Circularity Letters, Volume 2, Number 2 (2025) 1 – 7

Circularity Letters

journal homepage: www.circularityletters.circularitypublications.org

Circularity in Plastic Food Packaging - Principles, Problems and Prospects

[*]Abdullahi, A.A., Abolarin, M.S.
Department of Mechanical Engineering, Federal University of Technology, Minna, Nigeria.
***[*]Corresponding Author's Email:** aliuaabdullah@futminna.edu.ng*

Abstract

Plastic packaging of food covers single-use and re-use (multiple-use) categories. The single-use plastics are the most problematic to the environment and human/animal health. Furthermore, the beverage and personal care bottles/sachets, dry and wet food plastic packages influenced wastes and losses in food processing and supply chain. The Circular Economy (CE) has gained acceptance in operations and organisational management of firms as well as service organisations. Adopting or domesticating this technique, the CE framework(s) into organisational management, particularly in food packaging industry cannot be overemphasised. Therefore, this research review principles, problems and prospects of CE as it is applied to food packaging industry in African. The CE is developed based on three design driven principles, these are elimination/reduction of waste and pollution, extending shelf life of products and continuous use of materials, and restorative/regenerative industrial system that support environmental sustainability. Notable principles of CE developed include variants of "R" (3R, 7R and 9R) and other models/frameworks. The 9R (Reuse, Rethink, Repair, Recycle, Refuse, Remanufacture, Refurbish, Repurpose and Recover) and others include the Waste Hierarchy, Upcycle, Resources Efficiency, Closed Loop, Reverse Logistics, Industrial Symbiosis and Cradle-to-Cradle. Despite these principles adoption and implementation of CE in specific industry/organisation is hindered by number of issues and problems. In Africa some of these challenges include: recycling facility/technological deficit, wastes segregation and closed loop, reverse logistics, inadequate policy and public awareness, socio-economic factors and financial enablers as well as economy of African nations. Therefore, researchers, government and stakeholder are looking for suitable frameworks/strategies, regulations and policies. In addition, investments in CE driven projects and grant incentives, tax policies for firms/organisations will enhance sustainable development in African nations' economy. Therefore, continuous improvement of CE framework(s) for efficient food packaging and environmental sustainability is needed in our nations.

***Keywords**: Circular Economy, Environmental Sustainability, Food Packaging, Food Waste, and Product Design.*

Introduction

Packaging is an essential component across the food transportation supply chain. Various food packaging used include plastic, paper, cardboard, glass, aluminium, leaves and other agricultural products. Meanwhile, the single-use plastic products dominate in our societies. Unfortunately, most food packaging is designed as single-use and will end up in a landfill with little proportion given to reuse and recycling (Tanveer *et al*.,2023).

Plastics and plastic products have become the ubiquitous workhorse material of our societies combining unrivalled functional properties with low cost. The production and demand for plastic products has increased exponentially and is expected to double. Today nearly every home, everyone, everywhere, every day comes into contact with plastics especially plastic packaging. However, health threat, land and marine pollution are major problem of the plastic packaging that require urgent attention. Therefore, researchers, stakeholder and government are continuously looking for sustainable solutions through frameworks, policy and regulation.

It is predicted that in Nigeria, Egypt, South Africa, Morocco, Algeria, and Tunisia, the imports of plastics will double by 2030 (Babayemi, *et al.*, 2019). In the African context, implementing circularity in plastic food packaging is particularly relevant given the continent's rapid population growth, increasing urbanisation, and changing consumption patterns. The demand for packaged food products is projected to increase substantially. This growth presents both challenges and opportunities for establishing circular plastic packaging systems that can support sustainable development while addressing environmental concerns.

The transition toward circularity in plastic food packaging in Africa requires a comprehensive understanding of the principles, problems, and prospects associated with this approach. The aim of this review is to provide a critical and systematic analysis of these aspects, examining the current status of circular economy initiatives in plastic food packaging across Africa, identifying key challenges, and exploring potential opportunities for advancement.

Developments and challenges of circular economy for plastic food packaging

The concept of circular economy (CE) frameworks is developed based on three design driven principles, these are elimination/reduction of waste and pollution, extending shelf life of products and continuous use of materials, and restorative/regenerative industrial system that support environmental sustainability, this is illustrated in Figure 1.

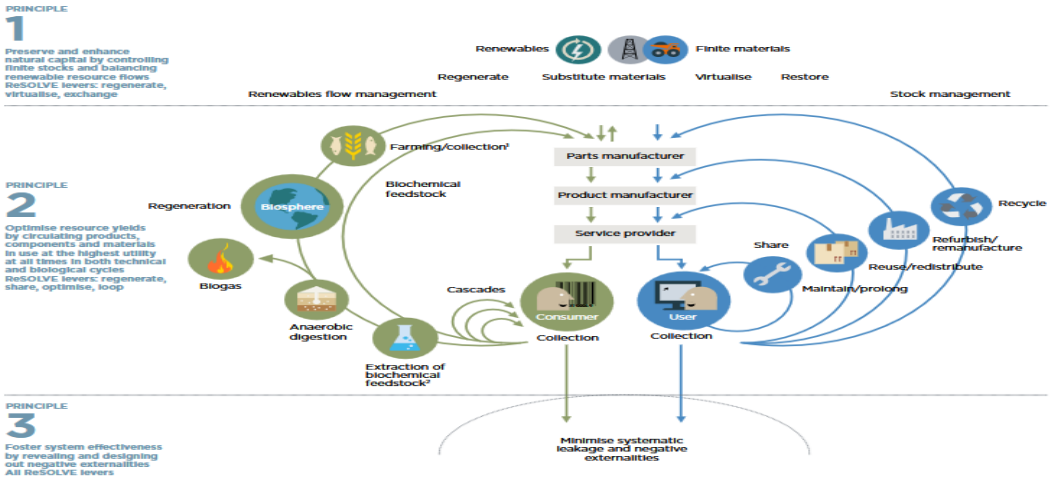

Figure 1: The concept of circular economy (Ellen Macarthur Foundation, 2017)

Suitable frameworks are developed for implementation of the CE in manufacturing and other fields. The notable principles of CE developed include variants of "R" (3R, 7R and 9R) and other models/frameworks. An illustrate of the 9R is shown in Figure 2. Others frameworks include the Waste Hierarchy, Upcycle, Resources Efficiency, Closed Loop, Reverse Logistics, Industrial Symbiosis and Cradle-to-Cradle (Awino and Apitz, 2022).

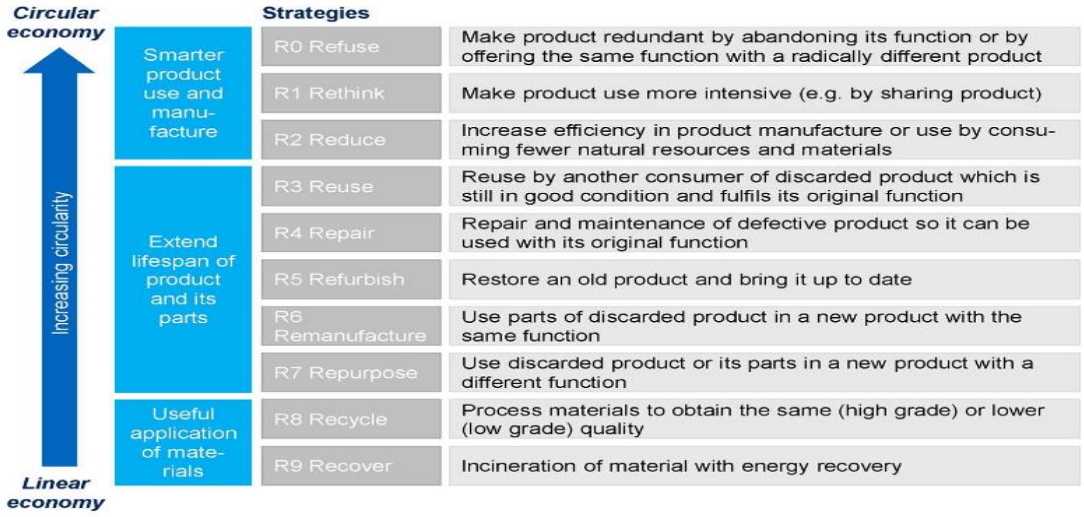

Figure 2: The 9R framework (Potting *et al*., 2017)

The CE concept represents a fundamental shift from traditional linear "take-make-dispose" model toward more sustainable approaches that minimise resource inputs and waste generation. This paradigm has emerged in response to the accelerating global consumption of goods and the resulting over-exploitation of natural resources, promoting more responsible production and consumption patterns (Kristensen *et al*., 2021). When applied to plastic food packaging, circular economy principles focus on reduction, reuse, recycling, and recovery of materials throughout the production, distribution, and consumption processes.

Implementation of circular economy principles offers potential co-benefits beyond waste reduction, including mitigating climate change and increasing employment opportunities. However, the potential health implications of circular economy strategies for plastic packaging remain poorly understood (Deeney *et al*., 2022). While increased recycling and reuse could reduce environmental impacts associated with virgin plastic production and end-of-life incineration, there are also potential health risks related to occupational chemical exposure during recycling processes and consumer exposure to contaminants in recycled or reused plastics (Deeney *et al*., 2022).

Sustainable alternatives to single-use plastic food packaging in Africa

The search for sustainable alternatives to conventional plastic food packaging has gained significant momentum in Africa as the continent faces increasing waste management challenges. Biodegradable biopolymers have emerged as promising alternatives for single-use food packaging applications, offering potential environmental benefits compared to traditional petroleum-based plastics (Ncube *et al*., 2021). These alternative materials are particularly relevant in the African context, where affordable and eco-friendly packaging solutions are urgently needed to address growing waste management challenges.

The global bioplastics market, including biodegradable and compostable plastics, is expanding rapidly and is expected to reach approximately 2.6 million metric tons by 2023, contributing to reduced environmental impacts from packaging (Zambujal-Oliveira and Fernandes, 2024). This growth presents opportunities for African countries to adopt these innovative materials as part of circular economy strategies for food packaging. However, the current recycling rate for plastic packaging remains low, with only 14% of plastic packaging used globally across diverse supply chains being collected for recycling (Zambujal-Oliveira and Fernandes, 2024). Increasing this recycling rate is essential for achieving complete circularity of packaging materials.

The development of affordable alternatives to conventional plastics requires thorough investigation to identify viable solutions for the African context (Ncube *et al.*, 2021). This research need is particularly pressing as Africa is projected to become the largest consumer of food packaging plastic materials in the coming decades (Ncube *et al*., 2021). Meeting this growing demand through circular and sustainable packaging innovations could help prevent significant environmental degradation while supporting economic development. Meanwhile, various sustainable food packaging materials include paper and cardboard, glass, metal, plastic, biopolymers, antimicrobial polymers, corn starch and popcorn, and packaging made from agricultural wastes which include mushrooms and waste avocado seeds (Thapliyal *et al*., 2024).

Policies to reduce single-use plastic pollution

Policies and financial investments/aid were identified as enabler to CE. Oyinlola (2022) report that to combat pollution by plastic waste in our environment there is need by governments / policymakers across Africa continent to act on plastic pollution, resulting in several promising policies and regulations initiatives that promote the circularity of plastics and plastic products. However, there are significant challenges associated with national and cross-border coordination and local implementation of the policies. The current regulatory landscape across the continent requires further improvement to become an enabler for the transition to a circular plastics economy (Schr¨oder *et al*., 2023). An extensive review of the policies and regulations by the governments of west African nations can be found in (Adam *et al*., 2020).

Prospects of circularity in plastic food packaging in Africa

The African Circular Economy Alliance has identified the African Free Trade Agreement as a potential tool for promoting circularity in plastics management, particularly through the harmonization of regulations and standards for plastics recycling (Kristensen *et al*., 2021). Such harmonization could address the concerns raised by private recyclers in Nigeria regarding the need for standardised approaches to recovered plastics, creating more favourable conditions for circular economy initiatives across the continent. In addition, (Schr¨oder *et al*, 2023) identify four key elements to hence circularity of plastics in Africa, the interactions of these elements are shown in Figure 3.

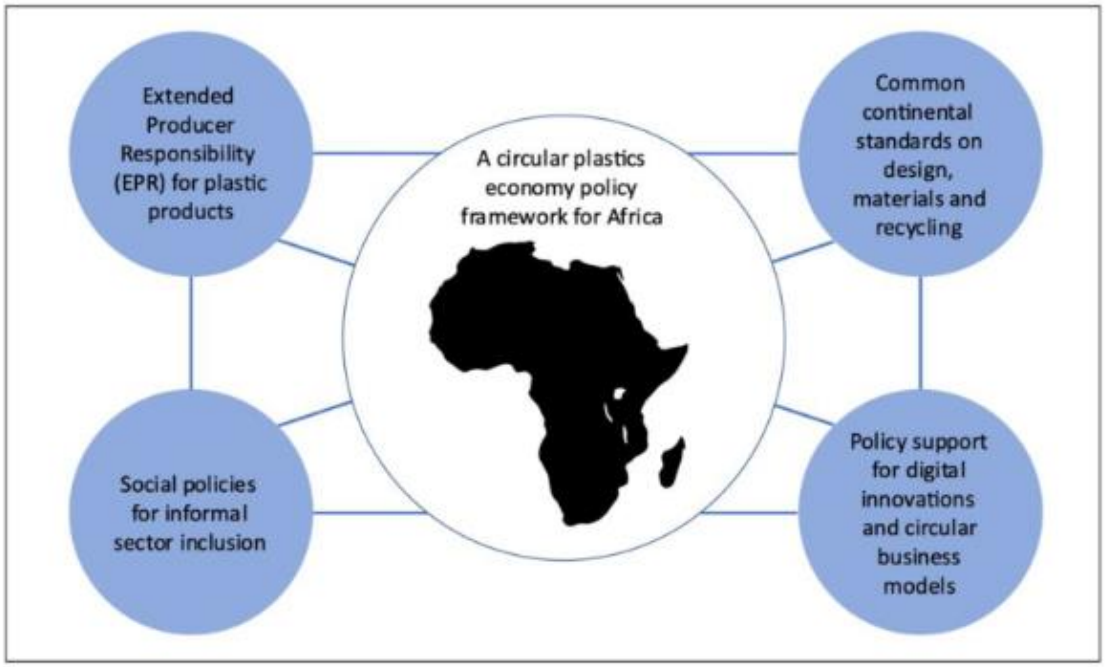

Figure 3: Four key elements to aid effective implementation of circularity in plastics through policy (Schr¨oder *et al*, 2023)

Furthermore, Dey *et al*., (2021) review challenges and solution of single-use plastics used in food packaging and provide a roadmap shown in Figure 4.

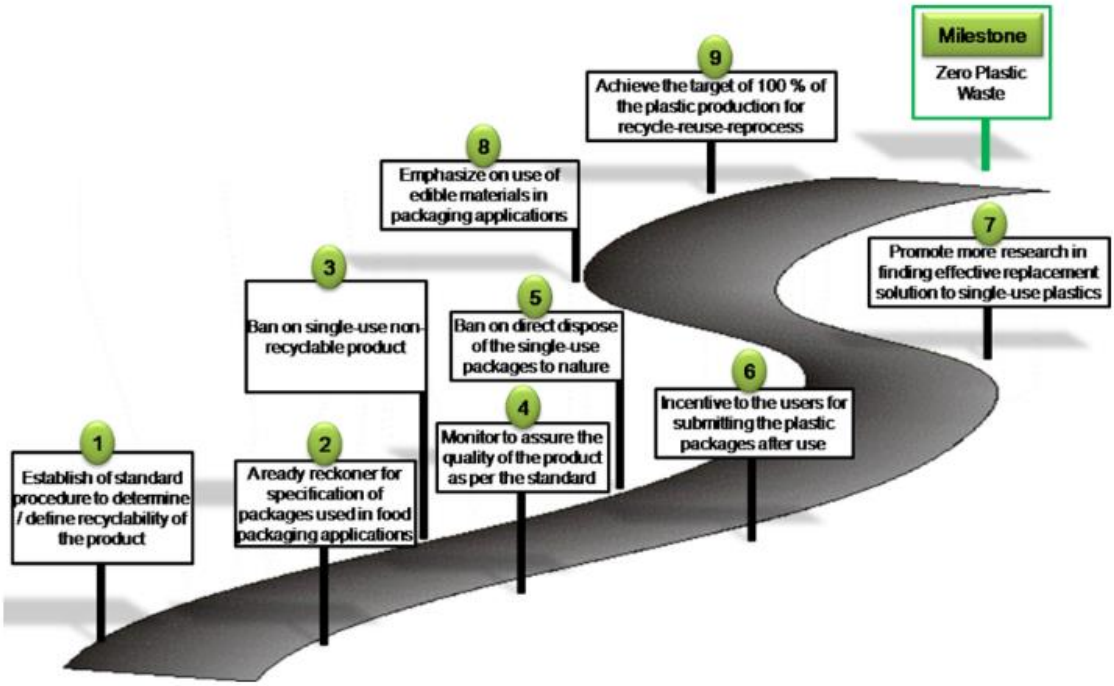

Figure 4: Road map showing steps to tackle plastic waste problem (Dey *et al*., 2021)

With a growing global urgency to put measures in place to curb plastic pollution, the time is now for African governments to participate in shaping global action, strengthen regional coordination and boost the national ambition (Sadan and De Kock, 2021).

Future Research Directions

Investigations on circularity of plastics and plastic products in African towards research fields outline as follows:

(i) zero waste strategies
(ii) development of sustainable packaging
(iii) policies and regulations in sustainable packaging
(iv) influence of recycle plastic packaging on quality of food.

Conclusions

The following conclusions are drawn:

(i) The principle of Circularity in food packaging tends to archive zero-waste or "waste does not exist"
(ii) Problems of plastic food packaging include environmental pollution, greenhouse gases and food wastages.
(iii) Employment, market and improve per capital income.

References

Adam, I. Walker, T. R., Bezerra, J. C. & Clayton, A. (2020). Policies to reduce single-use plastic marine pollution in West Africa. *Marine Policy* 116 (3) 103928-103938.

Awino, F. B. & Apitz, S. E. (2022). Solid waste management in the context of the waste hierarchy and circular economy frameworks: An international critical review. *Integrated Environmental Assessment and Management*, 20(1), 9–35.

Babayemi, J. O., Nnorom, I. C., Osibanjo, O., & Weber, R. (2019) Ensuring sustainability in plastics use in Africa: consumption, waste generation, and projections, *Environ Sci Eur* 31(1), 1-20.

Dey, A., Dhumal, C.V., Sengupta, P., Kumar, A., Pramanik, N. K., & Alam, T. (2021). Challenges and possible solutions to mitigate the problems of single-use plastics used for packaging food items: a review. *Journal of food science and Technology*, 58(9), 321-3269.

Ellen MacArthur Foundation, (2017). The new plastics economy: rethinking the future of plastics. Accessed on Wednesday 9th April, 2024 from http://www.ellenmacarthurfoundation.org/publications

Kristensen, H. S, Mosgaard, M. A., & Remmen, A. (2021). Circular Public Procurement practices in Danish Municipalities, *Journal of Clean Production.* 281, 124962.

Deeney, M., Green, R., Yan, X., Dooley, C., Yates, J., H. Rolker, H. B., & Kadiyala, S. (2022). Human health effects of recycling and reusing plastic packaging in the food system: a systematic review and meta-analysis of life cycle assessments. *medRxiv,* 2022-04.

Ncube, L. K., Ude, A. U., Ogunmuyiwa, E. N., Zulkifli, R. & Beas, I. N. (2021). An Overview of Plastic Waste Generation and Management in Food Packaging Industries. *Recycling*, 6(1), 12.

Oyinlola, M., Kolade, O., Schröder, P., Odumuyiwa, V., Rawn, B., Wakunuma, K., Sharifi, S., Lendelvo, S., Akanmu, I., Mtonga, R., Tijani, B., Whitehead, T., Brighty, G., Abolfathi, S., (2022). A Socio-Technical Perspective on Transitioning to a Circular Plastic Economy in Africa. SSRN Electron. J. https://doi.org/10.2139/ssrn.4332904

Potting, J., Hekkert, M. P., Worrell, E., & Hanemaaijer, A. (2017). Circular economy: measuring innovation in the product chain. *Planbureau voor de Leefomgeving*, (2544). Accessed on Accessed on Wednesday 9th April, 2024 from http://www.pbl.nl/sites/default/files/cms/publicaties/pbl-2016-circular-economy-measuring-innovation-in-product-chains-2544.pdf.

Sadan, Z. and De Kock, L. (2021). Plastic Pollution in Africa: Identifying policy gaps and opportunities. WWF South Africa, Cape Town, South Africa.

Schr¨oder, P., Oyinlola, M., Barrie, J., Bonmwa Fwangkwal, B., & Abolfathi, S.(2023). Making Policy work for Africa's circular plastics economy. Resources, *Conservation & Recycling* 190 (2023) 106868.

Tanveer, U., Ishaq, S., & Oqueli, T. (2023). An Insight into the Application of Gradations of Circularity in the Food Packaging Industry: A Systematic Literature Review and a Multiple Case Study. *Sustainability*, 15(4), 3007. https://doi.org/10.3390/su15043007

Thapliyal, D., Karale, M., Diwan, V., Kumra, S., Arya, R. K., Verros, G. D. (2024). Current Status of Sustainable Food Packaging Regulations: Global Perspective. *Sustainability* 2024, 16, 5554. https://doi.org/10.3390/su16135554

Zambujal-Oliveira, J. & Fernandes, C. (2024). The Contribution of Sustainable Packaging to the Circular Food Supply Chain. *Packaging technology & science,* 37(5), 443-456.