

Geo-Spatial Distribution and Utilization of Waste Disposal Facilities in Ilorin, Nigeria.

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abstract

Rapid urbanisation in developing countries has intensified challenges of waste management and environmental sanitation. This study investigates the geo-spatial distribution and utilization of waste disposal facilities in Ilorin, Nigeria. The objectives were to identify household disposal methods, examine the distribution of government facilities, assess utilization levels, and explore factors influencing non-use. Data were drawn from 400 residents through questionnaire, Records of waste disposal facilities were obtained from the Kwara State Ministry of Environment, population data were obtained from the National Population Commission (NPC), while administrative maps were sourced from the Office of the Surveyor-General, Ilorin, Kwara State. Analytical methods employed included descriptive statistics, Pearson correlation, and GIS techniques including buffering and nearest neighbor analysis. The findings reveal that private waste collection services dominate, used by 75.3% of households due to convenience. Proximity emerged as a major barrier, with 45% of respondents citing distance from Kwara State Environmental Protection Agency (KWEPA) Roll-in Roll Out (RORO) bins as a reason for non-utilization. Spatial analysis showed that government facilities are concentrated in only 12 of 20 wards, leaving significant gaps in coverage. The Nearest Neighbour Analysis confirmed a dispersed distribution pattern, while buffer analysis indicated that only 11 wards fall within a two-kilometer service radius. Regression analysis demonstrated that proximity accounts for about 50.9% of variance in facility utilization. Overall, the study highlights inequitable access to public disposal infrastructure, which limits utilization and fosters reliance on private or informal methods. On the basis of the findings, it is recommended that extending facilities to the nine underserved wards to promote equitable access, strengthen waste management, and support sustainable urban development in Ilorin metropolis.

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1. Introduction

Rapid urbanisation is a defining feature of contemporary global development, particularly in low- and middle-income countries where urban population growth is occurring at an unprecedented rate. Globally, cities generate over 2 billion tonnes of municipal solid waste annually, with projections indicating a significant increase in the coming decades due to population growth, economic expansion, and changing consumption patterns (Valavanidis, 2023). This rapid increase in waste generation has put considerable pressure on urban infrastructure systems, making solid waste management a critical component of sustainable urban development (Nubi et al., 2022). Inefficient waste management practices contribute to environmental degradation, greenhouse gas emissions, and serious public health risks, thereby positioning waste management at the centre of global urban policy and sustainability debates (Nubi et al., 2022).

In developing countries, the challenges associated with solid waste management are particularly acute. Rapid urban expansion often outpaces the provision of essential services, resulting in inadequate waste collection, limited disposal infrastructure, and widespread informal practices such as open dumping and burning (Zhang et al., 2024). Across sub-Saharan Africa, a substantial proportion of urban waste remains uncollected or improperly

managed, reflecting structural issues related to governance, financing, and institutional capacity (Udessa et al., 2026). These challenges are further compounded by spatial inequalities in service provision, where access to waste disposal facilities is unevenly distributed across urban areas.

In Nigeria, the problem of solid waste management has become increasingly severe as a result of inadequate infrastructure, weak enforcement of environmental regulations, and poor public attitudes toward waste disposal (Nsirim et al., 2018). Although waste management policies exist at federal and state levels, their implementation is largely devolved to local agencies that often lack the financial and technical capacity required for effective service delivery (Ekeu-wei, Azuma & Ogunmuyiwa, 2018). Consequently, many Nigerian cities experience persistent issues such as indiscriminate dumping, inefficient waste collection systems, and limited access to formal disposal facilities (Jegede & Taiwo, 2019; Geidam & Isa, 2019). These conditions reflect broader urban governance challenges and highlight the need for more spatially informed approaches to infrastructure planning.

Ilorin, the capital of Kwara State, exemplifies these dynamics. Despite the establishment of the Kwara State Environmental Protection Agency (KWEPA) to oversee waste management, the city continues to face significant sanitation challenges, including insufficient waste collection points and widespread informal disposal practices. Heaps of refuse frequently obstruct roads and drainage systems, particularly in densely populated areas, posing serious environmental and public health risks (Olagunju & Adeniyi, 2018). These challenges persist despite the involvement of both public institutions and private waste collection agents, largely due to the uneven

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spatial distribution of facilities, limited proximity to residential areas, and reliance on informal waste disposal methods.

Recent advancements in geospatial technologies, particularly Geographic Information Systems (GIS) and Global Positioning System (GPS), have enhanced the capacity to analyse spatial patterns of urban service delivery. In the context of solid waste management, these tools enable the mapping of disposal facilities, assessment of accessibility, and identification of underserved areas, thereby supporting evidence-based planning and decision-making (Hannan et al., 2015; Naibbi & Umar, 2017; Emmanuel, Musa & Nanpon, 2017). The integration of GIS into waste management aligns with global best practices that emphasise data-driven and spatially equitable approaches to urban infrastructure development.

Although previous studies in Nigeria have examined solid waste management and applied GIS for landfill site selection, route optimisation, and mapping of waste disposal facilities, relatively few have integrated spatial accessibility analysis with household-level utilisation behaviour. Consequently, limited empirical evidence exists on how the spatial distribution of government waste disposal facilities influences residents' utilisation decisions, particularly in medium-sized rapidly urbanising cities such as Ilorin. This study addresses this gap by integrating Geographic Information Systems (GIS) techniques with household survey data to evaluate both the spatial distribution of waste disposal facilities and the factors influencing their utilisation. By linking spatial accessibility with residents' disposal behaviour, the study provides evidence that can support more equitable and data-driven waste management planning.

To address this knowledge gap, this study examines the geo-spatial distribution and utilization of waste disposal facilities in Ilorin metropolis, Nigeria. Specifically, the study aims to: (i) identify the major household waste disposal methods; (ii) examine the spatial distribution of government waste disposal facilities; (iii) assess residents' utilization levels of these facilities; and (iv) identify factors influencing their non-utilization. The study focuses on the three Local Government Areas that constitute Ilorin metropolis, including Ilorin West, Ilorin East, and Ilorin South. The findings are expected to support evidence-based decision-making by the Kwara State Environmental Protection Agency (KWEPA) and contribute to broader discussions on equitable and sustainable waste management in rapidly urbanising cities.

Literature Review

Solid waste management has emerged as a critical urban challenge globally, particularly in rapidly urbanising regions of the developing world. Current estimates indicate that urban areas generate over 2 billion tonnes of municipal solid waste annually, with projections suggesting an increase to 3.4 billion tonnes by 2050 due to population growth, urban expansion, and changing consumption patterns (Valavanidis, 2023). Despite this growth, waste collection efficiency remains uneven, with developing regions experiencing significantly lower collection rates compared to developed countries. Consequently, large proportions of waste remain uncollected or are disposed of through informal and environmentally harmful practices.

In sub-Saharan Africa, solid waste management systems are characterised by structural inefficiencies, including inadequate infrastructure, limited financial resources, weak institutional capacity, and poor governance frameworks. Studies show that in many African cities, between 30% to 60% of generated waste is not formally collected, resulting in widespread practices such as open dumping, burning, and disposal in drainage systems (Adedara et al., 2023). These practices contribute to flooding, environmental degradation, and increased public health risks.

In Nigeria, the situation reflects these broader regional challenges. Research indicates that per capita waste generation ranges between 0.43 kg and 0.66 kg per day, depending on city size and socio-economic conditions (Ogwueleka, 2009; Mokuolu et al., 2021). However, collection efficiency remains low, with many urban centres unable to manage the volume of waste generated. Studies across cities such as Lagos, Port Harcourt, Ibadan, and Kano consistently highlight issues of inadequate waste infrastructure, irregular collection services, weak enforcement of environmental regulations, and low levels of public awareness (Ikebude, 2017; Nsirim et al., 2018).

A recurring theme in the literature is the spatial inequality in access to waste management services. Several studies have shown that waste disposal facilities are often unevenly distributed, with high-income or central areas receiving

better service coverage compared to peri-urban and low-income neighbourhoods (Abubakar et al., 2022; Maphanga et al., 2025). This spatial disparity significantly influences household waste disposal behaviour, as residents without access to nearby facilities are more likely to adopt informal disposal methods.

In response to these challenges, there has been growing interest in the application of geospatial technologies, particularly Geographic Information Systems (GIS), in waste management planning. GIS has proven effective in integrating spatial and non-spatial data to support decision-making processes. It has been widely applied in landfill site selection, route optimisation, facility location planning, and accessibility analysis (Kontos et al., 2003; Aziz & Khodakarami, 2013; Bera et al., 2016).

Recent studies demonstrate that GIS-based analyses, such as buffer analysis and network analysis, are particularly useful in assessing service coverage and identifying underserved areas. Similarly, spatial statistical techniques such as the Average Nearest Neighbour analysis help determine whether waste facilities are clustered, randomly distributed, or dispersed within urban environments (Danbuzu & Tanko, 2014; Nwosu & Pepple, 2016). These approaches contribute to more efficient resource allocation, reduced operational costs, and improved equity in service delivery.

Despite the increasing application of GIS in waste management planning, most existing studies have primarily focused on technical aspects such as landfill site selection, route optimisation, and facility mapping. Comparatively fewer studies have examined whether the spatial distribution of waste disposal facilities actually influences residents' utilisation behaviour. Consequently, evidence linking spatial accessibility with household waste disposal practices remains limited, particularly in medium-sized Nigerian cities such as Ilorin. Addressing this gap requires an integrated approach that combines geospatial analysis with household-level socio-economic data to provide a more comprehensive understanding of accessibility and facility utilisation.

Theoretical Framework: Distance Decay Theory

This study is anchored on the Distance Decay Theory, a key concept in spatial analysis which explains how interaction between two locations decreases as the distance between them increases. The theory is based on the principle of friction of distance, which suggests that distance imposes costs such as time, effort, and financial resources that reduce the likelihood of interaction (Fotheringham, 1981). The core concepts of the theory include:

- Spatial interaction: the movement or relationship between locations
- Accessibility: the ease with which a location can be reached
- Friction of distance: barriers that reduce interaction as distance increases

Distance decay has been widely applied in urban studies to explain patterns of service utilization, including access to healthcare, markets, education, and public infrastructure. Empirical studies have consistently shown that individuals are less likely to use services located farther from their residence due to increased travel costs and inconvenience (Mmom, 2017; Mmom, 2018).

In the context of solid waste management, the theory provides a useful framework for understanding household disposal behaviour. The location of waste disposal facilities relative to residential areas plays a critical role in determining whether they are used effectively. Where facilities are located within convenient distances, utilization tends to be higher. Conversely, when facilities are located far from households, residents are more likely to resort to alternative disposal methods such as burning, open dumping, or reliance on private waste collectors. In this study, the Distance Decay Theory is applied to examine how proximity to waste disposal facilities influences their utilization among residents of Ilorin metropolis.

Study Area

Ilorin metropolis, the capital of Kwara State, lies between latitudes 8°30' and 8°50'N and longitudes 4°20' and 4°35'E. The city covers an estimated area of about 765 km² and serves as the administrative and commercial hub of the state. Politically, Ilorin comprises three Local Government Areas namely;

Ilorin West, Ilorin East, and Ilorin South, and is further divided into twenty-five wards for administrative purposes (Figure 1).

Situated in the North Central geopolitical zone of Nigeria, Ilorin serves as a transitional zone between the predominantly Muslim North and the largely Christian Southwest, giving the city a rich cultural mix of Yoruba, Hausa, Fulani, Nupe, Baruba, and Igbo populations (Oloru, 1998; Ahmed, 2008). According to the 2006 National Census, Ilorin had a population of 777,755, which has grown substantially due to rural-urban migration and natural increase.

The city experiences a tropical wet and dry climate, with annual rainfall ranging between 1,000 mm and 1,500 mm, peaking from September to October, and mean monthly temperatures ranging from 23°C to 28°C. Its topography is generally undulating, with elevations between 273 m and 333 m, and it is underlain by Precambrian Basement Complex rocks. Ilorin's economy is diverse, featuring agriculture, trading, and small-scale industries such as food processing, leatherwork, weaving, and pottery. The city also hosts several commercial and service institutions that generate substantial solid waste daily. Rapid urbanization and population growth have increased waste generation beyond the capacity of available facilities.

To address these challenges, the Kwara State Environmental Protection Agency (KWEPA) and the Kwara Waste Management Company (KWMC) were established under the State Ministry of Environment and Tourism. Their

responsibilities include waste collection, transportation, dumpsite maintenance, and urban sanitation. Currently, Ilorin has about 21 official dumpsites and 108 RORO bins distributed across the metropolis (Olagunju & Adeniyi, 2018). However, inadequate funding, limited technical capacity, and poor public attitudes continue to hinder effective waste management, resulting in illegal dumping and poor sanitation in several wards.

Materials and Methods

Data Sources

Both primary and secondary data were used for this study. Primary data included information on respondents' socio-economic characteristics (age, sex, education, years of residence), household waste disposal methods, utilization of Kwara State Environmental Protection Agency (KWEPA) RORO bins, and factors influencing non-utilization. The geographic coordinates of waste disposal facilities were collected using a Garmin eTrex 30x GPS device. Secondary data comprise of records of existing waste disposal facilities obtained from the Kwara State Ministry of Environment, population data from the National Population Commission (NPC), and administrative maps from the Office of the Surveyor-General in Ilorin. A reconnaissance survey was first conducted to familiarize the researcher with the study area and to identify accessible households and disposal points.

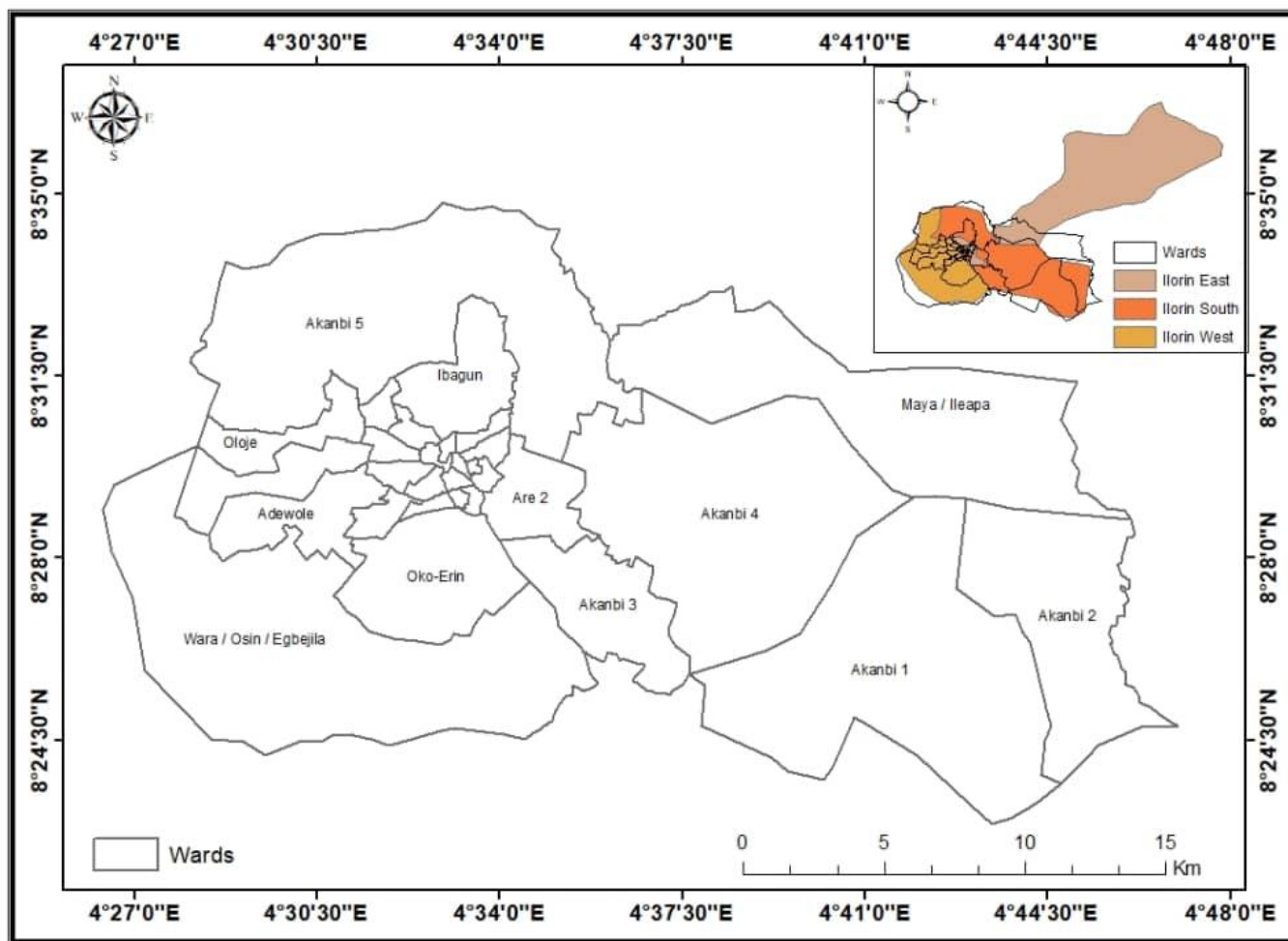


Figure 1 Ilorin Metropolis showing different Political Wards
Source: Office of the Surveyor General, Ilorin, Kwara State (2022)

Sampling Procedure and Sample Size

The study population was based on a 2021 projection derived from the 2006 National Population Commission (NPC) census figure of 777,667 persons. Using a standard annual growth rate of 3.2%, the population was estimated at approximately 1.25 million for the study year. The household sample size was determined using the Taro Yamane (1973) formula:

$$n = \frac{N}{1 + N(e)^2}$$

n = Sample size, N = Total population (1,250,000), e = Margin of error (0.05)

The calculation yielded approximately 400 respondents, which served as the final sample size for the study. Ilorin metropolis comprises 20 political wards, and the questionnaires were proportionally distributed among these wards based on their respective household populations to ensure representative data. A systematic random sampling technique was adopted to select households, with one questionnaire administered to an eligible respondent in each selected household. Sampling intervals were adjusted according to ward size to maintain even representation. Four trained enumerators assisted with the field administration and data verification process.

Data Analysis

Data analysis combined descriptive, inferential, and geospatial techniques. Socio-economic data and household disposal patterns were analysed using frequency counts, percentages, means, Pearson correlation, chi-square, and multiple regression in SPSS version 25 and Microsoft Excel. The spatial component involved the mapping and analysis of waste disposal facilities using ArcGIS 10.3. Point coordinates of dumpsites and communal bins were overlaid on the ward shapefile of Ilorin metropolis to examine the spatial distribution and accessibility of facilities. The Average Nearest Neighbour Analysis (ANN) was used to determine whether the distribution pattern of waste disposal facilities was clustered, random, or dispersed.

In addition, a two-kilometer buffer was created around each dumpsite to assess accessibility and identify underserved areas, following the World Health Organization's (WHO) guideline that waste disposal points should be accessible within a 2.0–2.2 km radius from residential areas. The generated buffers were overlaid on the ward shapefile to determine the proportion of wards that fall within and outside the service coverage area, thereby identifying underserved wards. The combination of statistical and spatial analyses provided an integrated understanding of the geo-spatial distribution and utilization of waste disposal facilities in Ilorin (Table 1).

Results and Discussion

Socio-Demographic Characteristics of Respondents

Out of the 400 respondents surveyed, females constituted a slightly higher proportion (60%) than males (40%), reflecting the prominent role of women in household waste management activities within the study area (Table 2). The majority of respondents (45.2%) were between 25 and 34 years of age, representing the economically active population responsible for most household consumption and waste generation. Educational attainment was relatively high, with 66.5% of respondents possessing secondary or tertiary

education, suggesting that environmental awareness alone may not explain poor waste disposal practices. Instead, infrastructural constraints such as accessibility to disposal facilities are likely to play a more significant role. Most respondents were married (64.3%), while nearly half (48.5%) had resided in Ilorin for less than five years, indicating a relatively mobile urban population. Household sizes were generally moderate, with 67% comprising three to four persons, implying a correspondingly moderate level of household waste generation. Collectively, these socio-demographic characteristics provide important context for understanding residents' waste disposal behaviour and the observed utilisation patterns of government waste disposal facilities.

Household Waste Disposal Methods

Solid waste constituted the major waste type generated in Ilorin, produced by nearly 80% of households, while 20% generated liquid waste (Figure 2). This aligns with Mokuolu, Iji and Aremu (2021), who noted that typical Ilorin households produce an average of 0.66 kg of solid waste daily. Regarding disposal frequency, 53.5% of respondents disposed of waste daily, while 46.5% did so weekly, indicating active but inconsistent waste management.

However, the continued use of open dumping and burning reflects limited access to formal disposal facilities and weak enforcement of waste management regulations. The major reasons for the choice of household waste disposal methods were availability (38.3%), affordability (37.3%), and convenience of use within the neighbourhood. A smaller proportion of respondents (7.5%) adopted a mixed strategy involving burning and private disposal agents, particularly for bulky household refuse. These findings suggest that accessibility, cost considerations, and practicality strongly shape waste disposal behaviour among residents of Ilorin metropolis.

Figure 2 shows that solid waste constituted the dominant household waste stream, accounting for approximately 80% of all wastes generated, whereas liquid waste represented only about one-fifth of household waste. This finding reflects the influence of the increasing urbanisation, population growth, and expanding commercial activities within Ilorin metropolis, all of which contribute to higher municipal solid waste generation. The predominance of solid waste is consistent with the findings of Mokuolu et al. (2021), who reported similar waste generation characteristics for Ilorin.

The study further revealed that households relied on multiple waste disposal methods. Private waste collection agents were the most commonly used option (75.3%), followed by KWEPA communal bins (59.3%), while smaller proportions of respondents reported burning, landfill disposal, and dumping in rivers or open spaces. The widespread dependence on private operators suggests that residents perceive private services as being more accessible, convenient, and reliable than government-provided facilities. However, the continued use of burning and informal dumping indicates that substantial gaps remain in the accessibility and effectiveness of formal waste management infrastructure (Plate 1). These findings suggest that convenience and proximity, rather than environmental awareness alone, largely determine household waste disposal behaviour in Ilorin metropolis.

Analytical Framework

Table 1: Summarizes the Data types, Analytical Tools, and presentation format for each objective

Objective	Data Required	Analytical Tools	Output/Presentation
1. Examine socio-economic characteristics of respondents	Age, sex, education, residence	Descriptive statistics	Tables and charts
2. Identify household waste disposal methods	Bin, dumpsite, pit, burning	Descriptive statistics	Tables and charts
3. Analyze spatial distribution of facilities	GPS coordinates of bins/dumpsites	ArcGIS 10.3	Tables, Maps and discussion
4. Assess utilization of KWEPA facilities	Household responses	Descriptive and Inferential statistics	Tables and charts
5. Determine factors influencing non-utilization	Distance, accessibility, awareness	Descriptive and inferential statistics	Tables and charts

Source: Author's fieldwork (2022)

Table 2: Socio-demographic Characteristics of Respondents

Variables	Frequency	Percentage
Gender		
Male	240	60.0
Female	160	40.0
Total	400	100.0
Age (years)		
Less than 20	45	11.3
20 – 24	97	24.3
25 – 29	112	28.0
30 – 34	69	17.2
35 and above	77	19.2
Total	400	100.0
Level of education		
No formal education	122	30.5
Primary education	12	3.0
Secondary education	140	35.0
Tertiary education	126	31.5
Total	400	100.0
Marital Status		
Single	135	33.6
Married		64.3
Widowed/widower	2	0.5
Divorced	1	0.3
Separated	5	1.3
Total	400	100.0
Years of residence		
Less than 5	194	48.5
5 – 10	128	32.0
11 – 15	68	17.0
16 – 20	0	0.0
21 and above	10	2.5
Total	400	100.0
Household size (persons)		
1 – 2	100	25.0
3 – 4	268	67.0
5 – 6	32	8.0
Total	400	100.0

Source: Author's fieldwork (2022)



Plate 1: Open Dumpsite at Post Office Area, Ilorin, Kwara State

Source: Authors' Fieldwork, 2022

Utilization of government waste disposal facilities by the respondents

The findings presented in Table 3 indicate that utilization of government-owned waste disposal facilities remains relatively low despite their availability across parts of Ilorin metropolis. Although all respondents reported using the facilities at least occasionally, only 34.0% indicated regular use, while the majority either used them occasionally (38.0%) or rarely (28.0%). This pattern suggests that the existing facilities have not become the primary means of household waste disposal. Instead, residents appear to supplement or replace government services with alternative disposal methods, particularly, the private waste collection services and the informal disposal practices identified earlier in the study.

Table 3: Use of Waste Disposal Facilities Provided by KWEPA in Ilorin

Variables	Frequency	Percentage
Do you use government waste disposal facilities?		
Yes, very well	136	34.0
Once in a while	152	38.0
Rarely	112	28.0
Not at all	0	0.0
Total	400	100.0
How often do you use this facility?		
Daily	126	31.5
Weekly	274	68.5
Monthly	0	0.0
Fortnightly	0	0.0
Total	400	100.0

Source: Author's fieldwork (2022)

Similarly, weekly disposal (68.5%) was more common than daily disposal (31.5%), indicating that many households do not interact with government disposal facilities frequently. This may reflect both the relatively long distances between residential areas and disposal points and residents' preference for disposal methods that require less travel or offer more flexible collection schedules. Consequently, the effectiveness of government waste

management infrastructure depends not only on the availability of facilities, but also on their accessibility and operational efficiency.

The observed underutilization may also reflect operational challenges such as irregular waste collection, overflowing communal bins, and offensive odours resulting from delayed evacuation (Plate 2). Such conditions reduce public confidence in government-managed facilities and encourage households to seek alternative disposal options. Similar observations have been reported in other Nigerian cities where poor maintenance has contributed to declining utilisation of public waste disposal infrastructure.

Distance and Accessibility to Waste Disposal Facilities

Distance emerged as one of the most important determinants of government waste disposal facility utilisation in Ilorin metropolis. Half of the respondents resided between 2.3 and 2.5 km from the nearest disposal facility, exceeding the World Health Organization's recommended service distance of 2.0–2.2 km. In contrast, only about one-quarter of households were located within 1–2 km of a disposal point. These findings demonstrate a clear spatial mismatch between the distribution of waste disposal infrastructure and residential settlements. Such unequal accessibility increases the time and effort required for proper waste disposal, thereby discouraging regular utilisation of government facilities.

Table 4: Proximity of Waste Disposal Facilities Provided by KWEPA to Respondent in Ilorin

Distance	Frequency	Percentage
Less than 1km	88	22.0
1– 2km	100	25.0
2.1 – 2.2km	12	3.0
2.3 – 2.5km	200	50.0
Above 2.5km	0	0.0
Total	400	100.0

Source: Author's fieldwork (2022)



Plate 2: Communal bin by KWEPA at Taiwo Isale, Ilorin Kwara State

Source: Author's fieldwork (2022)

The observed accessibility gap provides a plausible explanation for residents' reliance on private waste collection agents and informal disposal methods reported earlier in this study. These findings strongly support the Distance Decay Theory, which argues that the likelihood of using a service decreases as travel distance increases. Consequently, improving the spatial distribution of disposal facilities is likely to increase utilisation rates and reduce environmentally harmful disposal practices (Plate 3). Similar accessibility challenges have been reported in Port Harcourt by Akpotareno et al. (2021), suggesting that inadequate spatial planning remains a common limitation of municipal waste management systems in Nigerian cities.

Types of Waste Disposed Through KWEPA Facilities

Food waste, paper, and polythene were the most commonly disposed items, with over 70% of households occasionally using communal bins for these waste types. However, recyclable materials such as glass and metal scraps were rarely disposed of in government bins, as residents often reused or sold them. These patterns correspond with findings by Jegede and Taiwo (2019), who observed similar waste compositions in Ado-Ekiti.

Results on the types of household wastes generated showed that all 400 respondents (100.0%) reported generating food waste, house sweepings, kitchen waste, paper, and polythene. In addition, substantial proportions of households also generated ashes (86.8%), metal scrap (86.5%), other household rubbish (76.8%), and textile waste (62.5%). These percentages reflect multiple responses, as households typically generate more than one category of waste simultaneously. The findings, therefore, indicate that food waste, house sweepings, kitchen waste, paper, and polythene constitute the most commonly generated household waste streams among residents of Ilorin metropolis.

In Nigeria, the typical inhabitant generates 0.43kg of solid garbage every day (Ogwueleka, 2009). Solid waste, which has diminished the visual appeal of several major cities, results from inadequate understanding and application of

relevant concepts, approaches, and management techniques (Ikebude, 2017). Regarding the usage of government facilities for disposal of the generated household wastes, significant numbers of the respondents always use government waste disposal facilities to dispose polythene 121 (30.3%), other rubbish 96 (24.0%), food wastes 87 (21.8%), and house sweepings 66 (16.5%).

Relationship Between Access, Distance, and Usage

The Pearson correlation analysis provided in this work demonstrates that accessibility to government waste disposal facilities significantly influences household waste disposal behaviour. Significant associations ($p < 0.05$) were observed for most waste categories, indicating that improved access generally encourages greater utilisation of government disposal facilities. The absence of significant relationships for ashes and textile waste suggests that these materials are managed differently by households, possibly because they are more frequently burned, reused, or disposed of through alternative means (Table 5). Overall, these findings highlight accessibility as a key determinant of residents' willingness to utilise formal waste disposal infrastructure. The multiple linear regression analysis further reinforces the importance of proximity in determining facility utilisation. The model explained approximately 50.9% ($R^2 = 0.509$) of the variation in utilisation, indicating that distance alone accounts for about half of residents' decisions to use government waste disposal facilities. This represents a relatively strong explanatory relationship for household behavioural studies and underscores the importance of spatial accessibility in waste management planning. The significant negative influence of distance on the disposal of food waste, textiles, and glass further confirms that increasing travel distance discourages regular utilisation of government facilities. This confirms earlier research finding that the closer a disposal point is, the more likely it is to be used, aligning with Akpotareno et al. (2021).



Plate 3: Roadside dumping of household waste at Taiwo Isale Area, Ilorin, Kwara State.

Source: Author's Fieldwork (2022)

Table 5: Association between Access, Distance, and usage of Government Owned Waste Disposal Facilities

Use of communal bin provided by KWEPA	Access to the facilities (r-value)	(P-value)
Food waste	-0.227	0.000
House sweepings	0.103	0.000
Ashes	-0.061	0.223
Kitchen waste	0.346	0.000
Paper	0.305	0.000
Metal scrap	0.188	0.000
Polythene	-0.127	0.011
Textile	0.015	0.772
Glass	-0.479	0.000
Other rubbish	0.299	0.000

Source: Author's fieldwork (2022)

These findings indicate that improving physical access to government disposal facilities is likely to increase their utilisation across most household waste categories. However, the absence of significant relationships for ashes and textile waste suggests that other factors, such as household disposal preferences or alternative management practices, may influence the handling of these materials. Further investigation would therefore, be required to understand the behavioural factors associated with these specific waste types.

The chi-square analysis further demonstrates that the relationship between proximity and waste disposal behaviour varies across different waste categories. Significant associations were observed for food waste, ashes, kitchen waste, metal scrap, textiles, and glass ($p < 0.05$), indicating that proximity influences the disposal behaviour for these materials. In contrast, no significant associations were found for house sweepings, paper, polythene, and other household refuse, suggesting that factors other than distance may influence the disposal of these waste types. These findings indicate that while spatial accessibility remains an important determinant of facility utilisation, household disposal behaviour is also shaped by the characteristics of specific waste materials and the availability of alternative disposal options.

Factors Influencing Non-Utilization of KWEPA Facilities

The magnitude of the effect of factors influencing the non-utilization of KWEPA facilities is presented in Table 6. The results indicate that accessibility-related factors, together with the availability of alternative disposal options, constitute the primary barriers to the utilization of government-managed waste disposal facilities in Ilorin metropolis. Nearly half of the respondents identified the distance between their residences and KWEPA disposal facilities as a major barrier to utilization. An equally large proportion reported relying on alternative disposal methods such as burning, composting, open dumping, and private waste collection services. These findings reinforce the earlier accessibility analysis by demonstrating that residents tend to choose the most convenient disposal option rather than the officially designated one. Consequently, physical accessibility appears to be a stronger determinant of utilisation than awareness of the existence of government facilities.

A smaller proportion of respondents also attributed the low utilization of government facilities to poor public attitudes toward proper waste disposal, offensive odours resulting from inadequate facility maintenance, and limited awareness of available disposal facilities. These operational and behavioural challenges suggest that improving waste management requires not only expanding infrastructure but also strengthening public education and routine maintenance of disposal sites.

Spatial Distribution of KWEPA Waste Disposal Facilities in Ilorin

As illustrated in Figure 3, seventeen (17) waste Roro bins were located within Ilorin metropolis. The facility was located in the following areas: Oke Odo in Akanbi 4 Ward, Kulende in Akanbi Ward, Amilegbe in Balogun Fulani Ward, Ojagboro in Zango Ward, Gambari Junction in Balogun Gambari Ward, Oja-Oba in Balogun Fulani Ward, Omoda Roundabout in Oju ekun Ward, Pakata Roundabout in Adewole Ward, Centre Igboro in Balogun Fulani Ward, Baboko in Baboko Ward, Oja-Tuntun Baboko Ward, Taiwo Oke in Oko- Erin Ward, Taiwo Isale in Okaka Ward, Post Office and Challenge in Mogaji Are Ward.

The spatial distribution map (Figure 3) reveals that KWEPA waste disposal facilities are unevenly distributed across Ilorin metropolis. Although seventeen disposal points were identified; they are concentrated within selected wards, leaving several residential areas without adequate service coverage. Such spatial inequality reduces residents' physical access to disposal facilities and increases dependence on private waste collectors and informal waste disposal practices. This uneven distribution suggests that previous facility siting decisions may have been influenced more by administrative convenience than by population distribution or accessibility requirements. The observed pattern agrees with previous studies that identified inadequate numbers of waste collection points and poor spatial distribution as major constraints to effective municipal waste management (Batool & Nawaz, 2009; Joseph, 2015; Nachalida et al., 2017). However, unlike previous studies, the current research combines GIS analysis with household survey evidence to demonstrate that these spatial inequalities have measurable effects on residents' utilisation behaviour.

The Average Nearest Neighbour analysis produced a nearest-neighbour ratio of 1.399, indicating that waste disposal facilities exhibit a statistically significant dispersed spatial pattern rather than clustering (Figure 4). The positive z-score (3.148) and low probability value ($p = 0.00164$) confirm that this pattern is unlikely to have occurred by chance. While a dispersed arrangement generally implies that facilities are spread across the study area, dispersion alone does not guarantee equitable service accessibility. In Ilorin, the relatively small number of facilities means that large gaps remain between disposal points, resulting in extensive underserved areas despite the statistically dispersed pattern. Therefore, the ANN result should be interpreted alongside accessibility measures such as buffer analysis rather than as evidence of adequate service provision.

Table 6: The Factors Influencing Non-utilization of KWEPA Waste Disposal Facilities

Factors	Very Important	Important	Less Important	Not Important
KWEPA waste disposal facility is not close to residential house	180 (45.0)	38 (9.5)	38 (9.5)	144 (36.0)
I am not aware of the KWEPA waste disposal facility.	24 (6.0)	25 (6.3)	0	351 (87.8)
Offensive odour around KWEPA waste disposal facility as a result of improper management.	51 (12.8)	47 (11.8)	0	302 (75.5)
Non-challant attitude of proper waste disposal of the residents.	62 (15.5)	63 (15.8)	92 (23.0)	183(45.8)
I use other disposal method such as burning, open dumping, and burying, or composting.	180 (45.0)	37 (9.3)	0	183 (45.8)
I pay private waste disposal agents to dispose my wastes	180 (45.0)	37 (9.3)	0	183 (45.8)

Source: Author's fieldwork (2022)

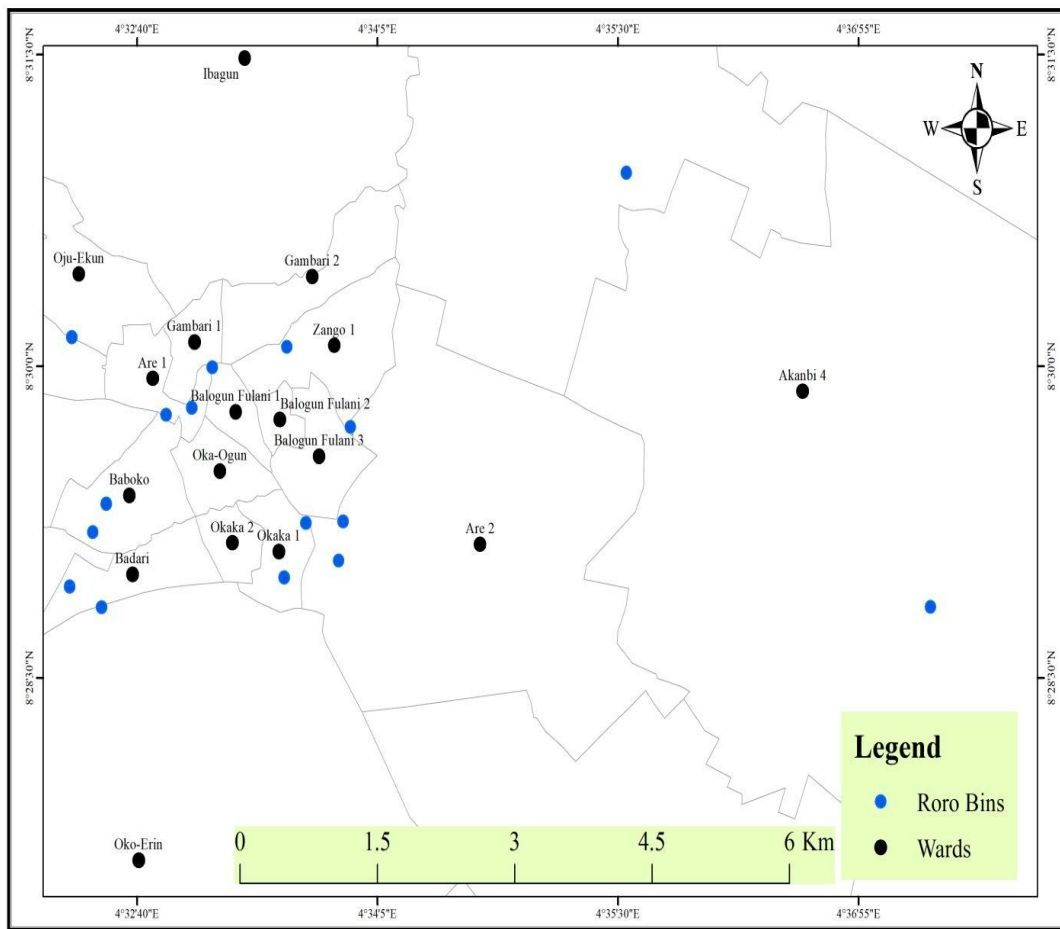


Figure 3: Spatial distribution of KWEPA waste disposal facility (Roro bin) locations in Ilorin Metropolis
Source: Author's fieldwork (2022)

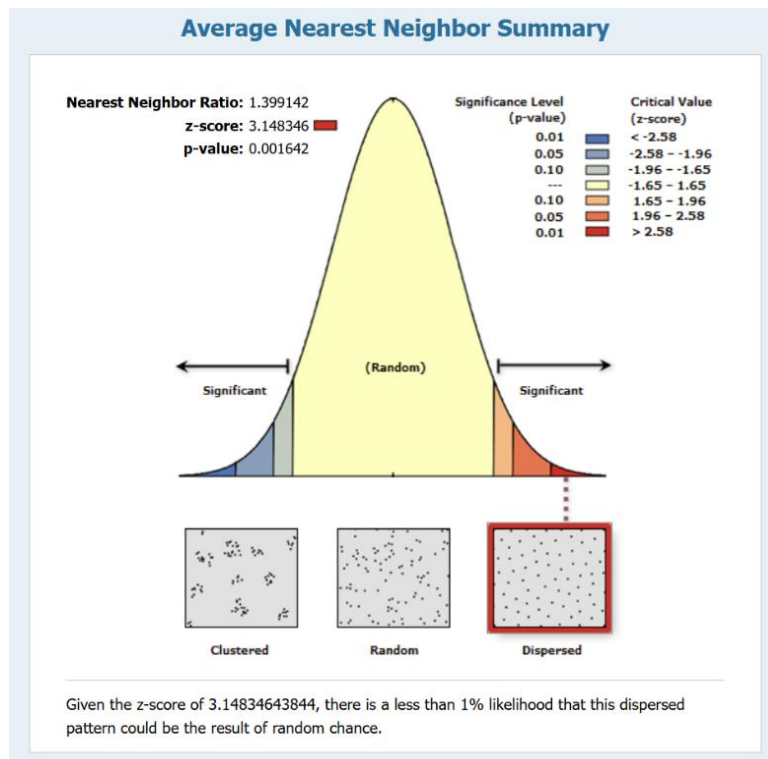


Figure 4: Average Nearest Neighbour summary for KWEPA waste facilities in Ilorin
Source: Author's fieldwork (2022)

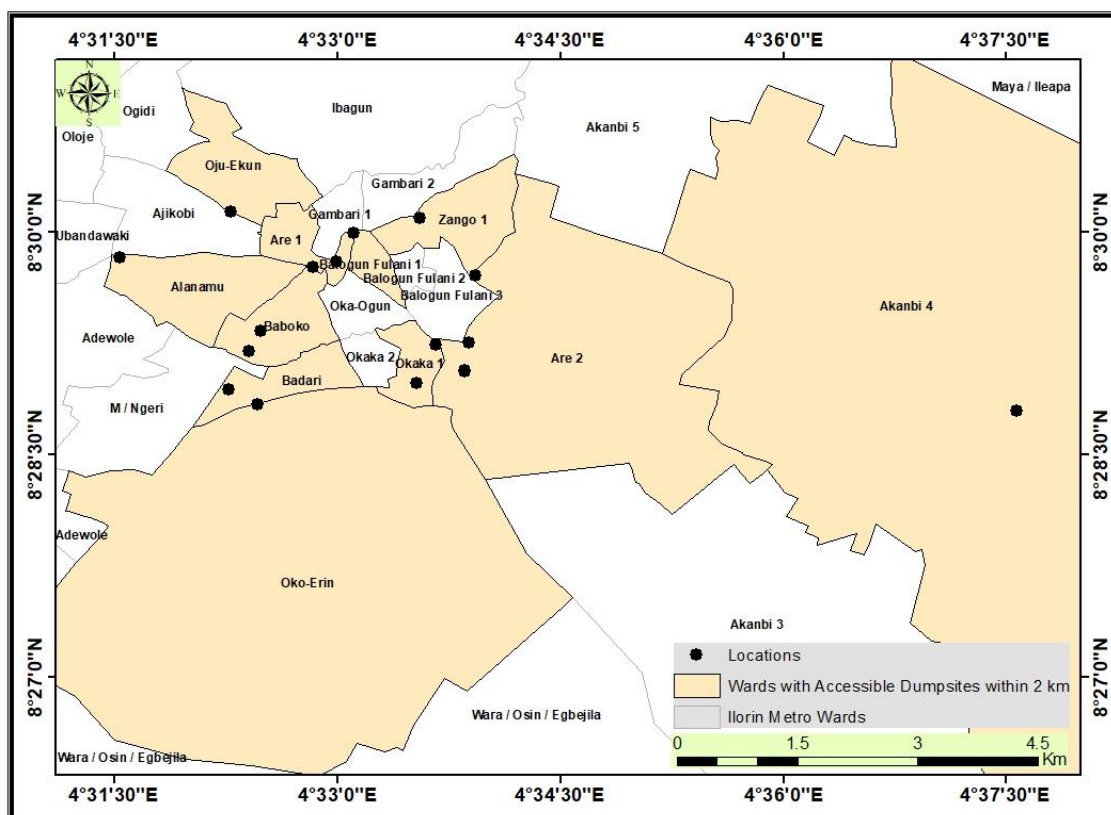


Figure 5: Wards coverage of KWEPA waste facilities in Ilorin based on 2-km buffers

Source: Author's fieldwork (2022)

Table 7: Identified Wards with adequate Facility Coverage

SN	WARD NAME	WARD CODE	LGA NAME
1	Mogaji Are 2	KWSKEY04	Ilorin East
2	Balogun Fulani 1	KWSFUF06	Ilorin South
3	Are 1	KWSKEY03	Ilorin East
4	Okaka 1	KWSFUF09	Ilorin South
5	Zango 1	KWSKEY12	Ilorin East
6	Baboko	KWSLRN04	Ilorin West
7	Alanamu	KWSLRN03	Ilorin West
8	Badari	KWSLRN05	Ilorin West
9	Oju-Ekun	KWSLRN08	Ilorin West
10	Akanbi 4	KWSFUF04	Ilorin South
11	Oko-Erin	KWSLRN09	Ilorin West

Source: Author's fieldwork (2022)

The 2-km buffer analysis provides a more realistic assessment of residents' accessibility to government waste disposal facilities (Table 7). Although the ANN analysis indicated a dispersed spatial pattern, the buffer analysis demonstrates that only eleven wards fall within the recommended service distance. Consequently, several wards remain underserved despite the apparent spatial spread of facilities (Figure 5). This finding confirms that spatial distribution alone is insufficient for evaluating service adequacy; accessibility must also consider population coverage and travel distance. The strong agreement between the GIS analysis and household survey responses strengthens the validity of the study by demonstrating that perceived accessibility constraints correspond closely with objectively measured spatial accessibility.

Collectively, the results highlight three key characteristics of Ilorin's waste management system:

- Unequal spatial distribution of disposal facilities;
- Overdependence on private agents due to convenience; and

- Low utilization of government-managed facilities resulting from poor proximity and inadequate maintenance.

These findings underscore the need for a spatially informed waste management policy. Therefore, incorporating GIS-based site planning to ensure equitable distribution of disposal points, integrating private operators into the formal waste management framework, and establishing facilities within a two-kilometer service radius would align with global best practices. Furthermore, introducing community-based waste monitoring could enhance accessibility, encourage participation, and improve the overall efficiency of the system.

Conclusions and Recommendations

This study examined the spatial distribution and utilization of government-managed waste disposal facilities in Ilorin metropolis by integrating household survey data with GIS-based spatial analysis. The findings demonstrate that although government waste disposal facilities are available

within parts of the metropolis, their spatial distribution does not adequately correspond with residential demand. Consequently, many households rely on private waste collectors and informal disposal practices because government facilities remain beyond convenient access for a substantial proportion of residents. These findings highlight spatial accessibility as one of the most important determinants of facility utilization and demonstrate that the effectiveness of waste management infrastructure depends not only on the number of facilities provided but also on their strategic spatial location. The combined application of the Average Nearest Neighbour Analysis and GIS-based buffer analysis provides important insights into the spatial performance of the existing waste management system. Although disposal facilities exhibit a statistically dispersed spatial pattern, the accessibility analysis demonstrates that this distribution does not translate into equitable service coverage. The consistency between the GIS analysis and household survey responses strengthens the validity of the findings by confirming that objectively measured accessibility closely reflects residents' experiences of waste disposal services. Based on these findings, waste management planning in Ilorin should prioritize the equitable spatial distribution of disposal facilities, particularly

within underserved wards identified through the GIS accessibility analysis. Future facility siting should adopt GIS-based decision-support models to ensure that residential communities fall within the recommended service distance. Given the important role already played by private waste operators, government agencies should formally integrate these providers into the municipal waste management framework through licensing, regulation, and performance monitoring. In addition, sustained investment in public awareness campaigns, routine maintenance of communal disposal facilities, and institutional capacity building within KWEPA will improve public confidence in government-managed waste services and encourage greater utilization.

More broadly, this study demonstrates the value of integrating GIS techniques with household survey data for evaluating municipal waste management systems in rapidly urbanizing cities. The approach provides a practical framework for identifying accessibility gaps, supporting evidence-based planning, and promoting more equitable and sustainable waste management policies in Nigeria and other developing countries facing similar urban environmental challenges.

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