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Land Suitability Analysis for Solid Waste Landfills in Kano Metropolis Using Multi-Criteria Evaluation Techniques

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Abstract

Solid waste has become one of the greatest challenges for developing countries is to understand how to manage large quantities of waste in a sustainable way. The aim of this study is to identify and analyse the most suitable site for solid waste landfills in Kano Metropolis. The objective is to determine the spatial distribution and suitable site for landfills. The integrated data used includes satellite image from Google Earth pro for the extraction of road networks, ASTER-GDEM from USGS for elevation and slope generation. Landsat-7 ETM+ image from USGS for land use land cover classification and list of the dumpsite addresses from the Ministry of Environment Kano State and their coordinates from field work. The datasets were integrated into the GIS environment using Multicriteria Evaluation in ArcGIS 10.7. The result reveals that the suitable areas occupied 3708 (ha) of land, that is 1.8% of the study area, moderately suitable with 121203 (ha) of land, that is 28% of the study area, then not suitable with 293031 (ha) of land that is 70.1% of the study area. The study concluded that GIS and remote sensing can factor in and help as a decision support tool. It is recommended for agencies such as the REMASAB to take the response action on the application of the technique in planning for exact areas of landfills.

Keywords: Solid waste, GIS, MCE, Landfills, Kano Metropolis

Analyse de l'adéquation des terres pour les décharges de déchets solides dans la métropole de Kano à l'aide de techniquesd'évaluation multicritères

Resume

Les déchets solides sont devenus l'un des plus grands défis pour les pays en développement est de comprendre comment gérer de grandes quantités de déchets de manière durable. L'objectif de cette étude est d'identifier et d'analyser le site le plus approprié pour les décharges de déchets solides dans la métropole de Kano. L'objectif est de déterminer la répartition spatiale et le site approprié pour les décharges. Les données intégrées utilisées comprennent l'image satellite de Google Earth pro pour l'extraction des réseaux routiers, ASTER-GDEM de l'USGS pour la génération d'élévation et de pente. Image Landsat-7 ETM+ de l'USGS pour la classification de la couverture terrestre et la liste des adresses des décharges du ministère de l'Environnement de l'État de Kano et leurs coordonnées du travail sur le terrain. Les jeux de données ont été intégrés dans l'environnement SIG à l'aide de Multicriteria Evaluation dans ArcGIS 10.7. Le résultat révèle que les zones appropriées occupaient 3708 (ha) de terres, soit 1,8% de la superficie d'étude, modérément appropriées avec 121203 (ha) de terres, soit 28% de la superficie d'étude, puis ne convenaient pas avec 293031 (ha) de terres qui représentent 70,1% de la zone d'étude. L'étude a conclu que les SIG et la télédétection peuvent être pris en compte et aider en tant qu'outil d'aide à la décision. Il est recommandé aux organismes tels que le REMASAB de prendre des mesures d'intervention sur l'application de la technique dans la planification des zones exactes des sites d'enfouissement.

Mots-clés : Déchets solides, SIG, MCE, Décharges, Kano Metropolis

INTRODUCTION

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 (Hoornweg and Bhada-Tata, 2012). Population growth and urbanization, coupled with expanded social and economic activities, have resulted in an increased generation of solid wastes and societal, economic, and environmental burdens associated with solid waste management (Adeniyi, Sule, Downs and Mihelcic, 2012). Recurrent increase in population and urbanization makes the task of public waste management challenging, coupled with issues like institutional decay, low capacity to carry out duties, wrong attitude of waste generators, amongst others (Achu, Inemesit and Ndem, 2015). In the view of Saeed, Nasir and Mujeebu (2008), lamented that the generation of solid waste is directly proportional to population, industrialization and urbanization, changing lifestyle, food, habits and living standards of the people. Due to the low level of available technology, as well as ineffective policies towards waste management practices, majority of the systems are open-burning.

The method of open-burning of solid waste has been used in Nigeria and has indicated to be one of the major problems and 80.6% of wastes generated in the country are combustibles and the estimation for the year 2020 shows that the MSW generated by the urban population of Nigeria ranges from 16.8-25.3 million tons with 0.58, between 2.4-3.7 million tons of the uncollected wastes are open-burned, while the an estimates shows that 14.3% of the MSW generated in Nigeria contain fossil carbon (Okedere *et al.,* 2019; Okafor *et al.,* 2022). As indicated by National Bureau of Statistics that 52% Nigerians concentrated in urban centers in 2020 with an annual mean growth rate of 2.62% within 2006–2020 and generates 0.49kg of solid waste per day with households and commercial centers contributing almost 90% (Solomon, 2009; World Bank, 2020). This has resulted to a serious impact of environmental pollution causing a tremendous growth in health-related problems, obstruct storm water runoff, spread of disease and environmental degradation and with inadequate collection and disposal of solid wastes (Bhambulkara and Khedikar, 2011; Afolayan *et al.,* 2013; Afolayan, Ibidunmoye, Thompson, 2013). Thus, the need for proper waste disposal which has been shown in most cities of the developing Worlds to be the glaring problem. The solution to such problem is the use of landfills. This approach has been utilized in many countries and has indicated to be a better way of managing the solid waste.

In Nigeria, the selection of suitable landfill sites that combine social, economic and environmental factors for locating waste dumpsites has been recognized as a major problem in planning and construction (Ademiju and Ukaegbu, 2017). Therefore, the main issue in the management of solid wastes is the location of proper sites for solid waste disposal and selection of appropriate sites far from residential areas, environmental resources and settlements (Ebistu and Minale, 2013). In order to mitigate the above problems, Geospatial technology (Geographical Information System) one of the technologies that has proven viable in selecting best possible solid waste dumping sites both in developed and developing environments according to researches, is useful.

The landfill siting problem in waste management has been studied by many researchers globally using Multi Criteria Decision Method (MCDM) techniques alone or in combination with other techniques. The models for problem-solving have evolved from the single-criterion, maximum models (maximizing the average or minimum distance between the source and the site) (Hale and Moberg 2003). Integration of GIS for landfill selection has been applied using different approaches across the World. Like using Analytical Hierarchy Process (AHP) and socio-economic (Yildirim, 2012; Gbanie *et al*. 2013; Eiselt and Marianov, 2014; Adewumi *et al,* 2019; Karabulut, *et al.,* 2022). Effect of solid waste and soil contamination using GIS (Ismat *et al.,* 2021; Muheeb and Bashir, 2021). Spatial distribution of dump sites (Ali, 2013; Danbuzu, *et al,* 2014; Naibbi and Musa, 2017; Hundu and Bibi, 2017). Others applied fuzzy logic (Chen, 2017; Ahmed and Suryabhagavan, 2019) and Multicriteria Evaluation (Adeyemi, *et al*, 2018; Rahimi, Hafizalkotob, Monavari, 2019 Muheeb and Bashir 2021; Sanu and Sumana 2021; Teshome, Setiye and Mengist, 2022; Jay *et al.,* 2022).

Most of these studies carried out in the study area includes plastic waste recycling, assessing Refuse Management and Sanitation Board (REMASAB) on waste management, solid waste characteristic, composition of municipal solid waste (Nabegu, 2008a Nabegu 2008b; Mukhtar, 2008 Nabegu and Mustapha, 2015; Salamatu and Rabiu, 2017) among others without analyzing the suitable location for landfill. Most of the studies conducted in the area using GIS concentrated on the spatial distribution on the dumpsites (Danbuzu, *et al,* 2014; Naibbi and Musa, 2017). While other studies concentrated at the southern part of the Nigeria which are less congestion using GIS and remote sensing (Olajire and Ojeh, 2017; Rowland and Omonefe, 2022).

Hence, this study focused on the site suitability for landfills using an integrated approach in the GIS environment. Therefore, the objective of the study is to identify and analyse the most suitable site for solid waste landfills in Kano Metropolis using Multicriteria Evaluation Technique in a view to identify the most suitable site for landfills.

Study Area

The study area is Kano Metropolis and it is located between Latitude 12 º 25' and 12 º 40' North of the Equator and Longitude 8 º 35' to 8 º 45' East of the Greenwich Meridian (Olofin, 1987), as shown in Figure 1.

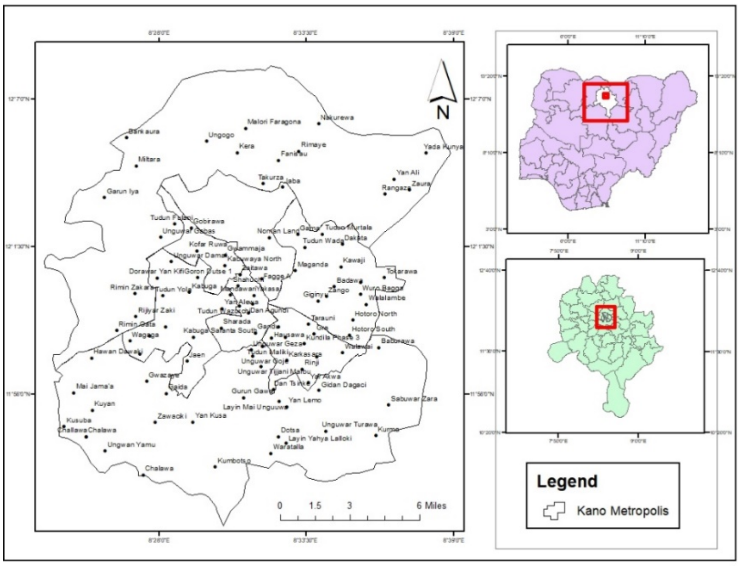

Figure 1: Kano Metropolis (Study Area)

It comprises of eight local governments which includes: Dala, Tarauni, Kumbotso, Fagge, Nassarawa, Ungogo, Kano Municipal, and Gwale (Nabegu and Mustapha, 2015). Population grow.h is another problem because the higher the population the higher the waste generated. Kano metropolis is among the fastest growing cities in Nigeria, with a population presently estimated at 3.5 million and a population density of about 1000 inhabitants per Kilometer. It is one of the most crowded cities, hence generation of municipal wastes in heaps on daily basis are enormous (Mohammed, 2019).

MATERIALS AND METHODS

The important factors considered for siting a sanitary landfill which includes slope, land use, road networks, and water body/river. These factors were generated in thematic layers in GIS environment, using the spatial analyst tool (Fig. 2). Different data sources were acquired for this study (See summary in Table 1). The Datasets were extracted from different sources;

i. Road networks were sourced from Google earth pro (2019)
ii. ASTER-GDEM was sourced from USGS for elevation and also generate slope of the terrain in the study area
iii. Land use map and water body were extracted from Landsat-7 ETM+ image, downloaded from USGS of (2018)
iv. The list of the dump sites addresses were sourced from Ministry of Environment, Kano State and the coordinates of the existing dumpsites within the study area was acquired using smartphone GPS through field work
v. Materials on solid waste and GIS were sourced from both library and online sources

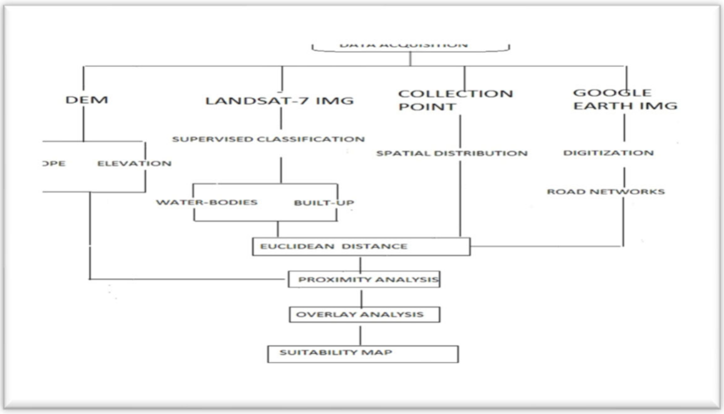

Figure 2: Summary of the Methodology

Table 1: Sources of the Data

Data	Class of data	Source	Year	Relevance
Landsat-7ETM+	Secondary	USGS	2018	For land use/land cover-type classification
ASTER-GDEM	Secondary	USGS	2011	For generating slope and elevation
GPS coordinates	Primary	Field work	2019	For coordinates of the existing solid waste dumpsites
Road network	Primary	Google-earth	2019	Extracted for road network

The study envisioned the use of GIS as a decision support tool that integrate and evaluates different criteria to determine a potentially suitable site for the location of a landfill for solid waste management (See Table 2). A new landfill should not be located within a distance of a housing area because of health effects associated with landfill. A safe distance necessary to locate a landfill site should be determined to prevent pollution and contamination hazards (Amakihe, 2011). This has been stated by the World Bank (2004) to be within 250 meters from the perimeter of the proposed landfill

Table 2: Criteria used for the study

S/N	Criteria	Highly Suitable	Moderately Suitable	Least Suitable	Not Suitable
1	Built-Up	600m>	300m-600m	250m-300m	<250m
2	Road network	200m-500m	500m-1.2km	>1.2km	<200m
3	Water body	>1300m	1000m-<1300m	500m-<1000m	<500m
4	Rivers	>1300m	1000m-<1300m	500m-<1000m	<500m
5	Slope	0°–2°	2°–6°	6°–9°	10°>
6	Elevation	425-<450	450-<480	480-<490	490-536
7	Existing Dump site	>7km	3km-6km	1km – 3km	< 1km

A suitable and proper selection of landfill sites is the key to effectively managing solid waste disposal problems. The landfills should be located at a transportable place and its siting should be cost-effective and environmentally friendly (Kareem and Pandey, 2016). The landfill should be close to the existing road network for accessibility and cost related issues in transporting the waste from generation or transfer station to the site. Because of this, proximity of road network is an important factor in locating a landfill site (Amakihe, 2011). A site accessible within 30 minutes travel time is considered (<1.2 Km) as in World Bank (2004).

The landfill site should not be placed within water resource areas in order to protect it from contamination. A safe distance should be maintained from all water sources such as surface water bodies, channels and rivers. A minimum distance between existing sources and a proposed site may be specified by the regulatory agency. Landfill disposal facilities should be located and designed so that the potential for surface drainage from adjacent areas onto the landfill is minimal (Guyer, 2009). Preferably, it should be at least >500 meters away from all water supplies (private, public drinking, irrigation and livestock supply wells) as in World Bank (2004). Slopes may have topographic surface impacts on a sanitary landfill. As according to World Bank (2004) indicated that a gently sloped topography is most preferable (like 2%) and considerable to development of sanitary landfill, slopes minimize the need for earthmoving and helps in obtaining the correct leachate drainage.

The record of the existing dumpsites with their addresses were sourced from Ministry of Environment Kano State and the inventory of their locations (Latitudes and Longitudes) were taken using the Garmin GPS. Nearest Neighborhood Analysis (NNA) was employed to examine the pattern of the distribution of the dumpsite in Kano Metropolis. The NNA uses the distance between each point and its closest neighboring point to determine if point pattern is clustered, random or dispersed. Different setbacks were applied from the factors such as distance from buildings, proximity to existing road networks, proximity to water sources, slope angles and elevations were used to determine the best location for landfill. Weighted overlay and analytic hierarchy process (AHP) were integrated in the GIS environment. The Analytic Hierarchy Process (AHP) is a multi-criteria decision-making strategy where all criteria are assigned to different levels using pairwise comparison in the matrix to derive the relative weights for criteria (Forman and Saul, 2001). It provides the judgment matrix by comparing the degree of significance of the relative element and each index's weight is relative to the general objective, thereby simplifying the decision-making process (Forman and Saul, 2001).

RESULT AND DISCUSSION

The spatial distribution of dumpsites indicated a random pattern. The Nearest Neighbour Analysis (NNA) of 0.85 index with z-score of -1.35 and p-value of 0.178. The result of the pattern does not appear to be significantly different than random (Figure 3).

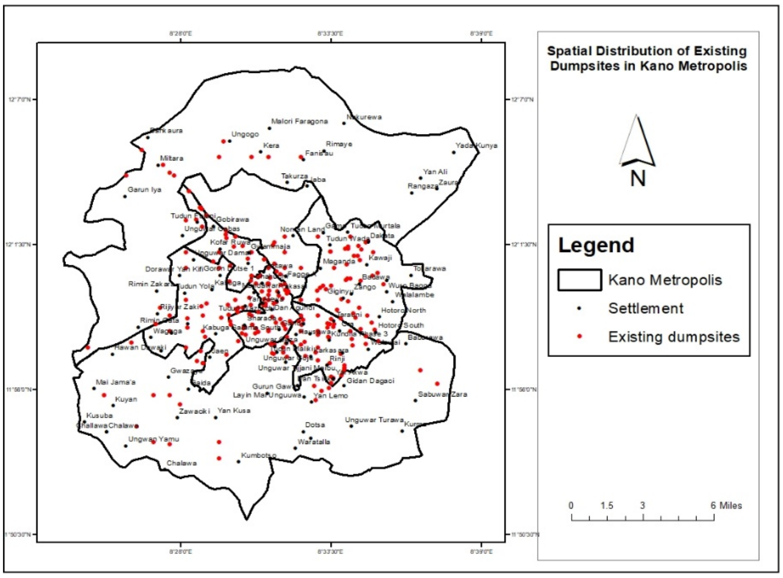

Figure 3: Distribution of Solid waste Dumpsites.

From the result, it shows that there is a random distribution. The result has shown a contrary distribution in Katsina metropolis, which shows a clustering of dumpsite within the city for both legal and illegal (Danbuzu, *et al.,* 2014). Furthermore, the Nearest Neighbor Analysis (NNA) is a very important tool for determining the spatial distribution pattern of objects on the surface of the Earth.

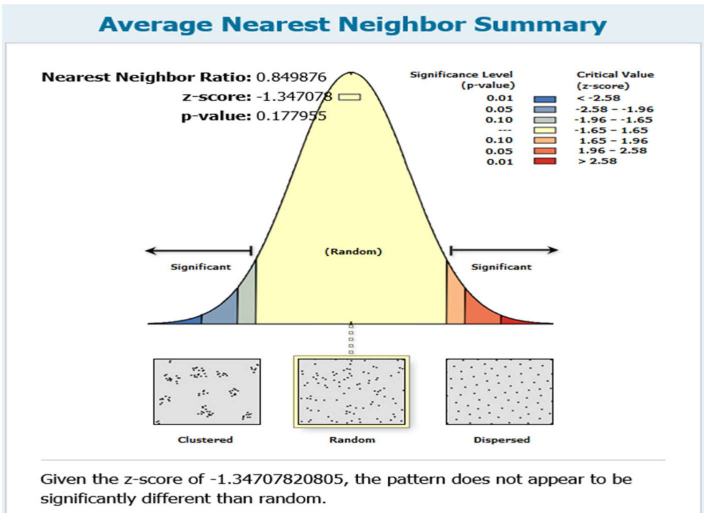

Figure 4: Average Nearest Neighbor Analysis

Factors used for the determination of landfill site

Different factors were used for the purpose of this study which includes distance from buildings, proximity to existing road networks, proximity to water sources, slope steepness, elevation each criterion was classified into sub-criteria in this research and assigned a suitability rating value from 1 to 9 adopted from Saaty and Vargas (2001).

Proximity to existing road network

Euclidean distance was created along the major road networks and then reclassified (see Figure 5) to determine the minimum and maximum distance from landfill locations, the criterion was characterized by the recommended distance according to the potential environmental risk, human health and excess cost, and by taking into account the requirements of government regulations.

The result shows that the distance of more than 2000m is not suitable for landfill sites as it is far away from the road network which makes it not accessible or difficult for the trucks to reach the landfill site while a distance of 500m is suitable for landfill site base on accessibility to the landfill (World Bank, 2004). It indicated that (Figure 5 and Table 3) places like *Hotoro North, Layin Labaran lalloki* are within the suitable areas in terms of accessibility to road networks whereas places like *Mai jama'a Walalambe, Kusuba, Takuza* are within the unsuitable area due to their proximity to road networks

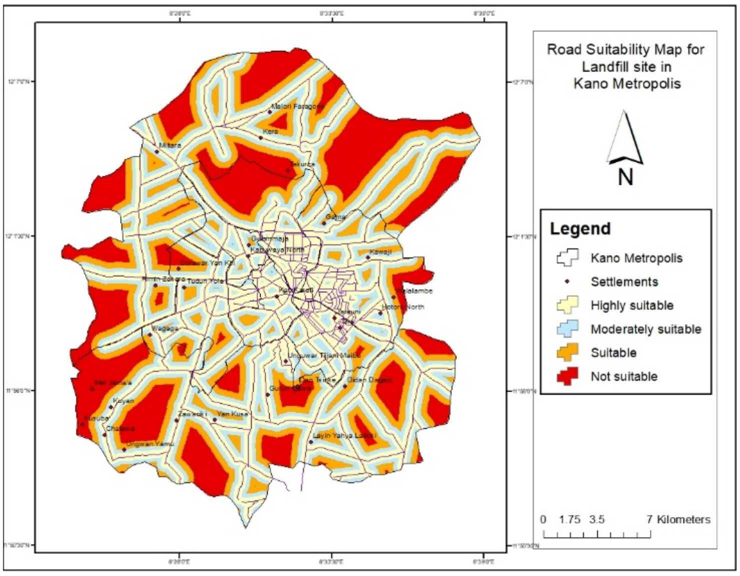

Figure 5A: Reclassified Road Suitability for Landfill Site in Kano Metropolis

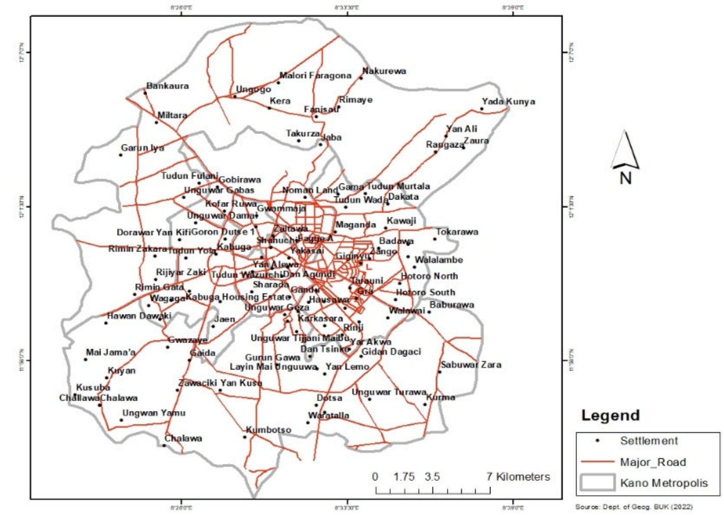

Figure 5B: Reclassified Road Suitability for Landfill Site in Kano Metropolis

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Table 3: Suitability classes for road network

S/N	Class	Area (ha)	(%)
1	Highly suitable	14,502.58	34.7
2	Moderately suitable	9,069.34	21.7
3	Suitable	8,567.82	20.5
4	Not suitable	9,616.85	23.01
	Total	41794.20	100

Proximity to water body

The result shows that places like *Wagaga, Kera, Tarauni, Dorayi unguwan kifi* and *Tundun Yola* are within the suitable site while places like *Kusuba, Gama, Gurun gawa, Kawaji* are within the unsuitable locations.

Water bodies such as; surface streams, lakes, rivers, wells, or wetlands are one of the major factors to be considered when siting a landfill. Also, proximity to wells and other underground water reservoir is an important criterion to be considered when locating suitable landfill site (Olaide 2014). According to Bera *et al* (2016) and Adewumi *et al,* (2019), indicated that locating landfills close to water sources would lead to the contamination of water quality thereby rendering the water unsuitable for human consumption. For this reason, Euclidean distance was created along all water bodies (river channels, ponds), 500-meters within the water bodies are term not suitable for locating a landfill site and as stated from the criteria for highly suitable (>1300m), moderately suitable (1000m-1300m), least suitable (500m-1000m) and Not suitable (<500m) (see Figure 6 and Table 4). This is also primarily due to environmental concerns, hence, locating it further away from surface water sources would be most preferred. This result is in conformity with the rules and regulation of National Environmental Standards and Regulations Enforcement Agency (NESREA) which stated that dumpsite should be placed at least 1000m away from surface water bodies to avoid hazardous emission as well as leaching from waste.

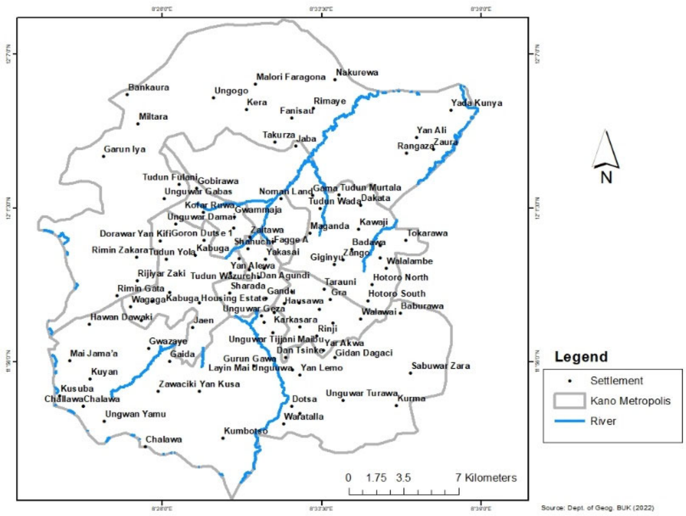

Figure 6 A: Surface Water (River) Constraint

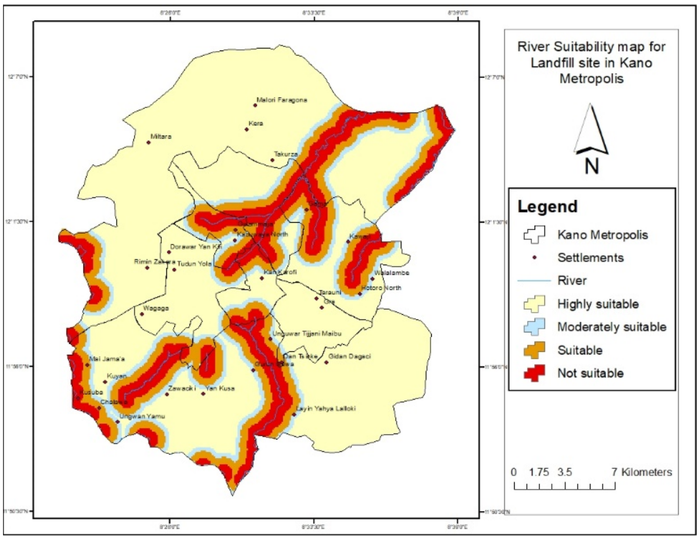

Figure 6 B: Surface water (River) Constraint

Table 4: Suitability Classes for River

S/N	Class	Area (ha)	(%)
1	Highly suitable	1713.56	4.1
2	Moderately suitable	2047.92	4.9
3	Suitable	34396.63	82.3
4	Not suitable	3594.30	8.6
Total		41794.20	100

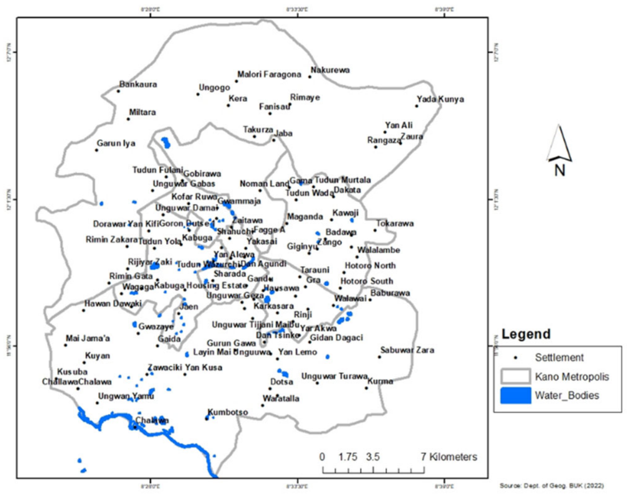

Figure 7A: Reclassified ponds suitability for landfill site in Kano Metropolis

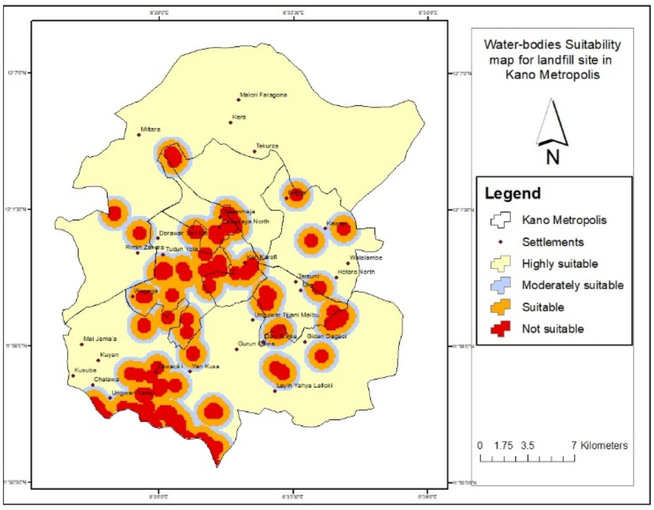

Figure 7B: Reclassified ponds suitability for landfill site in Kano Metropolis

This result shows that places like *Takurza, Gurun gawa, Kera, Mai jama'a* are within the suitable site while other places like *Gama, Kankarofi, Wagaga, Zawaciki* are within the unsuitable site.

Table 5: Suitability classes for waterbody

S/N	Class	Area (ha)	(%)
1	Highly suitable	7230.40	17.3
2	Moderately suitable	9219.80	22.06
3	Suitable	15171.29	36.3
4	**Not suitable**	10030.61	24
	Total	**41794.20**	100

Built-Up Suitability for Landfill Site in Kano Metropolis

Land use is seemingly the most imperative of all the criteria required for selecting a landfill since the settlements have to be taken into consideration when sitting landfills. This criterion prevents the chances of locating a landfill within the built-up environment of Kano metropolis due to rapid urbanization. However, areas that not too close to the built-up areas are considered as best options for siting landfills; thus, the outskirts of Kano metropolis become considerable (see Figure 8 and Table 6). The result shows that the entire core of the metropolis is not suitable like *KMC, Dala, Nassarawa, Gwale, Fagge and Tarauni* the only places that are within suitable sites are in *Ungoggo* and few areas in *Kumbotso.*

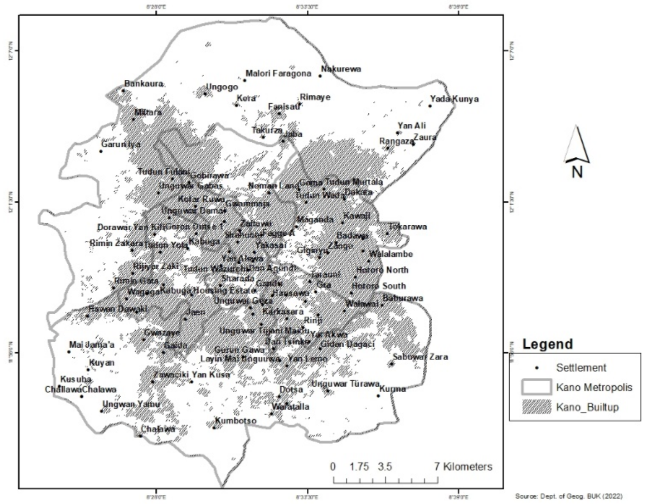

Figure 8A: Reclassified Built-Up suitability for landfill site in Kano Metropolis

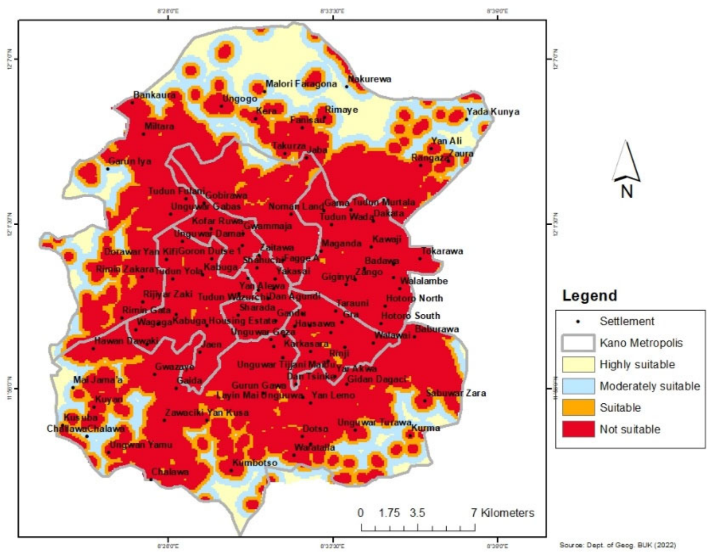

Figure 8B: Reclassified Built-Up suitability for landfill site in Kano Metropolis

Table 6: Suitability classes for built-up areas

S/N	Class	Area (ha)	(%)
1	Highly suitable	8191.67	19.6
2	Moderately suitable	13081.58	31.3
3	Suitable	13123.38	31.4
4	Not suitable	7313.99	17.5
Total		41794.20	100

Slope suitability for landfill site in Kano Metropolis.

The slope angles were extracted from DEM. The result shows that areas with slopes greater than 10^o are considered unsuitable for sanitary landfill see (Figure 9 and Table 7).

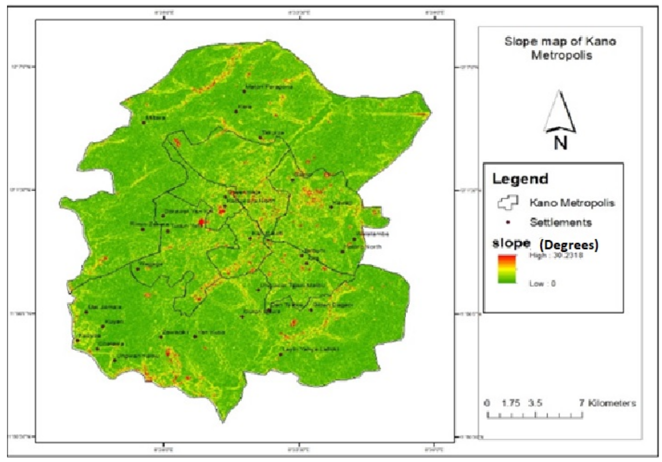

Figure 9A: Slope constraint

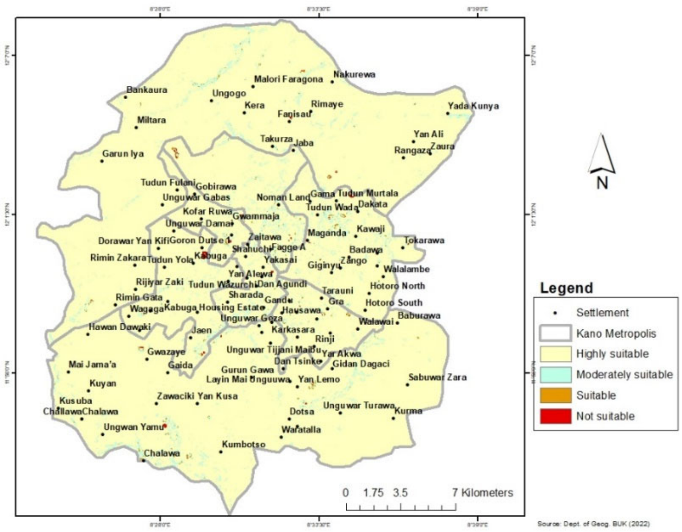

Figure 9B: Slope constraint

Table 7: Suitability classes for slope

S/N	Class	Area (ha)	(%)
1	Highly suitable	3552.51	8.5
2	Moderately suitable	1170.24	2.8
3	Suitable	961.27	2.3
4	Not suitable	36110.19	86.4
Total		41794.20	100

In general, the risk of runoff and leachate from landfills associated with the slope of the terrain (Lu, 2010). However, this study employed slope between the ranges of 0°–2° as the best suitable option to mitigate the adverse environmental impact. However, slope that is greater than 2 is considered to have chances of movement especially within the underlying rocks which are control by the nature of the geological formation of the area. Therefore, the lesser the steepness of the terrain the more suitable the location for a sanitary landfill (see Figure 9). The result shows that places like *Layin yahaya lalloki, Kuyan, Yan kusa, Miltara, Zawaciki, Mai jama;a* are having gentle slope and are within the suitable areas, whereas places like *Tudun yola, Kankarofi, Goron dutse* are having steep slope and are within the unsuitable site

Elevation suitability for landfill site in Kano Metropolis.

For the elevation, the result shows that 425-536 above mean sea level were classified into 4 classes respectively. From the result in Figure 10 and Table 8, appropriate elevations for the selection of landfill sites were classified into 4 classes. The result shows that places like *Miltara, Dorayi yan kifi, Tudun yola, Kankarofi, Wagaga* are all within the unsuitable areas whereas placrs like *Gama, Kusuba, Unguwan Yamu, Takurza, Mai jama'a, Kuyan* are within the suitable areas.

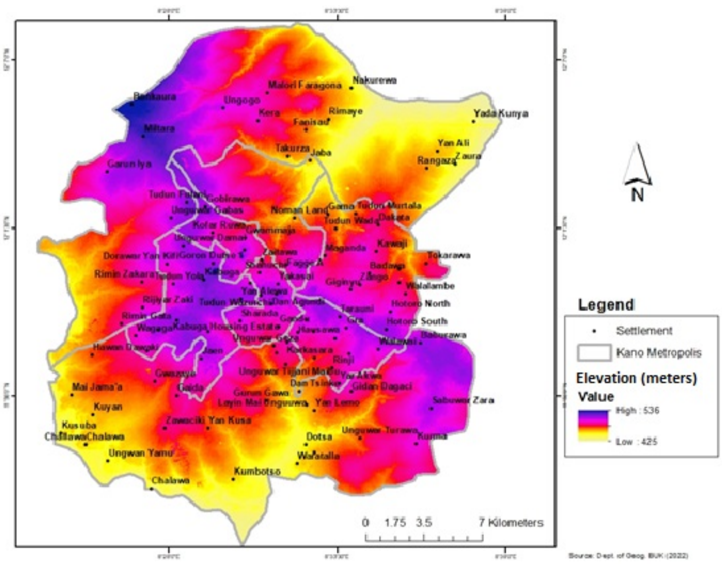

Figure 10A: Elevation constraint

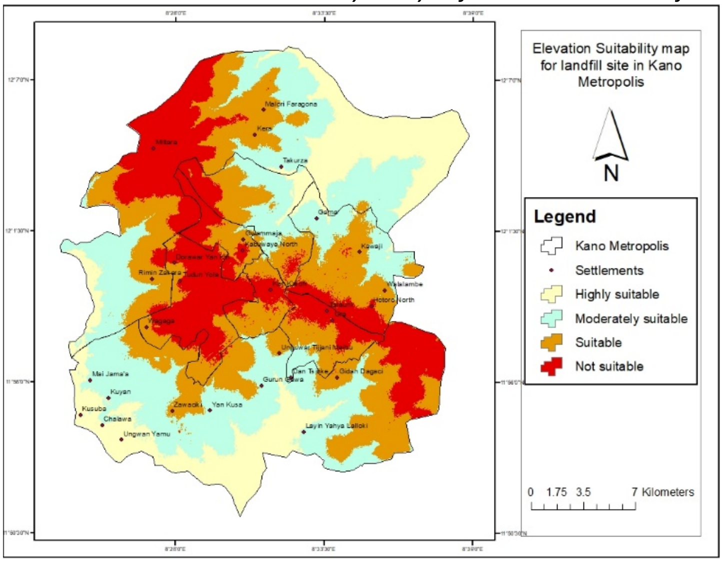

Figure 10B: Elevation constraint

Table 8: Suitability classes for elevation

S/N	Class	Area (ha)	(%)
1	Highly suitable	28712.62	68.7
2	Moderately suitable	4680.95	11.2
3	Suitable	1662.87	11.24
4	Not suitable	1139.15	7.7
Total		41794.20	100

Existing dump site suitability for landfill site in Kano Metropolis.

Locating landfills close to an existing one would lead to the contamination of any given environment, thereby, rendering the area unsuitable or inhabitable for human beings. For this reason, Euclidean distance was created around the existing dump site and then reclassified. 500 meters around the existing dump site are termed not suitable for locating a landfill site and 2 kilometers outward the existing dump site is termed moderately suitable, suitable and highly suitable (see Figure 11 and Table 9). This is also primarily due to environmental concerns, hence, locating it further away from existing dump site would be most preferred. The result shows that dumpsites are clustered around the core metropolis like *KMC, Dala, Nassarawa, Gwale, Fagge and Tarauni* while evenly distributed in *Ungoggo* and *Kumbotso*

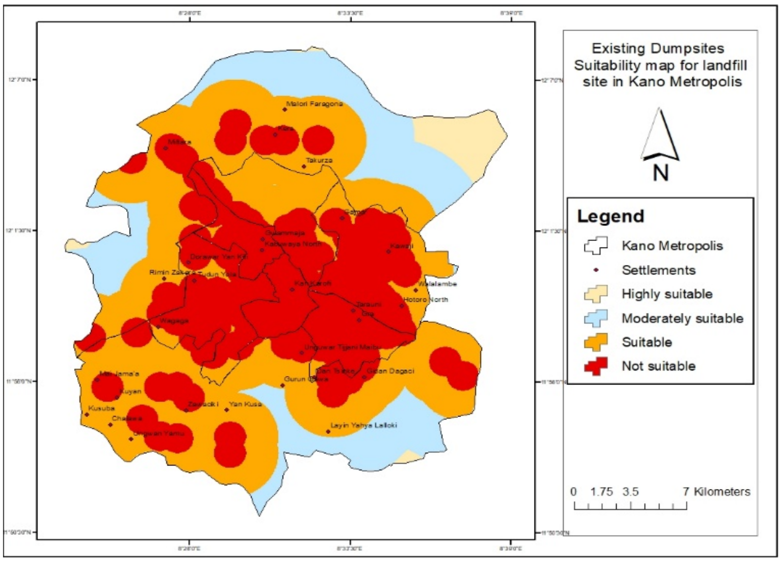

Figure 11A: Existing dumpsites constraint

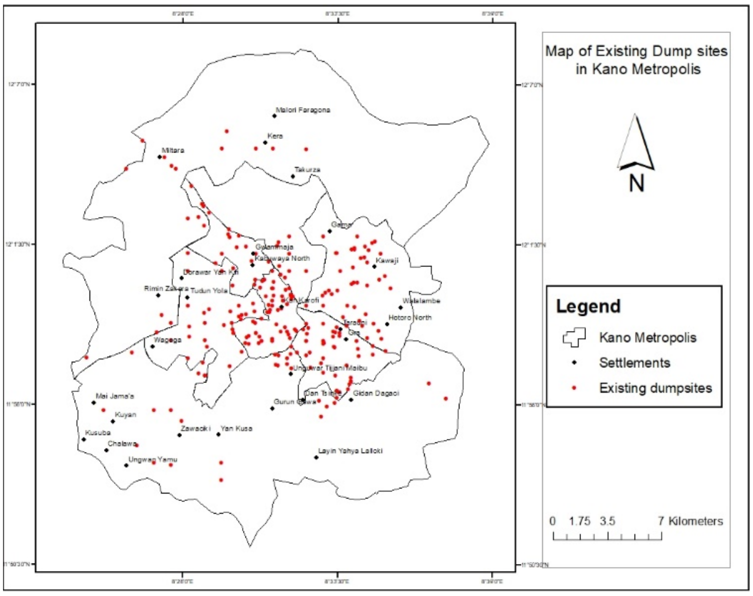

Figure 11B: Existing dumpsites constraint

Table 9: Suitability classes for existing dumpsite

S/N	Class	Area (ha)	(%)
1	Highly suitable	5809.39	13.9
2	Moderately suitable	10281.37	24.6
3	Suitable	13499.53	32.3
4	Not suitable	12120.32	29.0
Total		41794.20	100

Suitable Areas for Landfill sites in Kano Metropolis

The pairwise comparison matrix (PWCM) was carried out for rating and weighing of the different criteria. The fundamental scales given by Saaty for comparing the two criteria were used. The quantitative value from 1-9 scales was given (Saaty and Vargas, 2001), considering the comparative importance of two criteria. Based on expert's opinion, the overall rating for the comparison was generated in Table 10 which derived the weights with an acceptable consistency ratio. This was used in the generation of suitability map for landfill sites.

Table 10: Pairwise Comparison Matrix

S/N	Built-up	River	Water body	Dumpsite	Elevation	Slope	Road	Criteria weight
Built-up	1	5	5	4	4	5	2	0.317
River	0.2	1	2	0.25	0.2	5	0.2	0.069
Waterbody	0.2	0.5	1	0.2	0.2	0.33	0.14	0.031
Dumpsite	0.25	4	5	1	0.25	5	0.33	0.119
Elevation	0.25	5	5	4	1	3	0.33	0.160
Slope	5	3	3	0.2	0.33	1	0.2	0.065
Road	0.5	5	7	3	3	5	1	0.239
Total	**2.6**	**23.5**	**28**	**12.65**	**8.98**	**24.33**	**4.2**	**1**

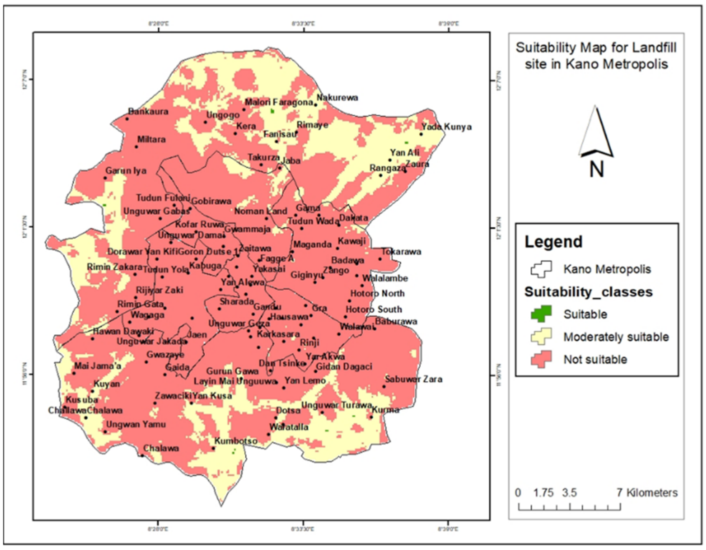

Figure 12: Suitability Areas for landfill site in Kano Metropolis.

The result shows that the most suitable site is located at the outskirts of the area (Figure 12 and Table 11). However, places in the northern part of the study area in Ungoggo Local Government along Panisau road and Wadakar close to Kwankwasiyya city in Kumbotso fall within the suitable areas, while places like Rangaza, Yan ali, Yada kunya, Malori faragona, Nakurewa fell within the moderately suitable sites. The entire core of the metropolis fell within not suitable area

Table11: Characteristics features of candidate landfill sites

S/N	Class	Area (ha)	(%)
1	Suitable	370.80	1.87
2	Moderately suitable	12120.30	28
3	Not suitable	29303.10	70.3
	Total	41794.20	100

It is also situated closest to road network to cut cost of transportation. The site can be characterized by gentle slope or almost relatively flat land with an elevation of (425m) and a favorable landuse (100 % usable area). This is similar to Adeyemi *et al.,* (2018) findings which conducted landfill site selection in Ado-Odo Ota LGA using GIS to identify the suitable site taking several criteria such as land use, vegetation classification, road networks, water bodies into consideration, the suitable areas were far away from residential areas to prevent unpleasant smell, the sites were relatively close to road networks and far away from all water sources to prevent leaching. Rahimi *et al*., (2019) carried out a sustainable landfill site selection for Municipal Solid Waste based on a hybrid decision-making approach. Also, similar findings in Katsina Ala Town which shown that the suitable place is far away from any water sources and other inputs considered in the analysis by applying similar criteria and Euclidean distance (Hundu and Bibi, 2017). This is an indication to show that even in areas of high rainfall and low elevation can be apply and achieve the same result.

CONCLUSION

It was concluded from the result of the Multi Criteria Evaluation concluded that GIS and remote sensing were appropriate as decision support tool for landfill suitability analysis. This study indicated the integrations of different factors as vital players in the site selection for landfill, because each factor contributed in the process. This study inferred that the majority of the suitable sites were found in the outskirts of metropolis, having low concentration of built-up areas and more of either cultivated land or bare land. The study recommended the integration of GIS and remote sensing to solid waste management, especially by the agency concern, such as REMASAB in Kano State to take an action on the application of the technique for planning and selection of suitable sites for landfills.

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