FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 8 No. 2, April, 2024, pp 315 - 322
DOI: https://doi.org/10.33003/fjs-2024-0802-2367

ANALYSIS OF SUITABLE DUMP SITES IN KAFANCHAN, JEMA'A LOCAL GOVERNMENT AREA KADUNA STATE, NIGERIA

Dogara Inkuza, Ajobunu Saliu Ibrahim, *Umar Jibril Haruna and Kennedy Adams

Department of Environmental Management, Kaduna State University, Kaduna, Nigeria

*Corresponding authors' email: jibril.umar@kasu.edu.ng

ABSTRACT

The research focuses on assessing the suitability of dump sites for solid waste disposal in Kafanchan town, Kaduna state, utilizing Surveying and Geo informatics techniques. With the escalating environmental impact of waste due to population growth, urbanization, and industrialization, the study aims to identify appropriate locations for waste disposal. The methodology employs Geographic Information System (GIS) tools, involving the overlaying of datasets and criteria such as drainage, land use, and road networks. The process includes investigating solid waste disposal in Kafanchan, acquiring data through a Global Positioning System (GPS) receiver, converting criteria into GIS layers, and processing the collected information on a computer system using ArcGIS software. The spatial analysis reveals potential sites suitable for solid waste disposal based on connectivity, contiguity, and overlay methods. The results advocate for the effectiveness of GIS in promptly selecting suitable waste disposal sites. The conclusion emphasizes the recommendation to adopt the identified sites for solid waste disposal in the area. Overall, the study underscores the significance of GIS in addressing contemporary environmental challenges related to waste management and highlights the practical application of spatial tools for sustainable solutions.

Keywords: Dumpsites, Waste management, Suitable locations

INTRODUCTION

The environment has been rendered susceptible due to man's manifold compulsive activities in his quest for survival. Nonetheless, the by-product of virtually all the human activities is waste generation, with improper ways of managing it a very topical issue in the present times. The amount of municipal solid waste (MSW), one of the most important by-products of an urban lifestyle, is growing even faster than the rate of urbanization as the world moves toward its urban future (Hoomweg, D., & Bhada-Tata, P., 2012). In addition, waste has become an inevitable product of society, and one of the greatest challenges for future generations is to understand how to manage large quantities of waste in a sustainable way (World Energy Council, 2016).

Ahmed (2006) and Afolayan et al. (2013) highlight that unsustainable waste disposal, characterized by direct dumping without proper inspection and separation, leads to significant environmental pollution and a surge in health-related problems. Additionally, Afolayan et al. (2013) emphasize that uncollected solid wastes can obstruct storm water runoff, creating stagnant water bodies that serve as breeding grounds for disease-causing agents. Bhambulkara and Khedikar (2011) further underscore that inadequate collection and disposal of solid wastes significantly contributes to disease spread and environmental degradation.

Howard and Irwin (1994) defined Waste as any substance or material which is not useful to human beings. Human activities generate waste materials that are usually disregarded as they are considered useless. These wastes are usually in solid, liquid or gaseous form. Waste has become an environmental issue in the world today due to the increasing growth in human population and their activities, urbanization, and industrialization. It is important to know that the danger and environmental hazard that results from waste has made it imperative for us to adopt measures for proper waste disposal and management. They further stated that an ideal waste disposal site is the one that is located reasonably close to the source of the waste, has convenient transportation access, is not situated in a low lying area or floodplain, and is underlain by geologically stable, strong and competent rock material." In order to achieve the goal of proper waste disposal, a site has to be chosen for the disposal based on some factors and the kind of wastes such as solid waste, organic or inorganic waste, etc. The New York state department of environmental conservation defined waste in simple words as any discarded (abandoned or considered waste like) materials can be solid, liquid, semi-solid or containerized gaseous material. Examples include: waste tires, scrap metal, latex paints, furniture and toys, domestic refuse (garbage), discarded appliances and vehicles, uncontaminated used oil and anti-freeze, empty aerosol cans, paint cans and compressed gas cylinders, construction and demolition debris, asbestos. It can also be seen as consisting of everyday items that are used and then thrown away such as, product packaging, grass clippings, furniture, clothing, bottles, food scraps, newspapers, appliances, paint, and batteries (New York State Department of Environmental Conservation) . Wastes come from homes, schools, hospitals, and businesses (EPA, 2011). Solid waste generation is experiencing a rapid increase all over the world as a result of continuous economic growth, urbanization and industrialization. It is estimated that in 2006 the total amount of municipal solid waste (MSW) generated globally reached 2.02 billion tones, representing a 7% annual increase since 2003 (Global Waste Management Market Report, 2007).

This research is focusing on the suitability analysis of dump sites in kafanchan, using Spatial Multi-criteria Evaluation (SMCE). Various sources in the Literature define solid wastes as non-liquid, non-gaseous residue generated form manufacturing industries, construction firms, cooking, recreation centers or agriculture. Solid wastes generated from homes, business centers, hospitals, hospitals, schools, markets, etc., are termed "Municipal solid wastes" (Miller, 2019). Municipal solid wastes encompass paper, plastics, glass, wood, metals, textiles organic wastes such as food and garbage. Different solid wastes disposal systems are utilized, with the selection based on various factors or criteria. Miller (2019) outline such factors including terrain, slope, present and future land use, road network, distance from neighboring

settlements and proximity to surface water bodies (e.g., rivers, lakes, streams).

In this study, GIS techniques were employed to conduct a suitability analysis for dump site selection. The methodology was applied to the layout province within the City of Kafanchan. Geographical Information System (GIS) is a tool utilized to capture, store, analyze, manage and present data linked to specific locations. GIS facilitates the analysis of spatial information, data editing, mapping and the presentation of operational results (Wu. & Liu, 2018)

MATERIALS AND METHODS

The Study Area

Kafanchan is located in the Southern part of Kaduna State, Nigeria, within the Jema'a Local Government Area. It is situated approximately 200 kilometers (124 miles) south of Kaduna City, the state capital. Kafanchan lies in the middle belt region of Nigeria, characterized by a mixture of savanna and woodland vegetation. The geographic coordinates of Kafanchan are approximately 9.5833^0N Latitude and 8.2833^0E Longitude.

Corporation (NRC) and it sits on the line connecting Port-Harcourt, Enugu, Kuru, Bauchi and Maiduguri. Kafanchan is bounded in the East by Kagoro in Kaura Local Government Area, in the North by Zonkwa and Ungwan Rimi District of Zangon-Kataf Local Government Area and in the South by Nassarawa State and in the South East by Sanga Local Government Area respectively.

Rapid urbanization in Kafanchan often leads to pressure on waste management systems. The problem usually emanates from population growth of the area, changing in consumption patterns, industrial and commercial activities, construction and demolition etc., These necessitates proactive measures to address the challenges associated with increased waste generation in Kafanchan area.

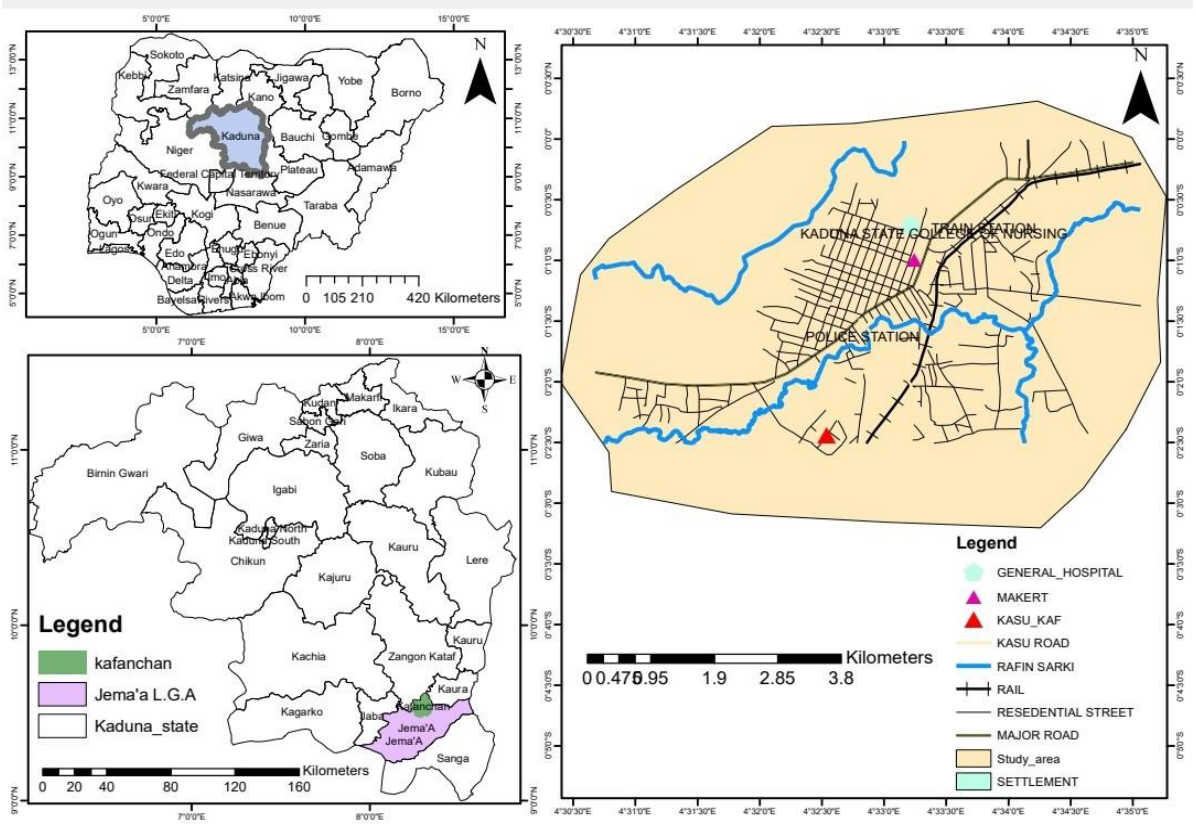

Figure 1: The Study Area Map
Source: Field work (2023)

Type and Sources of Data

Existing Maps of the Area (ArcGIS 10.8) Image of the Area from Google Global Positioning System (GPS)
KEPA (Kaduna State Environmental Protection Agency)

Table 1: The Adopted Data and their Sources

S/N	DATA	SOURCE	YEAR	RELEVANCE
1.	Digital maps	Google Earth Pro 7.0.2	2023	To extract the road network and also verify the water bodies within the study area
2.	Administrative map	Office of the surveyor General Kaduna	2022	Extract the boundary of the study LGA that made up the study area
3.	GPS coordinates Field Survey	GPS Waypoint (play store)	2023	For the coordinates of the existing solid waste dumpsites
4.	Location of the existing waste points	(KEPA)	2023	To extract the existing waste dumpsites within the study area

Source: Field work (2023)

Procedure for Data Collection

Data Presentation

General Framework

This research basically centered on determining suitable site for solid waste collection points. To achieve the objectives of the study, investigation about the existing solid waste disposal system in the study area was carried out in the course of which enquiries were made and information obtained from Kaduna State Environmental Protection Agency about the planning and operations of proper solid waste management system.

Analysis of suitable dump sites is based on the overlaying of datasets and places that satisfy certain suitability criteria. It is therefore combined the spatial analysis tools provided by GIS to integrate and evaluate criteria in order to determine potential waste sites. The principal sub-criteria that were used for spatial analysis include slope, built –up-area, road networks, drainage etc. hence, the exact operation of the methodology was approached in the following sequence:

Investigation of Dumpsite in kafanchan

Data Acquisition (Data Collection)

Conversion of the criteria into GIS layer

Data processing

RESULTS AND DISCUSSION

Existing Dumpsite Collection Points

The spatial analysis of X&Y coordinates of the existing dumpsites was retrieved in order to achieve the objective of the study. The coordinates of the existing dumpsites points were collected through field measurement/ field survey method. Hand-held GARMIN GPS was used to obtain the coordinates. These coordinates (both the formal and informal) are shown in the tables below:

Table 2: Showing Coordinates of formal Waste Collection Points Collected through Handheld GPS Receiver

S/N	Northing	Easting	Location
1	9.580412	8.284997	Abuja street
2	9.585183	8.292135	Old Market road
3	9.583727	8.291475	Magajiya street
4	9.583383	8.288912	Borno street
5	9.583700	8.288030	Bauchi street
6	9.586245	8.289050	Makafi street
7	9.590123	8.289148	Kinzaga street (maindump)
8	9.590770	8.293298	Jema'a street

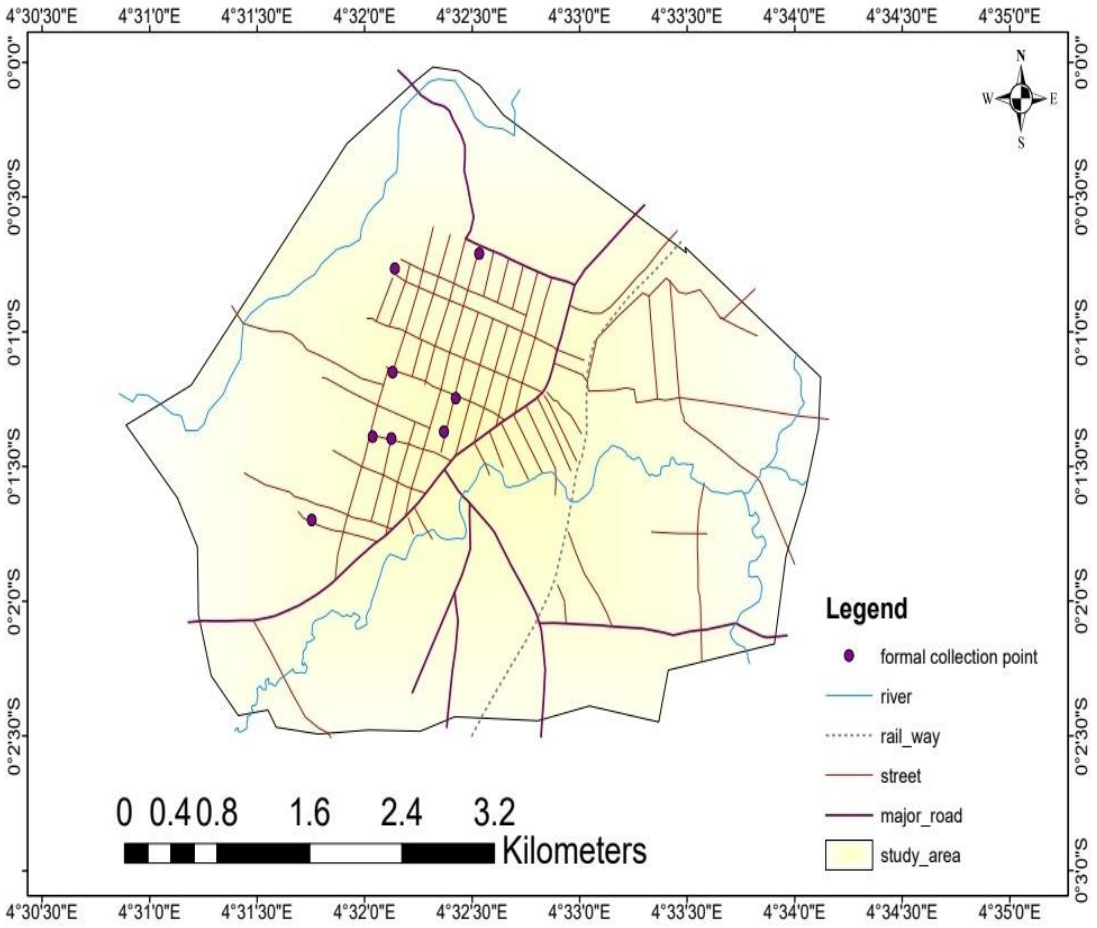

Figure 2: Map showing the existing formal collection points

Source: author work (2023)

Table 3: Showing Coordinates of informal Waste disposal Collected through Hand-Held GPS Receiver

S/N	Northings	Easting	Location
1	9°34'54.83"N	8°17'49.50"E	Jos street
2	9°34'48.73"N	8°17'25.85"E	Albarka street
3	9°35'1.88"N	8°17'55.13"E	new market site
4	9°34'41.03"N	8°17'48.85"E	unguwan musa road
5	9°34'35.43"N	8°17'46.24"E	takau 2 road
6	9°34'56.91"N	8°17'37.07"E	sol n co road
7	9°34'52.36"N	8°17'32.42"E	back police station
8	9°34'53.26"N	8°17'32.98"E	takau raod
9	9°34'46.55"N	8°17'23.58"E	albarka street 2
10	9°34'52.10"N	8°17'51.38"E	jos street 2

Source: Field work (2023)

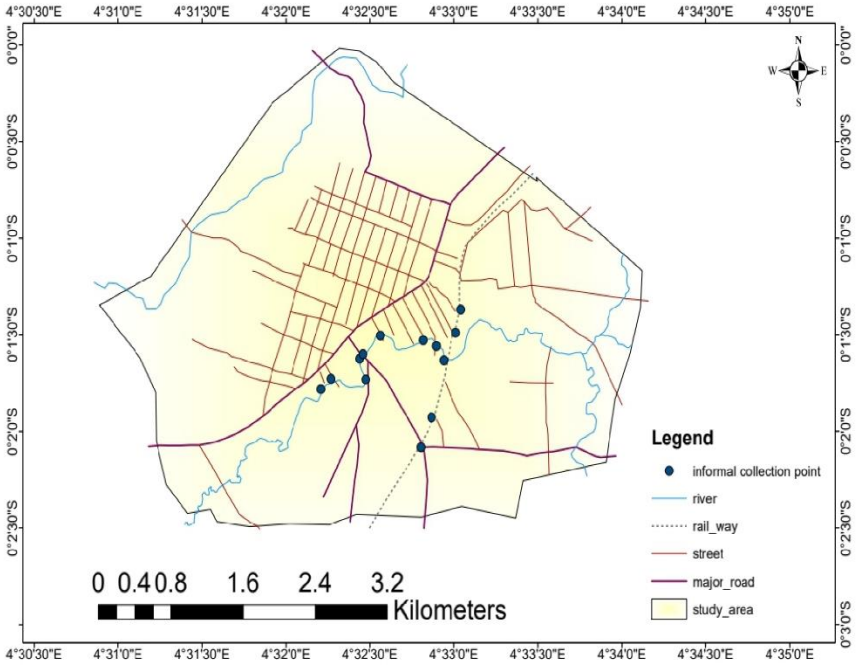

Figure 3: Map showing the existing informal disposal sites
Source: Author work (2023)

The coordinates of the existing solid waste sites collected during fieldwork were imported into the ArcGIS 10.8 as a text file then converted to shape-file to show the location of the sites. The points were superimposed on the result derived from the identification of potential solid waste dumpsites using multi-criteria analysis. This was to determine whether the existing sites within the study area met the stipulated standards.

Road Networks

The road networking the study area consists of major roads, minor roads and street roads. The waste disposal areas should not be too close to the road networks. The existing road network was obtained from GIS environment. The road network of the study area to its nearby was measured by buffer distance created in the ArcGIS environment using analysis tools. Therefore, a 20 m buffer zone is applied to these networks. This range of distance was chosen so as to aid the transportation and better accessibility and cost-effectiveness to the disposal site.

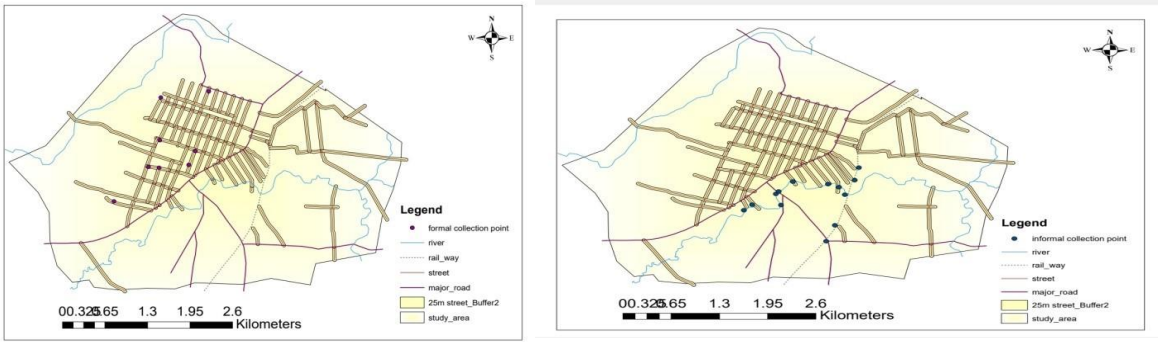

Figure 4: Road Networks Constraint Maps Showing Road buffer of 10m, 15m, 20m, and 25 m respectively.

Surface Water (Drainage)

The waste disposal areas should not be in the vicinity of rivers, lakes, or drainages where the underground water level is high. Since major rivers have a higher discharge and greater downstream influence, no collection point should be sited within the floodplains of rivers (Bagchi, 1994). Hence, buffers of 100 m and 70 m for permanent and temporary rivers are applied respectively. However, in the vicinity of the town permanent rivers are hardly found. Therefore, buffer of 70 m is considered.

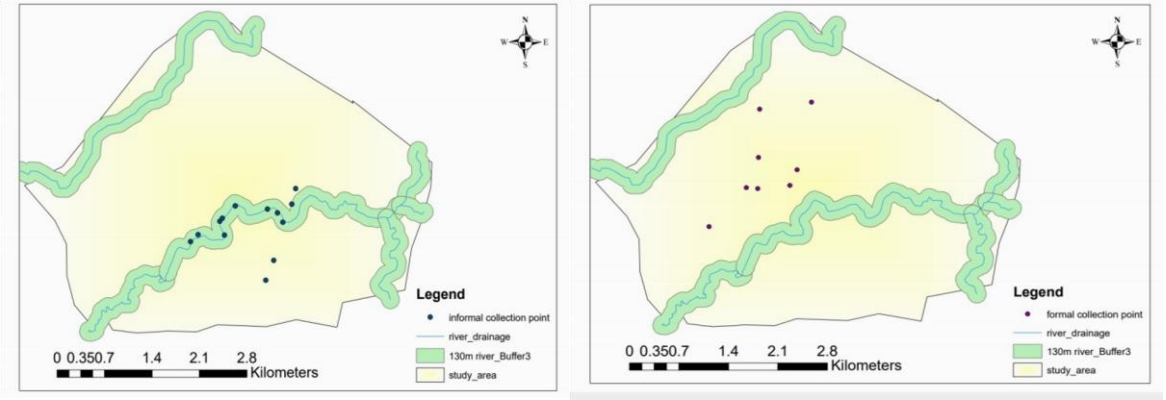

Figure 5: Surface Water (River/Drainage) Constraint Maps Showing drainage buffer of 70 m, 100m, 120m, and 130m respectively.
Source: author work (2023)

Residential and Commercial Areas

The waste disposal areas should not be in the vicinity of residential (Populated urban) areas. For this purpose a buffer zone of 10 m from all residential areas is applied to determine unacceptable areas. Since the location is majorly residential area, and according to (URPB) houses should be at least 20 m from major roads. Therefore, waste collection points can be located in between them. There is some government properties in the area made to serve public uses (hospitals, schools and water board etc.) Existing features such as Banks, shops, hotels and other buildings have been taken into consideration. In this study, a maximum distance of 20 (m) was used in which 10 (m) was considered the most suitable, based on the level of development in the area. This would create a protection zone around the buildings and other facilities to sitting waste disposal system. This was done in order to avoid pollution, ecological disturbance, and other health related issues and concern (Tchobanoglous, Theisen & Vigil. 1993).

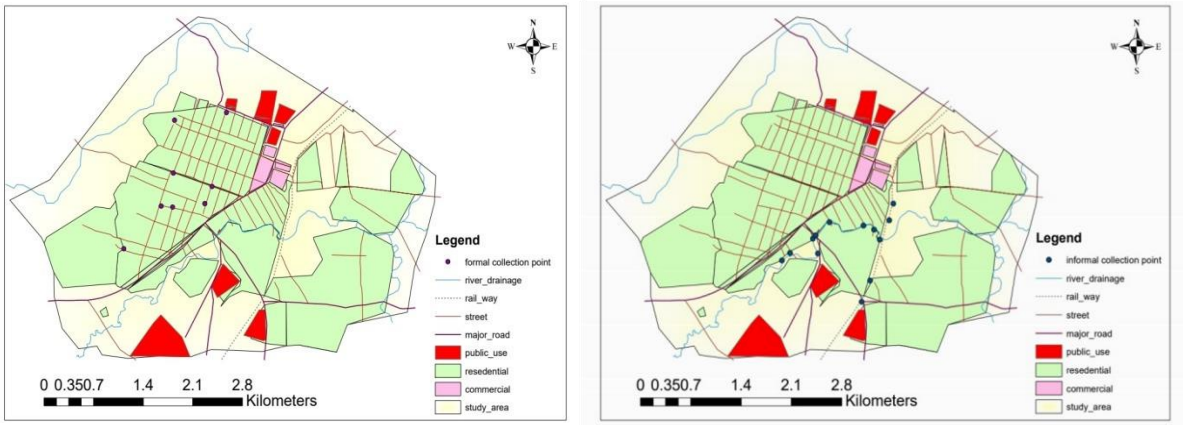

Figure 6: Land use constraint maps
Source: author work (2023)

Results

GIS desktop software package ArcGIS 10.8 and its extensions were used as the GIS tools; it is able to perform the analysis. In multi-criteria evaluation, a number of possible selections were taken into consideration and conflicting objectives to solve a location problem. In order to use GIS for site selection, the available information for the study area were collected and stored in the GIS. All digital maps of the study area including topographical maps were registered to UTM coordinate system, zone 32N. Present study designed to evaluate area for selecting a suitable site for Solid waste disposal.

Distance from Roads

Road networks inside the area is not much, however, accessibility to the disposal sites was important. Therefore, the sites closer to road are given a priority to help in reducing the cost of transporting solid waste to the disposal sites, for this reason the minimum distance of road is chosen as 10 m away from the disposal sites. In order to achieve this, a buffer distance of 24m maximum was specified for the road distance criterion. This range of distance was chosen so as to aid the transportation and better accessibility and cost-effectiveness to the disposal site. Multiple buffers created following road network suitability road distance interval, total four suitability classes were developed.

Table 4: Road Network Suitability

No	Suitability classes	Suitability Rank	Buffer Distance in (m)	Suitable Formal sites	Suitable Informal sites
1	Least suitable	1	10	17	6
2	Suitable	2	15	15	4
3	Moderately Suitable	3	20	11	3
4	Highly Suitable	4	25	9	2

Source: Author's work (2023)

Table 5: Road Network Unsuitability

No	Suitability classes	Suitability Rank	Buffer Distance in (m)	Unsuitable Formal sites	Unsuitable Informal sites
1	Least suitable	1	10	6	10
2	Suitable	2	15	8	12
3	Moderately Suitable	3	20	12	13
4	Highly Suitable	4	25	14	14

Source: Author's work (2023)
NOTE: There are only three (3) suitable sites.

Distance from Surface Water (Drainage)
Solid wastes are been disposed near and in the river which cause ecological problems, that have an extended impact for human and animal that use this water for various activities. Therefore, dump site should more distant from surface water.

Table 6: River Suitability

No	Suitability classes	Suitability Rank	Buffer Distance in (m)	Suitable Formal sites	Suitable Informal sites
1	Least suitable	1	70	20	15
2	Suitable	2	100	20	14
3	Moderately Suitable	3	120	18	14
4	Highly Suitable	4	130	18	14

Source: Author's work (2023)

Table 7: River Unsuitability

No	Suitability classes	Suitability Rank	Buffer Distance in(m)	Unsuitable Formal sites	Unsuitable Informal sites
1	Least suitable	1	70	3	1
2	Suitable	2	100	3	2
3	Moderately Suitable	3	120	5	2
4	Highly Suitable	4	130	5	2

Source: Author's work (2023)
NOTE: There are only four (4) suitable sites.

Distance From Built –Up Areas (Land Use)
Existing features such as Houses, schools, Hospitals and other buildings have been taken into consideration. In this study, a maximum distance of 18 meters was used in which fifteen meters (15m) was considered the most suitable. This would create a protection zone around the buildings and other facilities to sitting waste disposal system. This was done in order to avoid pollution, ecological disturbance, and other health related issues and concern. In urban planning and environmental studies, the concept of buffer zones around sensitive areas like residential buildings, schools, and hospitals is well-documented. For instance in the paper "Urban Waste Management: A case study of Lagos State, Nigeria" by Olusegun O. Oluwale and Olusola O. Sanya (2014) discuss the importance of creating buffer zones to mitigate the negative impacts of waste disposal on nearby infrastructure and communities. They suggest that a distance of around 15 meters is optimal for creating a protective zone around these facilities.

Discussions
The maps for commercial and residential areas were overlaid to have a combined suitable sites which again was queried to have the suitable sites, after which points that were within 100m proximity were expunged using the measure tool on ArcGIS, giving the most suitable sites for locating solid waste collection facilities in Kafanchan town. The collection points in the most suitable sites were pointed in relation to their coordinate values. The available portions specified by the system are the most suitable sites. Thus, the government can now use her discretion to place the bins (containers) at strategic points as specified. If bins are properly paced at these points, Kafanchan town will be:

i. A healthy environment for the inhabitants.
ii. Void of health hazards associated with indiscriminate dumping of solid wastes.
iii. Made a clean area in contrast to other cities of Nigeria and in line with the governments'
iv. Program of ensuring a clean and green city.
v. Made a model area in terms of efficient and effective solid waste management.

CONCLUSION
This study has examined the problems of the waste disposal sites in Kafanchan town and its implications on the residents of the town. The study revealed that the town has grown in

population as well as spatial extent over the years. The findings have shown the application of the GIS as a viable tool for analyzing the criteria for decision making the analysis has taken river (drainage), road, residential and commercial areas as determining factor in order to find appropriate site for solid waste sites. The results have shown that the sites selected are the most suitable. The sites are easy to access; manage for disposal of solid wastes. The locations are away from any water sources and other variables put into analysis. The integration of multi-criteria decision analysis is a useful tool in solving site selection problem, because it provides efficient spatial data manipulation and presentation. Hence, the capacity to use GIS for effective identification of suitable solid waste sites will minimize the environmental risk and human health problems.

The aim and objectives of this research have been achieved through the acquisition of necessary dataset and implementation of spatial analysis. The strength of this work lies in its simplicity, flexibility, and user-friendliness. The increase in commercial, residential and infrastructural development due to the population growth and urban expansion in Kafanchan is directly affecting the amount of waste generation in the area. This study is therefore considered very imperative because it serve as a catalyst in the area for further improvement on waste dump siting and management.

A cursory glance into the landscape of many Nigeria cities does not prove an exception. Indeed cities everywhere face a common dilemma of how best to respond to these challenges. The Nigerian Government included in its National Policy for the Environment (1989) that solid waste must be collected and disposed of in effective and environmentally safe manners.

RECOMMENDATIONS

For proper waste disposal systems and management to be maintained in the town, the following recommendations were suggested.

As result of population growth solid waste generation in the town has been increasing and becomes complex. Therefore, the concerned body should formulate for solid waste disposal sites by considering social, economic and environmental aspects to improve the status of solid waste management system of the town.

It is recommended that the site selected as a result of this study should be adopted for the disposal of solid wastes for the area.

Geographic information system (GIS) should be employed as a tool in decision making in environmental management issues.

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