collection drives through RWAs, schools, and offices.
- Use **digital media, influencers, and local networks** to shift public behaviour.
- Involve the **informal waste sector** as community recycling ambassadors.

Such campaigns can transform waste management by making **segregation at source a civic responsibility** and a key step toward a circular paper economy.

20.4.7. Proposed Initiatives and Actions

The targets, goals, and enabling strategies outlined earlier form the foundation for a comprehensive implementation roadmap (presented in **Table 20-2**). This roadmap will serve as a strategic guide to systematically achieve the defined objectives by translating high-level targets into concrete actions. The table below details specific initiatives and activities along with responsible stakeholders. **Table 20-3** presents the implementation risks and corresponding mitigation measures.

Table 20-2: Proposed Priority Actions to Achieve Circular Economy Targets

Initiative / Action	Priority	Roles & Responsibilities
Public awareness campaigns on paper recycling.	Short Term	**Central & State Governments / ULBs**: Fund and execute campaigns; **Academia / NGOs**: Develop and disseminate educational content.
Promote alternative materials (e.g., agro straw, bamboo utensils) for secondary wastepaper applications like fruit packaging and roadside eateries.	Short Term	**Industry:** Develop and produce alternatives; **ULBs / State Governments:** Mandate use in specific commercial sectors.
Develop and notify the Extended Producer Responsibility (EPR) guidelines for paper waste with clear stakeholder responsibilities and recovery targets.	Medium Term	**MoEFCC, CPCB:** Finalise the draft notification and enforce the rules.
Implement an integrated recycling system (PPP model) that mandates the registration and formalisation of the informal sector under the EPR regime.	Medium Term	**Central & State Governments/ULBs:** Regulatory oversight; **Industry:** Integration and supply chain management.
Introduce quality standards for recycled raw material and optimise the blend ratio of virgin and recycled fibre, guided by R&D from institutions.	Medium Term	**Academia/CPPRI:** Conduct R&D and develop standards; **Industry:** Adhere to new standards.
Invest in upgrading recycling infrastructure, including automated/AI-based sorting systems, to improve efficiency, quality, and lower operational costs.	Long Term	**Industry/Government:** Secure R&D funds and implement advanced technology.

Table 20-3: Implementation Risks and Mitigation

Implementation Risk	Mitigation Strategy (Based on Sources)
Resistance from the informal sector to integrate into the formalised collection system.	i. Integrate the informal sector by clustering them, ii. ensuring their self-registration under the EPR scheme, iii. formalising procurement to ensure financial stability.
Continued low quality and high contamination of domestic wastepaper feedstock affects paper quality and industrial viability.	i. Implement an extensive public education programme to mandate source segregation, this is to be coupled with investment in automated sorting systems.
Economic viability of domestic recycling is undermined by the surging import of cheap finished paper and paperboard.	i. Restrict the usage of imported finished paper by increasing customs duty (e.g., to 30%) and enforce Minimum Import Price (MIP) measures on specific grades. ii. Strictly ensure compliance to MoEF&CC Order (OM No. 13-1/2004 – HSMD dtd. 11th May 2010.) for import of paper, paperboard and paper product wastes without being contaminated with Municipal waste and limits of contaminants as prescribed.
The diversion of large quantities of wastepaper (43% of domestic consumption) to secondary, non-recyclable applications like roadside eateries and fruit packaging.	Promote alternate materials such as agro straw and bamboo-based utensils for packaging and food service, redirecting paper back to industrial recycling channels.

20.4.8. Monitoring and Accountability

- A registration system for stakeholders similar to that implemented by CPCB for plastic waste or e-waste should be established under the proposed EPR rules.
- Formal Wastepaper Recycling Agencies must submit annual returns regarding the quantity of waste-paper recycled to the SPCB/CPCB every financial year through online system (such as EPR portal)

20.4.9. Managing the E-commerce Waste Challenge

E-commerce platforms generate excessive corrugated cardboard and laminated paper bags, much of which is non-recyclable due to coatings and adhesives. A strong legislative mandate should:

- Enforce 100% recyclable or biodegradable labels/adhesives/packaging material.
- Bind marketplaces to EPR registration and disclose annual recycling rates.
- E-commerce network may implement a take-back system for paper packaging material from its customers.

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Chapter 21

CIRCULAR ECONOMY ACTION PLAN FOR ABSORBENT HYGIENE PRODUCTS

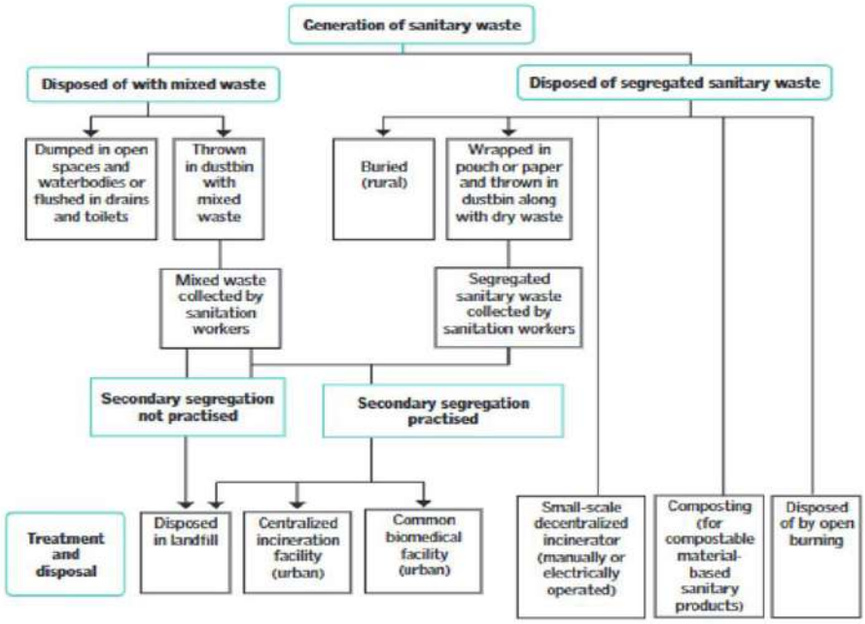
21.1. Material Landscape and Circularity Baseline

India faces a substantial sanitary waste challenge, with approximately 12.3 billion sanitary napkins reaching landfills annually as reported by DowntoEarth in 2021[1], and current estimations ranging between 1-2 million tonnes annually. The environmental and social implications of this waste stream have become increasingly critical in the nation's circular economy transition given that roughly 121 million women (36% of the menstruating population) use disposable sanitary products [2]

21.1.1. Material Value Chain and Current Challenge

The sanitary waste value chain in India is characterized by significant linear inefficiencies. Commercially available sanitary napkins contain 90% plastic content (equivalent to four plastic bags per pad), with components including super absorbent polymers derived from petrochemcials that take 500-800 years to decompose [2,3]. The lifecycle of sanitary products currently involves a conventional linear economy model: extraction of virgin materials → manufacture → use → disposal in landfills, open fields, buried pits or through open burning, composting or controlled incineration [2]. The controlled incineration can take place in centralised incinerators (>50kg/hr) of biomedical waste facilities and Urban Waste to Energy facilities. The resulting ash from incinerators is mostly stored in hazardous waste storage facilities or maybe used as construction materials [4].

Critical problems in sanitary waste management include non-segregation from household waste, exposing waste workers to health hazards from the soiled sanitary waste and the release of carcinogenic dioxins and furans when burned in low-temperature incinerators lacking emission controls[5,6]. The Solid Waste Management Rules 2016 mandate wrapping sanitary waste in paper with a red dot for separate collection, but implementation remains inconsistent due to inadequate infrastructure and poor public awareness [7]



Source: Sanitary Waste Management in India (Centre for Science and Environment)[8]

21.1.2. Strategic Importance and Environmental Footprint

While sanitary waste represents only 0.65-3% of India's total municipal solid waste (141,000 tonnes daily) its management is strategically critical [8]. The waste poses environmental burdens on multiple fronts: plastic pollution (sanitary napkins account upto 3% of India's 3.3 million tonnes annual plastic waste), greenhouse gas emissions through improper disposal, and contamination of soil and water bodies. Socially, improper disposal perpetuates health risks for women, waste pickers, and communities, while inadequate menstrual hygiene infrastructure in rural

areas and slums exacerbates the overall crisis [1,2,6,7].

21.1.3. Market Dynamics and Growth Projections

The Indian sanitary napkin market demonstrates robust growth, valued at USD 825.3 million in 2024 and projected to reach USD 1,765.7 million by 2033 (CAGR 8.38%) [9]. Simultaneously, the reusable sanitary napkin segment is expanding rapidly at 15.89% CAGR, expected to grow from INR 121 crore (2024) to INR 486.8 crore (2033)[10]. The biodegradable and compostable product segment shows the fastest growth at 15.7% CAGR[11] reflecting shifting consumer preferences towards sustainable alternatives.

21.1.4. Policy Framework and Incentives

Key policies and initiatives include:

1. Guidelines for management of Sanitary Waste by CPCB as per Solid Waste Management Rules 2016 which classify sanitary waste as a distinct category mandating involved stakeholders such as manufacturers, users and urban local bodies to facilitate segregated collection and appropriate disposal [5,7].
2. Menstrual Hygiene Management National Guidelines advising on sanitary waste segregation, collection and minimal human involvement for disposal and treatment [12]
3. Guidelines for Swachh Bharat Mission (SBM)-Urban and SBM-Gramin similarly advise sanitary waste source segregation, collection and disposal through incinerators [13,14]
4. Draft Extended Producer Responsibility (EPR) Rules 2024 mandate producers, importers, and brand owners to achieve recycling targets of 60% by 2026-27, escalating to 100% by 2029-30 for sanitary products[15].
5. State-level initiatives include Kerala's Haritha Keralam Mission, which implements decentralized waste management through the Haritha Karma Sena workforce of 36,000 members collecting segregated waste door-to-door including source separated sanitary waste collection [16,17]

21.1.5. Best Practices and Innovations fostering Circular Economy

Best practices include source segregated collection and high temperature incineration of sanitary waste in dedicated or common urban incinerators that meet emission standards. Incinerator ash, upon passing the toxic chemical leaching procedure (detailed in Schedule II, HWM 2016) test, can be used as partial-replacement of cement, sand/ fine aggregates in construction[4].

Kerala's Haritha Keralam Mission demonstrates effective state-level action through decentralized incinerator deployment in schools/public facilities, Haritha Karma Sena workforce training (36,000 members), and door-to-door segregated collection[16,17]. App based sanitary waste collection systems launched in Kochi in collaboration with Aakri Impact Pvt. Ltd uses 'Aakri' mobile app, whereby the waste generators schedule a sanitary waste collection request. Aakri is now being scaled up to the rest of the country. Emerging innovations include pilot recycling centers established by PadCare which developed attempts to transform sanitary waste into precursors for plastic and paper industry [18,19,20]. Spotless Dame developed women empowering community-based models to produce and distribute reusable bamboo fiber pads across 30 locations in Rajasthan, saving 31,219 kg plastic waste while creating employment for 25 women[21].

EU directives 2019/904 directs plastic product manufacturers such as those of sanitary napkins to inform on the packaging of appropriate waste management options or waste disposal means to be avoided. France's EPR

framework (AGEC Law 2020) mandates single-use sanitary textile registration from January 2025, with producers financing end-of-life management.[28] Similarly, Germany's EWKFondsG includes sanitary towels under EPR for single-use plastics.[29] RECALL project in Italy setup a sanitary waste recycling unit of 1500t/year to recover plastic and cellulose fiber from used absorbent hygiene products.[30] Similar recycling plants of have also been established across Japan to recover plastic and fibre. [31]

21.2. Gaps and Challenges in Advancing Circularity

India's transition to a circular economy for sanitary waste faces multifaceted barriers spanning policy enforcement, infrastructure, awareness, and market development. Despite progressive regulations, systemic gaps undermine the realization of sustainable menstrual waste management.

21.2.1. Policy Gaps and Enforcement Barriers

Critical policy ambiguities hinder effective implementation of sanitary waste handling.The Solid Waste Management Rules 2016 classify sanitary waste as a distinct category requiring segregation, yet confusion persists with Biomedical Waste Management Rules 2016, which also classify blood-contaminated materials as biomedical waste requiring microwaving or autoclaving based disposal. This regulatory overlap, coupled with multiplicity of laws and lack of coordination between government agencies, leads to ambiguity on process to be adopted[6,8,22]. The draft EPR rules on sanitary waste mandate EPR 60-100% of sanitary waste from 2026-2030[15] however implementation and monitoring mechanisms lack strict definition.

21.2.2. Material-Specific and Infrastructure Viability Challenges

Sanitary napkins/diaper waste typically contain 90% fossil derived plastic making it non-biodegradable and requiring up to 800 years to break down into microplastics[3].The absence of effective source segregation for sanitary waste makes its collection both challenging and hazardous, as it necessitates manual sorting by sanitation workers. Where waste is segregated at source, appropriate storage containers, transport means and incineration capacity may be lacking hindering safe disposal. Centralised incinerators dedicated for biomedical wastes are additionally used for disposing sanitary wastes by urban local bodies. Such disposal might face financial constraints when commercial rates are charged by private players or may face capacity constraints as the magnitude of sanitary waste increases with population increase.

Decentralised incinerators for local disposal of sanitary napkins in small volumes (150-200/day) may not meet emission norms causing detrimental health and environmental impacts[8]. Recycling ventures face feedstock availability challenges due to fragmented collection systems and non-segregation at source. PadCare Labs' subscription model (free bins, charges per pickup) addresses collection logistics but requires economic and technological viability at scale meeting minimum footfall thresholds and market acceptance of their pulp and plastic based incineration by-products[20,23]. Biodegradable pad manufacturing requires sourcing of raw materials such as banana fiber and bamboo at commercial scale.This can be challenging as it requires setting up new supply chain and dedicated infrastructure while economically competing with well-established non-biodegradable pad manufacturers in a market where women have limited financial means to access quality products.[24]

21.2.3. Awareness and Skills Deficits

Approximately 29% of households do not segregate waste, and among those that do, 70% segregate only into wet/dry categories, ignoring sanitary waste streams. Social stigma around menstruation prevents proper disposal—60-70% of surveyed individuals admit to disposing sanitary napkins unwrapped, exposing waste workers to pathogens[25]. Rural populations lack trained personnel and financial literacy, while municipal authorities face shortages of qualified waste management professionals [24]. Capacity-building initiatives remain ad-hoc; the Swachh Bharat Mission's Menstrual Hygiene Management guidelines emphasize district-level training for frontline workers (ASHA, teachers, panchayat officials) but implementation coverage is inconsistent[12]. Reusable sanitary napkins struggle with consumer hesitation around washing/maintenance and insufficient awareness campaigns demonstrating long-term savings

21.3. Vision and Targets for Circular Economy Transition

Circular economy progression in sanitary waste management is envisioned to transform it into a resource efficient system where **sanitary waste is minimised and segregated at source**, and the entire value chain (producer, user, collector, processor and regulator) works in tandem to ensure **zero unsafe disposal while maximising resource and energy recovery.**

Table 21-1: Proposed Targets

S.no	Proposed Target	2030 Target	Basis for Target
1	Source segregation of sanitary waste (% of total sanitary waste)	90%	Countries like Japan and South Korea achieve >90% through enforcement and public participation
2	EPR (% of sanitary waste produced)	100%	Draft EPR guidelines require full producer responsibility by 2030, consistent with EU and OECD frameworks[15]
3	Safe disposal through Material recovery from sanitary waste (% of sanitary waste)	20%	Pilot runs across cities in Japan and Italy are recovering plastic and cellulose fiber showing promise however on ground experience from pilot runs in India implying technical and economic unviability for now
4	Safe disposal through incineration in WtE plants or biomedical and hazardous waste treatment facilities (% of sanitary waste)	80%	Need of the hour to limit environmental and human health damage through improper disposal methods
5	Digital traceability and reporting (% cities/districts with real-time data)	100%	Expansion of CPCB and MoHUA digital platforms ensures traceability and compliance monitoring
6	Public awareness & behaviour change (% population reached by IEC campaigns)	100%	Effective information, education and communication campaigns critical for achieving segregation and recycling, supported by nationwide campaigns

21.4. Enablers and Implementation Framework

21.4.1. Policy Interventions & Market-Based Instruments

Effective policy frameworks form the foundation for circular sanitary waste management. India's regulatory landscape must enforce mandatory Extended Producer Responsibility (EPR) for all sanitary product manufacturers, importers, and brand owners, with annual escalating targets culminating in 100% recovery by 2030. The amended Solid Waste Management Rules (2024) mandate source segregation and scientifically managed treatment facilities. Complementing these, product standards requiring minimum recycled content in new sanitary products and bans on open dumping and uncontrolled incineration of untreated sanitary waste are critical.

21.4.2. Financing Tools and Incentives

Financial viability remains a significant barrier to circular infrastructure. Viability Gap Funding (VGF) administered by the Ministry of Finance provides capital subsidies up to 60% for socially desirable but financially unviable solid waste management projects, with the central government contributing 30% and state governments/statutory entities adding another 30%. Green public procurement policies mandating use of recycled sanitary waste derivatives in public projects create guaranteed offtake markets. Concessional loans from multilateral development banks (ADB, World Bank) and climate funds (Green Climate Fund) support pilot-scale demonstration projects.

21.4.3. Infrastructure Development

Decentralized infrastructure is essential for efficient collection, segregation, and processing. Circular Economy Parks integrating collection hubs, material recovery facilities, and recycling units should be established in major urban clusters under PPP models. These parks can house specialized technologies for converting sanitary waste into refuse-derived fuel (RDF), recycled polymers for construction materials, and nonwoven textiles. Upgrading municipal solid waste infrastructure to accommodate dedicated sanitary waste streams with digital tracking systems ensures traceability from source to processing.

21.4.4. Investment in Technology Development

Innovation ecosystems must be strengthened through R&D funding for biodegradable sanitary product alternatives, advanced sorting technologies (AI-based, RFID-enabled), and chemical recycling processes that maintain material quality. Academia-industry partnerships facilitated through schemes like the Atal Innovation Mission can accelerate commercialization of breakthrough technologies. Demonstration projects showcasing emerging solutions build investor confidence and enable technology transfer.

21.4.5. Promotion of Public-Private Partnerships

PPP models distribute risks and leverage private sector efficiency. Successful solid waste management PPPs in cities like Indore, Hyderabad, and Bengaluru demonstrate viability. Concession agreements for sanitary waste collection, transportation, and processing spanning 15-25 years provide revenue certainty through tipping fees and product sales. Integration of informal sector waste workers through social enterprises within PPP frameworks ensures inclusive growth.[32]

21.4.6. Capacity Building and Skills Development

Workforce competency determines operational success. Certification programs for municipal workers, informal collectors, and facility operators on safe handling, segregation protocols, and processing technologies are essential. Institutional capacity strengthening in Urban Local Bodies (ULBs) and State Pollution Control Boards (SPCBs) through training modules on EPR compliance monitoring, digital dashboard management, and contract supervision enhances implementation effectiveness.

21.4.7. Awareness and Behaviour Change Campaigns

Universal public engagement drives source segregation compliance. Information, Education, and Communication (IEC) campaigns leveraging mass media, schools, workplaces, and community groups must destigmatize sanitary waste and promote circular alternatives. Digital platforms, influencer partnerships, and grassroots mobilization through Self-Help Groups (SHGs) can achieve nationwide reach.

21.4.8. Implementation Risks and Mitigation

Key risks include fragmented state-level implementation, technology adoption gaps, informal sector resistance, and inadequate public awareness. Mitigation strategies involve phased rollouts prioritizing high-impact urban centers, dedicated technical support units in each state, stakeholder consultations ensuring informal worker integration, and real-time performance dashboards enabling course correction.

21.4.9. Monitoring and Accountability

Robust monitoring ensures target achievement. Digital dashboards linked to Swachh Bharat Mission portals and CPCB's EPR tracking system provide real-time data on waste generation, collection, processing, and recovery rates. Third-party audits and annual performance benchmarking against international standards maintain accountability. Clear assignment of nodal agencies at central, state, and local levels with defined penalties for non-compliance strengthens enforcement.

21.4.10. Implementation Roadmap

The targets, goals, and enabling strategies outlined earlier form the foundation for a comprehensive implementation road map (presented in **Table 21-2**). This roadmap will serve as a strategic guide to systematically achieve the defined objectives by translating high-level targets into concrete actions. The table below details specific initiatives and activities, mapped against the targeted outcomes, along with estimated timelines, key ownership, and responsible stakeholders. These actions encompass a range of critical areas, all aimed at ensuring a structured, coordinated, and impactful pathway toward sustainable waste management and circularity.

Table 21-2: Proposed Priority Actions to Achieve Circular Economy Targets

S.no	Target	Timeline	Action	Owners
1	Source segregation of sanitary waste (% of total sanitary waste)	2030	Enforce compulsory mandates for source segregation and tackle non-segregated waste through refusal to collection and strict monitoring and penalisation of illegal dumping	MoEFCC, CPCB, ULBs, State PCBs
			PPP concession for collection services	ULBs
2	EPR (% of sanitary waste produced)	As per EPR guidelines	Mandatory EPR registration for all producers on CPCB and 60% EPR target enforcement	MoEFCC, CPCB, Industry Association
			Phase wise EPR target escalation to 80%	CPCB, State PCBs, Producers
			Blockchain for transparent and secure EPR tracking system	CPCB
3	Safe disposal through Material recovery from sanitary waste (% recycled content in new products)	2030	Strict ban implementation on landfilling and open burning and strict emission standard for waste processing plants	MoEFCC, State PCBs, CPCB
			Subsidies/ Tax benefits for using recycled materials and grants for recycling plant setup and research	DST, ULBs, Ministry of Finance
			Circular product design development for sanitary products and for valorisation of material recovered from sanitary waste	DST, Academia, Industry R&D Centers
4	Safe disposal through incineration in WtE plants or biomedical and hazardous waste treatment facilities (% of sanitary waste)	2030	Viability gap funding and/or CAPEX subsidies for incineration facilities	Ministry of Finance, MoHUA.

S.no	Target	Timeline	Action	Owners
5	Digital traceability and reporting (% cities/districts with real-time data)	Immediate	Implementation of mandatory digital reporting on sanitary waste management throughout its lifecycle across multiple involved stakeholders	CPCB, SPCB
			Conditional funding and grants linked to digital compliance for ULBs	Ministry of Finance, MoHUA
6	Public awareness & behaviour change (% population reached by IEC campaigns)	Continuous	Media partnership programs for mass communication campaigns	MoHUA, Media Houses, NGOs
			Mandating workplace campaigns on segregation as part of corporate social responsibility	ULBs, Industry Associations

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