ASSESSMENT OF GLASS AND CERAMICS WASTE MANAGEMENT IN MUBI NORTH AND MUBI SOUTH LOCAL GOVERNMENT AREAS OF ADAMAWA STATE, NIGERIA

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ABSTRACT

This study investigated the generation, disposal, and recycling of glass and ceramic waste in Mubi North and Mubi South Local Government Areas of Adamawa State, Nigeria. A descriptive survey design was employed, integrating quantitative and qualitative methods. Data were collected from 384 households across 12 political wards using structured questionnaires, key informant interviews, and field observations. Descriptive statistics were used to summarize waste generation and disposal patterns, while inferential analyses examined the relationship between socio-demographic factors and recycling participation. Findings revealed that open dumping was the dominant disposal method (68.5%), with minimal recycling activity (14.3%), largely driven by informal collectors. Major constraints included inadequate collection infrastructure (78.9%), absence of formal recycling centers (72.4%), and weak market demand for recyclables (65.1%). Institutional gaps were characterized by poor enforcement of environmental regulations (78.4%), insufficient funding (70.6%), and limited public–private partnership involvement (55.2%). A significant positive relationship was observed between educational attainment and recycling behavior. The study concluded that glass and ceramic waste management was largely inefficient due to infrastructural, institutional, and behavioral challenges. Recommendations included the establishment of community-based recycling hubs, introduction of incentive schemes, enhancement of environmental education, strengthening of institutional capacity, promotion of public–private partnerships, and formal integration of informal waste collectors. Implementation of these measures was expected to facilitate a transition toward a circular and sustainable waste management system, improve environmental quality, and support local economic development.

KEYWORDS: Glass waste, Ceramic waste, Recycling, Waste management, Circular economy, Adamawa State.

1. INTRODUCTION

The increasing accumulation of glass and ceramic waste poses significant environmental challenges in urban and peri-urban areas across Nigeria. In Mubi North and Mubi South LGAs of Adamawa State, the rapid population growth, urbanization, and expansion of commercial activities have intensified the generation of non-biodegradable wastes, particularly glass and ceramics. These materials are durable, non-decomposable, and potentially hazardous when not properly managed (Abdullahi & Mohammed, 2021). The absence of effective collection, sorting, and recycling systems contribute to environmental degradation,

obstructed drainages, and injuries from broken shards. Glass and ceramic waste constitute a substantial portion of municipal solid waste but receive less attention compared to plastics and metals.Globally, countries have transitioned toward more sustainable waste management systems, emphasizing waste reduction, reuse, and recycling as key strategies for environmental protection and resource efficiency (Onwughara et al., 2019; European Environment Agency, 2020). However, in Nigeria, waste management systems are predominantly linear—centered on disposal rather than reuse or resource recovery (Ogunbiyi et al., 2021). In Mubi, where household and commercial glass waste are mostly disposed of in open dumps or water channels, poor waste segregation and lack of formal recycling structures exacerbate environmental pollution. This study, therefore, investigates the generation rates, recycling practices, and factors influencing glass and ceramics waste management in Mubi North and Mubi South. It also evaluates community participation, infrastructure availability, and the socio-economic variables shaping recycling behavior.

Waste management involves the systematic collection, transportation, processing, and disposal of waste materials to minimize their adverse effects on health and the environment (Kadafa, 2017). The waste management hierarchy prioritizes prevention, reuse, recycling, energy recovery, and disposal as a last resort, aligning with circular economy principles that maintain materials in productive use. Recycling transforms waste materials into reusable forms, conserving raw materials and energy. In the case of glass and ceramics, recycling helps reduce landfill burden and greenhouse gas emissions (Abila & Kantola, 2019).

Glass waste arises mainly from beverage bottles, window panes, and domestic items, while ceramic waste includes tiles, cups, pottery and sanitary wares. Both materials are inert and non-biodegradable but recyclable (Ezeudu et al.,

2020). However, effective recycling requires colour separation (clear, amber, green) and removal of contaminants such as ceramics, stones, metals, and organic matter. Glass can be re-melted endlessly without losing quality; however, contamination and colour separation remain key challenges in the Nigerian context (Ogunyemi & Adebisi, 2022).

In Nigeria, municipal authorities often lack the infrastructure and policies to handle glass waste effectively. The waste management sector is characterized by inadequate infrastructure, weak institutional capacity, and over-reliance on final disposal rather than upstream interventions. Studies in Lagos, Kano, and Yola revealed that over 70% of glass waste is landfilled or dumped in open sites, with less than 20% recovered by informal recyclers (Lawal et al., 2020; Garba & Musa, 2022). In Adamawa State, informal waste pickers play a vital role in glass recovery, though their operations are unregulated and unprofitable due to weak market demand (Buba et al., 2021).

Community engagement and awareness are central to successful recycling programs (Agunwamba et al., 2018). Education level and income strongly influence individuals' recycling behavior, as better-informed citizens tend to separate waste and appreciate its economic potential (Uzondu et al., 2023). Numerous studies demonstrate positive correlations between educational attainment and pro-environmental behaviors, including waste recycling. Educated individuals tend to possess greater environmental awareness, understand recycling benefits, and have higher self-efficacy in adopting sustainable practices. In rural and semi-urban areas like Mubi, poor environmental literacy and lack of incentives discourage waste sorting at source.

1.1 Theoretical Framework

The theoretical foundation of this study is anchored on the Circular Economy Theory and the Community-Based Waste Management (CBWM) Model, which together provide a comprehensive

framework for understanding waste generation, management practices, and sustainability outcomes in Mubi North and Mubi South Local Government Areas of Adamawa State, Nigeria. These complementary frameworks allow for an integrated examination of both structural and behavioral dimensions of waste management, particularly in relation to glass and ceramic waste streams.

The Circular Economy Theory represents a fundamental shift from the conventional linear economic model characterized by the "take–make–dispose" approach toward a regenerative system that emphasizes resource efficiency, waste minimization, and environmental sustainability. According to Geissdoerfer et al. (2017), the circular economy promotes closed-loop systems in which materials are continuously reused, recycled, and reintegrated into production processes, thereby reducing environmental degradation and dependence on virgin resources. This theoretical perspective is particularly relevant to glass and ceramic waste, which are non-biodegradable yet highly recyclable materials capable of retaining value through repeated recovery cycles. In contrast to linear waste management practices that dominate many developing urban contexts, circular economy principles advocate for the transformation of waste into economic resources, supporting both environmental protection and local economic development.

Within the context of Mubi North and South LGAs, the predominance of open dumping, limited recycling infrastructure, and weak institutional coordination reflects a departure from circular economy ideals. The absence of structured material recovery systems, market incentives, and regulatory enforcement has resulted in inefficient waste flows and environmental degradation. The circular economy framework therefore provides a macro-level analytical lens for evaluating the extent to which existing waste management practices align with or diverge from sustainable material management principles. It also facilitates the identification of systemic gaps in policy, infrastructure, and governance that constrain the transition toward more sustainable and resilient waste management systems.

Complementing this structural perspective, the Community-Based Waste Management (CBWM) Model emphasizes the social and behavioral dimensions of waste management by recognizing local communities as central actors in the generation, segregation, and recovery of waste. Rooted in participatory development theory, the CBWM model posits that sustainable waste management cannot be achieved solely through top-down policy interventions but requires active community involvement, shared responsibility, and local ownership of environmental initiatives. This approach is particularly relevant in developing contexts where formal municipal waste systems are often inadequate, and informal actors play a significant role in waste collection and recycling activities.

In the context of Mubi North and South, waste management practices are heavily influenced by household behaviors, socio-economic conditions, and levels of environmental awareness. The CBWM model provides a conceptual basis for understanding how education, income, cultural norms, and community organization shape waste disposal and recycling behaviors. It also highlights the importance of environmental education, public participation, and local leadership in fostering sustainable waste practices. By emphasizing bottom-up engagement, the model underscores the potential for community-driven initiatives to complement institutional efforts and enhance the effectiveness of waste management interventions.

The integration of the Circular Economy Theory and the Community-Based Waste Management Model offers a holistic framework that captures both macro-level structural dynamics and micro-level behavioral processes influencing waste management outcomes. While the circular economy framework elucidates systemic inefficiencies, material flows, and policy gaps, the CBWM model provides insight

into social participation, behavioral change, and community resilience. Together, these frameworks enable a comprehensive analysis of how institutional arrangements, socio-economic factors, and community practices interact to shape waste management outcomes in the study area.

By synthesizing these theoretical perspectives, the study is able to situate glass and ceramic waste management within a broader sustainability discourse, linking local practices to global environmental goals. The combined framework also guides the interpretation of empirical findings, informs the identification of policy and institutional gaps, and supports the development of context-specific recommendations aimed at promoting sustainable, inclusive, and circular waste management systems in Mubi North and Mubi South Local Government Areas of Adamawa State.

2. MATERIALS AND METHODS

The study was conducted in Mubi North and Mubi South Local Government Areas (LGAs) of Adamawa State, located in the northeastern part of Nigeria between latitudes 10°11′N and 10°30′N and longitudes 13°15′E and 13°45′E. The area is characterized by a mix of urban and peri-urban settlements, with livelihoods largely centered on trading, agriculture, artisanal activities, and small-scale manufacturing. These economic activities contribute significantly to the generation of municipal solid waste, including substantial quantities of glass and ceramic materials, thereby making the area suitable for investigating waste generation and management dynamics.

A descriptive survey research design was adopted for the study, integrating both quantitative and qualitative approaches to provide a comprehensive understanding of waste generation, disposal practices, and recycling behavior. This design was considered appropriate because it allows for systematic collection of data from a large population while also capturing contextual and behavioral dimensions associated with waste management practices. Structured questionnaires were employed as the primary data collection instrument to obtain information on household waste generation rates, disposal methods, recycling behavior, and perceptions regarding waste management systems.

The study population comprised households across the twelve political wards within Mubi North and Mubi South LGAs. Using Yamane's (1967) sample size determination formula, a total of 384 respondents was selected from an estimated population of 150,000 households. Stratified random sampling was employed to ensure adequate representation of residential, commercial, and institutional zones within the study area. This approach enhanced the representativeness of the sample and minimized sampling bias by capturing spatial and socio-economic diversity across the two LGAs.

Primary data were collected through field surveys using structured questionnaires administered directly to household heads or adult representatives. In addition, key informant interviews were conducted with waste collectors, market operators, and officials of local government environmental units to obtain contextual insights into waste management practices, institutional challenges, and operational constraints. Secondary data were sourced from relevant environmental reports, government documents, and peer-reviewed academic literature to support and contextualize the primary findings.

Waste generation and disposal patterns were determined through structured household questionnaires administered to 384 respondents across 12 wards in Mubi North and Mubi South LGAs. Respondents were asked to indicate average quantity of glass and ceramic waste generated weekly. Data were collected through self-reported household estimates, field observations of waste accumulation and cross-verification with informal waste collectors.

Institutional and policy gaps were identified using responses from household heads.

Key informant interviews with local government officials and waste handlers was conducted.

Observations of municipal waste operations was also carried-out. Respondents were asked to indicate perceived weaknesses in policy implementation and institutional support for waste management.

Data analysis was conducted using descriptive statistical techniques to align with the study's objectives. Frequencies, percentages, and mean values were calculated to summarize patterns of waste generation, disposal methods, and recycling practices. This approach facilitated the identification of key trends and associations, providing insights into the factors influencing waste management behaviors in the study area.

3. RESULTS

3.1 Waste Generation and Disposal

The dominance of open dumping (68.5%) indicates a weak formal waste collection system. Recycling remains minimal (14.3%), largely informal, and economically unstructured. This pattern reflects poor waste segregation practices and limited recycling infrastructure across Mubi North and South LGAs.

Table 1: Waste Generation and Disposal Practices in Mubi North and South LGAs

Disposal Method	Frequency (n)	Percentage (%)
Open dumping (streets, drains, open land)	263	68.5
Temporary storage (bags/bins awaiting disposal)	66	17.2
Recycling via informal collectors	55	14.3
Total	**384**	**100**

Source: Researchers' fieldwork, 2025.

3.2 Constraints to Effective Waste Management

Infrastructure Inadequacy emerged as the most critical constraint (78.9%), followed closely by the absence of recycling centers (72.4%). These findings indicate systemic institutional failure rather than individual behavioral shortcomings. Weak market demand further discourages private sector participation in recycling initiatives.

Table 2: Constraints to Effective Waste Management in Mubi North and South LGAs

Identified Constraint	Frequency (n)	Percentage (%)
Inadequate waste collection infrastructure	303	78.9
Absence of formal recycling centers	278	72.4
Weak market demand for recycled materials	250	65.1
Low public awareness of recycling benefits	233	60.7
Irregular municipal waste collection	198	51.6
Lack of waste segregation at source	184	47.9

Source: Researchers' fieldwork, 2025.

3.3 Institutional and Policy Gaps

Weak enforcement of environmental laws (78.4%) and lack of structured recycling programs (75.3%) reveal institutional fragility. The absence of public–private partnerships further limits innovation and investment in waste recovery systems. These gaps explain the persistent reliance on informal waste handling in Mubi North and South.

Table 3: Institutional and Policy Gaps Affecting Waste Management

Institutional / Policy Gap	Frequency (n)	Percentage (%)
Weak enforcement of environmental regulations	301	78.4
Absence of municipal recycling programs	289	75.3
Inadequate funding for waste management services	271	70.6
Poor coordination between state and local authorities	244	63.5
Lack of waste management education programs	226	58.9
Limited involvement of private sector/PPP	212	55.2

Source: Researchers' fieldwork, 2025.

4. DISCUSSION

The findings of this study reveal that waste management practices in Mubi North and Mubi South LGAs are predominantly linear in nature, characterized by indiscriminate disposal, limited material recovery, and weak institutional coordination. The dominance of open dumping as the primary waste disposal method reflects systemic inefficiencies in the local waste management framework and underscores the absence of structured recycling infrastructure. This pattern mirrors observations made by Buba et al. (2021) in Yola, where informal waste collectors dominate recovery processes in the absence of formalized systems. The persistence of such practices highlights the entrenched nature of linear waste management in many urban and peri-urban settlements across northern Nigeria, where waste is largely perceived as a nuisance rather than a resource.

The low rate of recycling observed in the study area further emphasizes the limited operationalization of circular economy principles. Despite the high recyclability potential of glass and ceramic materials, their recovery remains minimal due to inadequate collection systems, poor market incentives, and insufficient institutional support. This finding aligns with earlier studies indicating that the absence of formal recycling infrastructure and weak market linkages discourages both households and informal collectors from engaging in recycling activities (Ogunbiyi et al., 2021; Lawal et al., 2020). Consequently, recyclable materials that could otherwise contribute to resource efficiency and local economic development are lost through indiscriminate disposal.

A key outcome of the study is the statistically significant relationship between education level and participation in recycling activities. This finding reinforces the assertion by Uzondu et al. (2023) that environmental literacy plays a critical role in shaping pro-environmental behavior. Individuals with higher educational attainment are more likely to understand the environmental and economic benefits of recycling, leading to greater willingness to separate waste and engage in sustainable practices. This relationship underscores the importance of environmental education as a strategic tool for improving waste management outcomes, particularly in communities where formal waste systems are weak.

The study also exposes critical institutional deficiencies underpinning waste management challenges in Mubi North and South LGAs. The absence of formal recycling centers, inadequate funding for waste management services, and weak enforcement of environmental regulations collectively undermine effective waste governance. These shortcomings reflect broader structural challenges within local government institutions, including limited technical capacity, insufficient budgetary allocation, and weak inter-agency coordination. Such constraints inhibit the translation of policy intentions into practical action, reinforcing a cycle of poor service delivery and environmental degradation.

Contrastingly, experiences from parts of southern Nigeria demonstrate that community-based recycling initiatives,

when supported by functional institutional frameworks and market incentives, can significantly improve waste recovery rates. Studies by Adewumi et al. (2019) illustrate how local cooperatives, buy-back centers, and public–private partnerships have enhanced recycling participation and created livelihood opportunities in urban centers. The disparity between these regions and the study area underscores the importance of contextual governance structures and investment in waste infrastructure. It also suggests that the challenges observed in Mubi are not inherent but are largely a consequence of policy and institutional neglect.

Furthermore, the findings reinforce the relevance of the circular economy framework as a viable pathway for addressing waste management challenges in the study area. The current linear system characterized by extraction, consumption, and disposal—fails to capture the residual value embedded in waste materials. Transitioning toward a circular model would require deliberate efforts to integrate informal waste actors into formal systems, establish market incentives for recyclables, and promote waste segregation at the source. Such a transition would not only reduce environmental pollution but also create employment opportunities and stimulate local economic development.

The study also highlights the importance of community participation in achieving sustainable waste management outcomes. The reliance on informal collectors and household-level decisions indicates that community actors already play a central role in waste handling, albeit in an uncoordinated manner. Strengthening community engagement through education, capacity building, and institutional support could transform these informal practices into organized and efficient waste management systems. This aligns with the Community-Based Waste Management model, which emphasizes local ownership and participatory governance as foundations for sustainable environmental management.

Overall, the findings demonstrate that waste management challenges in Mubi North and South LGAs are multidimensional, arising from the interaction of socio-economic, institutional, and infrastructural factors. Addressing these challenges requires an integrated approach that combines policy reform, community participation, market development, and environmental education. By situating local waste management practices within broader theoretical and empirical contexts, this study contributes to a deeper understanding of how circular economy principles and community-based strategies can be operationalized in resource-constrained settings. Such insights are essential for informing policy interventions aimed at improving environmental sustainability, public health, and livelihood resilience in northern Nigeria and similar developing regions.

5. CONCLUSION

This study concludes that glass and ceramics waste management in Mubi North and South is largely inefficient, driven by inadequate infrastructure, poor awareness, and weak market demand for recyclables. Despite the moderate recycling potential, the absence of organized collection and processing systems hinders progress toward sustainability.

5.1 Recommendations

Based on the empirical evidence generated from this study, several targeted recommendations are proposed to address the structural, institutional, and behavioral constraints affecting glass and ceramic waste management in Mubi North and Mubi South Local Government Areas.

First, the establishment of decentralized community-based recycling hubs is recommended to address the absence of formal recycling infrastructure. These hubs should be strategically located in high waste–generating zones such as markets and densely populated residential areas and managed through collaborative arrangements involving local governments, community associations, and organized

waste collectors. Such decentralization would enhance accessibility, reduce indiscriminate dumping, and formalize existing informal recovery activities identified in the study.

Second, structured buy-back and incentive schemes should be introduced to stimulate household participation in waste segregation and recovery. The findings demonstrate that low recycling rates are closely linked to the absence of economic motivation. Financial or material incentives tied to the quantity and quality of recyclable glass and ceramic waste can significantly enhance participation and strengthen the local recycling value chain.

Third, the study underscores the need for strengthened environmental education and awareness programmes, particularly in light of the observed relationship between educational attainment and recycling behavior. Environmental education should be mainstreamed into formal school curricula and complemented by community-level sensitization using local media, religious institutions, and traditional leadership structures. Such initiatives are critical for fostering long-term behavioral change and environmental responsibility.

Fourth, institutional capacity and regulatory enforcement at the local government level must be strengthened. This includes improving funding allocation, technical training of environmental officers, and the enforcement of existing waste management regulations. Clear operational guidelines for waste segregation, collection schedules, and disposal standards should be institutionalized to enhance accountability and service delivery.

Fifth, the promotion of public–private partnerships (PPPs) is essential to mobilize financial and technical resources for waste infrastructure development. Partnerships with private recycling firms and manufacturing industries can facilitate the establishment of material recovery facilities and improve market access for recycled glass and ceramic products. Incentive mechanisms such as tax reliefs or access to land could further attract private investment.

Finally, the study recommends the formal integration of informal waste collectors into municipal waste management systems. Recognizing their role through registration, training, and provision of basic protective equipment would improve efficiency, occupational safety, and data reliability, while also enhancing inclusivity and livelihood security.

Overall, implementing these recommendations would contribute to the transition from a predominantly linear waste management system to a more circular, inclusive, and sustainable model. Such a transition would not only improve environmental quality and public health outcomes but also support local economic development and align waste governance in Mubi North and South with national circular economy and sustainability objectives.

REFERENCES

Abdullahi, M., & Mohammed, S. (2021). *Challenges of solid waste management in urban Nigeria: Focus on non-biodegradable waste*. Journal of Environmental Management, 28(2), 45–56.

Abila, B., & Kantola, J. (2019). *Recycling of glass and ceramics: Environmental and economic implications*. Resources, Conservation and Recycling, 145, 12–22. https://doi.org/10.1016/j.resconrec.2019.01.012

Adewumi, A., Oke, F., & Oladele, O. (2019). *Community-based recycling initiatives and livelihood creation in urban Nigeria*. Environmental Development, 29, 100–112. https://doi.org/10.1016/j.envdev.2019.01.005

Agunwamba, J. C., Okonkwo, C. C., & Obi, C. (2018). *Community participation in solid waste management in Nigeria: Lessons for sustainable practice*. Waste Management, 76, 623–633. https://doi.org/10.1016/j.wasman.2018.03.012

Buba, S., Garba, M., & Musa, A. (2021). *Informal waste collection and recycling in Adamawa State: Implications for municipal waste governance*. Nigerian Journal of Environmental Sciences, 10(1), 77–89.

Ezeudu, T., Ume, C., & Iwuoha, E. (2020). *Recyclability of glass and ceramic waste in Nigeria: Challenges and prospects*. Nigerian Journal of Waste Management, 8(2), 34–47.

European Environment Agency. (2020). *Circular economy and waste management in Europe: Status and perspectives*. Copenhagen: EEA Publications.

Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2017). *The Circular Economy – A new sustainability paradigm?* Journal of Cleaner Production, 143, 757–768. https://doi.org/10.1016/j.jclepro.2016.12.048

Kadafa, A. A. (2017). *Solid waste management in Nigeria: Challenges and solutions*. International Journal of Waste Resources, 7(2), 1–9. https://doi.org/10.4172/2252-5211.1000291

Lawal, A., Salihu, Y., & Ibrahim, L. (2020). *Glass waste management in Nigerian urban centres: Evidence from Lagos, Kano, and Yola*. Nigerian Journal of Environmental Research, 15(1), 55–70.

Ogunbiyi, O., Adewale, R., & Ojo, T. (2021). *Waste management practices in Nigeria: Linear vs circular approaches*. Waste Management & Research, 39(4), 523–533. https://doi.org/10.1177/0734242X20983149

Ogunyemi, A., & Adebisi, S. (2022). *Challenges of glass recycling in Nigeria: Contamination and color separation issues*. Journal of Environmental Sustainability, 14(3), 101–114.

Onwughara, I., Olumide, A., & Eze, P. (2019). *Global perspectives on sustainable waste management: Lessons for Nigeria*. Environmental Policy and Governance, 29(6), 435–449. https://doi.org/10.1002/eet.1862

Uzondu, C., Chukwu, E., & Okeke, P. (2023). *Socio-economic determinants of household recycling behavior in semi-urban Nigeria*. African Journal of Environmental Studies, 20(1), 44–58.

Yamane, T. (1967). *Statistics: An introductory analysis* (2nd ed.). New York: Harper & Row.