An Alternative Innovative Model for financing Solid Waste Management: A case of Lusaka City

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ABSTRACT

Solid Waste Management (SWM) remains a critical challenge in rapidly urbanizing cities, particularly in low and middle-income countries like Zambia, where financial and institutional capacities are constrained. This study investigates the effectiveness and sustainability of innovative financing models including Public-Private Partnerships (PPPs), technological integration, economic instruments and community participation in supporting SWM in Lusaka. Grounded in a pragmatist philosophy, a concurrent triangulation mixed-methods design was employed. Data were collected from 377 urban residents via structured questionnaires and 13 institutional stakeholders through semi-structured interviews. Quantitative analysis was conducted using SPSS, while qualitative data were thematically analyzed using Atlas.ti. Findings reveal that willingness to financially support improved SWM services is strongly influenced by the perceived importance of technology, prior experience with digital payment platforms and expectations of reliable service delivery. Education level emerged as a key factor shaping public attitudes toward financing approaches. Interestingly, models based on community contributions or PPPs were less favored by respondents, suggesting concerns around fairness, trust and governance. Qualitative insights reinforced these findings, highlighting challenges such as inconsistent service provision, limited stakeholder engagement and weak transparency in decision-making. Stakeholders emphasized the importance of digital transformation, inclusive education campaigns and stronger institutional accountability to build public trust and participation. The study concludes that no single financing model is universally applicable. It recommends tiered, technology-enabled and community-informed strategies tailored to the local context. The research provides practical insights for policymakers, urban planners, and development partners working toward more sustainable and inclusive urban waste systems.

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Introduction

Solid Waste Management (SWM) remains a growing concern for rapidly urbanizing cities globally, particularly in low and middle-income countries where institutional and financial capacities are often inadequate. Local Authorities in Zambia depend on traditional SWM financing methods such as government subsidies, donor support and user fees that have proven insufficient to meet increasing demand for efficient, equitable and environmentally responsible waste services. As urban populations expand, the pressure on local authorities to provide sustainable Waste Management (WM) solutions intensifies, making it necessary to explore alternative, innovative financing mechanisms.

In response to these challenges, attention has shifted toward models that leverage public private partnerships (PPPs), economic instruments and digital technologies. PPPs can mobilize private sector expertise and investment, while technology such as digital payment systems and smart waste monitoring tools can enhance service efficiency, transparency and user participation. Additionally, economic tools like landfill taxes and subsidies for recycling have shown potential in improving resource mobilization. However, the success of these models largely depends on local governance frameworks, institutional readiness and public engagement.

This study investigates the effectiveness and sustainability of these alternative financing models in the context of Lusaka.

It further explores the role of community participation and emerging Fourth Industrial Revolution technologies in shaping inclusive SWM solutions. Adopting a pragmatist worldview and a mixed-methods design, the study integrates stakeholder perspectives and statistical analysis to assess how innovative financing approaches can be aligned with the city's socio-economic realities.

The research is guided by key questions that aim to inform policy, improve implementation and promote financially viable urban waste systems

Literature Review and Synthesis

Introduction

A review of the global and regional literature reveals that PPPs have emerged as a dominant financing mechanism in SWM, particularly in Africa and Asia, where private sector expertise and resources supplement constrained public systems. Studies from Kenya, Ghana and Tanzania illustrate improved collection efficiency under PPP arrangements, though challenges such as limited transparency and public accountability persist. Community participation is frequently cited as a critical success factor, but it remains inconsistently applied across regions. In Asia, experiences vary, while India reports expanded service coverage through PPPs, issues of quality and sustainability remain unresolved. Countries like the Philippines have shown that localized governance and multi-stakeholder collaboration can enhance outcomes. Technological innovations, including Internet of Things-enabled smart bins and AI-driven sorting, are increasingly employed to improve operational efficiency and transparency. However, their adoption in low-income settings is often hampered by high initial costs and lack of institutional capacity. Economic instruments such as user fees and landfill taxes are widespread but vary in effectiveness, with blended finance models involving international donors offering promising but underexplored potential. Despite these advances, significant knowledge gaps exist, particularly regarding empirical assessments of community willingness to pay and the long-term sustainability of PPP and technology-based financing models.

This section synthesizes global and regional literature on alternative innovative models for financing SWM. The review is organized thematically and regionally, with a focus on PPPs, community involvement, technological innovation and economic instruments. The review draws on journal articles, case studies, government and NGO reports from Africa, Asia, Europe and the Americas.

Public-Private Partnerships (PPPs) and Community Engagement

PPPs emerge as a dominant financing model across regions. LCC initiated PPPs in 2003 to improve efficiency in urban SWM (Chisenga & Simbeye, 2024). Studies from Kenya, Ghana and Tanzania confirm similar trends, highlighting the expertise and resource availability of private firms (Toku & Mabe, 2024; Adedara & Taiwo, 2023; Amugsi & Muindi, 2022). However, some challenges persist, such as lack of transparency and limited public accountability (Kihila & Wernsted, 2021). Community participation is often emphasized as a success factor but remains inconsistently implemented.

In Asia, PPPs show mixed results. While India has seen expanded service coverage, service quality and sustainability vary (Ngullie & Maturi, 2021; Sandu, 2020). In Thailand and the Philippines, localized governance and multi-stakeholder collaboration have proven more effective (Wiangnon, 2023). Table 1 below is a comparative analysis of PPP implementation strength and weaknesses in Africa and Asia.

Table 1 Comparative Analysis of PPP Implementation in SWM (Africa vs. Asia)

Country	PPP Strength	PPP Weakness	Community Role
Zambia	Improved collection via LCC	Weak oversight, informal areas left	Emerging
India	Expanded Coverage	Inconsistent quality	Minimal
Philippines	Strong private engagement	Institutional fragmentation	Localized and growing

Technological Innovation in Financing and Operations

Across all continents, technological tools are transforming SWM financing and delivery. IoT-integrated smart bins and AI-driven sorting systems are improving operational efficiency (Spyrids & Argyriou, 2024; Ghahramani et al., 2022). Israel and Colombia have adopted technology-based financing models like landfill levies and tax exemptions for recycling (Cohen, 2024; Chioatto & Sospiro, 2023). South Korea offers long-term low-interest loans for SWM infrastructure (Park, 2019), and Japan provides direct capital subsidies.

The main strength of tech-based financing is its scalability and transparency. However, a common weakness is limited adoption in low-income regions due to capital costs and lack of institutional capacity. Table 2 below illustrates the use the technology by country, technology used, financing mechanism and challenges faced.

Table 2: Use of Technology in SWM Financing Across Regions

Country	Technology Used	Financing Mechanism	Challenges
Europe	IoT, AI, Tax incentives	Landfill levies, recycling credits	High capital investment
Asia	Smart bins, subsidies	Government loans and incentives	Unequal access, urban bias
Africa	Limited	Experimental PPPs	Infrastructure and funding gaps

Economic Instruments and Blended Finance

Economic instruments such as user fees, landfill taxes and international aid are widely used but unevenly effective. Bristow and Ezeudu (2024) argue that when user fees are transparently implemented alongside PPPs, they ensure financial sustainability. However, Bharadwaj et al. (2020) caution against over-reliance on subsidies, citing economic volatility and limited revenue generation.

Blended finance and international cooperation models, like the AIIB's support in Indonesia and Canada's Equality Fund, bring global capital to local contexts (AIIB, 2024; Wilcox, 2020). These require strong institutional coordination and policy frameworks, which are often weak in developing countries.

Critical Synthesis and Research Gaps

While the reviewed studies collectively highlight a range of innovative financing models, several gaps and limitations are evident:

- **Strengths:** Diverse models (PPPs, tech, loans) show promise when well-integrated with policy and stakeholder engagement.
- **Weaknesses:** Many studies lack empirical depth, especially in community-centered or informal settlement-focused financing models.
- **Contributions:** Literature from Asia and Latin America provides strong examples of blended finance, while African studies emphasize institutional reform needs.

Key Research Gaps Identified:

- Limited empirical research on community willingness to pay and use of digital payment systems in African cities.
- Lack of case-based analysis on adaptive, localized financing models in informal settlements.
- Insufficient comparative work evaluating long-term impacts of PPP and technology-based financing on service sustainability.

Underlying Philosophy

This research is grounded in a pragmatist philosophy, embracing a mixed-methods approach to generate both in-depth qualitative insights and quantitative evidence that can inform actionable policy and practice. Pragmatism is particularly suitable for this study as it allows the integration of multiple perspectives and methods to address complex, real-world challenges in sustainable WM financing. This philosophical stance supports the exploration of diverse

financing mechanisms and their contextual applications by prioritizing practical outcomes and stakeholder relevance. In research, pragmatism allows for methodological pluralism, prioritizing the research question over strict allegiance to either positivist or interpretivist paradigms (Creswell & Clark, 2018).

This approach is particularly relevant to the study of SWM financing, a field that involves complex interactions among technical, institutional and social systems. Pragmatism supports the use of mixed methods that include qualitative and quantitative to capture the multifaceted realities of these systems and the perspectives of various stakeholders. Pragmatism provides a flexible but rigorous foundation for integrating case-based interviews with numerical survey data, enabling both depth and generalizability (Tashakkori & Teddlie, 2010)

Moreover, this philosophical stance aligns with the applied and interdisciplinary nature of urban governance and sustainability research, where knowledge is often co-produced among academics, policymakers, private sector actors and communities (Nowotny & Gibbons, 2001). Pragmatism thus legitimizes the inclusion of diverse stakeholder perspectives and emphasizes useful knowledge that can inform practical decision-making in urban SWM systems.

In addressing the financial and institutional challenges of SWM, particularly in low and middle-income contexts, pragmatism allows the researcher to examine context-specific solutions rather than seeking universal truths. For example, evaluating PPPs, community-based models and technological interventions benefits from both subjective interpretation and empirical measurement a balance pragmatism encourages.

In summary, adopting a pragmatic worldview not only aligns with the study's problem-driven focus but also provides the epistemological flexibility to explore how various financing models function across different urban environments. This orientation helps bridge the gap between theory and practice, making the findings more actionable for stakeholders involved in urban waste governance.

Knowledge Gap

Despite increasing interest in innovative financing mechanisms for SWM, significant knowledge gaps persist, particularly in low and middle-income urban contexts such as Lusaka. One critical shortfall is the limited empirical research on community willingness to pay for improved waste services, especially in informal settlements and peri-urban areas. Existing studies often generalize payment behavior without accounting for variables such as trust in institutions, service reliability and affordability, all of which are crucial determinants of financial participation in these communities.

Another underexplored area is the integration of digital payment systems into SWM financing. While mobile money platforms have revolutionized sectors like retail and health in Africa, their application in waste services remains rare and poorly understood. Issues like low digital literacy, infrastructural deficits and user skepticism create barriers to adoption that require deeper investigation. The intersection between technological readiness and financial behavior remains largely uncharted.

Furthermore, there is a lack of longitudinal research evaluating the sustainability and equity of PPPs and technology-driven models. Most studies offer snapshots of short-term efficiency gains but fail to examine long-term outcomes such as institutional resilience, cost recovery, or socio-economic disparities in service access. Similarly, while blended finance and donor-supported models show promise, there is limited understanding of how they align with local governance structures or address community priorities.

Behavioral and social dimensions are also insufficiently addressed. Factors such as perceived fairness of fees**,** trust in service providers and the role of civic education are often treated as secondary rather than central to financing models. Additionally, few frameworks integrate financial, governance, and technological dimensions into a holistic, context-sensitive model that can be adapted across diverse urban environments.

Addressing these knowledge gaps is vital for designing inclusive, equitable and resilient financing strategies for urban SWM systems.

Methodology

Time Horizon

This study employed a cross-sectional time horizon**,** meaning data was collected at a single point in time. A cross-sectional

approach was selected for its cost-effectiveness and time efficiency, making it suitable for a study conducted with limited time and resources. It aligns with similar SWM studies that assess stakeholder awareness and practices in a defined period (Olwa & Mwesigwa, 2023). The study relates closely with the current study in several important ways that includes being conducted in Sub-Saharan (Uganda), making the urban governance and institutional dynamics related. It is also a mixed-method framework combining surveys and interviews for robust triangulation including focus on stakeholder awareness, engagement and their impact on SWM effectiveness.

Research Method and Justification

This study used a mixed-methods approach, combining qualitative and quantitative methods. The qualitative component involved semi-structured interviews with key SWM stakeholders in organizations, while the quantitative aspect utilized structured questionnaires for individuals in communities and Lusaka's Central Business District (CBD).

The concurrent triangulation design was applied to enable simultaneous data collection, allowing for the triangulation of results during analysis. This mixed-methods design was justified to address the limitations of using a single method and to strengthen the validity and credibility of the findings.

Sampling Size

The study used purposive sampling for the qualitative phase to select key informants involved in SWM at the organizational level. A probability sampling technique was used to ensure representativeness in the community and CBD populations for quantitative phase. Sample sizes were determined based on accessibility, stakeholder availability and population density, ensuring sufficient data for comparative and regression analysis.

Data Collection and Analysis

Data Collection

Data was collected in two phases, namely qualitative and quantitative. At the qualitative Phase, Semi-structured interviews were conducted with SWM officials and stakeholders to gain in-depth insights into current financing models and challenges. At the quantitative phase, structured questionnaires were administered in the CBD and selected communities, using a five-point Likert scale to capture perceptions and experiences.

Data Analysis

Qualitative Data was analyzed through thematic analysis conducted using **Atlas.ti** software. Themes were coded, grouped and interpreted and content analysis was applied to assess the frequency of recurring themes.

Quantitative Data was analyzed using statistical analysis using **SPSS**. This included:

i. Descriptive statistics and case processing summaries

ii. **Reliability tests** (Cronbach's Alpha)

iii. **Normality tests** (Shapiro-Wilk)

iv. **Cross-tabulation and Chi-square tests**

v. **ANOVA** and **Multiple Regression Analysis**

These methods helped determine the relationships between variables such as PPPs, tax incentives, digital systems and community participation in SWM financing

Reliability and Validity

The study ensured internal consistency through Cronbach's Alpha reliability tests. Questionnaire items were pre-tested, and necessary adjustments were made to enhance clarity and reliability. The use of SPSS supported rigorous quantitative reliability checks.

Triangulation was employed to improve construct and content validity by comparing data from interviews and questionnaires. This allowed a more comprehensive understanding of the research problem. The use of thematic and content analysis further ensured qualitative data validity.

Generalization of Research Findings

While the findings are context-specific to Lusaka City, the use of representative sampling and mixed methods allows for moderate generalizability to similar urban areas facing SWM challenges in developing countries. However, results should be interpreted within the local context due to socio-political and infrastructural differences.

Data Analysis Overview

This study used a mixed-methods approach to examine the factors and stakeholders influencing the adoption and sustainability of innovative financing models for SWM in Lusaka. Quantitative data were gathered from 377 respondents including community members, market operators, CBD representatives and dumpsite workers while qualitative insights were drawn from 13 institutional stakeholders in senior SWM roles.

The core of the quantitative analysis focused on willingness to pay for improved SWM services, using a five-point Likert scale. Multiple linear regression revealed that individuals who viewed technology as crucial for improving waste services were significantly more likely to support financing these improvements. Similarly, those already using digital payment platforms and those who supported other waste-related programs were more inclined to contribute financially. Willingness to pay regular fees provided services improved was another strong factor, along with support for tax-based funding models.

Interestingly, respondents who preferred community-funded projects or believed in PPPs were less willing to pay directly, possibly reflecting concerns over fairness or expectations that institutions or private firms should bear those costs. Beyond the regression, other statistical tests added depth. ANOVA showed that education level influenced views on financing, technology, and policy. Chi-square and crosstab analyses confirmed a clear trend that higher-educated individuals favored structured and tech-driven funding models, while those with less formal education preferred basic service improvements and were more likely to use informal disposal methods like burning or burying waste.

Qualitative findings mirrored these patterns. Institutional stakeholders emphasized the importance of digital transformation, better policy integration and inclusive stakeholder engagement. In contrast, many community-level respondents lacked formal employment, generated minimal daily waste, and had limited access to formal collection services.

Together, the data point to the need for tiered and inclusive SWM financing strategies that leverage technology, engage local communities and align with the capacities and needs of different stakeholder groups.

Findings

This study explored the factors influencing the adoption and sustainability of innovative financing models for SWM in Lusaka City using a mixed-methods approach. Quantitative findings were derived from surveys with 377 respondents, while qualitative insights were obtained through stakeholder interviews coded and analyzed in ATLAS.ti. The results provide a comprehensive understanding of behavioral, technological and policy-level dynamics shaping public willingness to financially support improved SWM.

7.1 Technological Readiness and Digital Payments emerged as strong determinants of financial commitment. Regression analysis showed that perceived importance of technology ($\beta = .510$, $p < .001$) and usage of digital payment options ($\beta = .247$, $p < .001$) significantly influenced willingness to pay for improved waste services. Triangulated qualitative data reinforced these findings, with stakeholders consistently highlighting tools like smart bins, tracking systems and mobile money as both operational enablers and trust-building mechanisms. These findings suggest that embedding digital tools into SWM processes can enhance efficiency, transparency and user engagement.

7.2 Behavioral Indicators such as general support for waste-related programs ($\beta = .192$, $p < .001$) and conditional fee acceptance ($\beta = .160$, $p = .001$) also played a key role in predicting willingness to pay. This demonstrates that respondents are more likely to contribute financially if service quality visibly improves. However, the study revealed a paradox where willingness to join community-funded projects was negatively associated with financial contribution ($\beta = –.119$, $p = .001$), suggesting a perceived divide between voluntary participation and monetary responsibility.

7.3 Public Distrust in PPPs surfaced as a recurring concern. While PPPs are often advocated for resource mobilization, regression results showed a negative association between belief in PPP effectiveness and willingness to pay ($\beta = –.116$,

p = .039). Qualitative quotes echoed this skepticism, with respondents citing past service delivery failures. This implies that PPP models must prioritize accountability and community inclusion to gain public support.

7.4 Demographic Insights revealed significant associations between educational attainment and support for various SWM initiatives. Chi-square and crosstab analyses showed that individuals with lower education levels prioritized basic services, while higher-educated respondents favored educational and innovative strategies. ANOVA confirmed that education significantly influenced attitudes toward paying for services, use of technology and perceived importance of funding (all $p < .001$).

7.5 Employment Status and Waste Generation were also crucial. Institutional stakeholders with formal employment and policy roles showed strong engagement with strategic SWM decisions. Conversely, a significant portion of the survey population was unemployed or informally employed, producing smaller volumes of waste. This disparity emphasizes the need for differentiated financing models targeted subsidies for low-income users and tiered responsibilities for high-volume generators.

7.6 Disposal Behavior varied by education and income, with higher-income groups using private services and lower-income users relying on informal methods. This highlighted infrastructure gaps and affirmed the need for inclusive, subsidized, or community-driven collection systems.

In summary, the findings underscore that successful financing of SWM in Lusaka depends on a combination of technology integration, digital financial tools, trust in governance structures and socially responsive models that reflect the city's diverse socio-economic landscape

8. Conclusion and Recommendation

This study examined the challenges and opportunities for innovative financing of SWM in Lusaka, revealing significant systemic gaps and behavioral constraints. The findings demonstrate that the city's current financing model overly dependent on central government grants and lacking inclusivity, digital innovation and community trust making it impossible to meet the LISWMC's 2030 WM targets. Public willingness to pay for improved services is shaped by education levels, technological readiness and trust in institutions, while the failure to integrate informal actors and adapt service packages to diverse socio-economic realities undermines sustainability.

However, the analysis also highlighted promising pathways. Experiences from peer cities show that mobile payment systems, smart technologies, performance-based PPPs and community waste banks can significantly enhance financial sustainability when contextualized. A hybrid, tiered financing model linked to digital platforms, behavioral incentives and stakeholder segmentation offers a feasible and inclusive solution for Lusaka.

Based on these findings, the study recommends that Lusaka adopt a differentiated financing framework tailored to income levels and waste generation volumes. Mobile money platforms should be prioritized to streamline payments and expand service coverage, especially in informal settlements. PPPs must be restructured with enforceable accountability mechanisms and citizen oversight to rebuild trust. Furthermore, community involvement must be incentivized through tangible rewards such as service discounts or community development benefits. Educational campaigns tailored to varying literacy levels can further strengthen engagement and payment compliance.

Ultimately, Lusaka's path to a cleaner, more sustainable urban environment requires not just technical fixes, but a renewed social contract between government, citizens and private actors. By embracing inclusive governance, digital innovation and targeted outreach, the city can unlock the financial resources and public trust needed to transform its WM system for the long term.

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