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DEVELOPING A SUSTAINABLE FRAMEWORK FOR PLASTIC WASTE-TO-VALUE INITIATIVES IN KADUNA METROPOLIS, NIGERIA

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Abstract
Plastic waste continues to pose a significant threat to the urban environment in Kaduna Metropolis, Nigeria, with current efforts toward its management being fragmented and unsustainable. Informal collectors and recyclers operate in isolation, with little support from structured policy or institutional frameworks. This study aimed to develop a sustainable framework for implementing plastic waste-to-value initiatives by examining current practices, economic viability, and stakeholder-driven strategies in Kaduna. A qualitative research design was adopted, involving five key informant interviews with actors from private recycling firms, government agencies, and regulatory bodies. Thematic content analysis was used to identify recurring themes and practical insights. Findings revealed that while the plastic waste sector has high economic and environmental potential, it is constrained by infrastructural deficiencies, lack of financing, high operational costs, and weak government support. Informal waste pickers are central to the collection system, and private companies demonstrate profitability, yet face sustainability challenges. One key recommendation is the institutionalization of public-private-community partnerships supported by consistent policy, access to finance, and technology adoption. The study concludes that a circular economy approach that integrates informal sectors, enforces regulations, and promotes community participation is essential to transform plastic waste into a valuable economic asset in Kaduna Metropolis.

Keywords: Plastic Waste, Sustainability, Waste-to-value, Circular Economy, Recycling, Kaduna Metropolis

Introduction

Plastic waste is a global environmental challenge, posing significant threats to ecosystems and public health. Developing a sustainable framework for plastic waste-to-value initiatives aims to address this issue. Plastic waste has emerged as one of the most persistent environmental challenges in developing countries, particularly in rapidly urbanizing areas such as Kaduna Metropolis, Nigeria. The widespread use of plastic products—due to their affordability, versatility, and durability—has led to massive environmental degradation, clogging drainage systems, polluting natural ecosystems, and contributing significantly to urban flooding and public health issues (Jambeck et al., 2015; Alabi et al., 2019). Despite increased global awareness of plastic pollution and the potential for recycling as a mitigation strategy, Nigeria continues to struggle with the effective management of plastic waste due to poor infrastructure, low public awareness, limited government involvement, and weak enforcement of environmental regulations (Nwafor & Nwogu, 2021). In recent years, there has been growing recognition of the economic potential embedded in plastic waste recycling, a concept often termed "waste-to-value." This model sees waste not merely as a disposal problem but as a resource with economic and social value. In urban centers like Kaduna, where informal and semi-formal recycling efforts exist, plastic waste-to-value initiatives could offer a sustainable solution by reducing environmental harm while simultaneously creating jobs, enhancing livelihoods, and contributing to the circular economy (Adelekan & Asiyanbi, 2021). However, the success of such initiatives depends heavily on the existence of an enabling framework that integrates institutional support, community participation, financial investment, regulatory mechanisms, and technological innovation (Wilson et al., 2012).

Kaduna Metropolis, like many Nigerian urban centers, faces a mounting plastic waste crisis. Informal waste collectors and recyclers play a substantial role in diverting plastics from landfills, yet their efforts remain fragmented, under-resourced, and largely unsupported by formal policies or institutional frameworks. According to recent field interviews with key stakeholders in the plastic waste recycling sector, challenges such as lack of funding, inadequate sorting infrastructure, high transportation costs, and the absence of regulatory enforcement hinder the scalability and efficiency of recycling operations. Moreover, while companies like CEETEE Recyclers Limited demonstrate the profitability and export potential of plastic recycling, their impact is constrained by inconsistent government support and limited access to advanced technologies. Despite Kaduna State's commitment to promoting sustainable development, there is no cohesive, sustainable framework guiding plastic waste-to-value initiatives. Current efforts are largely reactive, uncoordinated, and fail to leverage community engagement, private sector participation, or national environmental policies effectively. As a result, significant opportunities for economic empowerment, environmental protection, and social development are being lost. Developing a sustainable framework that harmonizes stakeholder efforts, facilitates access to resources, and promotes policy-driven solutions is therefore critical to addressing the growing plastic waste problem in Kaduna Metropolis. This study aims to develop a sustainable framework for implementing plastic waste-to-value initiatives in Kaduna Metropolis, Nigeria. Specifically, it seeks to examine the existing practices, challenges, and opportunities in plastic waste management and conversion in in Kaduna Metropolis, Nigeria.

Review of Related Literature

Conceptual Clarification: A sustainable framework refers to a structured and long-term strategy that integrates environmental, economic, and social goals to ensure the responsible use of resources without compromising future needs. In the context of waste management, sustainability involves creating systems that minimize environmental harm, promote resource efficiency, and generate economic opportunities (Bringezu et al., 2016). A sustainable framework, therefore, includes supportive policies, stakeholder engagement, funding mechanisms, and technological innovation that work together to maintain continuous and scalable impact over time. Plastic waste comprises discarded plastic materials that are no longer useful in their original form. These materials include single-use plastics such as bottles, bags, packaging, and containers. Due to their non-biodegradable nature, plastic waste poses serious environmental threats, particularly in urban centers where collection and disposal systems are often weak (Jambeck et al., 2015). In Nigeria, and Kaduna specifically, plastic waste has become a visible urban pollutant, contributing to flooding, poor sanitation, and environmental degradation (Nwafor & Nwogu, 2021). Waste-to-value initiatives involve transforming waste materials into economically valuable products, thereby extending their lifecycle and reducing environmental burdens. These initiatives can include mechanical recycling, chemical recycling, or upcycling processes that turn plastic waste into items such as construction materials, textiles, or reusable packaging (Hopewell et al., 2009). Waste-to-value also promotes the circular economy by enabling resource recovery and supporting livelihoods through waste collection, sorting, and processing activities (Wilson et al., 2012).

Theoretical Review

Circular Economy Theory: This study is underpinned by Circular Economy (CE) Theory, which promotes a regenerative system where resource input, waste, emissions, and energy leakage are minimized through closed-loop production cycles. Unlike the traditional linear economy (take–make–dispose), the circular economy emphasizes designing out waste, keeping products and materials in use, and regenerating natural systems (Ellen MacArthur Foundation, 2013). In the context of plastic waste, CE theory supports the transformation of waste materials into valuable resources through reuse, recycling, and recovery processes. This framework aligns directly with the objectives of the study by advocating for sustainable waste management practices that provide economic value while protecting the environment. Applying CE theory to the Kaduna context enables stakeholders to shift from informal, fragmented waste disposal systems toward integrated, value-generating recycling initiatives. It also highlights the importance of stakeholder collaboration, product lifecycle thinking, and supportive policy frameworks as essential components of a sustainable waste-to-value ecosystem (Geissdoerfer et al., 2017).

Empirical Review: The empirical literature on sustainable framework for implementing plastic waste-to-value initiatives reveals various perspectives and findings. Adelekan and Asiyanbi (2021) conducted a qualitative investigation to examine waste-to-wealth initiatives in Nigerian urban centers, focusing on identifying policy gaps that hinder sustainable waste management. Using semi-structured interviews with key waste actors in Lagos and Ibadan, they applied thematic content analysis to draw insights. Their findings revealed that although informal recycling activities were widespread and contributed to livelihood support, the absence of coherent institutional coordination and poor implementation of policies significantly restricted

the growth of plastic waste-to-value initiatives. Nwafor and Nwogu (2021) aimed to assess the key drivers and barriers to solid waste management in Nigeria. The study collected data through surveys and interviews involving municipal workers and local residents across various urban areas. The researchers analyzed the data using descriptive statistics and thematic analysis. Their results indicated that inadequate infrastructure, limited public awareness, and poor enforcement of existing waste regulations remained major challenges. They concluded that these structural barriers stifled the potential for effective plastic recycling and waste recovery programs.

Babayemi et al. (2019) evaluated the nature and volume of plastic waste generation in Lagos and assessed its implications for sustainable waste management. The study employed a combination of field sampling and stakeholder interviews, analyzing the data through both quantitative and qualitative methods. Findings indicated that polyethylene terephthalate (PET) and high-density polyethylene (HDPE) plastics were the most commonly generated and recyclable types. However, despite their recyclability, these materials were largely unmanaged due to a weak recycling system and minimal government intervention. Ogunjuyigbe et al. (2017) investigated the socioeconomic impact of recycling activities in Lagos. The study used structured questionnaires administered to individuals working in recycling companies and informal sectors. Statistical tools including regression and chi-square analysis were employed to interpret the data. The findings revealed that recycling provided a significant income stream for low-income households and created job opportunities. Nonetheless, the sector remained underdeveloped due to insufficient institutional support and lack of formal recognition. Oloruntade, Oluwadare, and Adegbite (2021) conducted a household survey across three Nigerian states to assess practices and attitudes related to plastic waste management. Using structured questionnaires, the authors collected and analyzed data using both descriptive and inferential statistics. The study found that while public awareness of plastic waste issues was increasing, behavioral change remained limited. The lack of incentives and infrastructure, such as sorting and recycling centers, discouraged consistent engagement in sustainable practices. Ikebude (2017) examined the effectiveness and sustainability of waste management systems in Port Harcourt, Nigeria. The researcher conducted field observations and interviews with waste managers and government officials, analyzing the results using SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis. The study found that while there was high potential for recycling, political interference, poor funding, and operational inefficiencies undermined progress toward sustainable waste management.

Oguntona and Arowolo (2020) conducted a study to assess the economic viability of plastic waste recycling in Southwestern Nigeria. Data were gathered through interviews with recycling entrepreneurs and review of financial records. Using cost-benefit analysis, the study demonstrated that plastic waste recycling was economically profitable, particularly for firms engaged in export. However, the researchers noted that lack of access to capital and inadequate government support hindered expansion and innovation in the sector. Agunwamba (2003) focused on waste scavenging as a key component of urban waste management in Nigeria. Data were collected through direct observation and interviews conducted in major urban dumpsites. The study used descriptive analysis to interpret the findings. It concluded that scavengers recovered over 60% of recyclable waste, making them critical to the waste recovery system. However, the study noted that these individuals often worked under hazardous conditions without social protection or policy inclusion. In a similar direction Wilson, Velis, and Cheeseman (2012) undertook a cross-national comparative study to explore the role of the informal sector in recycling across countries such as Nigeria, India, and Brazil. The researchers relied on case

studies and secondary data, applying comparative analysis techniques. Their study found that informal waste pickers played a central role in waste recovery, often recycling more efficiently than formal systems. However, they were largely excluded from official waste management policies, limiting their ability to scale operations and improve working conditions.

Hopewell, Dvorak, and Kosior (2009) provided a global review of the challenges and opportunities in plastic recycling. Drawing on secondary data and published reports, the authors used a narrative review method. Their findings emphasized that the major barriers to plastics recycling included technological limitations, contamination of waste streams, and inconsistent government regulations. They highlighted the need for investment in innovation and policy reform to improve recycling systems globally. Based on the reviewed empirical literature, a key gap was the lack of a context-specific, integrated framework that bring into line policy, private sector, and community-level actions for plastic waste-to-value conversion in Kaduna Metropolis. While many studies emphasize the economic potential of recycling, few provide practical, localized models for implementation in Northern Nigerian cities.

Methodology

This study adopted a qualitative research design to explore sustainable framework for implementing plastic waste-to-value initiatives in Kaduna Metropolis, Nigeria. A qualitative approach was deemed appropriate for gaining in-depth insights into the operational realities, challenges, and enabling factors related to plastic waste-to-value initiatives. The research was conducted in Kaduna Metropolis, the capital of Kaduna State, Nigeria. The area was selected due to its high population density, increasing plastic waste generation, and the presence of active formal and informal recycling actors (Creswell & Poth, 2018).Data were collected through key informant interviews (KIIs) with stakeholders directly involved in plastic waste management and recycling. Participants included representatives from private recycling companies (SPC Integrated Recycling Company; CEETEE Recyclers Ltd), government agencies (Kaduna State Environmental Protection Authority and Kaduna State Ministry of Environment), and regulatory bodies (NESREA). A total of five in-depth interviews were conducted using a semi-structured interview guide. Questions focused on collection practices, conversion processes, economic viability, regulatory challenges, and suggestions for sustainable framework development.

The study employed purposive sampling to select participants with relevant expertise and institutional authority in plastic waste management. This ensured the data collected were rich, context-specific, and aligned with the study objectives. Interview responses were analyzed using thematic content analysis. Transcripts were reviewed, coded, and grouped into thematic categories aligned with the study's objectives: current practices, economic viability, and framework development. This approach allowed for identifying patterns, shared experiences, and divergences among stakeholders (Braun & Clarke, 2006). Informed consent was obtained from all participants. Anonymity was maintained where requested, and data were used strictly for academic purposes, with full approval from the relevant ethical oversight body at Kaduna State University.

Results and Discussion

This section presents key insights from selected stakeholders in Kaduna Metropolis engaged in plastic waste management and conversion initiatives. These interviews offer practical, institutional, and regulatory perspectives that align with the objective of this study, develop a framework for implementing sustainable plastic waste-to-value initiatives in Kaduna metropolis. On developing a framework for implementing sustainable plastic waste-to-value initiatives this

what Mr. Muhammed Zaharadeen Yunus, personal communication Officer of SPC Integrated Recycling Company, explained:

> That company serves as an intermediary in the plastic recycling chain by purchasing sorted plastic waste from local collectors and reselling it to recyclers, without engaging in actual processing. He noted that clear plastics like PET bottles are more valuable, while the business is economically viable -yielding an average monthly profit of ₦150,000 - it faces challenges such as limited storage space, high transportation costs, and inconsistent funding. Yunus emphasized the sector's potential for job creation and environmental benefits. In proposing a framework for sustainable plastic waste-to-value initiatives, Mr. Yunus called for increased government support, better infrastructure, public awareness, and policy reforms to make plastic waste-to-value initiatives more sustainable (KII, 2024).

Regard to the developing of framework for implementing sustainable plastic waste-to-value initiatives this what Mr. Ibrahim Ismail, the CEO of CEETEE Recyclers Limited, described the company:

> The company's operations in processing polyethylene terephthalate (PET), high-density polyethylene (HDPE), and polypropylene (PP) plastics. Their procedures include collecting plastic waste, sorting by color, removing non-compatible materials (e.g., caps and labels), shredding, compressing, and transporting for either local manufacturing or export to European and Asian markets. The company pays its staff using a mixed wage system based on daily trips or kilograms sorted, which has reportedly improved efficiency. Ismail emphasized that exporting materials is more profitable due to exchange rate gains and that demand for recycled products such as packaging, household items, and building materials is consistently rising. He also acknowledged several challenges including high transport costs, insufficient infrastructure, and a lack of direct government support. Although they receive support from NGOs, such as Coca-Cola, Ismail stressed the importance of stronger public-private collaboration and policy frameworks to sustain the industry (KII, 2024).

Developing a framework for implementing sustainable plastic waste-to-value initiatives this what Mr. Bala Thomas Gure, Chief Town Planning Officer at KEPA, described:

> Kaduna's current waste collection model as largely informal and characterized by a "grab and dump" approach. Plastic waste is converted through sorting, washing, heating, and pelletizing. Gure highlighted the role of private companies as primary actors in this ecosystem. He cited sachet leather, plastic kettles, construction pipes, and automobile parts as major outputs of recycled plastics. Despite efforts, the sector faces challenges such as limited funding, high technology costs, and lack of structured incentives. Informal waste pickers, he noted, remain essential players in this ecosystem. Gure emphasized that with structured policies and community awareness, plastic waste conversion could significantly contribute to employment and environmental sustainability in Kaduna (KII, 2024).

Concerning the developing a framework for implementing sustainable plastic waste-to-value initiatives this what Mr. Hashim Usman, Head of Pollution and Sanitation Control at NESREA in Kaduna State discussed:

> Regulatory mechanisms such as the Pollutant Pay Principle (PPP) and Extended Producer Responsibility (EPR), which place accountability on producers and promote the engagement of waste collectors. According to Usman, conversion processes typically include manual sorting, washing, and heating of plastics into pellets. Products from recycling include household plastics and automotive components. Usman noted that while there is job creation and increased internal revenue generation, limitations such as high machinery costs, energy challenges, and poor access to funding hinder scalability. He advocated for broader public awareness campaigns, integration of informal collectors, and supportive government regulations to foster a sustainable circular economy (KII, 2024).

On developing a framework for implementing sustainable plastic waste-to-value initiatives this what Mr. Yusuf Usman Mu'azu, Director at the Kaduna State Ministry of Environment and Natural Resources, discussed:

> The dual waste management system comprising formal evacuation to dumpsites and informal collection by scavengers. He identified major outputs such as plastic pellets, belts, and packaging materials. Successful models, including Mubeco and Abdulrahman Gumi, demonstrate the viability of the sector. However, technological, financial, and infrastructural constraints persist. Mu'azu stressed that government policy, regulatory enforcement, and data-driven decision-making are essential to the success of plastic waste-to-value frameworks. He further recommended community clustering, public-private partnerships, and the creation of a conducive business environment to attract investment (KII, 2024).

To ensure a sustainable plastic waste-to-value framework, stakeholders emphasized the need for a collaborative and multi-sectoral approach involving government, private sector, NGOs, and local communities (Mr. Yusuf Usman Mu'azu, Director at the Kaduna State Ministry of Environment and Natural Resources, 2024; Mr. Bala Thomas Gure, Chief Town Planning Officer at KEPA, 2024). Key elements include policy and regulatory support, consistent government backing, access to financing, public awareness, and training programs (Mr. Hashim Usman, Head of Pollution and Sanitation Control at NESREA in Kaduna State, 2024). Suggestions for sustainability include launching educational campaigns, integrating informal sector actors through community collection centers, and supporting associations of waste collectors to address sector-wide issues (Muhammed Zaharadeen Yunus personal communication at SPC Integrated Recycling Company, 2024).

Successful models, such as the Lagos dumpsite system where pickers pay for access and sell materials to on-site buyers, were cited as adaptable to Kaduna's context (Gure, 2024). Government tax incentives and regulatory enforcement were highlighted as critical enablers for attracting private investment (Mu'azu, 2024). Stakeholders also stressed the importance of a metrics-based approach for monitoring social, environmental, and economic impacts, such as reduction in plastic pollution, job creation, and revenue increases (Mr. Ibrahim Ismail, the CEO of CEETEE Recyclers Limited, 2024). Public education via media (in local dialects), social media

campaigns, workshops, and traditional leader engagement are considered effective strategies to foster behavioral change (Gure, 2024; Usman, 2024). Ultimately, stakeholders advocate for a structured, well-financed, and inclusive framework that leverages data, technology, and grassroots participation to transition from informal waste disposal practices to a circular and profitable plastic waste economy.

These findings align with Adelekan and Asiyanbi (2021), who found that the absence of institutional coordination and policy implementation hinders the expansion of waste-to-wealth initiatives in Nigeria. Similarly, Ogunjuyigbe et al. (2017) observed that informal recycling generates significant income, but is limited by lack of formal recognition. The central role of informal waste pickers noted in this study echoes Wilson et al. (2012), who emphasized their efficiency in waste recovery despite being excluded from formal systems. From a theoretical perspective, the findings support the Circular Economy (CE) Theory, which advocates for resource regeneration through waste reuse, recycling, and closed-loop systems (Ellen MacArthur Foundation, 2013). The informal sector's role in keeping plastics in circulation and private firms' export of processed materials reflect core CE principles. However, without institutional support and policy integration, the system remains incomplete and unsustainable.

Conclusion and Recommendations

The study concludes that, while Kaduna Metropolis has a vibrant and growing plastic waste recycling sector, its potential is undermined by financial, infrastructural, and regulatory challenges. Informal waste pickers are the bedrock of the collection process, while private recyclers drive the conversion of plastic into valuable products. Based on the findings of this study, a sustainable waste-to-value framework in Kaduna Metropolis must be built on four critical pillars as recommended: policy enforcement, investment in modern technology, public-private collaboration, and inclusive community engagement. Firstly, policy enforcement is essential to ensure compliance with environmental standards and promote accountability across the plastic waste value chain. Regulatory bodies like NESREA and state environmental agencies must not only develop clear waste management policies but also implement and monitor them consistently. Stakeholders emphasized that without enforceable laws and incentives, informal and private actors will continue to operate in isolation, limiting the system's overall efficiency and sustainability. Secondly, investment in modern technology such as plastic sorting machines, pelletizing units, and clean energy-powered transport will address key infrastructure gaps. Respondents, particularly from the private sector, noted that access to affordable and efficient recycling technology is necessary to improve processing capacity, reduce costs, and enhance product quality for both local and international markets. Thirdly, public-private collaboration must be institutionalized through formal partnerships, financing mechanisms, and shared responsibility models. This collaboration would create a structured ecosystem where government provides enabling policies and infrastructure, while private actors drive innovation and operations.

Finally, inclusive community engagement, especially of informal waste collectors, is vital. Waste pickers are already central to the plastic recovery process and must be integrated into the formal value chain through training, support programs, and the establishment of community collection centers. With this integrated framework in place, Kaduna can transition from reactive waste disposal to a circular economy model where plastic waste is not just managed but leveraged as a source of economic growth, employment, and environmental protection.

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Appendix

Key In-Depth Interview Guide: Developing a Sustainable Framework for Implementing Plastic Waste-to-Value Initiatives

Introduction

This Key In-Depth Interview is to collect information/data to develop a sustainable framework for implementing plastic waste-to-value initiatives in Kaduna Metropolis, Nigeria. We are in your organization to hear your opinions and views. The information provided will be used by Tertiary Education Trust Fund (TETFund) and Kaduna State University (KASU) to provide policy framework for better programs.

Consent

Do you provide consent to document, use, store and share the information provided for reporting and communication purposes?

☐ Yes ☐ No (if Yes continue KII)

1. **Introduction and Purpose:** Briefly introduce the purpose of the interview and the key areas of focus (practices, viability, and framework). Explain the confidentiality of responses and encourage open, honest feedback.
2. **Interviewee Background:** Ask the interviewee to provide a brief background of their role and experience in plastic waste management.

Develop a Framework for Implementing Sustainable Plastic Waste-to-Value Initiatives

1. From your perspective, what are the essential elements needed to develop a successful plastic waste-to-value framework in Kaduna?
2. What steps would you suggest to make plastic recycling initiatives more sustainable in the long term?
3. How can local communities and informal sectors be better integrated into the waste-to-value chain?
4. What role should local and state governments play in supporting sustainable plastic recycling initiatives?
5. Are there any examples of frameworks from other states or countries that could be adapted for Kaduna State?
6. How can Kaduna State attract private sector investment into sustainable plastic waste conversion?
7. What strategies would you recommend to raise awareness and educate the public about the benefits of plastic waste recycling and reduction?
8. What are the potential environmental and economic impacts of implementing a comprehensive plastic waste-to-value framework?

Thank you for your time

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