Impact of Circular Economy in Reverse Logistics for E-Waste Management in India Aligning with SDG 12 and Vikasit Bharat 2047

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Abstract

This research explores the integration of Circular Economy practices and Reverse Logistics in the management of e-waste in India, aligning with Sustainable Development Goal 12 (Responsible Consumption and Production) and India's Vision 2047. It adopts a theoretical and qualitative approach, incorporating policy reviews, stakeholder interviews, and documentary analysis to examine the effectiveness of strategies such as the 3Rs (Reduce, Reuse, Recycle) and Extended Producer Responsibility (EPR). The study evaluates how these approaches enhance sustainability in e-waste disposal, improve recycling rates, and reduce environmental impact. Findings reveal that while India has made notable progress through regulatory reforms and digital tracking systems, challenges such as informal sector dominance, inadequate infrastructure, and poor enforcement still hinder optimal outcomes. The study emphasizes the need for stronger policy implementation, formal-informal sector integration, and public awareness to ensure a successful transition to a circular economy. By highlighting these insights, the research contributes to understanding how sustainable waste management practices can support national development goals and environmental responsibility in the long term.

Keywords Circular Economy, Reverse E-Logistics in E-Waste Management, Sustainable Development Goal 12 (SDG 12), Responsible Consumption and Production

Definition of Key Components

1) Circular Economy

The term "circular economy practices" refers to methods and frameworks that use concepts like reduction, reuse, recycling, refurbishment, and remanufacturing to constantly use resources and eliminate waste. A circular economy is restorative and regenerative by design, in contrast to the conventional linear economy ("take-make-dispose"), and it fosters resource efficiency, environmental sustainability, and economic resilience.

Circular economy techniques in the context of e-waste include extended producer responsibility (EPR), modularity, ease of disassembly, recycling of electronic components, and product design for longer usage.

2) Reverse E-Logistics in E-Waste Management

The process of gathering, moving, and processing used electronic devices from end users back to manufacturers, recyclers, or disposal facilities for reuse, recycling, recovery, or safe disposal is known as reverse logistics in the context of e-waste management. *In order to effectively manage electronic trash in a sustainable and legally acceptable way, it comprises logistics activities like collection stations, transportation networks, sorting centers, and recycling facilities.*

3) Sustainable Development Goal 12 (SDG 12) Responsible Consumption and Production

Ensuring sustainable patterns of production and consumption is the main objective of SDG 12. This entails cutting down on waste production, encouraging the prudent use of natural resources, supporting environmentally friendly company practices, and bolstering corporate responsibility and sustainable public procurement.

Environmentally responsible e-waste management and a notable decrease in waste production through prevention, reduction, recycling, and reuse are directly related to targets 12.4 and 12.5.

4) **Vikasit Bharat @2047**

The Government of India's long-term goal, Viksit Bharat @2047, is to make India a developed country by 2047, when it will have celebrated 100 years of independence. It contains a roadmap with an emphasis on inclusive development, infrastructure, economic growth, environmental sustainability, technology innovation, education, and health. *Regarding your subject, it illustrates how advancements in circular logistics and sustainable e-waste management may support both economic growth and environmental objectives under this national vision.*

Introduction

There are major health and environmental risks associated with the exponential rise in electronic garbage, or "e-waste," that has resulted from India's exponential boom in electronic consumption. The complexity and toxicity of e-waste are making traditional garbage disposal techniques inadequate. As a result, incorporating circular economy principles into the backward logistics of managing e-waste has become a viable substitute. Recycling, refurbishing, and extending the life of products are examples of circular economy tactics that aim to decrease resource extraction, close the material loop, and lessen their negative effects on the environment. These activities are made possible in large part by reverse logistics, which makes it easier for consumers to return unwanted electronics to manufacturers or recyclers for recovery and reuse.

This study aims to assess the effects of circular economy principles in India's e-waste reverse logistics system, with a particular emphasis on coordinating these initiatives with India's national development plan, Viksit Bharat @2047, and Sustainable Development Goal 12 (Responsible Consumption and Production). The Viksit Bharat vision envisions a future-ready India that places a higher priority on sustainable and equitable growth, whereas SDG 12 stresses waste reduction and efficient resource use. This study intends to identify existing gaps and propose a strategic model that promotes environmental sustainability, economic efficiency, and societal well-being through improved e-waste management in India by examining current systems, stakeholder roles, regulatory frameworks, and technological interventions.

Literature Review

ABP Live (2024), in the article "Circular Economy Revolution Paving the Way to Viksit Bharat 2047," presents a forward-looking view on how circular economy practices are essential for achieving India's developmental vision by 2047. The piece highlights the significance of integrating waste management strategies like recycling, reuse, and Extended Producer Responsibility (EPR) to minimize environmental impact. It underscores the transformative potential of CE in building a sustainable economy and meeting national environmental and social goals effectively.

Singh & Sharma (2022), in their study "Application of Circular Economy in E-Waste Management – A Review with an Indian Perspective," emphasize the relevance of circular economy (CE) practices such as Reduce, Reuse, and Recycle (3Rs), reverse logistics, and urban mining in addressing India's growing e-waste challenges. The paper explores the role of existing policies, industry practices, and the informal sector while advocating for stronger legislative support to enhance sustainability in the electronics sector through closed-loop systems and resource efficiency.

Kumar et al. (2022), in "E-Waste Management in India A Strategy for the Attainment of SDGs," analyze the critical linkage between sustainable e-waste practices and the achievement of Sustainable Development Goals, particularly SDG 12. The study outlines strategic interventions, including regulatory enforcement, awareness programs, and institutional collaboration. It highlights the need for stakeholder engagement and policy innovation to build a sustainable and responsible e-waste management framework that aligns with India's environmental commitments and long-term developmental goals.

The Energy and Resources Institute (TERI) (2021), in its report "Supporting India on SDG 12 Monitoring and Reporting," addresses India's progress in achieving SDG 12, which focuses on responsible consumption and production. The report identifies challenges in data collection and inconsistencies in indicators related to waste management. It emphasizes the role of the Central Pollution Control Board (CPCB) and recommends the development of a standardized, transparent reporting framework to enhance national and subnational monitoring of sustainable waste-related practices.

United Nations University (UNU), ITU, & ISWA (2020), in their comprehensive report "Global E-Waste Monitor 2020," offer critical insights into the global landscape of e-waste generation and management. The report reveals that only 17.4% of global e-waste was formally collected and recycled in 2019, highlighting a significant gap in sustainable practices. It underscores the pressing need for improved collection infrastructure, policy implementation, and international cooperation to address the environmental and health risks associated with informal e-waste handling and disposal.

Research Objectives

1) To evaluate how well circular economy techniques improve India's handling of e-waste.
2) To assess how reverse logistics might increase the recycling rates of e-waste in India.
3) To evaluate the degree to which India's e-waste management plans adhere to SDG 12 (Responsible Consumption and Production).
4) To investigate how Extended Producer Responsibility (EPR), in keeping with Vision 2047, affects India's sustainable e-waste disposal.

Research Methodology

This study adopts a **theoretical and qualitative approach** to evaluate the impact of circular economy practices on e-waste management in India, aligned with SDG 12 and Vision 2047. The theoretical framework is based on Circular Economy and Reverse Logistics theories, emphasizing sustainable practices and efficient resource recovery.

The qualitative methodology includes **semi-structured interviews, focus groups, and case studies with key stakeholders, such as government officials, industry experts, and NGOs**. Additionally, documentary analysis of reports and policies related to e-waste management will provide insights into current practices and challenges, offering a comprehensive understanding of the sector's alignment with sustainability goals.

OBJECTIVE 1 To evaluate how well circular economy techniques improve India's handling of e-waste.

The amount of e-waste generated in India has increased significantly; in the fiscal year 2023, almost 1.6 million metric tons were produced. There remains a significant gap in sustainable e-waste management procedures, nevertheless, since only roughly 33% of this e-waste was recycled the government wants to reach a recycling rate of 60% by FY 2024 and 80% by FY 2029. Although these goals are lofty, the current recycling rate shows how difficult it is to successfully use circular economy principles. As of June 2023, Uttar Pradesh had the largest capacity to recycle e-waste, processing 624.2 thousand metric tons annually, according to the Central Pollution Control Board (CPCB). This regional capability shows how circular economy projects could be expanded nationwide.

FIGURE 1 E-Waste Generation and Recycling 2015-19

Source researchgate.net

In Figure 1 The above data observes a steady increase in India's overall e-waste production. By 2019, it has risen rapidly from 3,420,000 tons in 2015 to 5,100,000 tons. Concurrently, there was an increase in the quantity of e-waste that was disposed of, which increased from 2,520,000 tons in 2015 to 3,650,000 tons in 2019. Even if the amount of e-waste recycled rose from 900,000 tons in 2015 to 1,450,000 tons in 2019, the percentage of recycled e-waste was still far lower than the amount that was generated and then disposed of. This suggests that efficiently handling the nation's growing amount of electronic waste is becoming more and more difficult.

Objective 2 To assess how reverse logistics might increase the recycling rates of e-waste in India.

India's e-waste management is evolving with the introduction of the E-Waste (Management) Rules, 2022, effective from April 1, 2023.These regulations mandate the establishment of a robust reverse logistics framework to facilitate the collection, transportation, and recycling of electronic waste.The Central Pollution Control Board (CPCB) has registered 569 recycling plants with a combined capacity of 1.78 million metric tons per annum. Additionally, the government aims to achieve a 60% e-waste recycling rate by FY 2024, increasing to 80% by FY 2029. Implementing effective reverse logistics is crucial to meet these targets, ensuring the efficient collection and processing of e-waste, thereby enhancing recycling rates and promoting environmental sustainability.

Objective 3 To evaluate the degree to which India's e-waste management plans adhere to SDG 12 (Responsible Consumption and Production).

India's e-waste management efforts have made notable strides toward aligning with SDG 12, which emphasizes responsible consumption and production patterns. The implementation of the E-Waste (Management) Rules, 2022, effective from April 1, 2023, introduced a comprehensive framework aimed at enhancing e-waste collection, recycling, and disposal practices. A key component of these rules is the Extended Producer Responsibility (EPR) mechanism, which holds producers accountable for the entire lifecycle of their products, including post-consumer waste.

Despite these advancements, challenges persist. In the fiscal year 2023–24, India generated approximately 1.75 million metric tons of e-waste, yet only 43% was recycled, indicating a significant gap in achieving SDG 12 targets. The informal sector continues to handle a substantial portion of e-waste, often employing environmentally hazardous methods.

To address these issues, the government has set ambitious recycling targets 60% by FY 2024, with incremental increases aiming for 80% by FY 2029. Achieving these targets necessitates enhanced enforcement of EPR regulations, increased public awareness, and greater collaboration with the informal sector to ensure environmentally sound recycling practices. See Table 1 and 2.

Table 2 E Waste Recycling Targets

Year	E-Waste Recycling Target (%)
FY 2024	60%
FY 2026	70%
FY 2028	80%

Source Statista

TABLE 2 E-Waste Generation and Recycled 2019-2024

YEAR	E-WASTE GENERATED (In Merit Tons)	E-WASTE RECYCLED
2019–20	1,014,000	22%
2020–21	1,346,496	26.33%
2021–22	1,601,155	2.9%
2022–23	1,609,117	Data Not Available
2023–24	1,751,000	43%

Source Ministry of Housing and Urban Affairs, Government of India

Objective 4 To investigate how Extended Producer Responsibility (EPR), in keeping with Vision 2047, affects India's sustainable e-waste disposal.

A key piece of policy in India's plan for disposing of e-waste sustainably is Extended Producer Responsibility, or EPR. Introduced under the E-Waste (Management) Rules, 2022, EPR requires manufacturers, importers, and producers to be in charge of collecting, recycling, and disposing of electronic items in an environmentally friendly manner when their useful lives are up. This is in line with India's Vision 2047, which highlights resource efficiency, environmental responsibility, and sustainable development as key national objectives. By pushing manufacturers to develop more durable, recyclable products and make investments in official recycling networks, EPR aims to establish a closed-loop system that supports circular economy principles.

However, several challenges must be addressed for EPR to truly contribute to sustainable e-waste management.

- Lack of awareness and technical capacity among small and medium producers often leads to poor compliance.
- The dominance of the informal sector, which handles over 90% of e-waste in India, makes formal channel implementation difficult.
- Inadequate infrastructure and logistical bottlenecks hinder the collection and reverse flow of e-waste, especially from rural and semi-urban areas.
- Limited monitoring and enforcement of EPR targets reduce accountability.
- Underreporting and data inconsistency across stakeholders challenge transparency and traceability in e-waste flows.

To meet EPR targets of 60% recycling by FY 2024 and 80% by FY 2028, India must strengthen enforcement mechanisms, improve coordination between the public and private sectors, integrate the informal sector, and invest in digital tracking and capacity building. Addressing these challenges is essential to ensuring that EPR becomes a robust pillar in India's sustainable transition and helps realize the goals of Vision 2047.

Conclusion

In conclusion, integrating Circular Economy practices and Reverse Logistics in e-waste management is crucial for advancing India’s sustainability agenda aligned with SDG 12 and Vision 2047. Theoretical and qualitative analyses reveal that Extended Producer Responsibility (EPR), policy reforms, and stakeholder engagement are key drivers of change. However, challenges such as informal sector dominance, inadequate infrastructure, and weak enforcement remain. Strengthening EPR implementation, enhancing awareness, and investing in green logistics can significantly improve recycling rates and resource efficiency, supporting India’s transition to a sustainable, inclusive, and circular economy by 2047.

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