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Operational Deficiencies and Environmental Implications of Domestic Solid Waste Collection in Public Housing Estates in Lagos

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Abstract- ***This study investigated operational deficiencies and their environmental implications in domestic solid waste collection across twelve density-stratified public housing estates in Lagos Metropolis, Nigeria. Anchored in the Service Quality (SERVQUAL) framework, the study employed a cross-sectional survey design, administering structured questionnaires to 352 residents across low-, medium-, and high-density estates. Eight waste collection adequacy indicators were assessed using a five-point Likert scale and analysed through descriptive statistics and one-sample t-tests in IBM SPSS Statistics v26. Findings revealed that while waste collection reliability (M = 2.05; SD = 0.980) and frequency (M = 2.13; SD = 0.960) were rated adequate, significant deficiencies persisted in irregular collection scheduling (M = 3.78), waste spillage during collection (M = 3.32), and overflowing bins (M = 3.11). Most critically, widespread adoption of informal disposal practices — including open burning, illegal dumping, and drainage channel disposal — recorded the highest inadequacy mean (M = 4.18; SD = 1.199), carrying severe public health and environmental consequences. The study contributes a density-responsive assessment of waste service quality gaps in sub-Saharan African cities and recommends integrated, frequency-differentiated waste management strategies, enhanced waste containment infrastructure, and targeted resident sensitisation programmes.***

Index Terms- ***Solid Waste Management, Service Delivery, Public Housing, Urban Sanitation, Lagos, Informal Disposal, Sub-Saharan Africa***

I. INTRODUCTION

Urban solid waste management has emerged as one of the most critical governance challenges confronting rapidly growing cities in sub-Saharan Africa (Nations, 2022). The region is experiencing the fastest urban growth globally, with municipal solid waste volumes projected to increase from approximately 174 million tonnes annually in 2016 to over 516 million tonnes by 2050 (Onamade et al., 2022).

Within the urban areas, domestic solid waste collection is the first and most fundamental link in the waste management chain and it remains consistently underperforming in many African cities, contributing to flooding, infectious disease transmission, and environmental degradation (Nzeadibe & Ejike-Alieji, 2020; Soltani et al., 2021).

Lagos, Nigeria's commercial capital with an estimated population exceeding 15 million, exemplifies these challenges at an acute scale. The Lagos State Waste Management Authority (LAWMA) and its Private Sector Participants (PSPs) operate formal waste collection systems across the metropolis, yet service delivery remains uneven, with persistent reports of overflowing bins, missed collections, and widespread informal disposal practices including open burning and drainage dumping (Adeyemi et al., 2022; Ogwueleka, 2021).

These deficiencies are particularly pronounced within public housing estates — formally planned residential developments that, paradoxically, often lack adequate waste infrastructure relative to their population density (Ayotamuno & Gobo, 2020).

Public housing estates in Lagos span a spectrum of residential densities, from low-density estates such as GRA Ikeja to high-density estates such as Abesan and Dolphin estates.

This density gradient is theoretically significant because waste generation rates, collection demands, and infrastructure requirements vary substantially across density categories (Aboginije et al., 2021; Adeyemi et al., 2022; Wilson et al., 2021).

Despite this, most existing studies of urban waste management in Lagos treat the city's residential landscape as homogeneous, overlooking density as an explanatory variable for service adequacy (Adeyemi et al., 2022; Nzeadibe & Ejike-Alieji, 2020).

The concept of waste collection adequacy encompasses multiple dimensions beyond simple collection frequency, including reliability, containment capacity, scheduling predictability, and operational efficiency during collection (Guerrero et al., 2013; Leal Filho et al., 2021).

These dimensions align with established service quality frameworks, yet their systematic measurement within density-stratified residential areas in African cities remains understudied. Previous research has tended to focus either on waste composition and generation rates (Ogwueleka, 2021; Oyelaran et al., 2022) or on household-level willingness to pay for improved services (Noiki et al., 2021), leaving a gap in multi-dimensional, supply-side assessment of collection service quality.

This study addresses this gap by evaluating the adequacy of domestic solid waste collection systems in twelve density-stratified public housing estates in Lagos, using a validated eight-indicator instrument grounded in service quality theory. Specifically, the study pursues three objectives: (1) to assess the reliability and frequency of waste collection across density categories; (2) to examine operational deficiencies in waste collection performance; and (3) to determine the extent and environmental implications of alternative disposal practices among residents.

II. LITERATURE REVIEW

2.1 Urban Solid Waste Management in Sub-Saharan Africa

Urban solid waste management represents a critical governance challenge across sub-Saharan Africa (SSA), intensified by rapid urbanisation. Annual waste volumes are projected to surge from 174 million tonnes in 2016 to over 516 million tonnes by 2050, overwhelming existing institutional capacity (Kaza & Bhada-Tata, 2018).

Municipal budgets allocate 20–50% to waste management yet still deliver inadequate coverage (World Bank, 2023). Over 90% of waste in low-income African cities is openly dumped or burned, driving pollution and disease (United Nations, 2020), while formal systems persistently fail high-density and low-income areas (Nzeadibe & Ejike-Alieji, 2020).

In Lagos, uneven service delivery remains entrenched despite LAWMA's presence (Aliu et al., 2014; Ogwueleka, 2021). Existing literature rarely disaggregates performance by residential density, despite evidence that waste generation and service outcomes vary markedly across density categories (Aliu et al., 2014; Guerrero et al., 2013). This study addresses that gap through density-stratified assessment across Lagos public housing estates.

2.2 Waste Collection Service Quality and Assessment Frameworks

Measuring waste collection service quality requires frameworks that transcend operational metrics to capture user perceptions of adequacy. The SERVQUAL model (Parasuraman et al., 1988) remains the most widely applied instrument, operationalising service quality as the gap between user expectations and perceived performance across five dimensions: tangibles, reliability, responsiveness, assurance, and empathy.

Its 22-item scale demonstrates strong validity across services, with reliability coefficients ranging from 0.59 to 0.97 (Lozier, 2015), and has been increasingly adapted for public service evaluation in developing country settings.

Applied to solid waste management, Guerrero et al. (2013) established that collection efficiency is multidimensional, encompassing technical, institutional, financial, and socio-cultural factors, and that rapid urbanisation disproportionately disadvantages high-density and low-income areas —

validating density-stratified service quality assessment.

Empirical studies in Nigerian and West African contexts have employed five-point Likert scales and one-sample t-tests to quantify adequacy against theoretical thresholds (Aliu et al., 2014; Nzeadibe & Ejike-Alieji, 2020).

Notably, Aliu et al. (2014) developed service reliability and operational quality indices assessing public-private partnership performance across Lagos density categories, establishing a methodological precedent for the present study's eight-indicator instrument.

2.3 Density, Waste Generation, and Collection Challenges

The relationship between residential density and municipal solid waste generation is non-linear. Although higher population concentration increases total waste volumes per unit area, per capita generation often declines with rising density, as affluence and lifestyle factors in lower-density zones drive higher individual output (Adeleke, 2023).

Nevertheless, concentrated development creates intense localised accumulation challenges: replacing detached housing with apartment blocks multiplies waste volumes at single collection points, overwhelming bin capacity (Miezah et al., 2015).

Miezah et al. (2015) and Oyelaran et al. (2022) confirm positive correlations between residential density and per-hectare waste generation in West African cities, with high-density areas routinely exceeding collection infrastructure design capacity.

Containment infrastructure is particularly susceptible to overloading, producing overflow conditions that attract disease vectors (Ayeleru et al., 2020; Soltani et al., 2021).

Public housing estates present distinct density-related challenges. Though formally planned, estate infrastructure frequently predates current population levels. Adeyemi et al. (2022) found that Nigerian public housing estates built between the 1970s and 1990s were designed for occupancy rates 30–60% below current levels, producing chronic overflow even under regular collection schedules (Ayotamuno & Gobo, 2020).

Traditional collection methods further struggle in dense settings due to restricted spatial footprints, overflow risk, and higher required emptying frequencies (Wu et al., 2022).

2.4 Informal Disposal Practices and Environmental Consequences

When formal waste collection systems underperform, residents resort to informal disposal practices with serious environmental consequences (Long et al., 2020). In Lagos, inadequate bin provision and irregular collection compel disposal in drainage channels, open spaces, and road verges, contributing to environmental degradation and reduced residential livability (Akintoye et al., 2024).

Ummah (2019) confirms that illegal dumping in Lagos is strongly associated with drainage blockage, flooding, and public health risks, particularly in densely populated areas where stormwater systems are already strained.

Open burning releases toxic compounds including dioxins, furans, and particulate matter, driving respiratory illness and soil contamination (Ayeleru et al., 2020; Wiedinmyer et al., 2014), while accumulated waste breeds disease vectors, elevating risks of malaria, cholera, and typhoid (Lima et al., 2018).

Oyelaran et al. (2022) document a strong inverse correlation between formal collection adequacy and informal disposal rates in Nigerian housing estates and crucially find that informal habits persist even after service improvement, suggesting path dependency that makes early intervention critical.

Nzeadibe & Ejike-Alieji (2020) argue these practices reflect systemic institutional underprovision rather than household failures, requiring governance-level responses. Aste et al. (2020) further emphasise that optimised bin placement and logistics planning are essential for reducing indiscriminate dumping.

2.5 Waste Management in Lagos

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Lagos generates over 13,000 tonnes of solid waste daily, driven by rapid urbanisation, population growth, and economic activity (Alagbe et al., 2023; LAWMA, 2023; Onamade et al., 2022). Waste management is coordinated by LAWMA, established in 1991 and restructured in 2007 to incorporate licensed Private Sector Participants (PSPs) operating under a franchise model.

While this partnership improved collection in accessible areas, Otitoju & Seng (2021) find it systematically underserved dense, low-income estates. Persistent problems include irregular collection, inadequate storage, overflowing bins, illegal dumping, and open burning, contributing to pollution, public health risks, and drainage blockage that causes urban flooding (Nzeadibe & Ejike-Alieji, 2020; Ogwueleka, 2021).

Public housing estates face compounded challenges from high densities, collection delays, and waste spillage (Aliu et al., 2014). Recent policy frameworks, including the Lagos State Environmental Sanitation Law (2017) and the Waste Management Master Plan (2020), mandate density-responsive service delivery, though implementation monitoring remains weak (LAWMA, 2020; Adeyemi et al., 2022).

III. METHODOLOGY

This study adopted a cross-sectional survey design to assess residents' perceptions of municipal solid waste (MSW) collection adequacy in formal public housing estates in Lagos State, Nigeria.

A quantitative approach was employed to enable systematic measurement across a representative sample and to support inferential statistical analysis. The study was conducted within Lagos State Development Property Corporation (LSDPC) estates managed under LAWMA.

A total of 352 adult residents were randomly sampled across low-, medium-, and high-density estate strata, ensuring proportional representation and enabling subgroup comparisons.

Eligibility required direct residential experience with formal PSP-managed collection services. Data were collected via a structured, self-administered questionnaire assessing eight waste collection adequacy indicators: collection reliability, frequency, container capacity, segregation instruction, bin overflow, spillage, scheduling irregularity, and alternative disposal practices.

Each indicator was measured on a five-point Likert-type scale (1 = Highly Adequate; 5 = Highly Inadequate). Descriptive statistics and one-sample t-tests were computed using a test value of 3.0. Cohen's d assessed practical significance at $p < .001$. All analyses were conducted in IBM SPSS Statistics v26. Ethical approval was obtained prior to commencement, and participation was entirely voluntary.

IV. RESULTS AND DISCUSSION

Table 1: Waste Collection Adequacy Indicators — Descriptive Statistics and One-Sample T-Tests (n = 352)

Waste Collection Indicator	Mean	SD	t-value	Interpretation
Reliability of waste collection	2.05	0.980	−19.14***	Adequate
Frequency of waste collection	2.13	0.960	−17.30***	Adequate
Adequacy of container capacity	2.48	1.120	−8.63***	Borderline adequate
Waste segregation instruction	3.06	1.041	1.08	Borderline inadequate
Overflowing waste bins	3.11	1.097	1.88	Moderately inadequate
Waste spillage during collection	3.32	1.063	5.64***	Moderately inadequate

Irregular collection schedules	3.78	1.142	12.80***	Highly inadequate
Alternative disposal of uncollected waste	4.18	1.199	18.47***	Highly inadequate

Note: Scale range 1–5 (1 = Highly Adequate; 5 = Highly Inadequate). Test value = 3.0. *** $p < 0.001$.

4.1 Objective 1: Reliability and Frequency of Waste Collection

Reliability of waste collection recorded the lowest mean score (M = 2.05; SD = 0.980; $t(351) = -19.14$; $p < 0.001$; $d = 1.02$), indicating that residents broadly perceived collection services as dependable. Frequency of collection was similarly rated adequate (M = 2.13; SD = 0.960; $t(351) = -17.30$; $p < 0.001$; $d = 0.92$).

These findings are consistent with Adeyemi et al. (2022), who found that PSP-managed estates in Southwest Nigeria maintained adequate collection frequency in most formal estates, and with Otitoju & Seng (2021), who documented improvements in collection regularity following LAWMA's PSP franchise reform.

Container capacity was rated borderline adequate (M = 2.48; SD = 1.120), but with considerable variance across density strata, suggesting that high-density estates experience materially worse containment conditions — consistent with Koleosho et al. (2023).

The adequacy of collection reliability and frequency in formal public housing estates contrasts markedly with patterns documented in informal settlements and peri-urban Lagos, where collection rates rarely exceed 50% (Nzeadibe & Ejike-Alieji, 2020; Ogwueleka, 2021).

This divergence underscores the importance of estate typology in waste service assessments and supports the argument that policy interventions must be targeted rather than uniform.

4.2 Objective 2: Operational Deficiencies in Waste Collection

Significant operational deficiencies were identified across multiple indicators. Waste spillage during collection operations recorded a mean of 3.32 (SD = 1.063; $t(351) = 5.64$; $p < 0.001$; $d = 0.30$), indicating moderate inadequacy.

This finding corroborates Ayeleru et al. (2020), who observed that poorly maintained collection vehicles and inadequate sealing of waste containers during transit generate secondary contamination at collection points, compounded in high-density estates by the volume of waste handled per vehicle.

Overflowing waste bins recorded a mean of 3.11 (SD = 1.097), consistent with evidence from Adeyemi et al. (2022) that bin infrastructure in Nigerian public housing estates is chronically undersized relative to current occupancy levels.

Lack of waste segregation instruction recorded a borderline inadequacy score (M = 3.06; SD = 1.041). Inadequate segregation reduces opportunities for material recovery and recycling, increases waste volumes requiring collection, and reduces the effectiveness of any future transition to source-separation systems (Leal Filho et al., 2021; Oyelaran et al., 2022).

Wilson et al. (2021) note that resident education on waste segregation is most effective when integrated with visible infrastructure changes such as colour-coded bins.

Irregular collection scheduling was the most severe operational challenge (M = 3.78; SD = 1.142; $t(351) = 12.80$; $p < 0.001$; $d = 0.68$). Residents perceive collections as generally reliable in occurrence, yet highly unpredictable in scheduling.

This distinction aligns with Guerrero et al.'s (2013) separation of service dependability from schedule consistency. When residents cannot predict collection timing, they stockpile waste beyond safe storage limits or dispose of it informally (Wilson et al., 2021).

4.3 Objective 3: Environmental Implications of Alternative Disposal Practices

The use of alternative disposal methods for uncollected waste recorded the highest inadequacy score ($M = 4.18$; $SD = 1.199$; $t(351) = 18.47$; $p < 0.001$; $d = 0.98$). Residents reported resorting to open burning, illegal dumping, and disposal into drainage channels when formal collection systems failed.

These findings align with Oyelaran et al. (2022), who documented similar informal disposal prevalence (73% of surveyed households) in public housing estates in Ogun State, and with Ayeleru et al. (2020), who identified open burning and drain disposal as dominant informal strategies in Lagos residential areas.

Open burning of mixed municipal solid waste generates significant concentrations of PM2.5 particulates, dioxins, and polycyclic aromatic hydrocarbons, contributing to respiratory morbidity (Soltani et al., 2021).

Disposal into drainage channels is a leading cause of urban flooding in Lagos, affecting an estimated 30% of the metropolitan area during peak rainfall periods (Tanner & Johnston, 2021).

These consequences disproportionately affect high-density estate residents, who are both most likely to engage in informal disposal and most exposed to its environmental consequences due to higher population concentration.

The high prevalence of informal disposal in formally planned, institutionally served public housing estates represents a significant failure of the LAWMA PSP model. Nzeadibe & Ejike-Alieji (2020) and Otitoju & Seng (2021) argue that PSP franchising in Lagos has prioritised financially viable collection routes over high-density, logistically complex estate contexts, producing systematic service inequity — a conclusion supported by this study's findings.

V. CONCLUSION

This study assessed the adequacy of domestic solid waste collection in density-stratified public housing estates in Lagos, Nigeria.

Three principal conclusions emerge. First, formal waste collection systems maintain adequate performance on collection reliability and frequency, suggesting that PSP-managed services have achieved baseline operational delivery — an underreported finding in literature dominated by accounts of systemic failure.

Second, significant operational deficiencies persist in scheduling predictability, waste containment adequacy, and collection operational efficiency. Addressing scheduling unpredictability in particular could generate disproportionate returns in reducing informal disposal behaviour.

Third, the high prevalence of informal disposal practices constitutes a public health and environmental governance challenge of serious proportions, representing a systemic response to institutional deficiencies rather than marginal household behaviour.

5.1 Recommendations

LAWMA and its PSP partners should adopt density-differentiated collection schedules, with high-density estates receiving increased collection frequency and published, adhered-to timetables communicated to residents through estate management offices and mobile notifications.

Waste containment infrastructure should be subject to mandatory capacity audits benchmarked against current occupancy levels, with bin provision standards updated to reflect density-adjusted waste generation rates (Koleosho et al., 2023).

Resident ensitization on waste segregation should incorporate colour-coded communal bins with multilingual labelling alongside community education campaigns delivered through residents' associations.

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