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ENHANCING SUSTAINABILITY: CIRCULAR ECONOMY PRACTICES TO REDUCE SUPPLY CHAIN WASTE IN DAR ES SALAAM'S FOOD AND BEVERAGE INDUSTRY

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Abstract

This study explores the potential of circular economy (CE) practices to enhance sustainability and reduce supply chain waste in Tanzania's manufacturing sector, with a focus on the food and beverage industry in Dar es Salaam. Using a mixed-methods approach that combines qualitative insights from key stakeholders and quantitative data on waste generation and recycling rates, the study identifies both opportunities and barriers to CE adoption. While awareness of CE remains low, industries such as food and beverage, textiles, and chemicals show substantial potential for improvement. However, challenges including inadequate infrastructure, outdated technology, and weak regulatory support hinder progress. The study recommends strengthening regulatory frameworks through extended producer responsibility (EPR) and tax incentives, as well as investing in recycling infrastructure, biogas production, and industrial symbiosis hubs. Cross-sector collaborations, pilot projects, and knowledge-sharing platforms are also essential for driving innovation and scaling up CE adoption. Public awareness campaigns and capacity-building initiatives are crucial for reshaping attitudes toward waste management. By addressing these challenges, Tanzania can align its manufacturing sector with global sustainability goals and position itself as a leader in circular industrial development.

Keywords: Circular Economy, Waste Reduction, Sustainable Supply Chains, Recycling, Manufacturing



INTRODUCTION

The global emphasis on sustainability has elevated the circular economy (CE) as a pivotal strategy to combat waste and enhance resource efficiency throughout supply chains (Carissimi *et al.*, 2024). Contrasting the traditional linear model of "take, make, dispose," CE advocates for the continuous utilization of resources by implementing practices such as recycling, remanufacturing, and waste reduction " (Rajkovic *et al.*, 2020; Oduniyi, 2022). This paradigm shift is vital for diminishing environmental impacts and bolstering long-term economic resilience and industrial competitiveness (Milhem *et al.*, 2024). By focusing on reusing, recycling, and minimizing waste, CE offers a sustainable alternative to the linear economy, aiming to reduce ecological footprints while improving economic outcomes (Kirchherr *et al.*, 2017).

The CE has been considered as a solution for harmonizing ambition for economic growth and environmental protection for developed and developing countries (Lieder and Rashid 2016). Experience from European countries shows that, circular economy principles have been integrated into national policies and industrial practices, resulting in significant progress in waste reduction and resource efficiency (Nelles *et al.*, 2016; Stahel, 2016). For instance, in Germany, the Packaging Act mandates producers to manage the lifecycle of their products, leading to recycling rates exceeding 70% (Ogunmakinde, 2019; Lah, 2016). Similarly, the Netherlands has adopted a national CE strategy aimed at becoming fully circular by 2050, supported by public-private partnerships and innovation hubs (Bittner *et al.*, 2024; Van Leeuwen *et al.*, 2018).

Similarly, in China, they have enacted the Circular Economy Law in 2008, and policies that govern the circular economy value chain from design, manufacturing, consumption, and waste treatment (McDowall *et al.*, 2017). This enhance the approach of reducing, reusing, and recycle activities conducted in the process of production, circulation, and consumption (Liu *et al.*, 2017). Yet, It has been noted that, eco-design and product lifecycle management have enabled industries to achieve economic and environmental benefits (Pesce *et al.*, 2020; Yuan *et al.*, 2006). Study by Hasgafvel and Sakaguchi (2021) indicated that, the Japanese government have introduced several approached to promote CE such as education for awareness raising, public collaboration, recycling laboratories, and design for repair, reuse, and recycling. These examples illustrate the global momentum towards circularity, supported by robust policies, technological innovations, and cultural shifts.

The adoption of the circular economy (CE) in Africa is still in its early stages but is gaining momentum, particularly in the realm of sustainable waste management (Nijman-Ross *et al.*, 2023; Babbit *et al.*, 2021). Debrah *et al.* (2022) highlight that while CE practices are emerging, many regions continue to rely on traditional linear models of waste management,

which involve the "take, make, dispose" approach. This linear system, coupled with limited recycling efforts, poses significant challenges to sustainable economic growth and environmental preservation (Neves and Marques, 2022; Pesce *et al.*, 2020). Research indicates a pressing need to transition from these linear models to circular systems that emphasize resource efficiency, waste reduction, and the continual use of materials (Debrah *et al.*, 2022; Boon *et al.*, 2020).

In East Africa, countries like Kenya and Rwanda are making strides toward circular waste management (Garces-Ayerbe *et al.*, 2019). These countries have introduced the Kenya's Sustainable Waste Management Act (2022) and Rwanda's "Waste to Energy" initiatives exemplify efforts to integrate CE principles into national policies and practices (Muriithu and Ngare, 2023; Ogotu *et al.*, 2023). These initiatives aim to reduce environmental impact, create green jobs, and foster sustainable economic growth (Sangwa *et al.*, 2023).

Moreover, the adoption of CE practices in developing economies, such as Tanzania is inevitable as waste generation in Tanzania keeps on increasing. Experience from Dar es Salaam city shows that, waste generation will be 4200 tons per day by 2025, this is due to rapid urbanization, population growth, industrialization, and socio-economic activities which pose environmental concerns (NBS, 2017; Kaza *et al.*, 2018). However, Tanzania's manufacturing sector especially the food and beverage, textile, chemical, and plastics industries faces significant barriers to implementing CE (Msuya & Kinabo, 2021). These include insufficient infrastructure, outdated technologies, limited awareness of circular principles, and weak regulatory frameworks. For example, despite being major contributors to waste, the food and beverage sector lacks facilities for recycling or biogas production; similarly, textiles suffer from inadequate systems to repurpose fabric offcuts, while the chemical and plastics industries contend with low recycling rates and limited processing capacity (Msuya & Kinabo, 2021).

Despite these challenges, the potential for economic and environmental benefits in Tanzania's manufacturing sector is substantial. The sector contributes significantly to the national GDP and employs a large workforce, making it a key area for intervention (Rweyendela & Kombe, 2021). Adopting CE practices could transform the sector by fostering resource efficiency, reducing costs, and mitigating environmental degradation. For instance, practices such as industrial symbiosis where waste from one industry becomes a resource for another have the potential to create economic value while reducing waste streams. Lessons from neighboring countries, such as South Africa's success in implementing public-private partnerships for waste management (Nkala & Mbohwa, 2020), highlight the feasibility of tailored CE strategies in addressing these challenges.

Recent research confirms growing awareness of CE principles in Tanzania, albeit with persistent obstacles. Ezeudu et al., (2022) report that while recycling and remanufacturing are increasingly recognized, major hurdles remain, including technical skill shortages and insufficient policy support. Msuya and Kinabo (2021) similarly emphasize the promise of industrial symbiosis, yet note that practical uptake remains limited. The food and beverage, textile, chemical, and plastics sectors continue to generate substantial waste with minimal recycling infrastructure or supportive policy, especially regarding organic waste and biogas.

In the context of supply chains, CE encourages closed-loop systems that prioritize the efficient use of materials and energy, leading to both environmental and economic benefits. In manufacturing, CE practices such as remanufacturing, material recovery, and industrial symbiosis have gained prominence for their potential to reduce supply chain waste (Lieder & Rashid, 2016). Remanufacturing involves restoring used products to a "like-new" condition, while industrial symbiosis promotes collaboration among industries to use one company's waste as another's resource. These practices are particularly relevant for developing economies like Tanzania, where resource constraints necessitate innovative approaches to waste reduction (Nkala & Mbohwa, 2020).

Recent studies have explored the potential for CE adoption in Tanzania's manufacturing sector. For instance, Ezeudu et al. (2022) found that while there is growing awareness of CE principles, the lack of technical expertise and supportive policies remains a significant barrier. Similarly, research by Msuya and Kinabo (2021) highlighted the potential of industrial symbiosis in fostering collaboration among manufacturers to reduce waste and optimize resource use.

In Tanzania, however, regulatory frameworks supporting CE are still in their nascent stages. The National Environmental Management Council (NEMC) has initiated efforts to promote waste management and recycling, but these initiatives lack the comprehensive scope needed to drive systemic change (Msuya & Kinabo, 2021). Strengthening policies to include mandatory recycling, tax incentives for green manufacturing, and public awareness campaigns could accelerate the adoption of CE practices.

A study by Aquilas et al. (2024) emphasizes the importance for manufacturing industries to incorporate Circular Economy principles into their operations. This integration aims to minimize packaging waste, thereby lessening environmental harm. Complementing this perspective, Mwansasu and Mwangike (2025) highlight that manufacturing firms can substantially mitigate their environmental footprint by embracing sustainable supply chain practices. These practices include adopting innovative packaging materials, offering clear disposal guidelines, and establishing efficient recycling systems. Such strategies not only contribute to

environmental conservation but also enhance operational efficiency and align with global sustainability goals.

Specifically, the food and beverage sector, one of the largest contributors to waste in Tanzania, generates substantial amounts of organic waste annually. However, limited recycling facilities and the absence of policies supporting biogas production have hindered progress. This study, therefore, seeks to examine the extent to which circular economy practices such as recycling, remanufacturing, and industrial symbiosis are applied in the food and beverage industry; To analyze the economic impact of CE practices on cost reduction, revenue generation, and resource efficiency in manufacturing operations; and to identify key challenges hindering the adoption of CE practices in Tanzania's food and beverage sector.

THEORETICAL FRAMEWORK

The study was guided by Resource Based View which was propounded by Barney in 1991. The theory argues that organizations can achieve a competitive advantage by utilizing unique, valuable, and inimitable resources (Barney, 1991). In the context of a circular economy (CE), waste materials, by-products, and remanufactured goods can be considered as strategic resources that offer economic and environmental benefits. For example, industrial symbiosis, a CE practice where the waste from one company becomes a resource for another, the theory demonstrates how firms can leverage by-products to create new revenue streams and reduce production costs. In Tanzania, industries in the food and beverage sector produce significant organic waste (250,000 tons annually), which can be converted into biogas or compost, adding value to waste materials while reducing environmental degradation. RBV theory, therefore, provides a lens for understanding how resource efficiency in supply chains can simultaneously reduce costs and support sustainability (Lieder & Rashid, 2016). RBV is particularly relevant to developing economies like Tanzania, where resource constraints require innovative solutions to maximize utility. Recycling and remanufacturing practices, such as converting plastic waste into usable raw materials, illustrate the practical application of RBV. By treating waste as a resource rather than a liability, organizations in Tanzania can reduce dependency on virgin materials, lower operational costs, and mitigate supply chain risks. This aligns with the study's findings on the economic benefits of CE practices, such as cost reductions of up to 25% through industrial symbiosis. Hence, RBV reinforces the argument that waste should be perceived as a strategic resource, unlocking opportunities for competitive advantage and sustainability.

METHODOLOGY

This study employed a mixed-methods research design, combining qualitative and quantitative approaches to ensure a comprehensive analysis of circular economy (CE) practices in Tanzania's manufacturing sector. The study was conducted in Dar es Salaam, the country's largest city and main industrial hub. This location was strategically selected due to its concentration of manufacturing activities, particularly in the food and beverage industry, which is known for generating significant amounts of organic waste and facing pressing sustainability challenges.

A convergent parallel mixed-methods design was adopted because it allows for the simultaneous collection and analysis of qualitative and quantitative data to gain both depth and breadth of understanding. Qualitative data provided insights into stakeholder experiences and perceptions, while quantitative data allowed for the analysis of waste generation patterns and recycling rates.

The study utilized purposive sampling to select 50 key participants actively involved in CE-related activities. The sample included manufacturers, policymakers, environmental NGOs, academic researchers, and recycling companies. These stakeholders were selected based on their experience and roles in influencing or implementing CE practices. Purposive sampling ensured that the insights collected were relevant and rich in context.

The qualitative data were collected through structured semi-structured interviews and focus group discussion. The semi-structured interviews were conducted with selected stakeholders to explore their experiences, challenges, and suggestions regarding CE practices. Moreover, the focus group discussions were conducted which enabled to shared dialogue among stakeholders from different sectors to uncover collective perspectives on waste management and CE barriers. Quantitative data were obtained from government reports, industry databases, and environmental assessments to analyze waste generation levels and recycling efficiencies across different manufacturing sectors.

Qualitative data from interviews and FGDs were analyzed using thematic analysis. This involved coding, categorizing, and interpreting responses to identify recurring themes such as infrastructure challenges, awareness levels, and financial barriers. Quantitative data were processed using descriptive statistics, including frequency distributions, percentages, and visual tools such as charts and tables. These were used to summarize waste generation volumes, recycling rates, and the economic impact of CE practices. The triangulation of findings from both qualitative and quantitative sources strengthened the validity and reliability of the study results by providing multiple perspectives on the same issues. Yet, all participants were informed about the purpose of the study and provided informed consent before participation. Confidentiality and

anonymity were maintained throughout the research process. Ethical approval was sought from relevant institutional bodies prior to data collection.

FINDINGS AND DISCUSSION

Waste Generation And Recycline Rate By Manufacturing Industries

The study aimed to assess the current status of waste generation and recycling rates in Tanzanian manufacturing industries, including the food and beverage, textile and apparel, chemical and plastics, metal and machinery, and paper and packaging sectors. The findings are summarized in Table 1.

Table 1. Waste Generation and Recycling Rates by Manufacturing Industries

Sector	Annual Waste Generated (tons)	Recycling Rate (%)	Major Waste Type
Food and Beverage	250,000	35	Organic
Textile and Apparel	150,000	22	Fabric Offcuts
Chemical and Plastics	200,000	18	Plastic and Chemical Waste
Metal and Machinery	100,000	45	Metal Scraps
Paper and Packaging	80,000	50	Cardboard and Paper

The findings in Table 1 highlights the waste generation and recycling rates across key manufacturing sectors in Tanzania, providing a snapshot of the magnitude of waste management challenges and opportunities for circular economy (CE) interventions. The food and beverage sector emerges as the largest waste generator, producing 250,000 tons of waste annually, predominantly organic in nature. Despite this, its recycling rate stands at 35%, which is moderately low considering the potential for organic waste to be converted into compost or energy through biogas systems. This finding indicates an untapped opportunity for targeted recycling initiatives to improve waste management and resource efficiency in this sector.

The chemical and plastics sector, which generates approximately 200,000 tons of waste annually, has the lowest recycling rate at 18%. This is particularly concerning given the long-lasting environmental impacts of chemical and plastic waste, which can persist for decades if not properly managed. In contrast, the paper and packaging sector demonstrates the highest recycling efficiency, achieving a 50% recycling rate largely due to well-established systems for processing cardboard and paper products. Meanwhile, sectors such as textile and apparel (22% recycling rate) and metal and machinery (45% recycling rate) continue to struggle with recycling efficiency. These challenges highlight the urgent need for technological innovation, stronger

policy frameworks, and increased public awareness to promote circularity across all manufacturing industries.

Economic Impact of Circular Economy Practices

The findings of this study underscore the transformative potential of circular economy (CE) practices in addressing the challenges of supply chain waste in Tanzania's manufacturing sector. By integrating both qualitative and quantitative analyses, the research offers a comprehensive understanding of the current state of CE adoption, the barriers hindering its implementation, and the opportunities it presents. The findings from the study revealed that reduced waste disposal cost, lower raw material procurement costs, and revenue generation from selling byproducts to other firms were the economic impact of circular economy.

Table 2. Economic Impact of CE Practices

CE Practice	Cost Reduction (%)	Revenue Increase (%)	Indicators
Recycling	15	10	Reduced waste disposal costs
Remanufacturing	20	12	Lower raw material procurement costs
Industrial Symbiosis	25	18	Revenue from selling byproducts to other firms

Findings in Table 2 illustrate the economic impact of circular economy (CE) practices on manufacturing operations, highlighting their potential for cost savings and revenue generation. Among the three CE practices analyzed, industrial symbiosis offers the most substantial economic benefits, reducing costs by 25% and increasing revenue by 18%. This has been achieved through the efficient utilization of byproducts and waste materials shared among companies, fostering collaboration and minimizing resource wastage. The study findings are supported by Nkala and Mbohwa, (2020) which demonstrates the economic benefits of waste exchange, with companies reusing byproducts to lower raw material costs and increase profitability. These examples reinforce the potential of industrial symbiosis as a viable strategy for the Tanzanian manufacturing sector.

Furthermore, recycling reduces costs by 15% and increases revenue by 10% by lowering waste disposal expenses and incorporating recycled materials back into production processes. The study highlights that the recycling rate in the Tanzanian food and beverage sector is only 35%, indicating significant untapped potential for waste reduction. Empirical

evidence from China supports the importance of enhancing recycling rates. In regions like Beijing, investments in advanced recycling technologies and public awareness campaigns have increased recycling rates to over 60%, reducing landfill waste and generating revenue from recycled materials (Lakhout, 2025).

Similarly, remanufacturing, on the other hand, achieves a 20% cost reduction by decreasing the reliance on procurement of raw material, while boosting revenue by 12% through the sale of restored products. These findings demonstrate that CE practices are not only environmentally beneficial but also economically advantageous, making them attractive for manufacturers seeking to improve profitability while contributing to sustainability goals. The study findings are supported by Agarwal et al. (2018) who found that community-level biogas plants have converted food waste into energy, reducing waste by 40% while providing affordable fuel for households and businesses

Challenges of Circular Economy Adoption in Tanzania

The study findings from the qualitative data revealed that despite of the benefits of CE practices are well-documented, several challenges hinder their adoption in Tanzania. These include limited awareness of CE principles, inadequate infrastructure for waste management, and a lack of financial incentives for manufacturers.

Limited Awareness of Circular Economy Practices

The qualitative findings revealed that, awareness of circular economy (CE) principles among stakeholders in Tanzania's manufacturing sector remains low, creating a major obstacle to adoption. Among the stakeholders interviewed, only 40% were familiar with fundamental CE concepts such as recycling, remanufacturing, and industrial symbiosis. This gap underscores the need for targeted educational programs to help businesses recognize the benefits of CE practices. One key informant was quoted saying that *"I've heard of recycling, but not remanufacturing or industrial symbiosis. We are not trained to see waste as a business opportunity"*. FGDs confirmed this observation. Participants emphasized that lack of training and education remains a key constraint, and that CE is rarely included in company strategies or government industrial outreach programs. The findings reflects the broader lack of organized waste management practices within the sector. The study findings are also in-line with the study by Msuya and Kinabo (2021) that cultural attitudes toward waste and recycling can pose challenges, as many communities in Tanzania lack awareness of the environmental and economic benefits of circularity.

Inadequate Infrastructure for Waste Management

The findings revealed a significant lack of infrastructure for effective waste management. Many manufacturers in Tanzania rely on outdated machinery and have limited access to advanced technologies necessary for processes such as recycling and remanufacturing. A manufacturer in the food and beverage sector noted, *“We lack the technology to process organic waste effectively. Exporting waste for recycling is expensive and not a viable option for most businesses”*. A participant in the FGD stated: *“We want to recycle organic waste, but there are no local plants that accept food waste. Sending it to landfills is cheaper, even though it's wasteful”*.

In addition to technical barriers, cultural attitudes toward waste further hinder progress. Waste is often perceived as a nuisance to be discarded rather than a resource with economic value. As one focus group participant observed, *“Changing the mindset of people is difficult many see waste as something to throw away, not something that can generate value”*. Addressing these challenges calls for a comprehensive approach involving investment in modern infrastructure, technological upgrades, supportive policy reforms, and public education to shift cultural perceptions around waste. Study by Ezeudu et al. (2022) argue that investing in modern technologies and providing technical training for workers could address these issues and facilitate the transition to CE practices.

Lack of Financial Incentives for Manufacturers

The study findings furthermore revealed that one of the key barriers to adopting circular economy (CE) practices in Tanzania's food and beverage industry is the lack of financial incentives for manufacturers. Transitioning to CE requires significant investment in new technologies, infrastructure, and operational adjustments, yet many businesses struggle to justify these costs without tangible financial benefits. Implementing CE strategies such as waste recycling, energy recovery, and sustainable packaging often requires purchasing specialized equipment and upgrading production processes. However, most small and medium-sized enterprises (SMEs) in the food and beverage sector operate on tight budgets and lack access to affordable financing options.

One of the key informants quoted saying that *“If there were loans or grants for green investments, we'd buy composting machines or biogas systems. But banks see it as high-risk”*. This indicates that lack of subsidies, tax incentives, or low-interest loans, many manufacturers find it financially unfeasible to transition to CE models. It was also noted that, although green financing options, such as sustainability-linked loans and grants, exist in other regions, they are scarce in Tanzania. Financial institutions often perceive CE investments as risky due to the

uncertainty of returns and the long payback periods. As a result, manufacturers have limited access to funding that could support the adoption of sustainable production methods, such as converting food waste into biogas or using biodegradable packaging.

Results Implications

The study's findings have significant implications for policy and practice, supporting both Tanzania's national development goals and its commitment to the UN Sustainable Development Goals (SDGs). It highlights the potential of circular economy (CE) practices such as recycling, remanufacturing, and industrial symbiosis in the food and beverage manufacturing sector to reduce waste and promote sustainable production, aligning with SDG 12. The study also identifies low recycling rates, particularly in the food and chemical sectors, emphasizing the need to shift from linear to circular models. Additionally, biogas is recognized as a viable solution for managing organic waste, supporting SDG 7 by offering a clean, renewable energy source that reduces pollution. These findings also align with Tanzania Development Vision 2025, which aims to achieve a semi-industrialized, middle-income economy through sustainable practices, as well as the National Environment Policy of 2021, which prioritizes waste management, pollution control, and green technology.

CONCLUDING REMARKS

Conclusion

This study highlights the transformative potential of circular economy (CE) practices in reducing supply chain waste and fostering sustainability in Tanzania's manufacturing sector. Despite limited awareness of CE principles, the sector presents significant opportunities for improvement, particularly in high-waste industries like food and beverage, textiles, and chemicals. However, inadequate infrastructure, outdated technology, and a lack of financial incentives for manufacturers hinder widespread adoption. The high initial costs of CE implementation, limited access to green financing, and the absence of government subsidies or tax breaks discourage businesses from investing in sustainable practices.

Recommendations

Overcoming these financial and structural barriers is essential for unlocking the economic and environmental benefits of circularity. To support CE implementation, policymakers should develop robust regulatory frameworks, including extended producer responsibility (EPR) schemes and tax incentives for green manufacturing. Additionally, targeted financial mechanisms such as low-interest loans, grants, and subsidies are crucial to help

manufacturers offset the costs of adopting sustainable technologies. Investments in modern recycling facilities and biogas plants are particularly needed in high-waste sectors like food and beverage, where organic waste could be converted into renewable energy. Collaborations with international organizations can facilitate technology transfer and capacity-building efforts to equip stakeholders with the necessary skills and tools. Industry leaders must also promote partnerships across sectors to foster industrial symbiosis and optimize resource utilization. It is also recommended that, establishing pilot projects in priority sectors can demonstrate CE's economic and environmental advantages, creating scalable models for broader adoption. Furthermore, knowledge-sharing platforms between industries, policymakers, and academia can drive innovation and accelerate CE adoption. Public awareness campaigns should play a central role in shifting cultural attitudes towards waste through educational initiatives that emphasize CE's role in economic competitiveness and environmental sustainability.

Limitations

While this study provides important insights into the application of circular economy (CE) practices in reducing supply chain waste within Tanzania's food and beverage industry, it is not without limitations. One major limitation lies in the geographical scope of the research. The study was conducted exclusively in Dar es Salaam, which, although it is the country's largest industrial hub, may not accurately represent other regions of Tanzania, particularly rural or less industrialized areas. Consequently, the findings may not be fully generalizable across the diverse economic and infrastructural landscapes present throughout the country. Another limitation pertains to the narrow sectoral focus. Although the food and beverage industry is one of the primary contributors to industrial waste, this focus excluded other relevant sectors such as construction, electronics, automotive, and healthcare manufacturing. These sectors may have distinct waste streams, infrastructure needs, and circular economy opportunities that warrant independent investigation. Therefore, the current findings provide only a partial view of the broader manufacturing landscape in Tanzania.

Areas for Future Research

Based on these limitations, two key areas for future research are recommended. One, future studies should research is to explore the role of small community groups and informal waste collectors in promoting recycling and waste reduction. Two, further research should also explore sustainable financing options, such as green loans or public-private partnerships, to support CE investments, especially for small and medium-sized enterprises that often lack access to capital.

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