# Analysis of Solid Waste Management Practices in Wudil Town, Kano State, Nigeria

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## ABSTRACT

Solid waste and its management are crucial to cities existence, particularly in third world communities. The advancement in GIS technology provides viable means of integrating digital and existing management practices in terms of spatial pattern and the distribution to aid waste management analysis and suggest effective strategies for efficient waste management. This study investigates the existing solid waste management practices in Wudil town through a careful examination of the spatial pattern of waste collection points (WCP) using Nearest Neighbor Analysis (NNA) in ArcGIS which was compared with world standards alongside residents' attitude towards waste management. The research employs the used of stratified and systematic random sampling where 396 questionnaire was returned and used in the analysis. The spatial analysis using NNA highlight the distribution of 70 informal WCP as compared to 9 formal WCP with Z-score of 0.013 and 3.203 indicating a 1% and less than 1% likelihood that the patterns of these WCP (Formal and informal) is Dispersed and Random respectively. The observable mean distance for formal WCP is found to be 48m above the maximum 500m standard set by the UN-Habitat and 211m for informal WCP suggesting indiscriminate refuse dumping. Attitudes towards waste disposal were observed to be in open spaces and drainages with 49.7% of the respondents engaging in such activity. The study reveals 24tons of daily waste generation in Wudil town from which residential land use contributes (17.7tons), commercial (4.3tons) and 2tons of waste from mix used developments putting Wudil at an estimate of 718tons of waste per month promoting youth employment in the informal sector through waste separation, scaling and further transportation to Kano metropolis for recycling. The study therefore concludes by recommending the integration of GIS techniques in waste management towards producing a more sustainable and viable waste management plan.

**Keywords:** Solid Waste, Waste Generation, Waste collection points, Nearest Neighbor Analysis, Wudil Town

## INTRODUCTION

Solid waste management is a pressing challenge in many urban areas worldwide, Urban residents, particularly in low- to middle-income nations, face serious risks to public health as a result of improper solid waste management, as 2 billion people lack access to solid waste collection and 3 billion lack access to controlled solid waste disposal facilities (UN-Habitat, 2020). This is a result of rapid urban growth brought on by rural-urban migration for better jobs, facilities, and convenience a phenomenon that has been observed in developing nations coupled with rising consumption patterns that exacerbate municipal solid waste (MSW) generation, which frequently exceeds the capacity of current waste management systems (World Bank, 2018; Prabhjot, et.al., 2021).

Globally, solid waste generation is rising quickly due to ongoing economic expansion, urbanization, and industrialization. An estimated 1.5 billion tons of municipal solid waste were produced worldwide in 2011, and by 2025, that amount is expected to rise to 2.2 billion tons (Hoornweg & Bhada-Tata, 2017). Global solid waste generation is predicted to reach 3.4 billion tons annually by 2050, according to the World Bank (2022), which

emphasizes the need for more creative and sustainable waste management techniques. These represents a 7% annual increase since 2003, and 37.3% between 2007 and 2011 rising to an equivalent of about 8% increase per year (Global Waste Management Market Report 2007). These trends indicate increasing waste generation due to urbanization and population growth at an arithmetic rise up to a 70% increase in municipal solid waste by 2050 (Systems Change Lab, 2023).

According to estimates, one to two thirds of the solid waste produced in most urban areas in developing nations, including Nigeria, is not collected. This leads to environmental problems due urbanization creating management challenges (Adamu, Dibal, & Duhu, 2014; Akpu & Yusuf, 2011). The poor state of municipal solid waste management is further exacerbated by inadequate resources and a lack of planning considerations (Oyinloye, 2013). Hoornweg and Bhada-Tata (2012) therefore, viewed solid waste management as a crucial urban service that aims to preserve environmental health, promote public safety, and ensure aesthetic quality. According to UNICEF (2006), solid waste is defined as discarded materials that are no longer valuable from homes, businesses, or industries. The management of solid waste includes the collection, transportation, storage, and disposal of trash produced in homes, businesses, and institutions. As a result, it involves a very intricate set of processes that must be carried out on a massive scale.

Solid waste management has grown to be a significant social and environmental issue in Sub-Saharan Africa due to rising generation rates and new products in the waste stream, (Idowu, Adagunodo, Esimai, & Olopade, 2012). Solid waste management is inefficient in many African cities and rural areas (Maity, 2014). Despite efforts by the international community, national, and local governments, environmental sanitation remains a major problem in Nigerian cities, especially when it comes to solid waste management. According to research, the main reason for these countries' issues with solid waste management practices was the low priority that many African countries, including Nigeria, gave to solid waste management (SWM) on their political agendas (Saleh & Azizan, 2024).

Asian countries alone spent about US$25 billion on solid waste management per year in the early 1900s and the figure is expected to grow to about US$50 billion by 2025 (Hoornweg & Thomas, 2009). For instance, it is estimated that Karachi, Pakistan, and few Asian countries generate up to 3000tons daily (Saleh & Azizan, 2024). 2,732tons of known waste in 2015 (unknown excluded) are accumulated daily in Kano metropolis out of which only 800 tons are being evacuated from the total accumulated at full capacity on daily basis, the figure hit an estimated 3085 tons of solid waste by 2017, while sky rocketing to 3702 tons in 2024 using an average waste output of 0.88kg per person in Kano metropolis (Nabegu, 2015; 2017; Saleh & Azizan, 2024). This implies that Kano metropolis alone produce up to this figure however, the Kano state Refuse Management and Sanitation Board (REMASAB) can only collect and dispose less than 30% of the generated waste (Liman, Nabegu, & Yusuf, 2025; Mshelia, Mbaya & Galkaye, 2020). However, the REMASAB claims that in order to manage one of Kano Metropolis' four dump sites, at least ₦12, 500,000 (US$8,600) is required per week to prevent or reduce environmental hazards like disease outbreaks, but to no avail due to insufficient resources poured in waste management (Saleh & Azizan, 2024).

Nabegu, (2010) viewed solid waste as a resource that should be recycled for further usage rather than being discarded to constitute nuisance. It is a sector that generate massive job and employment opportunities if efficiently managed. In India, it employs three to six individuals per 1000 persons; in Pakistan, it employs 15,000 at Karachi Municipal Corporation; while in Nigeria, it employs 103 workers at REMASAB, which oversees all waste generated in Kano Metropolis (Brown & McGranahan, 2016; Saleh & Azizan, 2024). Street sweeping, transportation, cleaning, driving, equipment maintenance, and machine operators are among the jobs generated by waste collection (Hakizimana, Gómez, & Ntaganda, 2024). The environment can be safeguarded, natural resources can be preserved, economic gains can be produced, and communities can adopt sustainable practices by implementing sustainable waste management techniques (Bhide & Narayana 2018).

Proper solid waste management is a critical aspect of urban planning as it ensures environmental cleanliness, public health and sustainable urban development. Furthermore, as a sustainable solution, smart waste management systems that incorporate technology for effective collection, segregation, and recycling are being investigated more and more (IEEE Xplore, 2024). Over time, Nigerian waste management practices has proven to be ineffective, in contrast to those in developed countries where solid waste is fully recovered and recycled.

While most local government areas in Nigeria lack the facilities for effective collection and management of solid waste, it is grossly inadequate among the few that have them. This has made most people dump their wastes on the streets serving as the collection points (Kofoworola, 2007) including Wudil town in Wudil Local Government Area. Solid waste management is however successful at the local level inclusive of community in the process. In this regard, the Kano State Government vide Edict, No. 2 of the 1991 Kano State Local Government Environmental Sanitation bestows considerable responsibility to the local government authorities to carry out solid waste collection, disposal and may give permit to any person(s) to deposit waste on designated refuse disposal sites and may be charge fees as deemed necessary for that permit (Saleh & Azizan, 2024). Despite these efforts, solid waste management is still an issue in many of the state's towns and local governments, including Wudil town, which is home to the Wudil local government headquarters. However, insufficient distribution of collection points and ineffective disposal and collection practices frequently result in flooding, environmental deterioration, health risks, and a lower standard of living.

In a research on urban solid waste management in developing nations, Hoornweg and Bhada-Tata (2012) emphasized the necessity of community-driven strategies and improved funding sources for sustainable waste management. Alam and Ahmade (2013) examined the efficacy of recycling and waste segregation methods in South Asia and found that integrating informal waste pickers into formal systems greatly reduced waste accumulation.

Similarly, in Africa, Danbuzu, et al. (2014) examines the spatial distribution of solid waste collection points using GIS approach in urban Katsina revealing the clustering and randomness pattern of legal and illegal collection points recommending for more authorized collection points in the medium population density areas. Wilson, (2020) examined the role of public-private partnerships in improving waste collection services in Lagos, Nigeria, demonstrating that collaborative efforts enhance service delivery and cost efficiency.

In Kano metropolis, Yusuf et al. (2021) identified poor waste disposal habits, inadequate collection points and lack of public awareness as major challenges affecting urban areas in Nigeria. Findings of the research underscore the necessity for comprehensive waste management frameworks tailored to local contexts, integrating public education and government support.

In Wudil town, these global and local issues are evident in the absence of designated waste collection points, inefficient transportation systems and reliance on informal disposal methods. These challenges contribute to environmental degradation, clogging of drainage systems and public health hazards. This study seeks to address these challenges by analyzing solid waste management practices in Wudil town through the combination of field data and GIS techniques alongside world best standard practices in distribution of waste collection points. The objectives are therefore; to examine the distributional pattern of solid waste collection points and evaluate current waste management practices in Wudil town.

**Study Area**

Wudil town located in Wudil LGA is home to the Wudil local government headquarter in Kano state located at about 35km from Kano metropolis in the south-eastern region of the State. The town lies between the latitudes $11^0 45'$N to $11^0 50'$N and longitude $8^0 49'$E to $8^0 53'$E of the Equatorial and Greenwich meridian. Wudil is known for its historical, economic and recently educational significance in the region. Its economy is primarily based on agriculture, fishing and small-scale trading, with a major local weekly (Kara) market playing an important role in the state economy. Additionally, recent development of Aliko Dangote University of Science and Technology (ADUSTECH), formerly Kano University of Science and Technology (KUST) triggers population increase, investments, education and job opportunities influencing solid waste generation and management in Wudil.

Wudil LGA is bounded by Warawa LGA to the west and north, Gaya LGA to the east, Garko and Albasu to the South (see Figure 1) and a population of 185,189 persons at the 2006 census projected to 326,474 in 2025 using the National growth rate of 3.2% in Kano State. Predominantly, the population is composed of Hausa and a mix of other Nigerian ethnicities and religions, particularly in areas like the Sabon gari district. This blend fosters a vibrant cultural setting where traditional Hausa values meet modern influences.

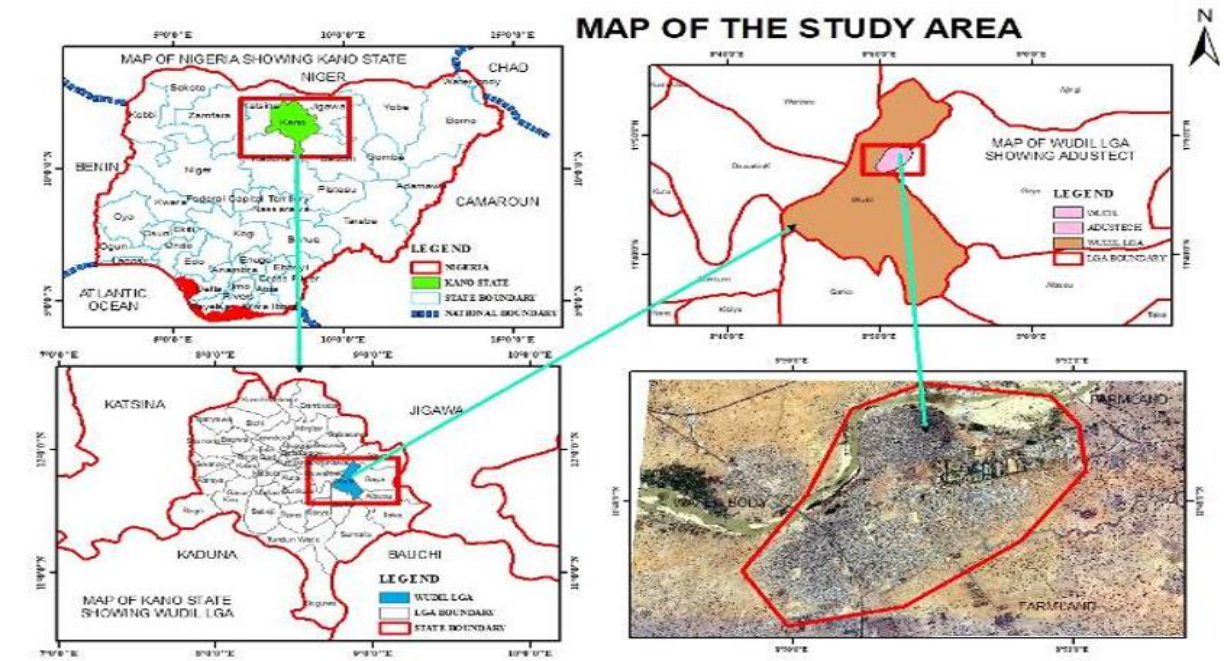


Figure 1: Wudil Town in Kano state, Nigeria

## METHODOLOGY

This study employs the use of Garmin eTrex 32x Global Positioning System (GPS) to obtain x, y coordinates of solid waste collection points through which a database was created and the location; formal and informality of the collection points was established. Digital camera was also used to capture the nature of some selected wastes collection/disposal points as well as the existing management practice.

Data on land use, waste generation, frequency of waste collection, types of waste disposed, attitudes toward waste segregation and recycling, were collected through field observation, satellite image, and structured questionnaires. Focus Group Discussions (FGD) was carried out with Wudil Self Help Association (WSHA), while information on WCP and formal management strategies were sourced out from Wudil local government secretariat, Wudil Primary Health Care Board (WPHCB) and Wudil General Hospital (WGH) in a Key Informant Interview (KII) exercise.

### Sampling

Yamane, (1967) formula $n = \frac{N}{1+N(e)^2}$ was applied to determine sample size. Where, n = Sample size, N = Population size (326,474), e = Margin of error (0.05 for 95% confidence level); 400 questionnaires were administered to individuals of age 18 and above. Stratified and systematic random sampling were employed to categorize the study area into different strata (Land uses,) (Table 1), while respondents were selected randomly from every 15$^{th}$ household and businesses. As such, 396 questionnaires were collected and use for the analysis.

Table1: Sample Size distribution in Wudil Town

| Uses | Structures | Sample size |
|---|---|---|
| Residential | 8248 | 335 |
| Commercial | 1008 | 41 |
| Mixed use developments | 477 | 20 |

Source: Author 2025

### Data Analysis and Presentation

Waste collection points should be easily accessible to residents within a walking distance of 200–500 meters in residential areas, depending on population density (UN-Habitat, 2010; 2020). Dump sites and landfills must be located at least 500 meters from residential areas to mitigate odor, leachate pollution and health hazards (WHO, 2016). Therefore, the analysis methods include NNA to determine observable distances and spatial pattern of solid waste collection points, use of frequencies, percentages, maps and charts.

## RESULTS AND DISCUSSION

### Distributional Pattern of Solid Waste Collection Points in Wudil Town

The spatial analysis reveals 9 formal waste collection points around major and distributor roads, strategically placed for vehicle access but rendered ineffective by a lack of operational support according to interview with the local authorities. This resulted in widespread reliance on informal waste disposal practices with 70 points throughout Wudil town (Figure 2).

While formal collection points exist, they are currently non-functional due to inadequate support systems, such as proper collection vehicles and regular schedules leaving residents resorting to informal disposal methods, primarily on open spaces and streets predominantly in residential and commercial areas creating a pattern of unregulated dumping that exacerbates environmental and health hazards.

The NNA further reveal the spatial pattern of solid waste collection points in different categories that is, formal and informal. The analysis in Figure 3 depicts dispersed pattern of formal waste collection points with R-value of 1.56 and Z-score of 3.203, while the range of critical value centered around +2.58 and the p-value implying a significant level less than 0.01 indicating less than 1% likelihood that this dispersed pattern could be the result of random chance.

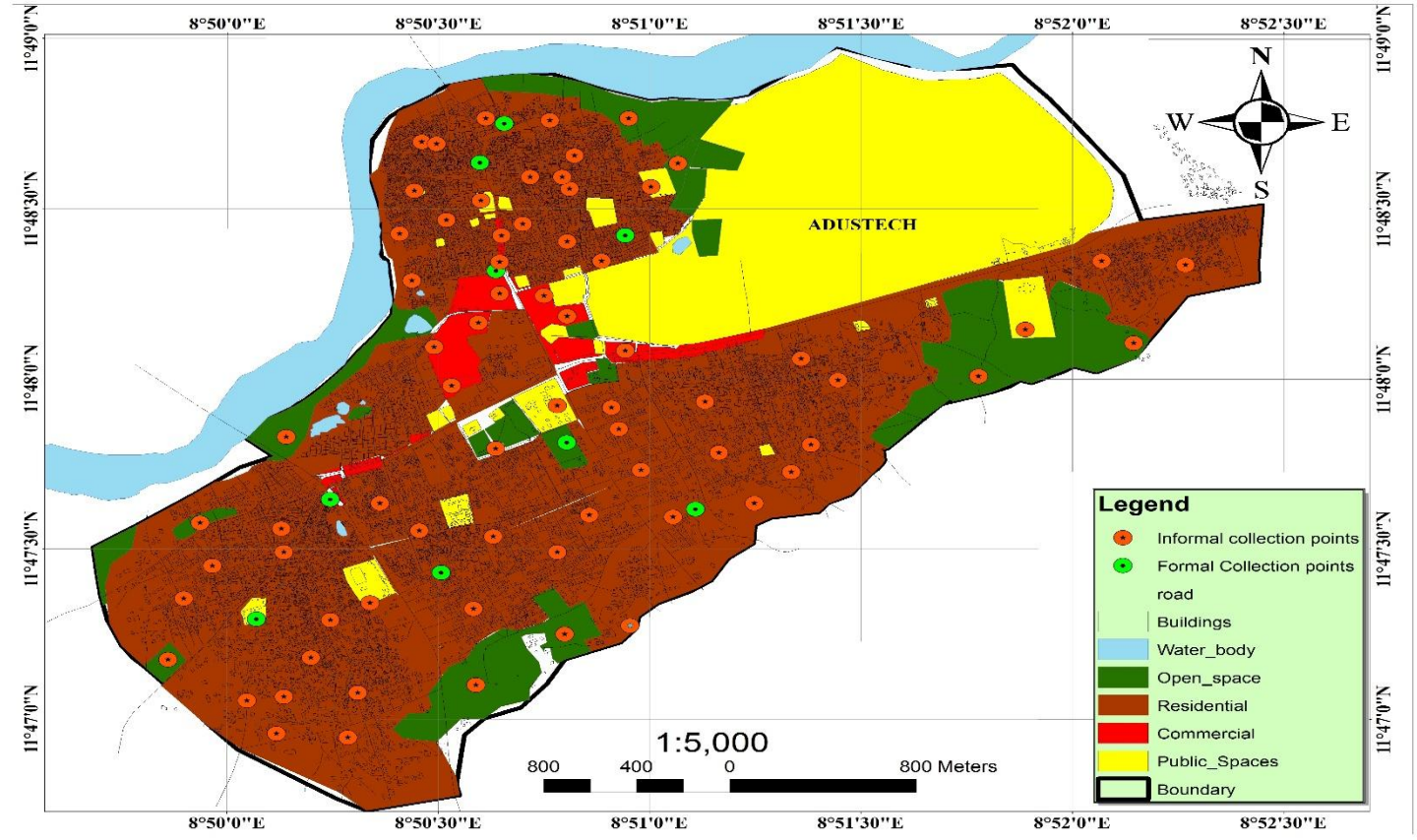


Figure 2: Existing Land use in Wudil Town

Source: Field Survey & Google Earth Pro, 2025

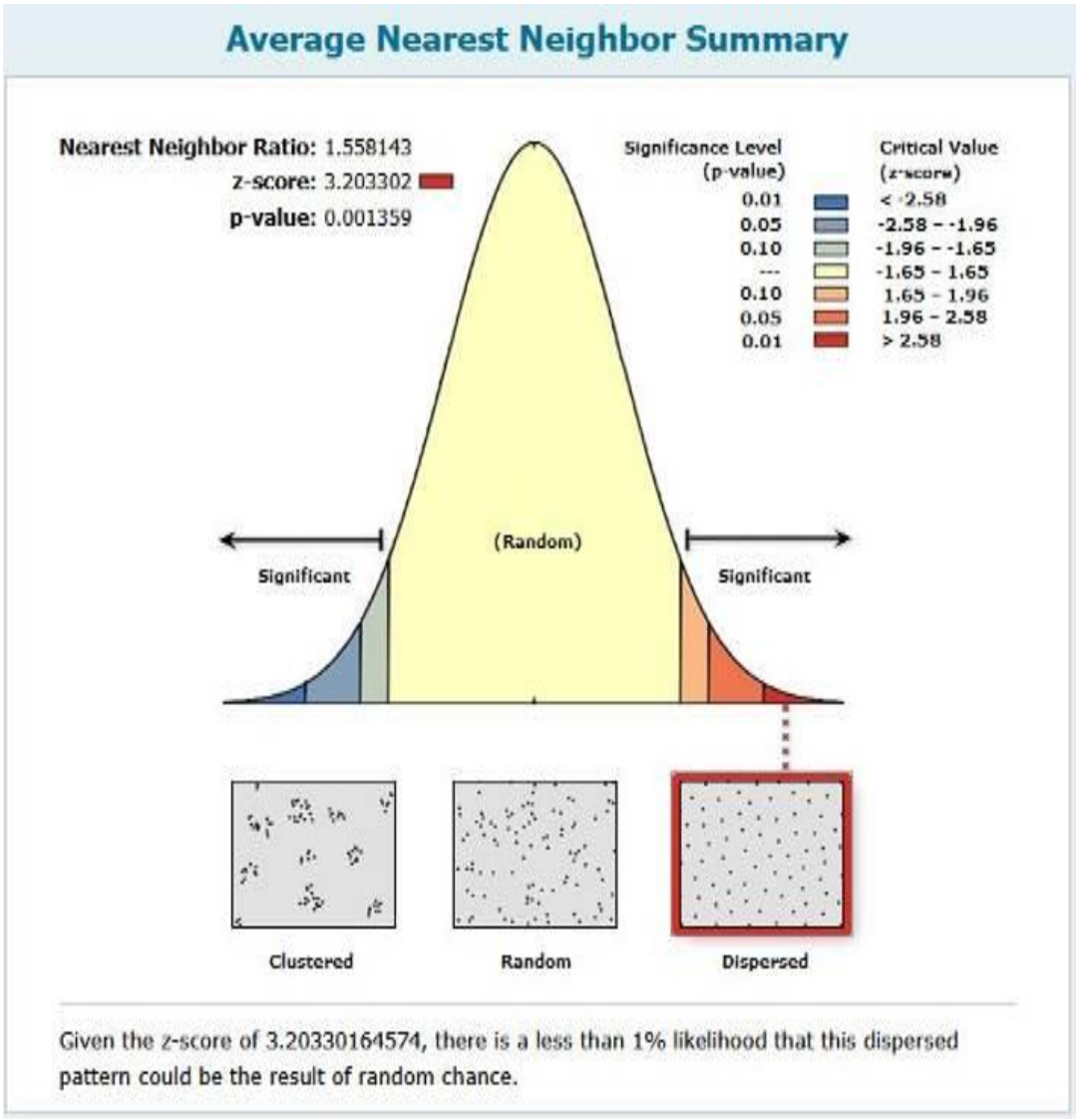


Figure 4: NNA of Formal Waste Collection Points

Source: Authors GIS Analysis, 2025

The observable distance based on the analysis went slightly higher than the UN-Habitat threshold of 500m implying non-compliance with standard practices (Table 2) demonstrating the long distance covered by residences to waste collection points calling for indiscriminate waste disposal along streets and on drainage lines.

Table 2: Mean Distance Observed for Formal Waste Collection Points

**Average Nearest Neighbor Summary**

| | |
|---|---|
| **Observed Mean Distance:** | 548.2363 Meters |
| **Expected Mean Distance:** | 351.8523 Meters |
| **Nearest Neighbor Ratio:** | 1.558143 |
| **z-score:** | 3.203302 |
| **p-value:** | 0.001359 |

Source: Authors GIS Analysis, 2025

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Likewise the spatial pattern of informal waste collection points in Figure 5 revealed randomness with the R-value of 1.00 Z-score of 0.013 and critical values between -1.65 to +1.65. This indicates a p-value of about 1.0 suggesting that the pattern does not appear to be significantly different than random. This reiterate on the haphazard dilemma of the random waste disposal practice in Wudil town owing to the lack of personnel currently in WPHCB that manages the solid waste in Kara Market and some part of the town. This finding is almost similar to that of Danbuzu et al. (2014) revealing a weak cluster pattern of illegal collection points moving towards random distribution in urban Katsina.

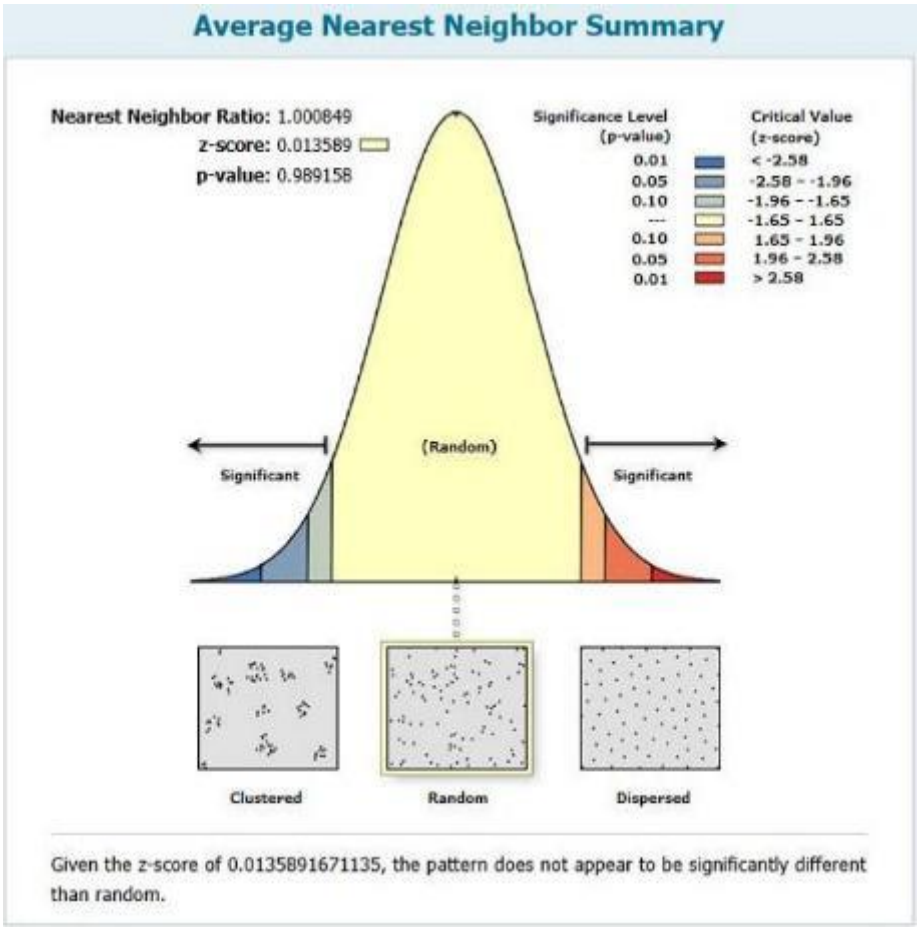


Figure 5: NNA of Informal Waste Collection Points

Source: Authors GIS Analysis, 2025

Further investigation identifies a compliance with UN-Habitat standards between 200-500m with an observable mean distance of 212m breaking new grounds in informality standard adherence (see Table 3) but to no avail due to the indiscriminate nature of the disposal practice.

Table 3: Observed Mean Distance of Informal Waste Collection Points in Wudil Town

**Average Nearest Neighbor Summary**

| | |
|---|---|
| **Observed Mean Distance:** | 211.6956 Meters |
| **Expected Mean Distance:** | 211.5160 Meters |
| **Nearest Neighbor Ratio:** | 1.000849 |
| **z-score:** | 0.013589 |
| **p-value:** | 0.989158 |

Source: Authors GIS Analysis, 2025

**Existing Waste Management Practices in Wudil Town**

Figure 6 demonstrate the operational waste management framework in Wudil town. It is obvious that the town solely rely on the informal waste management system except for the public land use consisting of the ADUSTECH, WGH, and others that has a workable system which contained and manage the waste independent of the township system. Based on field observations and discussions with WSHA, waste generated from residential and commercial land uses are mostly disposed in open spaces where street scavengers pick reusable items in the waste stream. Major scavengers pick reusable items from both WCP within WGH, ADUSTECH and open grounds for further separation and scaling as there are no recycling machines and proper Dump site in Wudil town except for WGH that reported to have contained its waste within the wall of the hospital. However, all incinerators both old, local and modern are abandon due to lack of operational force and government will leaving the modern incinerator in a dilapidated state (Plate 1). Therefore waste generation is not computed for public land use since they are independent while open spaces do not generate waste instead becomes the disposal grounds for residential and commercial land use.

Plate 1: Abandoned and dilapidated incinerators in Wudil General Hospital

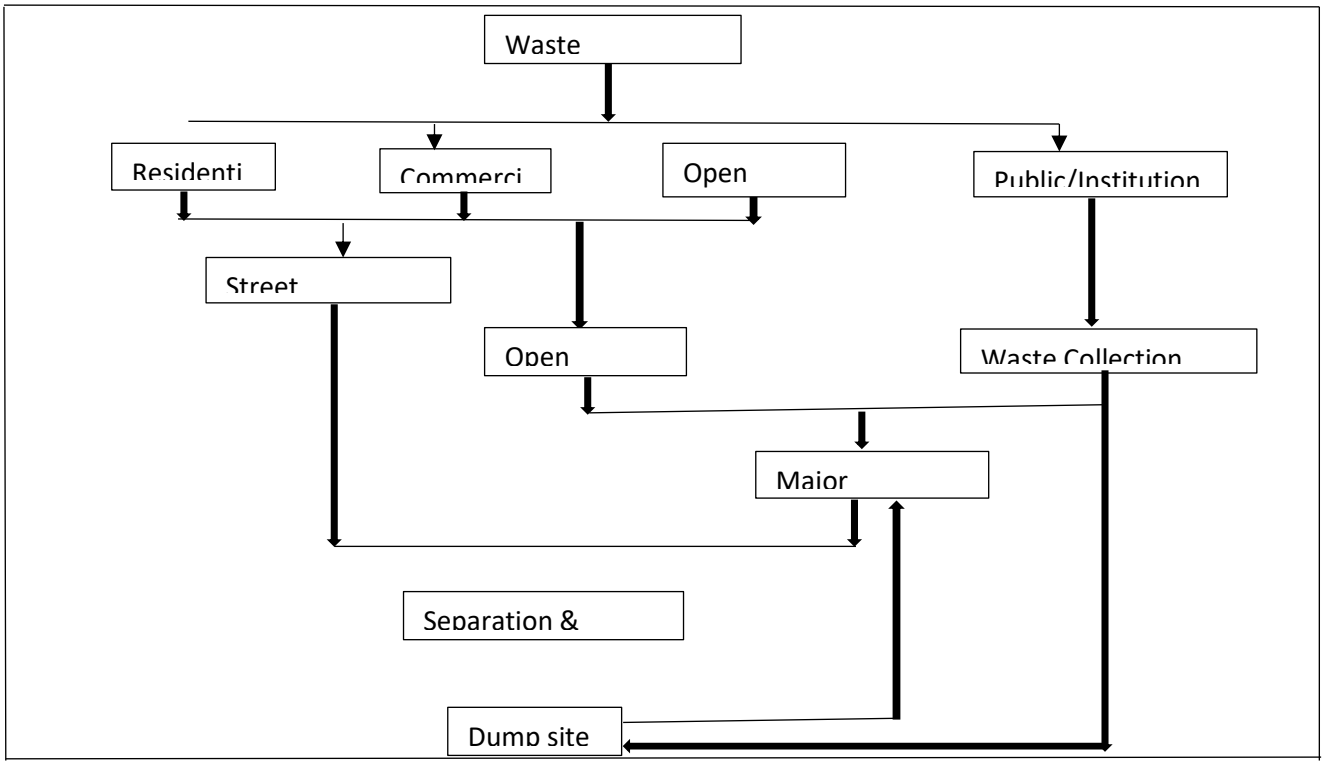


Figure 6: Existing Solid Waste Management Framework in Wudil Town.

Source: Author, 2025

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**Solid Waste Generation in Wudil Town**

This process was carried out after harvest in the month of November within 7 days of measurement and observations across Wudil town putting average residential waste at 2.15kg per unit, 4.33kg for commercial and 3.91kg for mixed use developments. From Figure 2 above. It is obvious that Wudil town harbors 9733 buildings out of which 8248 structures are residential, 508 commercial and 477 mixed use development obtained through database arrangement shown in Table 4 manifested into 23962.9kg of waste generation daily in Wudil town; that is, 718tons generated monthly.

Table 4: Estimate of Waste Generation by Land use type Wudil Town

| **Structures** | **Frequency** | **Waste per unit (kg)** | **Estimated Weight (kg)** |
|---|---|---|---|
| Residential | 8248 | 2.15 | 17733.2 |
| Commercial | 1008 | 4.33 | 4364.6 |
| Mixed use | 477 | 3.91 | 1865.1 |
| **Total** | **9733** | **10.39** | **23962.9** |

Source: Field Survey, 2025

The analysis of waste types indicates that organic waste is the most common in Wudil town (Table 5), accounting for 44.4% of the total waste generated, recyclable waste having 36.7%, while non-recyclables waste makes 18.9% of the waste composition respectively. The dominance of organic waste suggests a significant potential for composting as a sustainable waste management solution. This is supported by the work of Saleh and Azizan, (2024) having food waste as the largest contributor in the waste stream. However, the presence of plastics and other non-biodegradable materials highlights the need for targeted recycling initiatives and proper disposal strategies for hazardous biomedical waste.

Table 5: Composition of Waste Generation in Wudil Town

| **Type of Waste** | **Weight(kg)** | **Percentage (%)** |
|---|---|---|
| Organic Waste | 10639.5 | 44.4 |
| Recyclable | 8794.4 | 36.7 |
| Non-recyclable | 4529.0 | 18.9 |
| **Total** | **23962.9** | **100** |

Source: Field Survey, 2025

**Waste Disposal Practices in Wudil Town**

In terms of disposal practices (see Table 6), a larger proportion 49.7% of respondents disposed their waste in open spaces and drainages channels, 28.3% use collection point, while 22.0% resort to burning and the subsequent usage as fertilizer on farms due to the economic nature of the town which is agrarian (Plate 2 and 3). This demonstrates the lack of adequate distribution of formal waste collection points in the town as depicted in Figure 3 above highlighting closest open spaces, uncompleted buildings and drainages as alternative disposal options promoting flood events and serving as breeding corridors for vectors thereby affecting residents' wellbeing. WSHA reported longer distance travelled when accessing the only Dump site outskirt of the town usually at the beginning of the wet season to clear drainages as a form of community service (aikin gayya). This

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long distance journey contributes to the attitude of waste disposal in open spaces, drainages and any available corridor since in the absence of a workable system.

Table 6: Waste Disposal Practice in Wudil

| **Waste Disposal** | **Frequency** | **Percentage %** |
|---|---|---|
| Use Collection Point | 112 | 28.3 |
| Burning | 87 | 22.0 |
| Dump in Open Space/drainages | 197 | 49.7 |
| **Total** | **396** | **100** |

Source: Field Survey 2025

Plate 1: Refuse Disposal on Drainage Channel and Uncompleted Building

Notably, respondent's tries using formal collection points, highlighting the absence of such infrastructure in designated places. These findings underscore the reliance on informal disposal methods, which pose significant environmental and health risks, emphasizing the urgent need for formalized waste management systems and further substantiates similar findings of Liman et al., (2025) that reports 23.2% of the respondents in Kano metropolis dump waste in drainages, few know the consequences yet still little or nothing to do in terms of the evacuation of the generated waste and the provision of waste storage facilities in their community. Based on the KII with the staff of WPHCB, Kara market alone is having about 40 personnel in charge of SWM but had all retired leaving the market now to the informal sector. This is owing to the fact that poor solid waste management issues include inadequate personnel, budgetary constraints as well as technological choices, and waste management logistics (like garbage collecting containers). Saleh and Azizan, (2024).

Plate 3: Burned Waste in Open spaces

The frequency of waste disposal varies significantly in the study area. It is obvious that 42.2% of the respondents disposed waste several times in a week, a significant proportion with 25.7%, engage in daily disposal indicating the high volume of waste generated and a need for immediate disposal solutions (see Figure 7). While 23.7% did so twice in a week, only 8% of the respondents disposed of their waste weekly in Wudil town. The data highlights a reliance on informal disposal methods, with limited infrastructure preventing consistent, hygienic waste management.

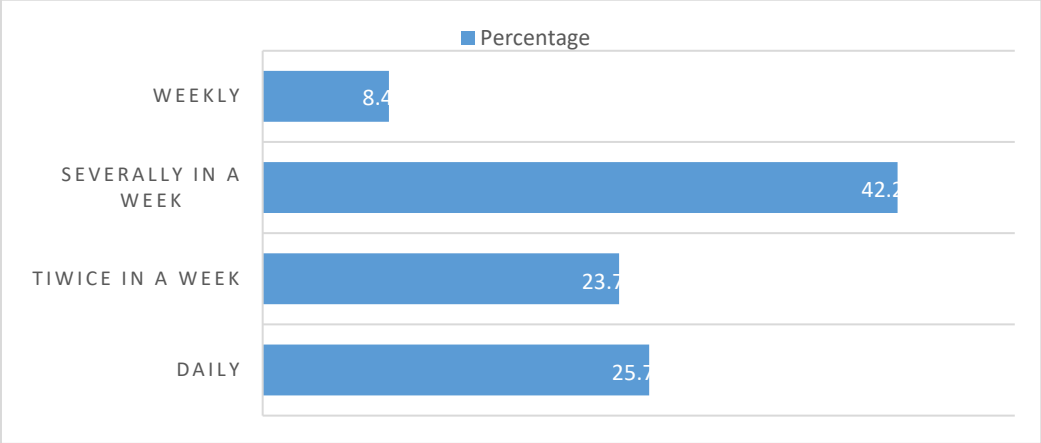


Figure 7: Frequency of Waste disposal

Source: Field Survey 2025

According to the FGD's a significant number of youths are self-employed in the Solid waste sector providing jobs for teen agers between 12 – 16yrs mostly engaged in street and major scavenging activities. These teen agers also formed the larger groups of itinerant waste pickers from street to street throughout Wudil town and carrying out waste separation as well (see Plate 4). While separation and scaling of the waste were carried out in Wudil town, they are transported to Kano metropolis for recycling. These finding suggests that despite providing employment, the waste in Wudil town is being reused and recycle which is one of the world best management approaches to solid waste (Nabegu, 2010; Saleh & Azizan, 2024) but remains haphazard dilemma.

Plate 4: Solid Waste Separation and Scaling

## CONCLUSION AND RECOMMENDATIONS

Solid Waste has been identified to yield numerous benefits that are highly advantageous to both individuals and communities if properly managed. It provides employment and serve as source of revenue generation to governments. This study critically examined the state of solid waste management in Wudil town, focusing on the spatial pattern of waste collection points, existing practices, challenges, and the environmental and health

implications associated with improper waste disposal. Absence of formal waste collection services and designated disposal facilities triggers long distances coverage to disposed waste leading to widespread reliance on informal practices, such as dumping in open spaces, drainages and burning contributing significantly to environmental degradation, public health risks, increased risk of flooding and reduced residents quality of life.

The study therefore, recommends that efforts should be made towards formalized waste collection systems, infrastructure development, public awareness campaigns, and collaborative efforts between local authorities and stakeholders. These should be integrated with the use of GIS as a tool for waste management in urban planning for Wudil town towards providing a more viable Waste management plan for the town.

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