Suitability Location of Solid Waste Collection Points for Chanchaga Local Government Area, Niger State

[1*]Baba M., [2]Musa A.W., [1]Olaniyi A.M., [3]Bala M.K. & [4]Tanko F.
[1]Department of Surveying & Geoinformatics, Federal University of Technology, Minna
[2]Department of Urban & Regional Planning, Federal University of Technology, Minna
[3]Department of Estate Management, Federal University of Technology, Minna
[4]Department of Soil Science & Land Management, Federal University of Technology, Minna
[*]Corresponding author: mahmud.baba@futminna.edu.ng

Received: 9/08/2024 **Revised: 3/10/2024** **Accepted: 21/10/2024**

Population growth and uncontrolled urbanization has made solid waste management an imperative issue for environmental management and sustainability. The study conducted site suitability analysis for solid waste disposal in each wards of Chanchaga Local Government Area (LGA) of Niger State with a view to recommending most suitable sites for solid waste collection in the study area. The data used for the study was Landsat 8 OLI of 30m spatial resolution, soil map was obtained from Food and Agricultural Organization (FAO), Digital Terrain Model (DTM), Administrative map and the geo-location of the existing solid waste collection points in Chanchaga LGA. The derived factors were reclassified and spatially analysed based on the minimum standard setup by Environmental Protection Agency (EPA), 2006 for high, moderate and least suitable waste collection site. The outcome depicted that about 90% of the solid waste collection site does not meet up with the standard setup by EPA, 2006. Furthermore, the study revealed that most residential buildings were located in a confine radius of less than 50m to most of these collection sites, which is inappropriate and unacceptable. Indiscriminate dumping of waste within residential areas, water body, road network and drainage systems should be discouraged. Provision of waste cans for household and frequent evacuation by the relevant authorities should be encouraged. Finally, based on the EPA 2006 minimum standard, suitable solid waste collection sites were determined and recommended for use in the study area.

Keywords: Solid Waste Collection Site, Environmental Protection Agency, Offensive Odour, Cultural and Social Inclination

https://dx.doi.org/10.4314/etsj.v15i2.11

Introduction

Solid waste is a seriously challenges facing most countries (Abdel-shafy & Mansour, 2018). It is rapidly expanding and has gradual become a major global concern (Allende, 2009). Due to high pace of population expansion, rising per capita income, and significant industrial discharge, the effect of solid waste now seems difficult to handle. Consequently, endangering both human health and impacting negatively to the environment (Javaheri, 2006). The local communities also experience major hit in-terms of the end product due to it indiscriminate waste site locations. Management of landfilled waste dumpsites is acutely important to all communities. The long-term effects could negatively impact everyone's life as well as the environment if they are not appropriately managed (Alam & Ahmade, 2013). According to Jilanin (2006), the most frequent issues which arose as a result of poor solid waste management (SWM) are the spread of infections, fire risks, odour complaints, air and water pollution, aesthetic complaints, and financial losses. The entire generation of waste materials have increased due to growing home and industrial activity, as well as population growth. Therefore, in order to protect lives and benefit from their environment, organizations, communities, and individuals must figure out how to manage these wastes. Waste has a huge economic worth nowadays (Balasubramanian, 2020). Its efficient use has resulted in a cleaner, less polluted environment. It has been able to produce a great deal of resources, including clean and green power, income, jobs, and other forms of development (Holt & Littlewood, 2016). In order for waste materials to have an economic value, there is needs to create awareness on waste management systems among the government, organizations, and individuals in that particular area (Braimah, 2023). However, in order to achieve the said objective, there is also the need to collaborate with the necessary apparatus such as government, agencies and the locals towards achieving the lucrative value and to have a solid understanding of the economic significance of waste (Ella *et al*., 2022).

To determine the most suitable location for a solid waste dump disposal site (SWDs), a comprehensive assessment procedure is required, taking into account social, environmental, economic, and medical aspects (Al-Sabbagh *et al*., 2012; Brunner, 2013). However, in locating solid waste dump site may jeopardize the local ecological and biophysical environment. Hence, environmental considerations are crucial when choosing a location (Su *et al*., 2010). According to Sener and Karaguzel (2010), locations with mildly undulating hills that are not prone to flooding make for the best terrain conditions for the placement of solid waste dumpsites. Vegetable matter, food scraps and leftovers, papers, rags, and copious amounts of dust and soil material from sweeping streets and residential building surrounds are among the many components that make up urban solid wastes (Arlosoroff, 1982;

Leton & Omotosho, 2004). In many areas of the nation's cities and metropolitan hubs, these materials are piled up to form dumps. Using solid waste disposal sites is one way that is frequently employed in Nigeria to address the issue of disposing of waste. By spreading the waste in thin layers, compacting it to the smallest practical volume, and covering it with compacted soil by the end of each working day or more frequently if necessary, a solid waste disposal site is an engineered way to dispose of solid waste on land in a way that protects the environment (Omole *et al.*, 2016). However, because solid waste disposal involves several goals and is very labour-intensive, choosing appropriate locations has traditionally been the most difficult assignment. Taking into account the population's growth of the area, poverty, and diversity of cultures. As a result, waste has been dumped in inappropriate places including borrow dumps, alongside roadways, and on empty lots inside and outside of cities like Minna, the capital of Niger State. Numerous health issues, pollution, and other related issues have been caused by this act throughout the state (Ike *et al.*, 2018).

The locals have located the current trash collection site in the Chanchaga LGA carelessly to meet their waste deposition needs, disregarding the standard specification and its unfavourable repercussions. It is strange to learn that certain Solid Waste collection site (SWCS) locations designated by the government are not in the correct locations. To lessen the spread of diseases among the indigenous people of the LGA, it is crucial to create well-suited SWCS in each ward of the CLGA while taking into account their unique cultural practices. This study aims to integrate geospatial techniques with multi-criteria decision analysis (McDA) to identify the most suitable site location for solid waste disposal across Minna metropolis's wards.

Study Area

The CLGA of Niger State, has an area of 72 km² and a population of 201,429 as at (2006 census). The LGA is located between the latitude of $9^0 31'18''$ to $9^0 34'39''$ N and longitude of $6^0 33'25''$ to $6^0 35'10''$ E of the Greenwich meridian. Figure 1, depicts the study area of the research. The LGA was created in the year 1976, it is located within the basement complex area of the country, which is characterized, by different forms of sedimentary rocks and alluvial deposit (Alabi, 2012). It has a tolerable climate, immense opportunities for socio-economic and agricultural activities. It comprises of eleven wards constituting the LGA. The economy of Chanchaga is based on agriculture, with the main crops being millet, sorghum, rice, and cassava.

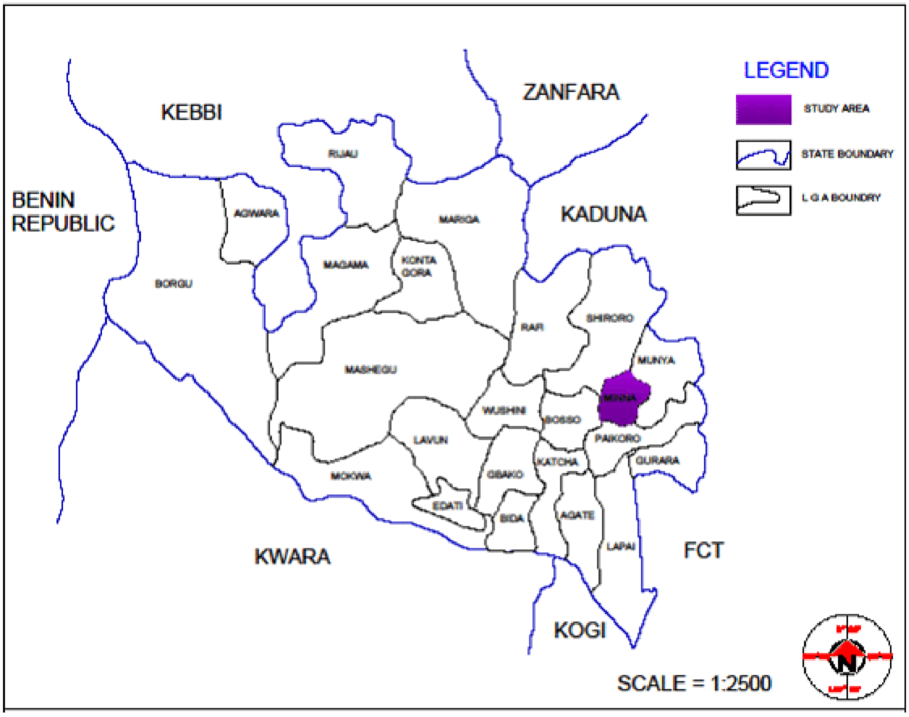

Figure 1: Study Area (Sule *et al.*, 2014)

Materials and Methods

Data acquisition

Table 1, summarized the data characteristic for the research. Field survey data observation were used to gather the primary data for this research. These datasets include the indiscriminate solid waste collecting site across all the wards in the study area.

Table 1: Data Characteristics Used

Data	Resolution	Year	Sources	Relevance
Satellite Image Landsat 8	30m	2022	USGS	To generate land used land cover map
Digital terrain model (ASTERM)	30m	2024		To extract the slope of the research
Geological Map	1:250,000	1965	Nigeria geological survey	To extract the geological map of the study area
Administrative Map	1:1,300.000		OSGOF	To extract the boundary of each LGA and wards
Geometric Data	3m	2024	Field survey	Geo-locate the solid waste dump/collection site
Soil Map	1:500,000	1988	FAO	To delineate the soil type across the LGA/wards

The positions of existing solid waste collection points were collected using the handheld Global Positioning System (GPS) instrument. Satellite Image data was collected via USGS archive covering the study area. Also, Asterm DEM was used to generate the slope of the study area while the Soil map of the study area was extracted from global archive of food and agricultural organization. Figure 2, described the conceptual flow diagram of the research.

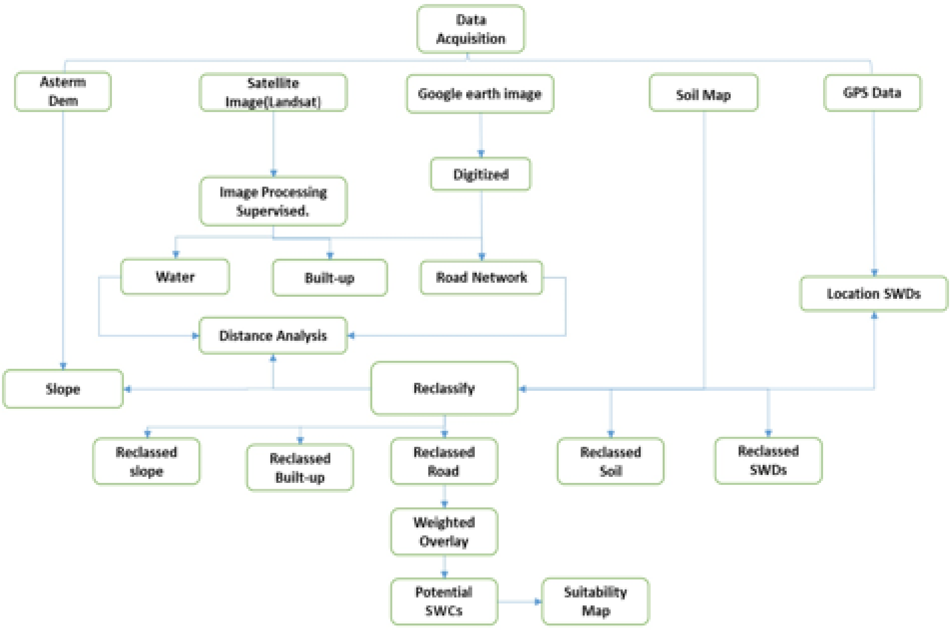

Figure 2: Conceptual Diagram

The satellite image data underwent atmospheric correction aimed at improving the clarity of the image data. Also, it was geometrically corrected to remove the effects of terrain displacement, restore the correct proportions and geometry to objects in the scene. Supervised image classification using maximum likelihood classifier, the selected categories for the land cover land cover was (built-up, waterbodies, vegetation and Bare land surface patches

Identification of potential solid waste collection sites (SWCS) using multi-criteria analysis

To generate suitability map for solid waste collection site of the study area, there is need to evaluate literature on the criteria for location of SW collection site. Tables 2 and 3 show the constraint and suitable criteria for SWC site location by Environmental Protection Agency (EPA) landfilled manual, 2006

Table 2: Constraint Criteria Table

Criteria	Unsuitable
Distance to Water Body	Less than 160m
Slope Areas	Greater the 15^0
Distance to Residential Areas	Less than 100m
Soil Areas	Alluvial soil
Distance to the road	Less than 100m

Table 3: Factor Criteria Table

Criteria	Least suitable	Moderate suitable	High suitable
Distance to water body	160-480m	480-960m	> 960
Slope	$10^0 - 15^0$	$5^0 - 10^0$	$0^0 - 5^0$
Distance to road	2000m	1000m-2000m	100-1000m
Distance to residential area	300-500m	500-800m	> 800
Soil		Alisols	Nilesols

Result and Discussion

In order to facilitate easy understanding, the results are first presented in line with the methodology. Table 4 shows the list of wards that constitute CLGA of Niger State.

Table 4: Wards in Chanchaga Local Government Area

Limawa	Limawa, B	Makera	Minnna central
Minna south	Nasarawa A	Nasarawa B	Nasarawa C
Sabon Gari	Tudun Wada North	Tudun Wada South	

Figure 3 shows the map of CLGA showing the locations of solid waste collection sites found in each ward of the LGA. The geo-location of each waste dumpsite was positioned using handheld GPS instrument, given the point of each SWCs location. The location of the waste dump site reveals that the residence from each of wards did not consider basic criteria before setting up location of waste dumpsite for each ward of the LGA. Though, some of the solid waste site geo-position fulfilled some criteria while others did not. Nasarawa A, B and C wards did not meet up with the minimum criteria of at least 100m to the road. The resident where dumping of waste materials where found few meters to the road, this will pose obstruction and nuisance to the commuters. Oluwagbemiga *et al.* (2022) the proximity of the SW collection site is to create easy access to trucks to enable easy disposition of waste materials.

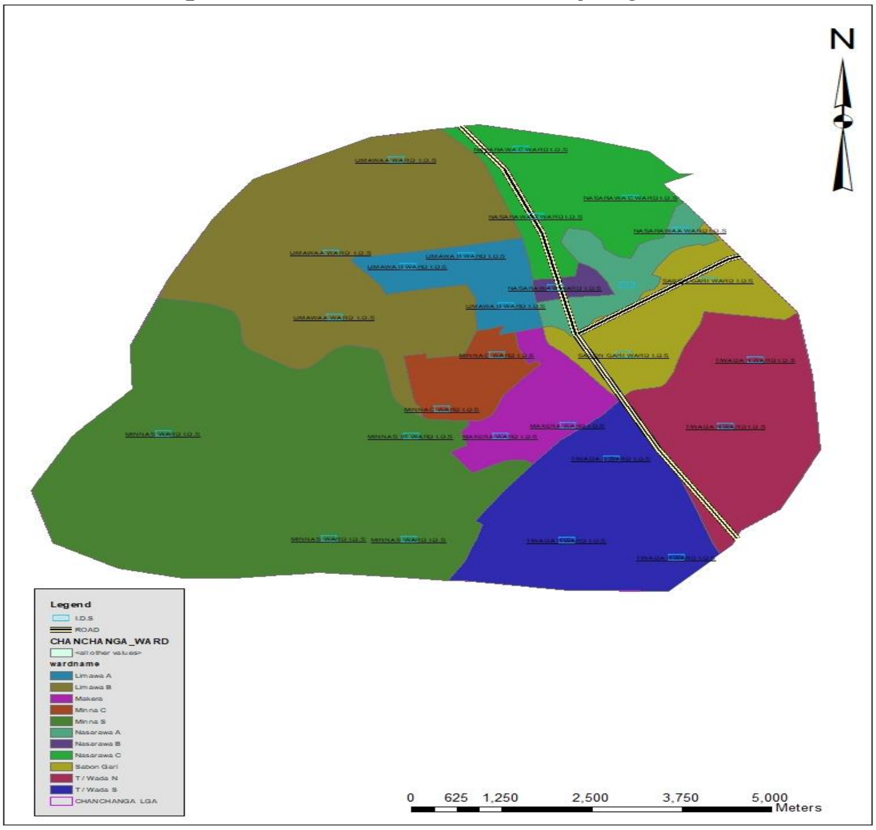

Figure 3: Solid Waste Collection site at CLGA

Table 5 shows the geo-position coordinate of the Solid waste collection site across the various wards of the study area. The table depicts the present geolocation of SWCs across the LGA. However, in order to design the most suitable location of the waste site, there is need to overlay prerequisite conditions from literature. The suitable design of SWCs location in the LGA is a function of the criteria below.

Table 5: Geolocation of Government Dumpsite at Chanchaga LGA

Wards	Easting	Northing
Limawa A Ward	227800.3	1065392
Limawa A Ward	227846.6	1064146
Limawa A Ward	228703.9	1067193
Limawa B Ward	228869.2	1065128
Limawa B Ward	230232	1064374
Limawa B Ward	229681.7	1065337
Minna C Ward	229337.7	1062372
Minna S 01 Ward	228908.3	1061846
Minna S Ward	225474.1	1061898
Minna S Ward	227775.3	1059861
Minna S Ward	228873.7	1059853
Minna C Ward	230099	1063417
Nasarawa A Ward	232664.3	1065834
Nasarawa A Ward	231917.3	1064769
Nasarawa B Ward	230904.3	1064719
T/Wada N Ward	233282.5	1062035
T/Wada N Ward	233694.5	1063325
T/Wada S Ward	232599.8	1059501
T/Wada S Ward	231689.7	1061411
T/Wada S Ward	231070.3	1059838
Makera Ward	231086.1	1062051
Makera Ward	230143.2	1061853
Nasarawa C Ward	230442.4	1067396
Nasarawa C Ward	231959.4	1066456
Nasarawa C Ward	230647	1066105
Sabon Gari Ward	233030	1064856
Sabon Gari Ward I	231871.1	1063422

Factors to be considered before siting solid waste collection site

Proximity to river or water surface

The solid waste dumping zone must not be located close to any surface streams, lakes, rivers or wetlands. 300m buffer placed of river and 200m buffer place of water surface (Surajit *et al.,* 2006). However, considering the peculiarities of the people of CLGA environment, 200m will not be an ideal distance as buffer. This will be as a result of the social inclination level of the community, poverty and cultural system where solid waste are seen as manure even without been processed. According to EPA (2006), distance of 960m radius buffer should be made available in a water log area. This is to reduce the possibility of waste percolation and infiltrating the underground water which happen to be the main source of water in the LGA (Abderrazzak *et al.,* 2021).

Distance from transport route

This is a critical criterion for positioning SWCs, it will pave ways for easy transportation from the temporary dumpsite to the major where it will be deposited for further action. Considering the transport network of CLGA and where the waste sites are geo-located, it has posed reason for the high rate of pollution, pervasive odour causing nuisance to neighbourhood.

Figure 3: Solid waste collection site at Limawa A

However, in designing suitable waste dumpsite, aesthetics of the environment and human health must also be taken into consideration. The waste disposal facility should be at least 300m away from the town's transportation network and on the outskirts of the city.

Distance from urban centres

The standard location distance of the waste dumpsite to residential building should be a function of the size of the facility, characteristics of the waste materials, the pollution procedure to be used and the potential nuisance it could create to the environs (Oluwagbemiga *et al.*, 2022). According to Surajit *et al.* (2016), suggest buffer zone of 200m from the settlement area.

The field survey reveals about six wards (Makera, Limawa B, Nasarawa A, B and Tudun Wada North) in the LGA that failed to meet the distance threshold. This implies that negative impact relating to problems of water quality, aquatic habitat loss, disturbance, or modification will have a significant impact on them (EPA, 2006).

Figure 4: Solid waste dumpsite at Makera and Limawa B

Land use/land cover

This is another important factor to be considered before siting solid waste collection site. Especially in an undeveloped community where solid waste disposal is used as manure directly without been processed. Figure 6 depicts the LULCC and the contour map of the study area.

The land use land cover information provides areas relatively to the land used and land cover data of CLGA. The image classifications categories for the land used types was vegetation, build-up areas, water bodies and bare-land patches. This will initiate safety precaution not to position waste dumpsite in areas designated for residential, water patches or commercial activities on the designed map. The contour map was also developed to define the topographic reality of the area, this will aid in making positive judgement when proposing the waste dumpsite location and also help in providing relevant engineering parameters for its construction.

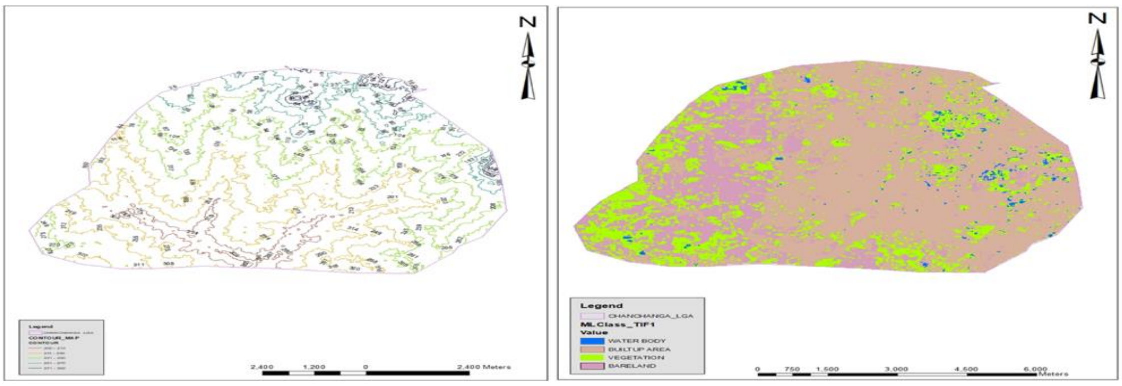

Figure 5: Land Use Land Cover Change and the Contour Map of the Study Area

Slope of the area

Slope of the terrain is another important aspect to be consider when it comes to the design and geo-location of solid waste dumpsites facilities. It is also a critical factor to be consider when it comes to construction cost. Figure 6 depicts the slope pattern of the study area.

Unfortunately, most SWC sites in the LGA were not formally designed rather they were arbitrarily designated by the community neglecting other relevant consideration on terrain configuration and on how the disposal procedure will be carry out talk less of it management system. The digital elevation model of the LGA was used to create the slope layer for this investigation (DEM). Slopes of more than 12° are deemed desirable for sanitary landfills (EPA 2006). The slope map (Figure 6) shows that much of the site have an average slope within < 28°, which is not suitable for the proposed dumpsite. Makera, Tudun Wada, Nasarawa A and B ward has steep slope of about greater than 27° depicting not suitable for siting dumpsite as it will attract more cost to be level. However, the anomaly in terrain undulation can be easily corrected provided the engineering parameters are made available. Extremely steep or mild slopes are not suited for trash disposal, moderate slope is most preferred (Oyinloye & Fasakin, 2013).

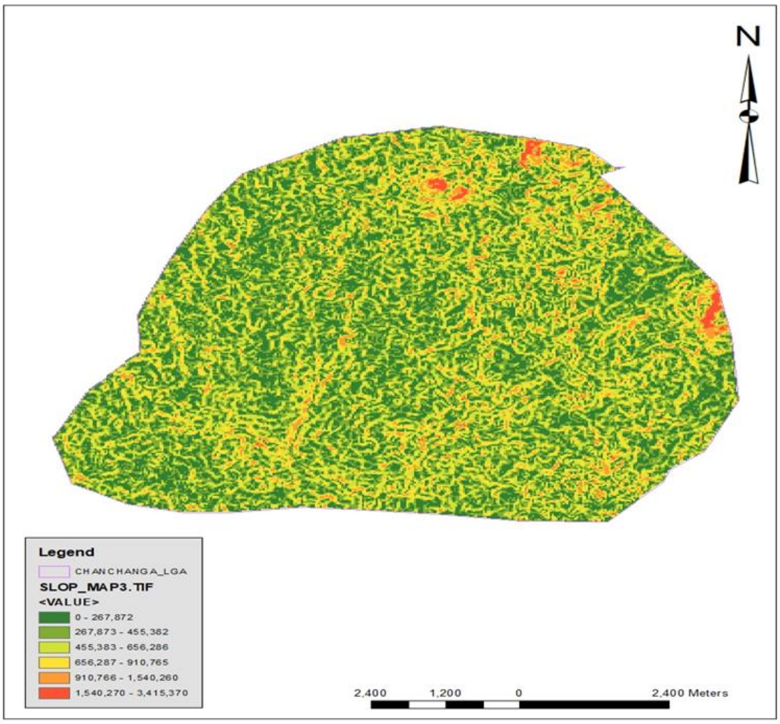

Figure 6: Slope map of the study area

Soil type

Soil characteristics make it easier to build and operate a dumpsite in a safer and more cost-effective manner. The soil type is a function of the compaction strength, bearing capacity and the leaching rate which influenced the choice of SWD site. Other important soil issues include permeability, effective porosity, and workability (Atkinson *et al.,* 1995). Figure 7 shows the soil characteristics of the study area.

As a result, texture analysis allows soils to be classified based on the criteria listed below. Wards in the LGA having Soils with significant silt and clay fractions preserve groundwater and are less cost-effective way to build a dumpsite and by extension, reduces the rate of water percolation into the soil. According to Dorhofer and Siebert (1998), in maintaining groundwater quality levels, Alisol and Nilesols is most preferable. However, clay soil is the least when locating SWCs. hence, if the latter is not accessible, it should be replaced by a geo-synthetic system.

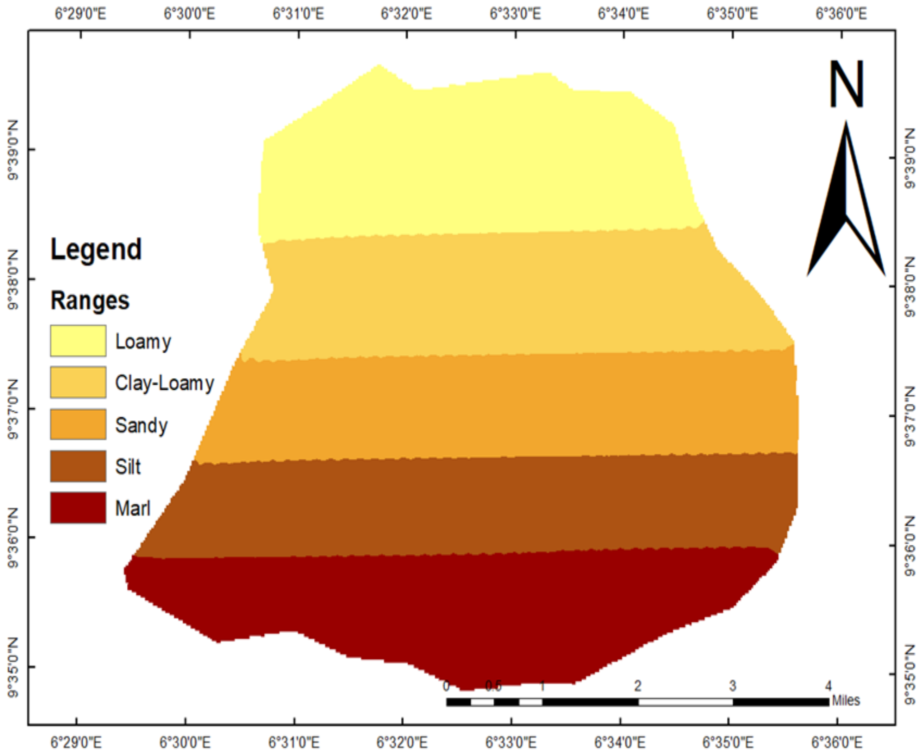

Figure 7: Soil Map of the Study Areas

Wind direction

The direction of wind need to be evaluated especially in areas where congested settlement, residential buildings and other inhabitants structure are built. Wind velocity has the potential to blow around debris and other harmful materials from landfill sites and other waste sites to the nearest structures. Table 6 shows the wind speed of study area. Harmful substances such as volatile organic compounds, particulate matter and carbon monoxide could be release from the decomposed Waste site. All of these pollutants can be transported around by the wind and they also undergo chemical reaction that give rise to even more pollutants, especially when exposed to abundant sunlight and warm temperatures. However, if the wind is monitored, the environmental and social impact of waste management can be minimized greatly.

Table 6: Wind Spend Across CLGA

	YEAR	wind speed(m/s)
1	2013	2.7075
2	2014	2.606666667
3	2015	2.958333333
4	2016	2.67
5	2017	2.469166667
6	2018	2.843333333
7	2019	2.729166667
8	2020	2.797
9	2021	2.556
10	2022	2.587

Suitability map design showing location of solid waste collection points in each ward

The major goal of this research is to best geo-position solid waste dumpsite across the wards of CLGA. The selection process was carefully carried to ensure that the disposal facility is located at the best location possible with little negative impact to the environment and by extension, decrease the level of health-related issues emanated from wrongly placed solid waste dumpsites across the LGA. Using Arc GIS 10.1 software creating different thematic maps layer and overlay analysis were done and identify eleven wards making up CLGA. The selected zone at each ward of the LGA was careful proffered considering the factors explained earlier. Figure 8 and Table 7 show the suitability map zone across the eleven wards and also their geographic coordinates of CLGA of Niger State.

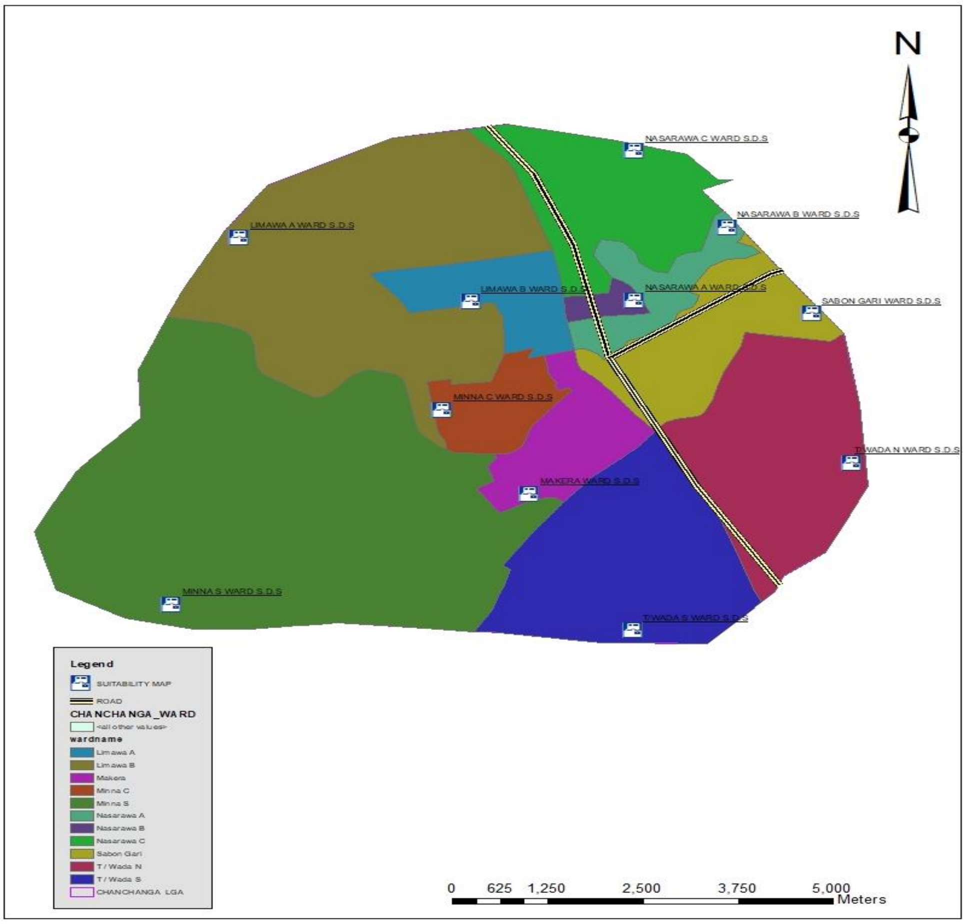

Figure 8: Suitability Map Zone across the Wards of CLGA

Table 7: Geographic Coordinate of the Suitable Solid Waste Dumpsites

Suitability SWDs	Point_X	Point_Y
Limawa A Ward	226343.6	1065908
Minna S Ward	225449.5	1059535
T/Wada N Ward	234384	1061999
T/Wada S Ward	231508.5	1059086
Makera Ward	230156.8	1061458
Minna C Ward	229001.6	1062920
Limawa B Ward	229382.6	1064800
Sabon Gari Ward	233867.9	1064592
Nasarawa B Ward	232749.6	1066091
Nasarawa C Ward	231533.1	1067418
Nasarawa A Ward	231527.2	1064824

Conclusion

This study used the integration of GIS and Remote Sensing in identifying the most suitable sites for the collection solid waste materials in each of the wards of CLGA Niger state, Nigeria. A multi-criteria approach was employed in conjunction with GIS-based overlay analysis to identify the most suitable site for solid waste collection site. The study was based on set of key criteria, which were selected in relation to already available knowledge from research literature as well as the pre-existing local level factors of the area. During the course of the research, it was observed that the community designated location solid waste collection site where not properly position considering the criteria for siting waste collection site. Most communities designate waste dumpsite site relatively to vacant land available and proximity to the dumping site without taking cognizance of the extended effect such as congestion, pollution, pervasive odour of which may result to outbreak of diseases affecting the whole community at the long run

Eleven (11) potential sites designated at the ward level of the LGA were identified as the most suitable sites for solid waste collection after critical evaluation initiated by the criteria. The integration of GIS and Remote Sensing techniques contributed to the achievement of the results obtained. Remote Sensing techniques made it possible to study the various land cover types within the study area whereas GIS aided in the modelling and preparation of needed maps. Indeed, it has been an effective and efficient tool in carrying out this study.

Based on the study, the following measures should be put in place:

i. The authority responsible in the LGAs of the state should strictly adhered to EPA Landfill Manual standards when designating solid waste collection points.
ii. Open solid waste collection sites across the LGAs should be avoided, as they can lead to increase pollution and the spread of debris by wind. Therefore, disposal sites should be properly enclosed or barricaded to prevent the risk of disease outbreaks.
iii. The adoption of sanitary landfills, incineration, or recycling systems should be considered, as these methods can create job opportunities for the large youth population in the LGA. More importantly, they can transform solid waste into valuable resources, generating wealth for the community.
iv. Encroachment has been a common issue at all existing solid waste collection sites across the LGA. Therefore, when designating collection points, an adequate buffer zone should be included in the planning stage.
v. The aesthetic appeal of the state capital is gradually declining. It is crucial that those responsible for sanitation exercise enforcement should bring back the monthly sanitation exercise in the LGA so as to restore and maintain its beauty.

References

Abdel-Shafy, H. I. & Mansour, M. S. (2018). Solid waste issue: Sources, composition, disposal, recycling, and valorization. *Egyptian Journal of Petroleum*, 27(4), 1275-1290.

Abderrazzak, G., Redouane, M., Bellarbi, A. & Khairdar, M. (2021). Use of a Cascade System Based on Marine Sand and Button Ash in the Treatment of Cardboard Manufacturing Wastewater Infiltration Percolation. Doi.10.1088/1402-4896/Ac2659

Al Sabbagh, M. K., Velis, C. A., Wilson, D. C. & Cheeseman, C. R. (2012). Resource management performance in Bahrain: a systematic analysis of municipal waste management, secondary material flows and organizational aspects. *Waste Management & Research*, 30(8), 813-824.

Alabi, A. A (2012). Geology and Environment Impact Assessment and Benefit of Granitic Rock of Minna Area, Northwestern Nigeria. *Ethiopian Journal of Environment Studies and Management.* DOI. 10.4314/ejesm.v4i4.5

Alam, P. & Ahmade, K. (2013). Impact of solid waste on health and the environment. *International Journal of Sustainable Development and Green Economics (IJSDGE)*, 2(1), 165-168.

Arlosoroff, S. (1982). WB/UNDP—Integrated Resource Recovery Project: Recycling of Wastes in Developing Countries. In *Appropriate waste management for developing countries* (pp. 81-94). Boston, MA: Springer US.

Atkinson, S. F., Schoolmaster, F. A., Lyons, D. I., & Coffey, J. M. (1995). A geographic information systems (GIS) approach to sanitary landfill siting procedures: A case study. *Environmental Professional*,17(1), 20–26

Balasubramanian, M. (2020). Economics of solid waste management: A review. *Strategies of Sustainable Solid Waste Management*.

Braimah, S. M., & Mensah, J. T. (2023). Petrochemical Resource Management. In *Sustainability Management in the Oil and Gas Industry* (pp. 256-266). Routledge.

Brunner, P.H. (2013). Cycles, spirals and linear flows. *Waste Management Resources*, 31(10), 1–2

Dörhöfer, G. & Siebert, H. (1998). The search for landfill sites–requirements and implementation in Lower Saxony, Germany. *Environmental Geology*, 35, 55-65.

Ella, D. M. L., Lim, D. M., Lu, B. & Cabauatan, R. (2022). The impact of solid waste management to the economic growth in selected OECD countries and Philippines. *Journal of*

Economics, Finance and Accounting Studies, 4(1), 297-313.

Holt, D. & Littlewood, D. (2017). Waste livelihoods amongst the poor–Through the lens of bricolage. *Business Strategy and the Environment*, 26(2), 253-264.

Ike, C. C., Ezeibe, C. C., Anijiofor, S. C. & Daud, N. N. (2018). Solid waste management in Nigeria: problems, prospects, and policies. *The Journal of Solid Waste Technology and Management*, 44(2), 163-172.

Javaheri, S. (2006). Sleep disorders in systolic heart failure: a prospective study of 100 male patients. The final report. *International Journal of Cardiology*, 106(1), 21-28.

Jilani, S. (2006). Bioremediation and It Application in Waste Management. *International Journal of Biology and Biotechnology*, 3(3)

Leton, T. G. & Omotosho, O. (2004). Landfill operations in the Niger delta region of Nigeria. *Engineering Geology*, 73(1-2), 171-177.

Oluwagbemiga, A. O. & Adebayo, A. E. (2022). Site Suitability Analysis of Solid Waste Disposal in Ilesa, Nigeria. *European Journal of Development Studies*. DOI: http://dx.doi.org/10.24018/

Omole, D. O., Isiorho, S. A. & Ndambuki, J. M. (2016). Waste management practices in Nigeria: Impacts and mitigation. *Geoscience for the Public Good and Global Development: Toward a Sustainable Future*, 377-386.

Oyinloye, M. A. & Fasakin, J. O. (2013) Application of geographical information system (GIS) for Siting and management of solid waste disposal in Akure, Nigeria. *IOSR J Environ Sci Toxicology Food Technology*, 4(2), 6–17

Şener, S. & Karagüzel, R. (2010). Solid waste disposal site selection with GIS and AHP methodology: a case study in Senirkent– Uluborlu (Isparta) Basin, Turkey. *Environmental Monitoring Assess*, 173(1-4), 533-554.

Su, J. P., Hung, M. L., Chao, C. W. & Ma, H. W. (2010). Applying multi-criteria decision-making to improve the waste reduction policy in Taiwan. *Waste Management & Research*, 28(1), 20-28.

Sule, O. J., Aliyu, A. Y. & Umar, S. M. (2014). Application of GIS in Solid Waste Management in Changchaga Local Government Area of Niger State, Nigeria. DOI. 10.9790/2402-08921722

Surajit, B., Ahmad, M. & Kuma, K (2016). Suitable Site Selection for Urban Solid Waste Management using GIS Technique- a Case Study of Dhanbad Block. *International Research Journal of Engineering and Technology (IRJET)*