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"Driving Sustainability: A study on role of multi-dimensional Programs in Supply Chain Orchestration for Circular Economy"

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Abstract
Circular economy as a model works on eliminating waste and pollution by keeping product and material in a continuous use. This model as an economic model, regenerative in sustainable which works on inclusion of leasing, reusing, repairing, refurbishing, recycling, and sharing.In India, several schemes and policies are promoting circular economy practices and enhance resource efficiency across various sectors. Initiatives such as the National Resource Efficiency Policy, Extended Producer Responsibility (EPR), Plastic Waste Management Rules, E-Waste Management Rules, Battery Waste Management Rules, Vehicle Scrappage Policy, National Green Hydrogen Mission, GOBAR-Dhan Scheme, Smart Cities Mission, and the Zero Defect Zero Effect (ZED) and way more are play a crucial role in encouraging waste reduction, recycling, reuse, and sustainable production and consumption patterns. Furthermore, effective supply chain orchestration facilitates the coordination of stakeholders involved in resource recovery, reverse logistics, and circular value creation. This study examines the role of these schemes in advancing the circular economy in India and explores how supply chain orchestration supports their successful implementation. The findings suggest that government interventions, combined with efficient supply chain coordination, contribute significantly to environmental protection, resource conservation, economic growth, and sustainable national development. The study highlights the importance of policy support and integrated supply chain management in accelerating India's transition toward a more sustainable and circular economic model.Therefore, this paper proposes a circular supply chain orchestration approach to understand responses of circular economy adoption through various programs in India by highlighting the impact factors.

Key words: Circular economy, Sustainability, Supply chain orchestration, Zero Defect Zero Effect (ZED), and GOBAR-Dhan Scheme.

I. Introduction:

The growing pressure on natural resources, increasing levels of waste generation, and concerns regarding climate change have highlighted the need for a development model that can support long-term environmental, social, and economic well-being. Traditional patterns of production and consumption, which largely depend on the extraction, use, and disposal of resources, have created significant sustainability challenges across the globe.

As a result, governments, industries, and communities are seeking innovative approaches that can promote resource efficiency while ensuring economic growth and social progress. The increasing demand for natural resources, coupled with rising levels of waste generation and environmental degradation, has raised concerns about the long-term sustainability of current economic systems. Achieving sustainability requires a balance between economic development, environmental conservation, and societal welfare, making it one of the most important objectives of contemporary policy and business practices.

The circular economy has emerged as a promising framework for addressing these challenges. It seeks to minimize waste and

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maximize resource value by extending product life cycles through strategies such as reuse, repair, remanufacturing, and recycling. By transforming waste into valuable resources and reducing dependence on virgin materials, the circular economy contributes to environmental conservation, economic resilience, and social well-being.Consequently, the circular economy is increasingly recognized as a key pathway toward building resilient economies and achieving a sustainable future that benefits both current and future generations.

For a developing economy like India, the adoption of circular economy principles is particularly important due to rapid urbanization, industrial expansion, and increasing consumption patterns. Programs such as the Swachh Bharat Mission, Extended Producer Responsibility framework, Plastic Waste Management Rules, Battery Waste Management Rules, GOBAR dhan Scheme, and the National Green Hydrogen Mission reflect the country's commitment to integrating circular economy principles into its development strategy.

II. Review Of Literature:

The review of literature provides a comprehensive understanding of the concepts, theories, and previous studies related to the Circular Economy and sustainability. It examines existing research on waste management practices, government initiatives, circular economy governance, and sustainable development strategies. Furthermore, it highlights the significance of circular economy practices in addressing environmental challenges and promoting resource efficiency and long-term sustainability.

Circular Economy and sustainability:

Nisha R Y, Rupesh M and Saravan K. **(2016)**, in literature on waste management in India suggests that existing systems face challenges such as inefficient collection, inadequate segregation, and limited recycling infrastructure. Researchers have examined various waste management initiatives, including private-sector innovations and successful practices adopted in developed countries. This study indicate that while technological advancements and green consumerism have improved waste handling, they often fail to address the root causes of waste generation. Evidence from India, China, and the United Kingdom demonstrates that CE can enhance sustainability and support long-term economic, environmental, and social development.

According to Martin G et al.**(2017),** highlights the gap and aims to provide conceptual clarity by distinguishing the terms and synthesising the different types of relationships between Circular Economy and sustainability. They conducted an extensive literature review, employing bibliometric analysis and snowballing techniques to investigate the state of the art in the field and synthesise the similarities, differences and relationships between both terms. We identified eight different relationship types in the literature and illustrated the most evident similarities and differences between both concepts

Collaboration in sustainable development:

Jacqueline Cramer **(2021)** in his paper explained theStudies on Circular Economy (CE) governance highlight the significance of government leadership and stakeholder collaboration in achieving sustainable development. Comparative research across sixteen countries suggests that both public governance and network governance are essential for managing the complex transition toward a circular economy. The literature further emphasizes that governance strategies should be tailored to different socio-economic and political contexts for successful outcomes.

Strategies to facilitate circular economy:

J Fiksel, P Sanjay & K Raman. **(2021),** in their research on Circular Economy (CE) highlights its role in addressing environmental and resource-related challenges through waste reduction and resource recovery. Studies conducted in India demonstrate that CE initiatives can strengthen sustainability and community resilience. The World Institute of Sustainable Energy's e-waste management program in Pune and Barefoot College's rural waste management model have shown positive environmental, economic, and social impacts. Theseinitiatives emphasize stakeholder participation and integrated approaches as key factors for achieving long-term sustainable development.

Achieving sustainability through supply chain orchestration

A study by C. Erminiet al.**(2024)** on Circular Supply Chains (CSCs) emphasizes the need for stakeholder collaboration and efficient resource management to support Sustainability-Oriented Innovation. Nevertheless, empirical evidence on the successful implementation of circular strategies remains limited. Research conducted in the sustainable fashion industry

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indicates that effective coordination of resources and capabilities enables firms to develop innovative solutions, including collaborative partnerships, circular services, and social initiatives.

Objectives of the study:

1. To understand the concept of the circular economy and its relationship with sustainability.
2. To analyse major initiatives promoting circular economy practices in India.
3. To identify the Economic benefits and recommendations for strengthening circular economy adoption in India.

Research methodology:

This paper is an attempt of conceptual study where this article provided and limited to the study by collection of data, purely based on secondary sources of data collection.

Objective 01: To understand the concept of the circular economy and its relationship with sustainability

Concept of circular economy:

The Circular Economy (CE) has emerged as an alternative to the traditional linear economy by promoting the reuse, repair, refurbishment, and recycling of materials and products. The growing depletion of natural resources, increasing waste generation, and environmental degradation have highlighted the need for sustainable economic models. By extending product life cycles and minimizing waste, CE aims to enhance resource efficiency and create long-term economic, environmental, and social benefits. As governments and industries worldwide seek sustainable development solutions, the adoption of circular economy principles has gained significant attention for its potential to reduce environmental impacts and support a more resilient and sustainable future.

Three Core Principles of the Circular Economy:

These principles are embedded in product and system design to minimize environmental impact while maximizing resource efficiency.

1. Eliminate waste and pollution: preventing waste and pollution from being created in the first place. Products, materials, and processes are designed to reduce resource consumption, avoid harmful substances, and minimize environmental damage throughout their life cycle.

While eliminating waste is an ideal objective, achieving zero waste is difficult in practice due to technological limitations, complex supply chains, and consumer behaviour.

2. Circulate products and materials at their highest value: The circular economy encourages keeping products, components, and materials in use for as long as possible through reuse, repair, refurbishment, remanufacturing, and recycling. This extends product life cycles and reduces the demand for virgin resources.Although circulation of materials improves resource efficiency, it often requires significant investment in collection, sorting, repair, and recycling infrastructure.

3. Regenerate nature: Beyond reducing environmental harm, the circular economy seeks to restore and enhance natural ecosystems. This includes practices such as sustainable agriculture, renewable energy adoption, biodiversity conservation, and the replenishment of natural resources.Nature regeneration initiatives can produce long-term environmental benefits, but their outcomes are often difficult to measure and may take years to become visible. Furthermore, economic growth objectives can sometimes conflict with ecological restoration efforts, creating challenges for policymakers and businesses.

Objective 02: To analyse major initiatives promoting circular economy practices in India.

Conceptual Framework of Initiatives Supporting Circular Economy in India

The India has increasingly incorporated circular economy principles into its policy framework to address challenges related to resource scarcity, waste generation, environmental degradation, and sustainable development. Rather than treating waste as an end product, these initiatives emphasize the continuous circulation of resources within the economy through efficient utilization, recovery, recycling, and regeneration. Collectively, these policies reflect a shift from a linear model of production and consumption toward a more sustainable and restorative economic system.

Major initiatives promoting circular economy practices in India are:

Swachh Bharat Mission (SBM): The SBM was launched by the in the year 2014 with the objective of achieving an Open Defecation Free India and improving sanitation standards across the country. The mission was introduced to address sanitation challenges, promote hygiene practices, and contribute to public health and environmental sustainability. It also supports Sustainable Development Goal (SDG) 6, which focuses on ensuring access to clean water and sanitation for all.

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SBM was implemented through a collaborative effort between the central and state governments, with active participation from local communities and development partners. The programme emphasized the construction of household toilets, sanitation facilities in schools and public institutions, and large-scale behaviour change campaigns. Information, Education, and Communication (IEC) activities played a crucial role in encouraging people to adopt hygienic practices and eliminate open defecation.The mission led to the construction of over 100 million household toilets, benefiting around 500 million people across rural India. It improved public health, reduced environmental contamination, and generated employment opportunities in sanitation-related sectors.

National Resource Efficiency Policy (NREP): Ministry of Environment, Forest and Climate Change (MOEF&CC) has proposed to introduce the National Resource Efficiency Policy (NREP) 2019 with a mission to establish resource efficiency in the country. The policy shall facilitate RE across all critical resources like metals, minerals, fossil fuels, biomass, air, water, land, forests etc. over their entire life cycle, i.e. from extraction of raw materials till end-of-life management.

Through the NREP, the government intends to provide a supportive regulatory framework to institute resource efficiency and productivity by leveraging cross-sectoral synergies, formulating policy instruments and action plans and developing rigorous implementation and monitoring frameworks.

The policy describes resource efficiency strategies for seven relevant sectors viz. automotive sector, plastic packaging sector, building and construction sector, electrical and electronic equipment sector, solar photo voltaic sector, steel sector and aluminium sector.

Extended Producer Responsibility (EPR): Extended Producer Responsibility (EPR) is a policy approach that makes producers responsible for their products along the entire lifecycle, including at the post-consumer stage1. This specially designed environmental policy approach shifts the burden of managing certain end-of-life products from municipalities and taxpayers to the producers who place those products in the market.

Beyond the end-of-life management stage, EPR also has the capacity in stimulating greater engagement of producers in the overall redesign of products and packaging, with the ultimate aim of reducing waste; thus mitigating environmental and health impacts.

Plastic Waste Management Rules, 2016: The rules cast Extended Producer Responsibility (EPR) on Producer, Importer, Brand Owner for collection and recycling of plastic packaging waste. EPR shall be applicable to both pre-consumer and post-consumer plastic packaging waste. The regulation provides framework for implementation of Extended Producer Responsibility. The regulation set out the roles and responsibilities of Producers, Importers, Brand Owners, CPCB/SPCBs/PCCs, recyclers and waste processors for effective implementation of EPR.By promoting collection, recycling, and responsible disposal of plastics, the framework seeks to reduce environmental leakage and enhance material circularity.

E-Waste Management Rules: These new rules intend to manage e-waste in an environmentally sound manner and put in place an improved Extended Producer Responsibility (EPR) regime for e-waste recycling wherein all the manufacturer, producer, refurbishers and recycler are required to register on portal developed by CPCB. The new provisions would facilitate and channelize the informal sector to formal sector for doing business and ensure recycling of E-waste in environmentally sound manner. Provisions for environmental compensation and verification & audit has also been introduced.

Battery Waste Management Rules, 2022: The rules emphasize resource recovery and closed-loop material flows. By facilitating the recycling of batteries and extraction of critical minerals, they contribute to resource conservation and sustainable industrial development. The Battery Waste Management Rules 2022 establish comprehensive regulations for the collection, recycling and management of all types of batteries in India, including automotive, portable, industrial and electric vehicle batteries. The regulations aim to create a circular economy for battery materials while ensuring environmentally sound management of battery waste. They place significant emphasis on proper documentation, tracking and verification of recycling activities.

Vehicle Scrappage Policy: This policy supports circularity by enabling the recovery and reuse of metals, components, and materials from end-of-life vehicles. It promotes efficient resource utilization while reducing environmental impacts associated with obsolete vehicles.

The vehicle scrappage policy in India is introduced as a voluntary vehicle fleet modernization program aimed at reducing pollution and improving road safety by removing unfit vehicles from circulation. The policy formalizes the scrappage ecosystem by

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shifting disposal away from informal dismantling practices into a regulated system that works through fitness testing at Automated Testing Stations, ELV marking in VAHAN records, and final dismantling at Registered Vehicle Scrapping Facilities. This structured chain connects vehicle fitness, legal deregistration, recycling, and incentives into one governed process.

GOBARdhan Scheme: Galvanizing Organic Bio-Agro Resources Dhan (GOBARdhan) scheme was launched under Swachh Bharat Mission (Grameen) in year 2018. GOBARdhan is an integral component of solid waste management under SBM(G) for ensuring cleanliness in villages by converting bio-waste including animal waste, kitchen leftovers, crop residue and market waste into biogas and bio slurry to improve the lives of villagers. GOBARdhan projects support biodegradable waste recovery by incentivizing Gram Panchayats to convert cattle dung and solid agricultural waste into biogas and bio-slurry.

National Green Hydrogen Mission: The Mission will lead to significant decarbonisation of the economy, reduced dependence on fossil fuel imports, and enable India to assume technology and market leadership in Green Hydrogen. The mission contributes to a sustainable and low-carbon economy by promoting clean energy alternatives. It aligns with circular economy objectives through efficient resource utilization and reduced dependence on fossil fuels. The Mission will identify and develop regions capable of supporting large scale production and/or utilization of Hydrogen as Green Hydrogen Hubs.Development of necessary infrastructure for such hubs will be supported under the Mission.It is planned to set up at least two such Green Hydrogen hubs in the initial phase.Outlay of ₹ 400 crore up to 2025-26 for Hubs and other projects.

Smart Cities Mission: The Smart Cities Mission integrates circular economy concepts into urban development by encouraging resource-efficient infrastructure, water reuse, sustainable mobility, and integrated waste management systems.

PM Gati Shakti: Conceptually, PM Gati Shakti supports circularity through optimized infrastructure planning and efficient logistics networks. Improved connectivity reduces resource wastage, energy consumption, and environmental externalities associated with transportation.

Zero Defect Zero Effect (ZED) Certification Scheme: The ZED Scheme promotes sustainable manufacturing by encouraging industries to minimize waste generation, improve resource efficiency, and reduce environmental impacts. It reflects the broader circular economy objective of achieving economic growth with minimal ecological footprint.

Objective 03: To identify the Economic benefitsand recommendations for strengthening circular economy adoption in India.

Economic Benefits of the Circular Economy in India

The circular economy offers substantial economic advantages for India by improving resource efficiency, reducing waste, and creating new business opportunities.

1. Large Market Potential: The transition to a circular economy has the potential to unlock significant economic value in India. Studies estimate that circular economy strategies could create a market opportunity of nearly $2 trillion by 2050 through efficient resource utilization, sustainable production systems, and innovative business models. This transformation can enhance productivity and stimulate economic growth across multiple sectors.

2. Job Creation: The circular economy promotes employment generation through activities such as recycling, repair, remanufacturing, refurbishment, and waste management. These sectors are labor-intensive and can create a large number of green jobs, particularly for skilled and semi-skilled workers, thereby contributing to inclusive economic development.

3. Reduced Dependence on Raw Material Imports: India relies heavily on imports of metals, minerals, and other raw materials to meet industrial demand. By promoting recycling, resource recovery, and the reuse of materials, the circular economy can reduce import dependency, improve resource security, and strengthen domestic supply chains. This can also help lower production costs and improve trade balances.

4. Industrial Innovation and Competitiveness: Circular business models encourage industries to develop innovative products, production processes, and recycling technologies. Companies are motivated to design products that are durable, repairable, and recyclable, leading to greater efficiency and competitiveness. Such innovation can position India as a leader in sustainable manufacturing and resource management.

5. Growth of Recycling and Repair Industries: The circular economy supports the expansion of industries involved in repair, refurbishment, remanufacturing, and recycling. These activities extend product life cycles, reduce waste generation,

and create new revenue streams. The growth of these sectors can foster entrepreneurship, attract investment, and contribute significantly to the national economy.

III. Recommendations:

To accelerate India's transition toward a circular economy, the following measures are recommended:

Strengthen Policy Implementation and Monitoring: Ensure effective enforcement of existing environmental regulations and establish monitoring mechanisms to track progress.

Increase Investments in Recycling and Recovery Technologies: Promote advanced technologies for waste recycling, resource recovery, and efficient material utilization.

Promote Research and Innovation in Circular Business Models: Encourage research institutions and industries to develop innovative products, services, and business models that minimize waste.

Enhance Public Awareness and Environmental Education: Conduct awareness campaigns and educational programs to encourage sustainable consumption and waste management practices.

Encourage Collaboration Among Government, Industry, and Civil Society: Foster partnerships among stakeholders to share knowledge, resources, and best practices for circular economy initiatives.

Support Small and Medium Enterprises (SMEs) in Adopting Circular Practices: Provide financial incentives, technical assistance, and training to help SMEs implement sustainable production methods.

Develop Robust Waste Collection and Segregation Systems: Improve infrastructure for source segregation, collection, transportation, and processing of waste materials.

Foster Public-Private Partnerships for Sustainable Resource Management: Encourage joint efforts between public and private sectors to develop sustainable waste management and resource recovery projects.

IV. Conclusion:

This study examines the role of the circular economy in advancing sustainability and analyses the major government initiatives undertaken in India to facilitate this transition. The paper further evaluates the benefits, challenges, and future opportunities associated with implementing circular economy practices, highlighting their importance in achieving sustainable and inclusive economic growth.

Government schemes and programs play a significant role in promoting the circular economy in India. These initiatives encourage the efficient use of resources, waste reduction, recycling, reuse, and sustainable production practices. By fostering responsible consumption and production patterns, these schemes help protect the environment and preserve ecosystems. Furthermore, they strengthen resource efficiency, support sustainable supply chains, and contribute to economic growth while minimizing environmental degradation. Collectively, these government efforts facilitate the transition towards a circular economy, ultimately leading to sustainable national development and improved environmental sustainability.

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