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Sustainable Resource Management and Environmental Protection: A Review of Strategic Pathways for a Circular Economy in Nigeria.

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Abstract

Nigeria's rich natural resources coexist with critical challenges such as inefficient resource use, rising waste generation, pollution, and weak recovery systems. Circular economy models provide a strategic alternative to the country's largely linear resource system. This article identifies pathways for transitioning Nigeria toward a circular economy through institutional reinforcement, cleaner production, waste-valorization, and inclusive resource governance. The study synthesizes circular economy principles with national sector insights, emphasizing bio-waste loops, materials recovery, and policy instruments tailored to Nigeria's socio-economic and environmental context. High-value circular opportunities exist in agriculture (organic waste to energy and compost), plastics, construction materials, e-waste urban mining, and water/wastewater recycling. Critical enablers include regulatory strengthening under the Federal Ministry of Environment, standards enforcement via National Environmental Standards and Regulations Enforcement Agency, renewable-energy catalysis through the Rural Electrification Agency, and sustainable building alignment with Sustainable Development Goals. Circular transition enhances resource security, reduces pollution, incubates green SMEs, creates jobs for youth and women, and strengthens community resilience and environmental health. Delivering circular outcomes demands policy harmonization, phased investment in recycling/value-addition infrastructure, improved data systems, and mass public awareness to embed circular resource behavior.

Keywords: *Circular economy; sustainable resource management; environmental protection; waste-to-wealth; Nigeria.*

1. 0 Introduction

1.1 Background to the Paper

Growing global material consumption and climate pressures have exposed the limitations of linear economic systems, leading to increased advocacy for circular resource loops that prioritize reuse, recovery, and ecological regeneration (Kirchherr, Reike, & Hekkert, 2017; Ghisellini, Cialani, & Ulgiati, 2016). The Circular Economy offers solutions to resource insecurity affecting energy, water, arable land, metals, and industrial feedstock shortages (Ellen MacArthur Foundation, 2015). The drive for carbon neutrality, resource efficiency, and sustainable production has gained policy traction across regions facing extraction-induced ecological stress (UNFCCC, 2015; World Bank, 2021).

Nigeria has substantial natural and industrial resource potential but faces persistent inefficiencies in extraction-to-use systems, limited recycling infrastructure, and under-developed industrial symbiosis networks (Ogunmakinde, 2019; Nwosu, 2020). Biomass residues from oil-palm, crop production, and sawmills remain largely unprocessed, worsening environmental stress while limiting cleaner energy alternatives (Ike et al., 2021). These realities motivate national circular pathways for improved resource security, economic diversification, and pollution reduction.

1.2 Problem Statement and Research Gap

While circular pathways have advanced in many emerging economies, Nigeria lacks sufficient integrative synthesis connecting sectoral circular loops to institutional enforcement, pollution metrics, community-inclusive governance, and economic instruments for scaled adoption (Nwosu, 2020). Existing studies remain sector-isolated, documentation-sparse, and under-scaled (Ike et al., 2021). This gap constrains national planning for actionable circular industrial ecosystems. The aim of this paper is to synthesize strategic pathways for circular resource transition in Nigeria anchored on sustainability, pollution reduction, and institutional accountability. The Objectives are to:

(i) examine Nigeria's resource-use challenges,
(ii) map sectoral circular opportunities,
(iii) review institutional and policy imperatives, and
(iv) provide strategic scaling priorities for circular adoption.

The article reviews material and energy loops across agriculture, plastics, construction, and water systems within Nigeria's institutional, economic, and ecological context.

1.3 Significance of the Paper: Policy, Economy, Environment and Public Health

Policy relevance includes strengthening regulatory accountability under national environmental governance systems (Ogunmakinde, 2019). Economic significance lies in supporting SME emergence, local raw-material cycles, renewable bio-energy alternatives, and industrial symbiosis clusters (Ellen MacArthur Foundation, 2015; Ike et al., 2021). Environmental value arises from reduced emissions, waste elimination, and soil–water system restoration (Ghisellini et al., 2016). Public-health importance includes mitigating airborne toxins, open-burning exposure, and pollution-linked disease burdens impacting community well-being and life expectancy (Oladejo, Adetunji, & Olasunkanmi, 2021).

2.0 Conceptual & Theoretical Framework

2.1 Definition of Circular Economy and its Principles

The Circular Economy (CE) is an economic system that replaces the linear "take–make–dispose" model with a closed-loop approach that prioritizes waste elimination, material recovery, and natural-system regeneration (Kirchherr, Reike, & Hekkert, 2017). Its guiding principles include: (i) designing out waste and pollution, (ii) keeping materials/products in continuous use cycles,

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and (iii) regenerating ecological systems (Ellen MacArthur Foundation, 2015; Ghisellini, Cialani, & Ulgiati, 2016). CE adoption supports resource security and low-carbon development, particularly in economies with increasing extraction-induced ecological stress (UNFCCC, 2015).

2.2 Resource Management Models

DPSIR Framework: The Drivers–Pressures–State–Impact–Response model explains the causal chains between socio-economic drivers (e.g., demography, markets), resulting environmental pressures (e.g., extraction, waste, emissions), ecological state changes, observed impacts, and policy/system responses required to restore thresholds (Smeets & Weterings, 1999; Kristensen, 2004).

Regenerative Design: Regenerative design models such as Cradle-to-Cradle (C2C) advocate product lifecycles where waste becomes input for new production cycles, differentiating technical and biological metabolism for pollution-free systems (McDonough & Braungart, 2002; Bocken et al., 2016).

Industrial Symbiosis: Circular resource exchange between industries, communities, and markets (industrial symbiosis) is rooted in Industrial Ecology, which promotes energy/material co-exchange systems that mimic natural ecosystem loops for secondary resource reintegration (Frosch & Gallopoulos, 1989; Boons & Howard-Grenville, 2009).

2.3 Key CE Pillars for Nigeria

Nigeria demonstrates circular potential in (i) biomass circularity (crop residues, palm fibre, kernel shells, empty fruit bunch to energy/compost), (ii) plastic circularity (collection, recycling, polymer reintegration), (iii) e-waste urban mining (recovery of rare/printed metals and second-life components), (iv) construction material loops (modular longevity, inert/ferrous recovery), and (v) water circularity (decentralized reuse and wastewater recovery) (Ike et al., 2021; Ogunmakinde, 2019; Nzeadibe & Ajaero, 2010). These CE pillars also align with sustainable manufacturing, secondary materials markets, and renewable decentralized resource loops (Nwosu, 2020; World Bank, 2021).

2.4 Integrated Conceptual Pathway

An integrated national circular transition pathway combines sectoral drivers with systemic responses:

Socio-economic drivers → Linear extraction and waste pressures → Ecological degradation state → Health/environmental impacts → Circular policy, design, enforcement, and industrial-symbiosis responses (Smeets & Weterings, 1999; Ellen MacArthur Foundation, 2015; Kirchherr et al., 2017; Ike et al., 2021). CE outcomes depend strongly on institutional accountability, cleaner production, community participation, renewable energy transitions, and industrial-cluster synergy that reintegrates wastes as feedstock for new production cycles (Ogunmakinde, 2019; Bocken et al., 2016).

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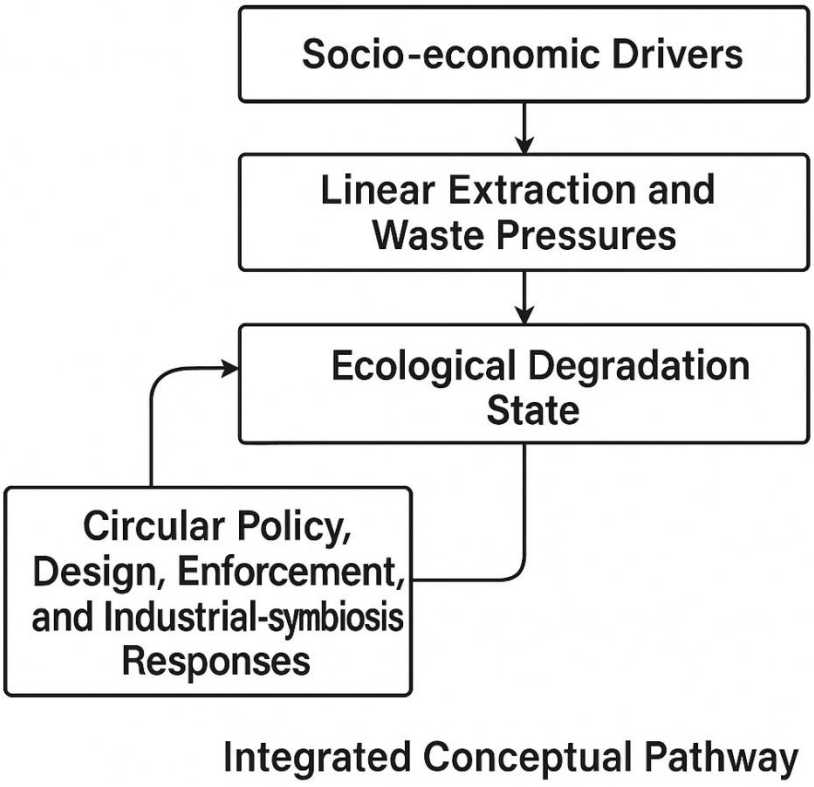


Figure 1: Integrated Conceptual Pathway

3.0 Literature Review

3.1 Global Transition from Linear to Circular Economy

The global transition from linear to circular economic systems represents one of the most fundamental shifts in sustainable development discourse over the last decade. Rising rates of raw material extraction, currently exceeding the planet's natural replenishment capacity; have heightened concerns about long-term resource security (UNEP, 2011; Ghisellini, Cialani, & Ulgiati, 2016). This has triggered a policy and industrial rethink, with circular economy (CE) models now promoted as strategic pathways to reduce extraction intensity, eliminate waste by design, and foster regenerative material cycles (Kirchherr, Reike, & Hekkert, 2017). The linear model, defined by a "take → make → use → dispose" flow, is increasingly unsustainable because it externalizes environmental costs into landfills, open burning emissions, and ecosystem degradation (Ellen MacArthur Foundation, 2015; Blomsma & Brennan, 2017).

Regional studies show that economies embracing circularity reduce dependency on virgin raw materials and unlock secondary resource loops through industrial symbiosis, product life extension, and recycling markets (Boons & Howard-Grenville, 2009; Lieder & Rashid, 2016). Europe, North America, and East Asia demonstrate that CE transitions succeed when supported by strong governance, harmonized regulations, and

investment-driven recycling infrastructure (Schröder, Anggraeni, & Weber, 2019). The policy acceleration for circularity globally has also been reinforced by climate thresholds that obligate nations to rethink production emissions and material loops (UNFCCC, 2015). In both developed and emerging nations, CE adoption is now recognized as a strategic tool that generates economic, ecological, and climate-mitigation co-benefits simultaneously (World Bank, 2021; Velenturf & Purnell, 2021).

However, critics argue that transition progress remains uneven due to technological readiness gaps, inconsistent policies, and capital-intensive recycling supply chains (Velenturf & Purnell, 2021). For many developing markets, informal waste aggregation still forms the largest, yet least structured, materials economy, making national circular readiness highly context-dependent (Nzeadibe & Ajaero, 2010; World Bank, 2021). In sum, global circular transitions increasingly emphasize not just material looping but also economic restructuring, institutional accountability, and pollution-exposure risk reduction to safeguard human and ecological well-being (Ellen MacArthur Foundation, 2015; Ike et al., 2021).

From the foregoing, one can draw the following inference;

i. Circular transitions are driven by resource limits, climate pressures, and waste burdens (Ghisellini et al., 2016).

ii. CE success depends on design for waste elimination and keeping materials in cycles (Kirchherr et al., 2017).

iii. Strong institutions and aligned financing instruments are critical for transition scale-up (World Bank, 2021).

iv. Informal sector integration remains essential in emerging economies for materials aggregation (Nzeadibe & Ajaero, 2010).

3.2 CE Implementation in Emerging and Resource-Dependent Economies

The implementation of circular economy (CE) in emerging and resource-dependent economies is shaped by structural conditions that differ markedly from those of industrialized countries. High population growth, rapid urbanization, and expanding manufacturing increase resource demand while intensifying waste burdens, often without commensurate advancement in recovery infrastructure (Schröder, Anggraeni, & Weber, 2019; Ghisellini, Cialani, & Ulgiati, 2016). Circular transitions in these economies therefore prioritize pragmatic, high-yield loops including agricultural residue valorization, plastics recovery, urban mining, and inter-industry resource exchange systems; to reduce extraction intensity and retain material value in local production chains (Geng, Sarkis, & Xue, 2012; Lieder & Rashid, 2016).

A dominant feature in many emerging economies is the informality of waste and recyclables aggregation, where a large proportion of material flows through unregulated collection clusters, open markets, and micro-enterprises, rather than structured municipal or industrial recycling systems (Nzeadibe & Ajaero, 2010; World Bank, 2021). Policy literature shows that CE frameworks gain traction when governments

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strategically align enabling economic instruments such as recyclables import waivers, secondary-raw-materials subsidies, and green energy incentives with institutional capacity, sectoral coordination, and enforcement accountability (Geng et al., 2012; World Bank, 2021; Velenturf & Purnell, 2021). For example, China scaled its CE transition by combining national policy coordination, recyclable-market incentives, cleaner production, and eco-industrial clusters that convert waste into structured technical feedstock for prioritized sectors (Yuan, Bi, & Moriguichi, 2006; Geng et al., 2012).

CE-supporting evidence from Brazil and India further shows that emerging markets benefit from circular agriculture, scrap-metal recovery, e-waste value reclamation, eco-design, and industrial symbiosis when delivered through phased infrastructure investment and large-scale materials aggregation systems that convert wastes into economically viable new-product cycles (Urban & Mitchell, 2011; Lieder & Rashid, 2016). However, barriers persist in these regions around energy-access instability, reverse-logistics costs, recycling plant deficits, overlapping policies, limited market incentives, and financing gaps for industrial CE scale-up (Nzeadibe & Ajaero, 2010; Ike et al., 2021; Ogunmakinde, 2019).

Collectively, these studies establish that successful CE deployment in emerging economies depends on three conditions: (i) aggregation scale (national clusters, not isolated pilots), (ii) enforcement-capacity reform, and (iii) economic-policy alignment that ensures waste evolves from a burden to a marketable new-cycle resource (World Bank, 2021; Velenturf & Purnell, 2021). Without these, CE adoption remains fragmented and under-scaled.

3.3 Nigerian Studies on Sustainable Resource Efficiency and Circular Opportunities

Nigeria possesses vast circular-resource potential across biomass, industrial by-products, and secondary material markets, yet practical deployment remains limited and poorly integrated at scale (Ogunmakinde, 2019; Nwosu, 2020). Early scholarship on resource efficiency highlights systemic inefficiencies in material use, weak recycling supply chains, and a dominance of open disposal and informal dumps (Nzeadibe & Ajaero, 2010). While informal recycling networks support partial materials aggregation, they operate largely outside structured governance, reducing national capacity for secondary raw-material reintegration (Nzeadibe, 2009; Nzeadibe & Ajaero, 2010).

Recent reviews show that oil-palm biomass residues (including palm kernel shell, palm fibre, and empty fruit bunch) remain largely unprocessed, worsening environmental pressures while constraining decentralized bioenergy adoption (Ike et al., 2021; Oke et al., 2022). Studies demonstrate that bio-waste valorisation and circular agriculture pathways could reduce extraction intensity, extend resource longevity, and stimulate new energy-materials markets if supported by infrastructure reform and policy coherence (Ogunmakinde, 2019; Ike et al., 2021). Secondary material circularity evidence further shows viable opportunities in scrap-metal reuse, construction-inert loops, and e-waste metal recovery (Okoye et al., 2023; Nwosu, 2020).

Analysts also argue that CE transitions must incorporate local-market circular catalysts such as resource-loop industrial clusters, decentralized waste aggregation, renewable energy-materials synergy, and informal-to-formal recyclables integration to improve waste-to-value systems for youth-driven SMEs (Ike et al., 2021; Okoye et al., 2023). However, barriers remain around unreliable energy access, poor recovery logistics, capital-intensive recycling plants, policy inconsistency, low CE awareness, and enforcement constraints to scale-up (Nwosu, 2020; Ogunmakinde, 2019).

Overall, the literature shows a common conclusion: Nigeria's CE progress is pilot-fragmented, documentation-sparse, and under-scaled, with insufficient synthesis connecting biomass, metallurgical loops, institutional enforcement, community inclusion, and investment pathways into national circular-economy strategies. This underscores the need for integrative systems that merge policy reforms, infrastructure investment, and behavioral change for circular-resource transitions.

3.4 Pollution Metrics, Degradation Indices, and Health–Environment Impacts

Nigeria's pollution burden reflects systemic drivers and pressures linked to accelerated extraction, urban waste accumulation, and informal disposal regimes (Nzeadibe & Ajaero, 2010; Oladejo, Adetunji, & Olasunkanmi, 2021). Soil contamination metrics remain severe in oil-, mining-, and dumpsite-adjacent corridors where leachates, heavy metals, and polymer residues alter ecological equilibrium and reduce land productivity (Iwegbue et al., 2016; Ike et al., 2021). Air-quality indicators capture rising particulate matter ($PM_{2.5}$/PM_{10}), volatile organic compounds (VOCs), and black carbon concentrations largely attributed to open waste burning and poorly controlled industrial emissions, increasing respiratory and long-term exposure risks (Oladejo et al., 2021; Egwurugwu, 2022).

A dominant causal interpretive model for tracking environmental pressures and policy response logic across Nigerian literature is the DPSIR (Smeets & Weterings, 1999; Kristensen, 2004). Using this systems lens, Nigeria's ecological degradation state is measurable through declining vegetation indices, deforestation fractions, eroding biodiversity corridors, increasing desertification susceptibility in the North, and compromised soil/water integrity in the Niger Delta (Akinbami & Adewale, 2020; Ike et al., 2021). Water-quality indices (WQI), biochemical oxygen demand (BOD), chemical oxygen demand (COD), turbidity levels, and microbial-contamination indicators highlight poor surface-water integrity downstream of waste clusters and extraction zones, signalling recovery and reuse failures (Ike et al., 2021; World Bank, 2021).

Health–environment studies in Nigeria correlate unstructured pollution exposure—especially air and water vectors—with increased disease burden, reduced human productivity, and public-health vulnerabilities, particularly in children, adolescents, and informal-sector workers lacking material-safety buffers (Oladejo et al., 2021; Ezugwu, 2023). Chronic CE-relevant impacts include pollution-induced morbidities, heat-stress escalation, malaria-environment linkages

worsened by poor urban sanitation and stagnant surface-water pools, and worsening community resilience thresholds (Ezekoye & Uche, 2021; Ezugwu, 2023). Analysts conclude that without structured pollution-response systems, Nigeria will continue to lose recoverable materials, degrade productive ecosystems, and expand avoidable health risks across communities.

3.5 CE Policy Frameworks: UNEP Role and SDGs Alignment

The mainstreaming of circular economy (CE) in developing regions increasingly draws legitimacy from global environmental policy coordination and sustainability targets (UNEP, 2011; UN, 2015). CE policy pathways are strongly anchored on the *Sustainable Consumption and Production (SCP)* doctrine articulated by the United Nations Environment Programme, which provides strategic guidance on resource looping, waste minimization, and pollution prevention for emerging economies (UNEP, 2011; Bocken et al., 2016). Policy literature emphasizes that CE transitions in Africa require contextual financing instruments, institutional accountability, secondary material aggregation, and informal-sector inclusion to unlock national-scale circularity (World Bank, 2021; Schröder et al., 2019).

Nigeria's circular-resource policy aspirations align directly with prioritized sustainability targets within the Sustainable Development Goals. These goals obligate nations to pursue sustainable cities (Goal 11), responsible consumption and waste-to-resource reintegration (Goal 12), and climate-risk mitigation including emissions reduction (Goal 13) (UN, 2015; Ike et al., 2021). CE policy reviews argue that Nigeria's progress remains constrained by policy overlap, weak enforcement, unreliable recovery logistics, low awareness, and infrastructure financing gaps that limit alignment with SDG thresholds at scale (Nwosu, 2020; Ogunmakinde, 2019).

Scholarly consensus therefore stresses that to meet SDG obligations, Nigeria requires institutional reform, policy harmonization, decentralized energy-material loops (especially biomass-to-briquettes and pellets), national waste aggregation systems, recyclable-market incentives, reverse-logistics coordination, and regulatory accountability to scale-up CE outcomes across sectors and communities (Ike et al., 2021; Velenturf & Purnell, 2021). Without this, CE adoption will continue to remain pilot-fragmented and under-optimized in Nigeria.

., 2021).

4. Methodology

4.0 Review-Paper Design and Thematic Synthesis

This review adopts a *narrative, desktop research design* using thematic synthesis to analyze Nigeria's circular-transition readiness across resource and environmental protection domains (Snyder, 2019). Literature and policy evidence were retrieved through structured keyword and semantic searches in multidisciplinary scientific repositories (Xiao & Watson, 2019). Sources included peer-reviewed journal articles, national environmental regulations and resource-governance policies, institutional reports, and circular-economy strategy publications. The search logic combined (i) keyword retrieval (e.g., "circular economy Nigeria," "biomass valorisation," "pollution metrics," "waste-to-

wealth"), (ii) sectoral theme grouping (agriculture/biomass, plastics, construction, e-waste, water loops), and (iii) policy-to-loop mapping, connecting governance and enforcement levers to circular pathways (Xiao & Watson, 2019; Velenturf & Purnell, 2021).

Inclusion criteria targeted works that addressed CE principles, resource-efficiency gaps, pollution pressure metrics, renewable material/energy loops (briquettes, pellets, compost, secondary metals, wastewater reuse), institutional accountability, and scalable waste-to-value economic models relevant to Nigeria (Ike et al., 2021; Ogunmakinde, 2019). Non-scholarly, anecdotal articles, opinion-only commentaries, and linear-system papers without measurable environmental or circular-transition relevance were excluded to preserve review rigor (Snyder, 2019). The synthesis prioritized evidence demonstrating cross-sector circular opportunities, governance alignment, enforcement performance, and socio-ecological impacts, without engaging empirical experimentation, consistent with accepted review-paper methodology conventions.

Framework Anchors Consulted in Literature Search

- Systems pressure and response analysis: DPSIR (Smeets & Weterings, 1999; Kristensen, 2004)
- Regenerative product-design metabolism: Cradle-to-Cradle (McDonough & Braungart, 2002)
- Industrial symbiosis and ecosystem mimicry: Industrial Ecology (Frosch & Gallopoulos, 1989; Boons & Howard-Grenville, 2009)
- Global sustainability obligation alignment: Sustainable Development Goals (UN, 2015)
- Circular-transition doctrine for emerging markets: United Nations Environment Programme (UNEP, 2011)

5.0 Analysis and Discussion

5.1 Thematic Synthesis of Literature Insights

The literature demonstrates that Nigeria's transition toward circularity is motivated by extraction-induced ecosystem stress, rising waste burdens, and weak secondary-material loops (Ike et al., 2021; Nwosu, 2020). Circular-transition success is consistently linked to infrastructure readiness, regulatory accountability, waste-to-value markets, and informal-sector aggregation scale (Ogunmakinde, 2019; Schröder et al., 2019). Scholars agree that biomass residues, industrial scraps, wastewater, and e-waste represent core circular feedstock, yet Nigeria remains largely disposal-driven rather than loop-driven (Nzeadibe & Ajaero, 2010; Ike et al., 2021). Policy fragmentation and overlapping mandates weaken enforcement outcomes and slow CE adoption at scale (Nwosu, 2020).

5.2 Sector-Based Circular Opportunity Mapping

Sectoral evidence reveals scalable circular pathways: *agriculture and oil-palm biomass loops* (empty fruit bunch, kernel shell, fibre → bioenergy, compost), *plastic circularity* (polymers recovery and reintegration), *construction-inert loops* (ferrous scraps and materials recovery for modular longevity), e-

waste urban mining (rare/printed metals and second-life components), and *water circularity* (wastewater reuse and decentralized capture systems) (Ike et al., 2021; Okoye et al., 2023; Ogunmakinde, 2019). CE-compatible renewable-energy loops, especially briquettes and pellets, offer high extraction-reduction benefits if aggregated at scale (Ike et al., 2021).

5.3 Institutional Accountability and Policy Coherence

Review evidence indicates that nationwide CE enforcement depends on strong institutions and accountability. Nigeria's primary standards-compliance actor is the National Environmental Standards and Regulations Enforcement Agency (NESREA, 2007), but performance remains hampered by low capacity, overlapping regulators, and weak reverse-logistics coordination (Nwosu, 2020; World Bank, 2021). CE adoption should be harmonized under full national policy coherence that integrates energy, material recovery, recyclables incentives, and enforcement tightening, strongly aligning Nigeria's action thresholds with the Sustainable Development Goals (UN, 2015; Ike et al., 2021).

5.4 Comparative Insights from Other Economies

Comparative literature on China, India, and Brazil shows that CE transitions in resource-dependent emerging markets scale faster when governments deploy *aggregation clusters, secondary-raw-materials incentives, green-SME incubation, and eco-industrial symbiosis* (Yuan et al., 2006; Geng et al., 2012; Lieder & Rashid, 2016). These regions illustrate that pilot success must evolve into national clusters, not isolated pilots (Geng et al., 2012). Lessons underscore that circularity delivers economic and health co-benefits when reverse-logistics is supported by stable energy and clear enforcement roles (World Bank, 2021).

5.5 Strategic Priorities and Sequencing for Nigeria

Because Nigeria's CE adoption remains fragmented, review evidence supports a sequenced transition logic, emphasizing:

1. Scale-driven biomass and materials aggregation via youth-led SMEs and circular-market clusters (Ike et al., 2021; Schröder et al., 2019).
2. Policy harmonization and enforcement capacity reform under national regulatory coherence (Ogunmakinde, 2019; Nwosu, 2020).
3. Clean-energy loops investment (briquettes/pellets) to stabilize energy-driven CE clusters (Ike et al., 2021).
4. Construction-material circular loops and urban mining to retain industrial feedstock and reduce ecological footprints (Okoye et al., 2023).
5. Public awareness programmes to shift behaviour away from open burning and unstructured disposal (Ogunmakinde, 2019).

Strategic sequencing for Nigeria therefore prioritizes cluster-based aggregation, policy coherence, enforcement accountability, infrastructure investment, and behavioural transition, as foundational levers for scalable circular-industrial and ecological outcomes.

6.0 Conclusion

Nigeria's circular transition imperative is validated by global thresholds on resource security, emissions reduction, and waste elimination (Kirchherr, Reike, & Hekkert, 2017; Ghisellini, Cialani, & Ulgiati, 2016). This review confirms that the Circular Economy model is no longer optional but strategically essential for resource-dependent emerging economies, including Nigeria, where linear extraction continues to degrade soils, ecosystems, and public health buffers (Ike et al., 2021; Nzeadibe & Ajaero, 2010; Ogunmakinde, 2019). The synthesis shows that Nigeria possesses substantial circular feedstock potential across oil-palm biomass, plastics, scrap metals, construction-inerts, wastewater, and e-waste, but adoption remains pilot-fragmented and structurally weak due to limited recovery infrastructure, unreliable energy access, and inconsistent enforcement capacity (Nwosu, 2020; World Bank, 2021). Scholars agree that informal-sector circular clusters—particularly youth-driven SMEs—are central to materials aggregation but remain poorly institutionalized (Schröder, Anggraeni, & Weber, 2019).

Conclusively**,** Nigeria's most strategic pathways for circular transition should prioritize: (i) cluster-based biomass and recyclables aggregation at scale, (ii) institutional accountability tightening under national environmental compliance actors, especially the National Environmental Standards and Regulations Enforcement Agency, (iii) renewable bioenergy loops (briquettes and pellets) to stabilize CE supply chains, (iv) urban mining and construction-material loops to retain industrial feedstock, and (v) **policy harmonization aligned directly with the Sustainable Development Goals (Ike et al., 2021; Ogunmakinde, 2019; Velenturf & Purnell, 2021).

Without coordinated investment in reverse-logistics infrastructure, stable decentralized energy, and strengthened enforcement accountability, Nigeria risks continued raw-resource loss and avoidable pollution-linked disease burdens (World Bank, 2021; Egwurugwu, 2022). The strategic sequencing recommended in this review provides a practical route to mainstream circularity nationally, diversify the economy, regenerate degraded ecosystems, and reduce environmental determinants of disease, particularly for youth and informal-sector workers.

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