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ASSESSMENT OF SUSTAINABLE WASTE MANAGEMENT PRACTICES IN URBAN ENVIRONMENTS

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Abstract

Rapid urbanisation has significantly increased municipal solid waste generation, creating serious environmental and management challenges in urban areas. This paper has evaluated sustainable waste management practices in an urban environment with an emphasis on establishing gaps that need more attention and exposure. The research design applied was descriptive and analytical, and both primary and secondary data, in the form of household surveys, interviews, and field observations as well as secondary data in the form of reports and literature, were used. The main parameters included segregation of wastes, efficiency of collection, recycling, public awareness, and policy implementation. The findings revealed that, in spite of the fact that waste management systems were in place, they had a number of critical gaps. The source segregation of waste was also observed to be low, with most households discarding mixed waste. Collection services were inconsistent in their efficiency, especially in remote locations, which resulted in the piling up of waste and environmental issues. There was a lack of development of recycling and resource recovery practices, which are predominantly informal, and composting and sustainable waste utilisation were also underdeveloped. Also, the level of public awareness and engagement was average, yet it was not enough to instigate a steady change of behaviour, and implementation of policies at the ground level was observed to be patchy. The research identifies the necessity of better infrastructure, better policy implementation, better awareness of the population and the introduction of new technologies to reinforce the waste management system. More attention should be paid to the unexplored aspects, including the inclusion of the community and the informal sector in the process of waste management in urban areas in order to attain sustainable development of the waste management system.

Keywords: Sustainable waste management, Urban environment, Waste segregation, Recycling practices, Environmental sustainability

1. Introduction

The growing rate of urbanisation has contributed to the high rate of municipal solid waste production, which has raised enormous environmental, social and economic issues, more so in the developing and emerging economies. Poor waste management systems cause harm to the environment, human health, and natural resources, and sustainable waste management is a key field of applied science (Abubakar et al., 2022; Pernebayev and Aitimbetova, 2026). With the growth of cities, the volume of waste materials to be handled, such as organic, plastic, and hazardous waste, necessitate holistic and dynamic approaches that extend beyond traditional collection and disposal techniques. Current waste management systems in urban areas are not always able to keep up with the increase in the population and consumption trends, which means that more efficient and environmentally friendly methods of waste management are urgently required (Kosoe et al., 2021; Vardopoulos et al., 2021).

Sustainable waste management is becoming a prominent part of sustainable urban development, integrating the concepts of resource efficiency, circular economy, and environmental safety. It has suggested different frameworks and assessment models to measure the efficiency of waste management systems, such as life cycle assessment (LCA), environmental indicators, and integrated planning approaches (Iqbal et al., 2020; Deus et al., 2020). Recent works insist on the need to shift to the model of circular cities, where waste is considered as a resource and reused in production processes, thus minimising the impact on the environment and increasing the resilience of the city (Moraes et al., 2023; Ragazou et al., 2024). Also, the contribution of smart technologies and data-driven systems to the optimization of the waste collection, segregation, and recycling processes have been receiving growing interest in the framework of smart cities (Szpilko et al., 2023; Bokhad et al., 2024).

Even with these improvements, there are still big holes in the use and effectiveness of sustainable waste management practices, especially at the local and municipal levels. While many studies offer theoretical frameworks and global viewpoints, there remains insufficient emphasis on context-specific challenges, such as infrastructure constraints, governance dilemmas, and fluctuations in waste generation patterns (Khosravani et al., 2023; Kosoe & Ogwu, 2025). Additionally, the measurement of waste generation, particularly in urban compared to peri-urban areas, is still not reliable, which makes it harder to plan and make policies (Eades et al., 2020). These gaps show that we need more localized assessments that can give us useful information on how to make waste management systems better in real-world cities. In this context, the current study seeks to evaluate sustainable waste management practices in urban settings, specifically highlighting underexplored domains that necessitate increased attention and visibility. This research aims to enhance the development of more efficient, inclusive, and sustainable waste management strategies by analyzing current practices, assessing their effectiveness, and identifying significant challenges. The study conforms to the applied science perspective by amalgamating empirical observations with established theoretical frameworks, thus providing pragmatic recommendations for policymakers, urban planners, and researchers striving for sustainable urban development.

This study represents specific objectives:

1. To evaluate the current status of waste management practices in urban environments.
2. To identify key gaps and underexplored areas requiring greater focus and exposure.
3. To propose practical and sustainable strategies for improving urban waste management systems.

2. Materials and Methods

2.1 Study Area

The study took place in a city where the population was growing quickly, people were buying more, and the city's solid waste management systems were under a lot of stress. The chosen study area exemplified a conventional urban environment within a developing framework, featuring a diverse amalgamation of residential, commercial, and peri-urban transitional zones. These areas had different levels of infrastructure development, access to city services, and social and economic diversity, all of which affect how people make and deal with waste. Special attention was paid to things like population density, estimated per capita waste generation, and the current system for collecting, moving, and throwing away trash. The study area was intentionally chosen to represent the complexities and systemic inefficiencies frequently encountered in urban waste management systems, thereby enabling a more grounded and application-oriented assessment.

2.2 Research Design

The research utilized a descriptive-analytical framework to systematically assess existing waste management practices and pinpoint significant deficiencies within the system. The descriptive part helped record how things are done now, how infrastructure is working, and how residents behave. The analytical part helped look at how different variables, like awareness, participation, and service efficiency, are related to each other. The study adhered to an applied research framework, emphasizing practical problem-solving and real-world relevance over mere theoretical investigation. A mixed-method approach was utilised, combining qualitative insights with quantitative measurements to strengthen the robustness and validity of the results. This design enabled a thorough assessment of both the technical and socio-behavioural aspects of urban waste management.

2.3 Data Collection

The primary and secondary sources were combined to gather data to ascertain the triangulation and reliability of information. Structured questionnaires were used to collect the primary data by administering them to the households within the study area. These questionnaires were structured to involve the rich information on the waste generation trends, source segregation, disposal techniques and the extent of awareness on sustainable waste management. Other than conducting surveys, semi-structured interviews were also used to establish views on areas of operation, gaps in the implementation of policies, and infrastructural limitation by interviewing the key stakeholders such as the municipal officials, sanitation workers, and waste collectors. Direct field observations were also done to evaluate real life practices concerning waste collection, transportation logistics, storage facilities and disposal sites thus verifying the answers received during surveys and interviews. Municipal records, official government reports, and other publications of scholars were used as secondary sources of data to give background information and facilitated comparison analysis. This multi source data gathering method increased the quality, believability and holism of the research.

2.4 Sampling Technique

Probabilistic random sampling process was used so that no particular section of the urban population was favored to use. The sample population consisted of households in different residential areas which reflected different socio-economic classes, low-income, middle-income, high-income. This stratified representation was important to represent the differences in waste generation behaviour, awareness and engagement in sustainable practice. The sample size was selected according to the practical feasibility, availability, and the need to obtain adequate statistical representation to make meaningful analysis. To eliminate spatial bias and to settle on the overall urban picture and not to localized conditions, the sample was distributed proportionally across the various zones. This design helped to make the results generalizable and reliable.

2.5 Parameters Assessed

The research assessed various parameters that are key in determining the effectiveness and sustainability of urban waste management systems. These parameters were the degree of segregation of waste at the source, which is a key condition of effective recycling and recovery of resources; the efficiency, frequency, and coverage of waste collection services; and the availability and use of recycling, composting, and reuse mechanisms. The research also evaluated the level of public awareness, the attitude towards waste management, and the levels of community engagement in sustainable practices. The efficiency of municipal policy, waste processing facilities, and the sufficiency of logistical support were also considered among institutional and infrastructural factors. These parameters were chosen as they give a multidimensional and holistic evaluation of the system and allow identifying both the technical inefficient areas and behavioural gaps.

2.6 Data Analysis

The data collected was analyzed through a mixture of descriptive and comparative statistical methods to come up with meaningful insights. The quantitative data collected in the survey of households were analyzed by frequency distributions, percentages, and tabular formats in order to find out the prevailing trends and patterns in the waste management practices. A comparison was carried out as a means of assessing the differences between the recommended sustainable practices and the observed practices in the field of study. Moreover, a systematic gap analysis has been conducted to demonstrate inconsistencies between policy frameworks and on-ground implementation to determine the areas that need more attention and intervention. Thematic analysis was performed

ASSESSMENT OF SUSTAINABLE WASTE MANAGEMENT PRACTICES IN URBAN ENVIRONMENTS on qualitative data collected through interviews and field observations to find out repetitive problems, operational problems and perspectives of stakeholders. Quantitative and qualitative analysis presentation helped to obtain a holistic picture of the system and helped to detect the unexplored areas which need to be paid more attention and be represented in the field of urban waste management.

3. Results

3.1 Current Waste Generation and Composition

The study results showed that the production of municipal solid waste in the chosen city was considerable and varied considerably among the various areas. Regions of concentrated population and commercialization had a higher rate of waste production than those that were only residential, or less developed. In the composition analysis, biodegradable waste had the highest percentage of total waste produced and this was mainly food and household based organic waste. This was accompanied by non-biodegradable elements like plastics, paper, glass and metals. An interesting fact was the increase in the percentage of plastic waste, which is indicative of a shift in the consumption pattern and the growing use of packaged products. Nevertheless, with the absence of systematic segregation practices, the majority of the waste was discarded in a mixed form, thereby lowering the efficiency of downstream processes like recycling and composting. Such a mixed waste stream did not only curtailed resource recovery, but also aggravated the load on landfill facilities and also polluted the environment.

Table 1: Composition of Municipal Solid Waste

Waste Type	Percentage (%)
Biodegradable Waste	48%
Plastics	22%
Paper/Cardboard	12%
Glass & Metals	8%
Others	10%

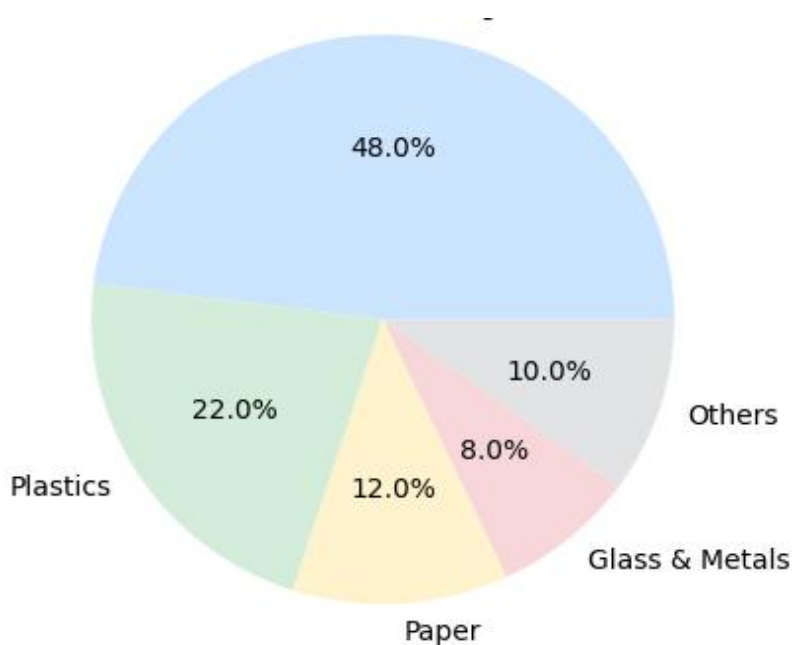


Figure 1. Municipal solid waste composition

3.2 Waste Segregation Practices

The results showed that source segregation was one of the least effective aspects of the waste management system. Most of the households did not have systematic segregation of garbage into biodegradable and non-biodegradable. Though, the percentage of those who reported partial segregation was low, it was usually disjointed and not based on standardised guidelines. Poor segregation practices were due to the lack of awareness, inadequate infrastructure like color coded bins and enforcement of municipal rules. In a number of occasions, even the households which tried to segregate complained that the collectors of waste mixed the waste together when collecting and discouraged them. This decouples the measures of the household level and the municipal activity which points to a critical gap in the system. This was due to the fact that with the absence of segregation, recycling and composting could only be minimized thus impacting the overall sustainability of the waste management practices.

Table 2: Household Waste Segregation Practices

Segregation Practice	Percentage (%)
No Segregation	64%
Partial Segregation	26%
Proper Segregation	10%

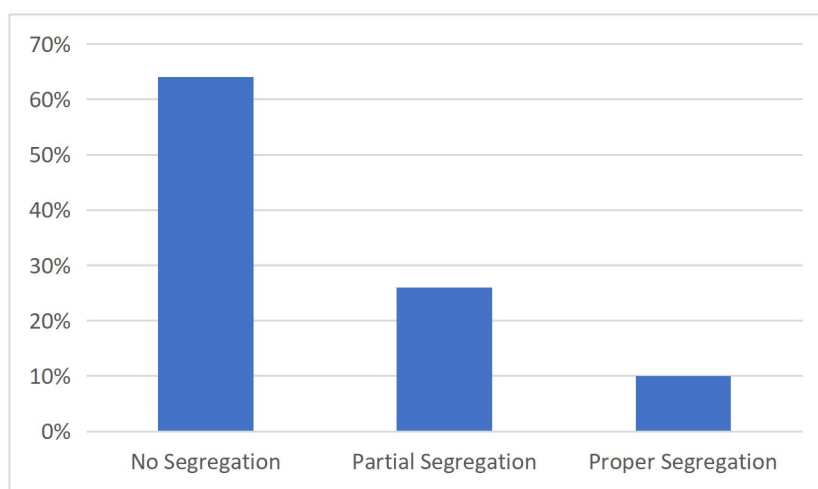


Figure 2. Household waste segregation practices

3.3 Waste Collection and Transportation Efficiency

The research revealed that service provision for waste collection was generally available throughout the urban region; but the efficiency and reliability of the services varied. Waste collection in the developed and central areas was relatively frequent, typically daily or alternate days. However, in less developed and less accessible areas, collection was less frequent, which resulted in waste being left in public spaces and along streets. This not only posed a sanitary problem but also risk of diseases and pollution. Waste collection and transportation typically involved traditional vehicles with minimal use of modern and efficient logistics solutions. In some cases, the waste was not transported properly leading to spills and pollution. Insufficient route planning and fleet management also played a role in the inefficiencies. In summary, the study identified the need for better planning and infrastructure to ensure well-coordinated and efficient collection and transportation services.

Table 3: Waste Collection Efficiency Across Zones

Area Type	Collection Frequency	Efficiency Level
Central Urban Area	Daily	High
Residential Area	Alternate Days	Moderate
Peripheral Area	Irregular	Low

3.4 Recycling and Resource Recovery Practices

The study showed that recycling and resource recovery were not well established or properly integrated into the formal waste management system. Recyclables were largely reclaimed through informal means, mainly by informal collectors and scrap merchants. These informal actors helped recover valuable resources like plastics, metals and paper; but these activities were not properly encouraged or integrated within formal waste management frameworks. Formal recycling plants were either few or poorly used due to the contamination of the collected waste. Furthermore, organic waste composting was found to be limited, with only a handful of households or community-based activities engaging in this activity. This suggested an opportunity to harness biodegradable waste for resource recovery, such as compost or biogas production. The lack of organised recycling and incentives for resource recovery hindered the effectiveness and sustainability of waste management in the region.

Table 4: Waste Management Practices Adoption

Practice Type	Adoption Level (%)
Recycling	28%
Composting	12%
Reuse Practices	20%
No Sustainable Practice	40%

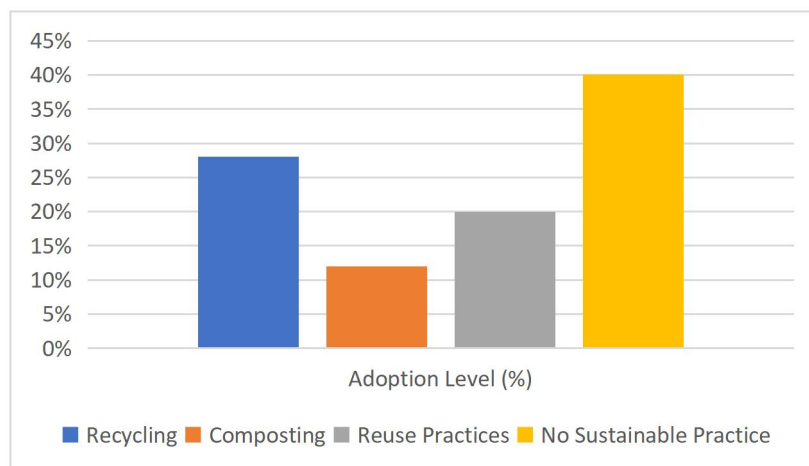


Figure 3. Adoption of waste management practices

3.5 Public Awareness and Participation

The study found that while the level of awareness about sustainable waste management practices was moderate, it was not enough to promote regular behaviour. Although some of the community was familiar with sustainability practices such as waste segregation, recycling and environmental conservation, this knowledge did not always lead to practice. Residents were keen to practice sustainable lifestyles but faced challenges such as the unavailability of infrastructure, convenience and lack of support from the government. Community-based waste management programs had low levels of participation, and there was a lack of structured programs aimed at engaging communities

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in sustainable practices. Awareness campaigns and educational programs were either inadequate or not well targeted, leading to limited community participation. The study highlighted the importance of behavioural and social factors in influencing waste management and the need to incorporate these factors into policy and program development.

4. Discussion

Waste management practices in urban areas are effective to some extent; but there are significant gaps in their implementation, involvement, and integration of systems." The findings showed that while urban regions have waste management systems, they are not effectively functioning due to infrastructural challenges, human behaviour, and poor policy implementation. This finding is supported by earlier studies that highlight that achieving sustainable urban waste management in developing areas is multifaceted and depends on socio-economic and institutional factors (Akbar et al., 2024; Činčikaitė, 2025).

The most pressing problem observed in this study was improper source segregation of solid waste. Most households were observed to throw their waste in mixed form, which hampers the effectiveness of recycling and circular economy. This is consistent with Akbar et al. (2024), who found that urban household practices in peri-urban regions are often poor due to the lack of awareness and infrastructure. Likewise, the lack of public participation in this study is indicative of the lack of environmental awareness and behavioural practices among urban population. According to Nahar et al. (2023) while urban residents may have basic environmental awareness, this does not necessarily translate into sustainable behavioural practices, which further supports the need for specific awareness-raising and behavioural change programs.

Our research also highlighted waste collection and transportation inefficiencies, especially in the outskirts and marginalised neighbourhoods. Inconsistent collection schedules and poor logistics contributed to waste piling up and environmental problems. This echoes the findings of case studies such as Činčikaitė (2025), which showed that even in urban systems with formal structures and services, operational inefficiencies can impact the effectiveness of the system. The uneven service provision across zones suggests inequalities in infrastructure and resource provision, which needs to be rectified to ensure sustainable and equitable waste management practices.

A key observation was the lack of formalisation of recycling and resource recovery. The research revealed that much of the recycling work was undertaken by the informal sector, such as waste pickers, who are important in the recycling chain but often overlooked. Although they make a significant contribution, the lack of formal-informal integration within the system decreases efficiency. The use of technologies like AI and IoT-based waste management systems have been proposed to enhance the efficiency and monitoring of the system (Lakhout, 2025). But the implementation of these technologies is not widespread in many cities due to cost and technological barriers. And new technologies, such as advanced composting techniques, as outlined by Jaisankar et al. (2024) can be used for organic waste management but are not widely adopted at the community level.

The influence of urban planning and environmental management on waste management was also highlighted. Effective waste management in sustainable urban systems needs to be approached from an integrated planning perspective, taking waste management into account as part of urban infrastructure. Research has demonstrated that the integration of environmental management approaches into urban planning processes can enhance the efficiency and sustainability of waste management (Kosoe & Ogwu, 2025). Furthermore, the emergence of smart and sustainable

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cities highlights the need to adopt integrated approaches that integrate technology, policy and community engagement (Bokhad et al., 2024). But the results of this research suggest that such holistic approaches are still in their infancy in many cities. External factors such as global trends and environmental change also contribute to urban waste management. For example, the COVID-19 pandemic has led to shifts in waste generation and additional challenges for waste managers, especially in developing regions (Islam et al., 2024). These changing circumstances underline the importance of flexible and resilient waste management approaches that can accommodate urban change.

Besides technological and institutional aspects, ecological factors like green infrastructure and urban planning may impact waste management. While not directly related to waste management, the incorporation of green belts into urban development can enhance environmental sustainability and, in turn, support waste management through ecosystem balance (Verdú-Vázquez et al., 2021). Moreover, innovative analytical tools, such as incorporating fuzzy logic in the life cycle assessment (LCA) model, can aid decision-making processes and enhance waste management systems (Андрієнко et al., 2025). In summary, the debate stresses that urban waste management is a complex process that needs to tackle technical, behavioural and institutional problems. The results highlight the importance of better policy enforcement, enhanced infrastructure, heightened public awareness, and emerging technologies. More significantly, the study highlights the need to pay attention to the less-addressed aspects of community engagement, informal sector inclusion, and local solutions. Closing these gaps is critical to creating effective, participatory and sustainable urban waste management strategies in line with environmental and urban development objectives.

5. Conclusion

Current urban waste management approaches are a system that is functioning but has yet to fully embrace the ideals of sustainability and efficiency. Our analysis suggests that although basic waste collection systems are operational, key elements like source segregation, recycling and public involvement need to be strengthened. These shortcomings diminish the efficiency of waste management and limit the shift towards more environmentally and resource efficient cities. Continued disposal of mixed waste, uneven service provision in some areas and low integration of recycling practices demonstrate structural and operational limitations. Furthermore, behavioural aspects such as limited public awareness and participation limit the sustainability efforts. Policy and institutional constraints such as lack of policy implementation and coordination between stakeholders also play a role in the implementation gap. A holistic approach involving infrastructure upgrades, policy enhancements and behaviour change programs is essential to tackle these challenges. Raising public awareness, encouraging source segregation and incorporating the informal sector into the formal economy can enhance efficiency. Additionally, embracing innovative and technology-based approaches can improve waste management operations and enable evidence-based decision making. More attention needs to be given to other areas that need more work, especially at the local level. The emphasis on these areas will enhance waste management efficiency and support gains in environmental sustainability and urban resilience. A more participatory, integrated and actionable approach is needed to build sustainable waste management that can cope with the challenges of urbanisation.

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