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ASSESSMENT OF LANDFILL SITE SUITABILITY IN IJEBU-ODE LOCAL GOVERNMENT AREA, USING GEOSPATIAL TECHNIQUES

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Abstract:

Landfills have been regarded as an effective waste disposal method. This study aims at determining the most suitable sites for siting landfills in Ijebu Ode Local Government Area of Ogun State. The spatial distribution of current open dumpsites were determined. Five factors of landfill suitability selection used in this study are: soil, distance from road networks, slope, elevation, geology, and land use/land cover. This study uses a combination of Weighted Linear Combination (WLC) and GIS technology to produce maps of each of the landfill suitability selection factors. By combining the criteria weights produced by the suitability modeller technique, the suitability of the existing landfills were determined and the best location for landfill sites were identified. According to the survey, 13.36% of the region is classified as unsuitable, 4.81% as fairly suitable, 30.64% as moderately suitable, and only 0.1% as highly suitable.

Key Words - Geospatial Information, Landfills, Ijebu ode, Suitability modeller Technique, Weighted Linear Combination (WLC)

1.0 INTRODUCTION

Waste is any unused or unwanted item or material desired to be disposed of. Any substance or material may become unwanted as a result of breakage, contamination, worn out or spoilt and as such is considered to have lost its purpose or usefulness [3]. As the world population increases and more cities are emerging, solid waste has become an environmental problem globally. Solid waste includes all waste materials generated from human and animal activities that are generally in solid form and which are removed as being useless or unwanted. It also includes substances derived from the production processes or those that must be thrown away according to the law [15]. The management of Municipal Solid Waste (MSW) is a critical issue faced by urban areas worldwide due to rapid population growth and urbanization [22]. The major way to dispose of MSW is by landfills, thus choosing a location carefully is important to reduce any negative effects on the environment and public health. Previously, the selection of landfills was based on oversimplified factors such the sites' proximity to transportation hubs and population centers [9]. These methods, however, frequently resulted in less-than-ideal site selections and had detrimental effects on the ecosystems and communities nearby.

The assessment of landfill site suitability has been transformed by advances in geospatial technology [5]. Nonetheless, these approaches often resulted in choices of sites which are less suitable and as such, may bring adverse effect on the surrounding environment and social setting. With the introduction of new geospatial technologies such as the Geographic Information Systems (GIS) and Remote Sensing (RS), this has brought tremendous changes in the assessment of landfill site suitability [5]. Such methods involve the integration of several spatial variables, which include land use and topography, hydrology, and environmental constraints, therefore influencing better decisions in the choice of appropriate locations.

Several scholars have demonstrated that geospatial approaches for selecting landfill sites are productive. Li et al., [8], for example, used a GIS-based multi-criteria evaluation to find appropriate landfill sites in rural locations, taking into account variables including slope, proximity to water bodies, and distance to roads. Similarly, Rezapour et al., [19] evaluated the feasibility of a landfill site in a dry location by taking socioeconomic restrictions and environmental considerations into account. Hazardous waste management is a common problem in urban areas such as Ijebu Ode where waste is disposed of in open dumps. Such an approach to waste management has adverse effects on the environment such as soil erosion, air and water contamination, and verminous proliferation as well as diseases. Apart from degrading the environment, open dumpsites have negative effects on health of those who reside in the vicinity of a dumpsite. Based on the foregoing, it is possible to highlight possible threats posed by open dumping to health. Siting of the existing dumpsites in Ijebu Ode are not based on any known any suitability selection criteria [21]. More effective methods of waste disposal are urgently needed in Ijebu Ode to address the threat posed to the environment by open dumpsites. The aim of the present research is to determine the suitability of existing landfill sites and determine an optimally-sited landfill location using a combination of Weighted Linear Combination (WLC) and GIS technology.

2.0 STUDY AREA

Ijebu-Ode is a major town in Ogun State with a distance of about 110km in the north eastern part of Lagos. It is bounded by latitude 6^0 49′ and 6^0 52′ in the northern hemisphere as well as longitude 3^0 52′ and 3^0 57′ in the eastern hemisphere. The area extent of Ijebu Ode is about 190.5 km^2 [17] and a population of 157,161 based on 2006 national population census. The Ijebu Ode people are known for trading among people of the South-western Nigeria although a good number of Ijebu people also engage in farming. The map of Ijebu Ode local is as presented in Figure 1.

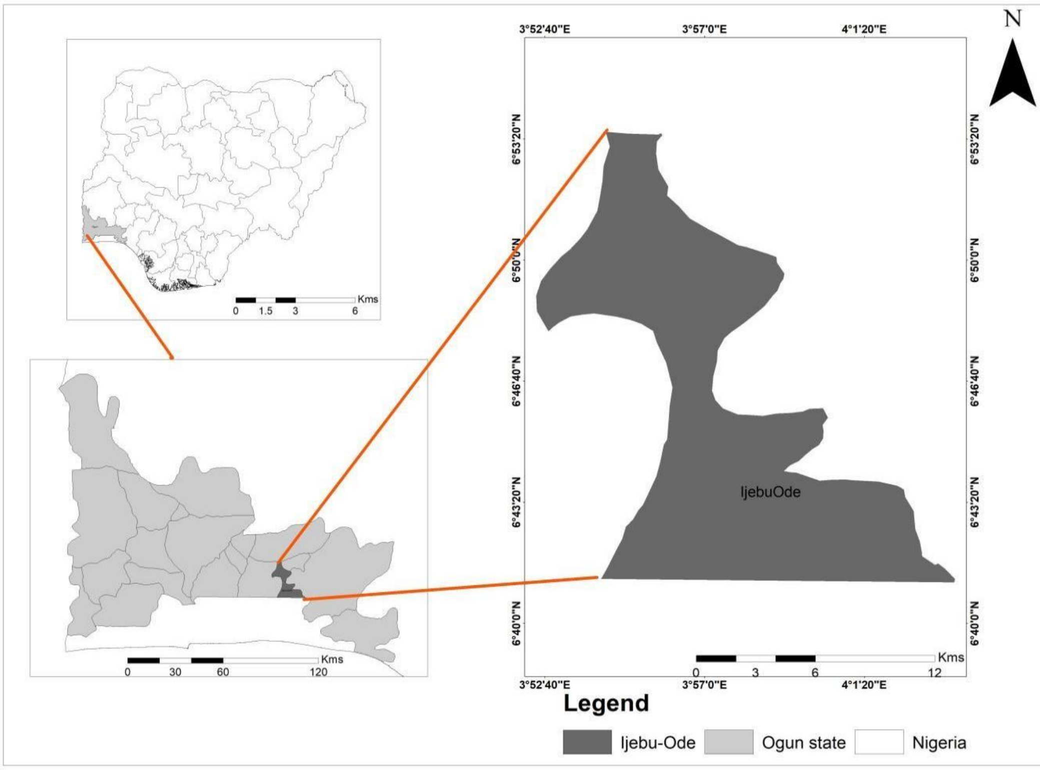

Figure 1: Map showing the study area (Source: Authors'' compilation)

3.0 MATERIALS AND METHODS

The administrative map of the study area was obtained from the bureau of lands and Survey in Ogun State. Landfill site selection data are classified into two: environmental and socioeconomic factors. The only socioeconomic factor considered in this study is transportation routes. Other factors of landfill which are: geological structures, soil, Land use and land cover (LULC) and slope and elevation belong to the environmental class. This classification are as presented in Figure 2. The coordinate of the existing landfill were acquired with the use of hand held GPS. Table 1 shows the data acquired for the study and their sources. Landfill criteria were classified into two categories which are constraint and factor criteria. The constraint criteria account for areas unsuitable for landfill while the factor criteria account for areas suitable for landfill siting. The flowchart used for the execution of this study is displayed in Figure 3.GIS buffering was employed to eliminate regions which did not conform to the set parameters. All the constraint criterion maps were used to create the last area factor map. The location of existing coordinate obtained through handheld GPS observation is as presented in Figure 4.

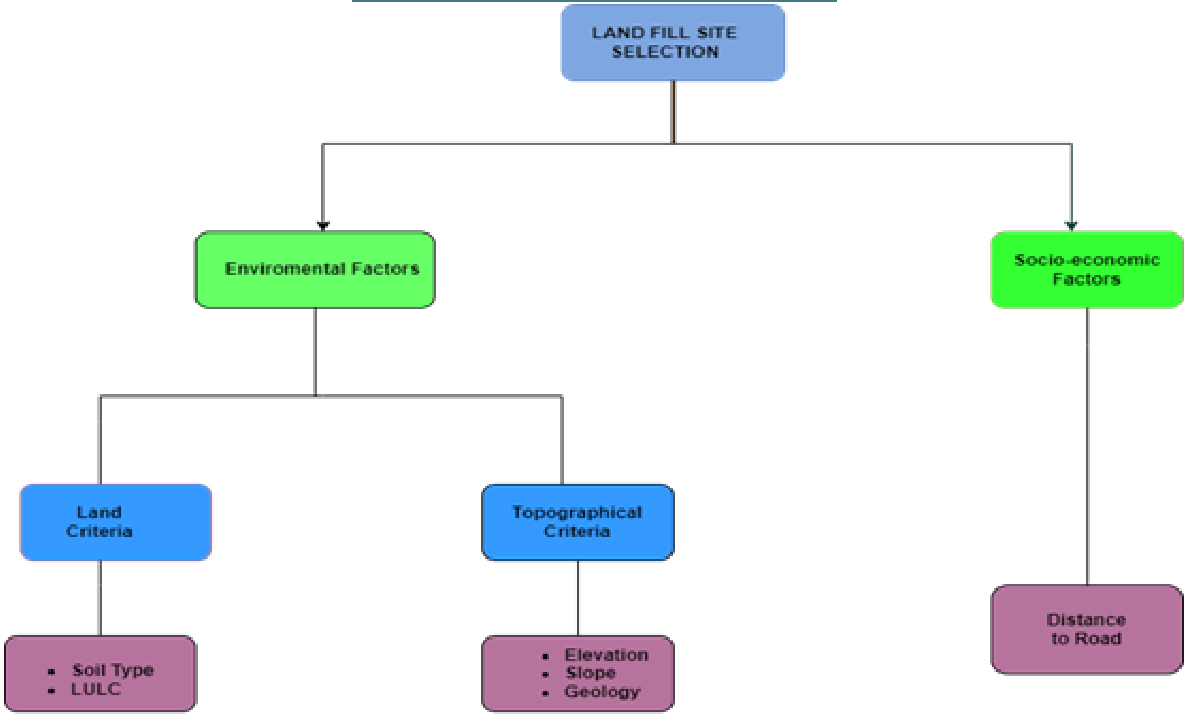

Figure 2: Decision process hierarchical scheme for landfill suitability selection

Table 1: Geospatial data used in this Study

Factor	Description	Format	Source
Transport Network	All classes of road network	Vector data	ArcGIS open street map
Geological Structures	Rocks and rock surfaces	Vector data	Bureau of lands and survey Ogun state
Soil	Earth materials on the outermost part of the earth	Vector data	FAO
LULC	Land utilized by human and natural cover	Vector data	Esri Sentinel-2 Land, Cover Explorer
Slope and Elevation	Relief of a particular area	Raster data	Shuttle Radar Topography Mission (SRTM)
Administrative map	To extract the boundary of the LGAs that made up the study area.	Vector data	Bureau of lands and survey Ogun state
GPS coordinates	Geometric data of locations in rectangular coordinate	Rectangular coordinates	Field survey

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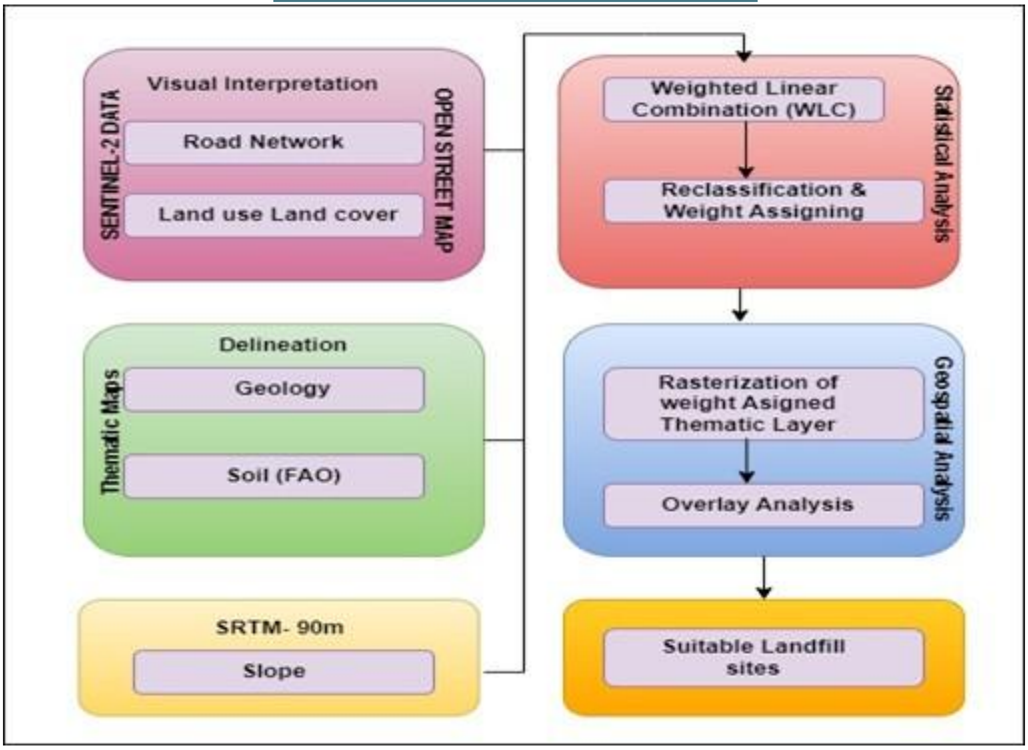

Figure 3: Flow chart illustrating technical process incorporated in this Study

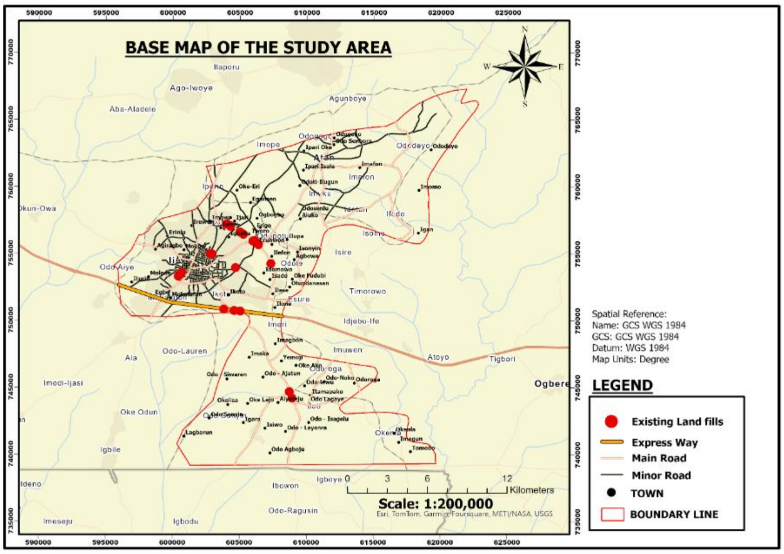

Figure 4: Base map showing existing landfills around the study Area

(source: Bureau of Lands and survey, Ogun-state)

4.0 RESULTS AND DISCUSSION

This section analyzes the influence of each criterion on the determination of a fitting landfill site and discusses the results of the geoprocessing operations carried out on each criterion. The outputs are in different spatial forms with the results illustrating areas considered appropriate or not according to each suited selected criterion.

4.1 Slope Map

Most of the study area falls under the slope class of 2-10º. According to Olanibi and Emmanuel, [16], areas where the slope is less than 10 degrees are preferred for this kind of activities. Slope map of the study area is presented in Figure 5.

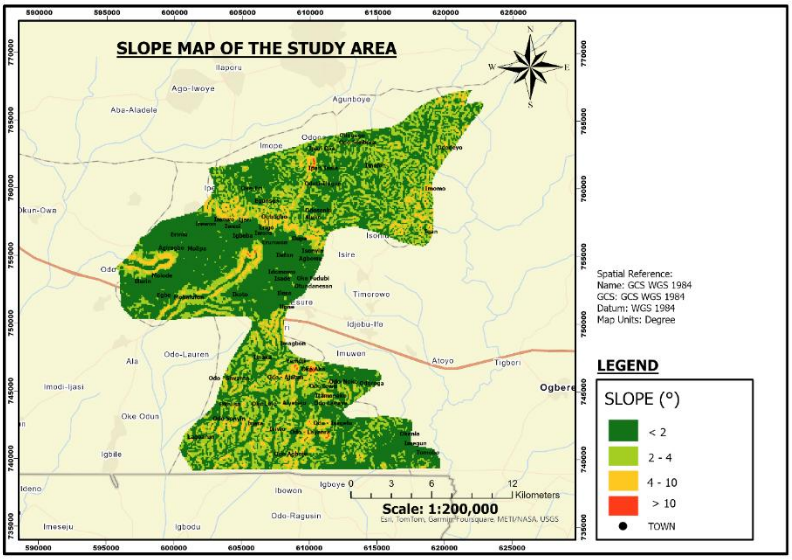

Figure 5: Map showing the slope of the area

4.2 Elevation Map

The elevation of the ground is a crucial consideration when choosing landfill locations. Low-lying areas with level terrain are good sites for landfills [7]. Elevation map of the study area is presented in Figure 6.

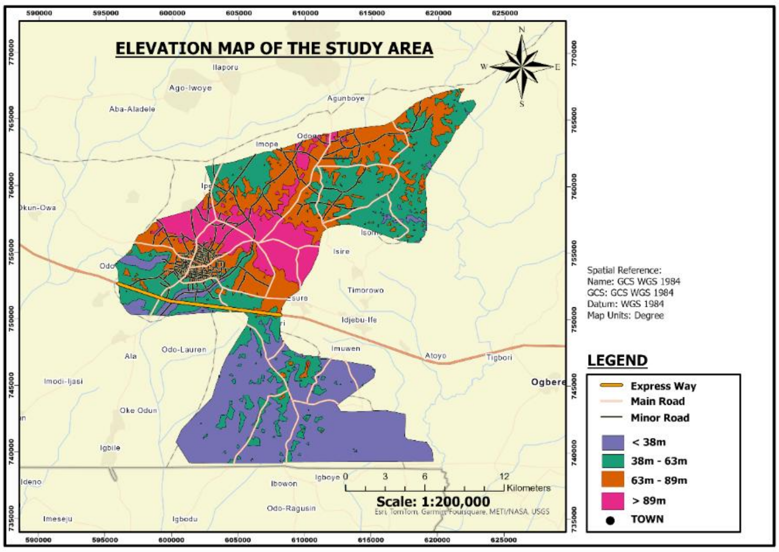

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Figure 6: Map showing the elevation of the area

4.3 Soil Map

The soil map of the Study area was obtained from the world soil map of the Food and Agriculture Organization (FAO). The map of the soil shows the three soil texture sandy clay loam, sandy loam and red loam. The soil map of the study area is in Figure 7.

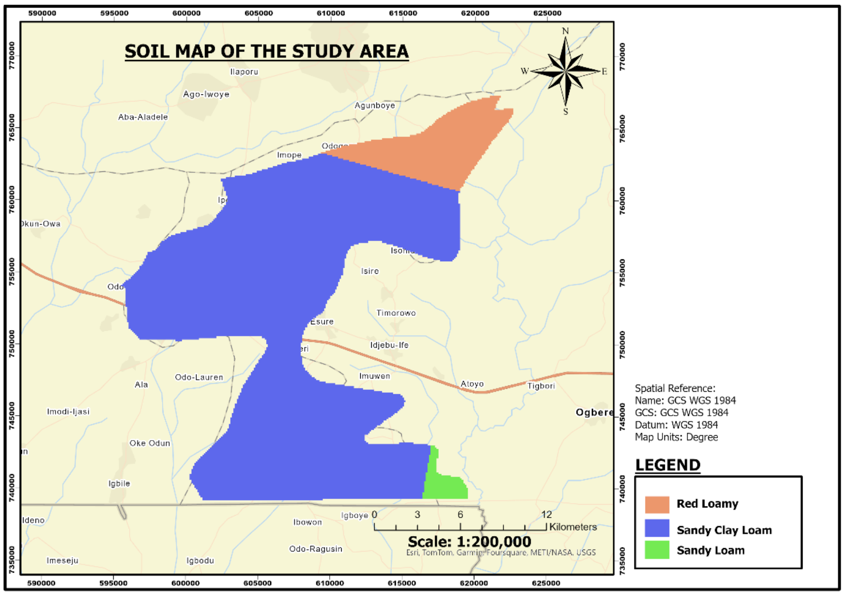

Figure 7: Map showing the soil type of the area

4.4 Geology Map

The geology of the Study area constitutes Cretaceous Sediments and Tertiary Recent Sediments. Figure 8 below shows the geology map of the study area.

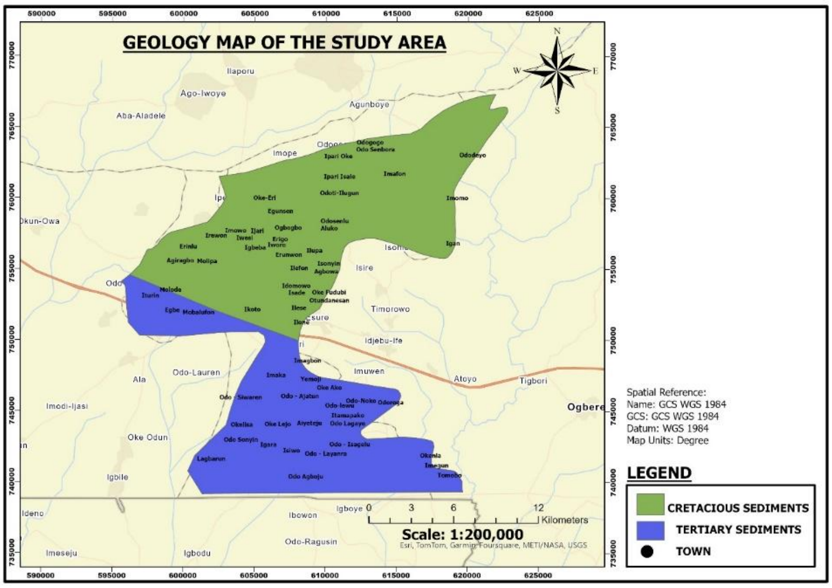

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Figure 8: Map showing the Geology map of the area

4.5 Land Use / Land Cover

The majority of the Study area is occupied by agriculture activity. Based on Land use land cover suitability, out of total study area 4.18% is highly suitable and 68.44% least suitable for landfill sites, whereas the remaining 27.38% of the Study area are not suitable for landfill sites. LULC map is presented in Figure 9.

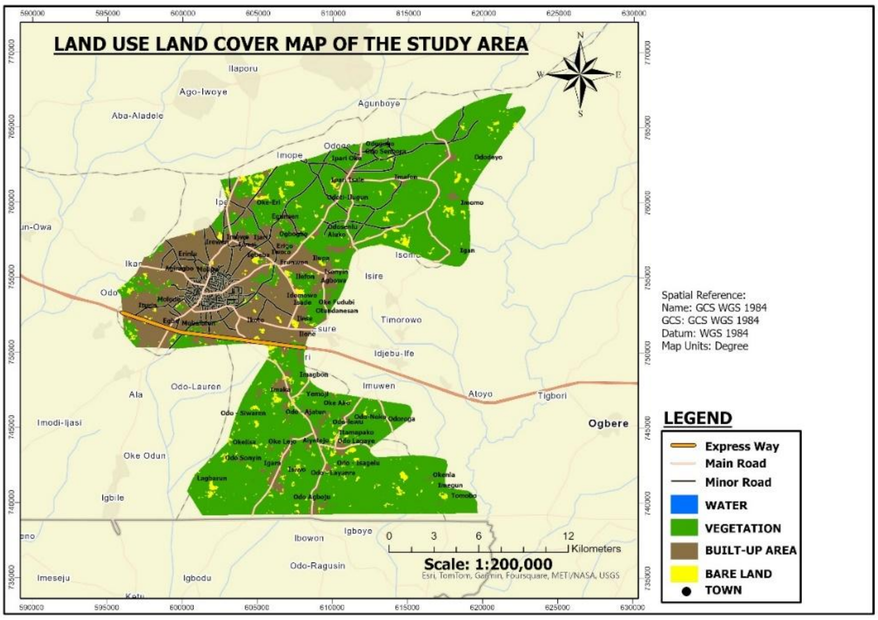

Figure 9: Land use land cover map of the study area

4.6 Road Network Map

In situating a landfill site, we do not have an explicit limitation but many investigations have indicated that the landfill site preferable places a distance of 1 km from the roads [2]. The road inventory of the study area was collected from the sentinel 2 data as well as the administrative map provided by the bureau of Lands and Survey, Ogun state before being exported into the GIS as a vector. GIS spatial analysis was also used to generate a buffer around the road network. Based on the recommendation of Al-Hanbali et al., [2], any distance range greater than 500 meters shall attain a weight 2. Another weight of 2 was assigned to distances of lesser than a length of 500 meters and greater than 350 meters. Road network map of the study area is in Figure 10.

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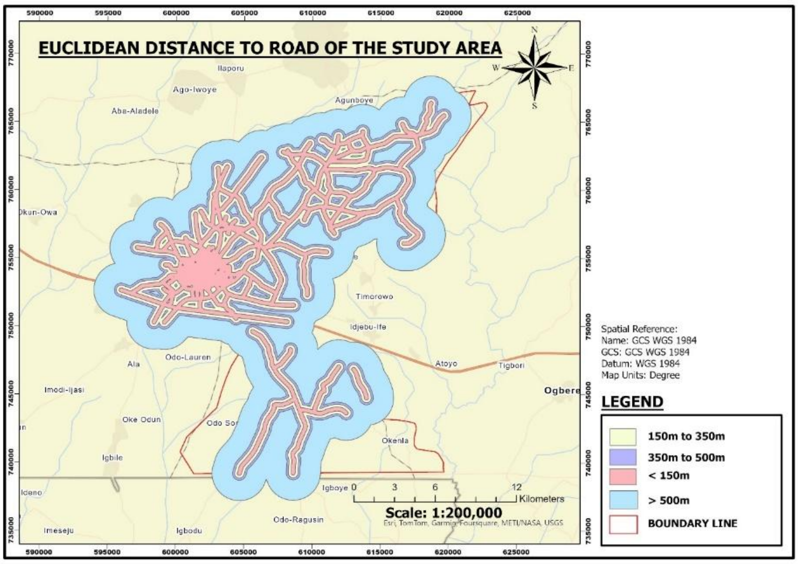

Figure 10: Reclassified Euclidean distance of the road network

4.7 The WLC and GIS Procedure

All geographic information system packages are equipped with basic functionality necessary for assessment of Multi-Criteria Decision Analysis (MCDA) models. The greatest difficulties arise in applying standardization approaches to criterion score and assessing the proper weights. The Weighted Linear Combination (WLC) model is one of the most popular decision support system techniques based on GIS [2]; [4]; [11]. This technique is often used for land use/suitability assessment, site optimization, and resource allocation tasks. Several GIS steps performed include: Buffer, Clip, Extract, Overlay, Proximity, Convert, and Reclassify, and Map Algebra to come up with the final criteria needed for this study. Each of the criterion was reclassified and ranked according to specified scheme and final composite map was prepared using WLC method [2]; [4]; [6]; [11]. The weights and scores were assigned based on the recommendations by Al-Hanbali et al., [2]; Moeinaddini et al., [12] and Saeed et al., [20].

4.7.1 Establishing the Theme Weights and Criteria Score

The weighted linear combination comparison analysis used in this study was developed based on equation (1). By this methodology, all factors are cumulated, with the addition of weights to each of them, and finally the overall sum gives a specific output suitability map i.e.:

$$S = w_i \times x_i \qquad \text{(i)}$$

where S means the suitability, ***wi*** is the weighting of the factor i, in other words, the importance of this factor and *xi* is a criterion score of a factor ***i***. After the valuation was fixed, Multi-Criteria Decision Analysis (MCDA), which is a module for the evaluation of factors and constraints - was applied through the use of a weighted linear combination to achieve this end. The scores of each objective are assigned within geographical space in a manner that the stipulated criteria are observed.

Table 5. Score, Weight and map rating of each of criteria used for land fill site suitability [14].

Theme	Criteria	Suitability	Score	Weight	Map rating of each criteria
Transport Network	< 150 m	Not Suitable	2	2	4
	150-350 m	Not Suitable	6		12
	350-500 m	Not Suitable	8		16
	>500 m	Highly Suitable	4		8
Geological Structure	Cretaceous Sediments	Moderate Suitable	6	1.5	9
	Tertiary recent Sediments	Not Suitable	2		3
Soil	Sandy Clay Loam	Highly Suitable	8	1.5	12
	Red Loamy	Least Suitable	6		9
	Sandy loam	Moderate Suitable	4		6
LULC	Vegetation	Least Suitable	4	2	8
	Built Up	Not Suitable	2		4
	Bare Land	Highly Suitable	8		6
	Water Body	Not Suitable	2		4
Elevation	< 38m	Not suitable	2	2	4
	38m – 63m	Least suitable	4		8
	63m – 69m	Moderately suitable	6		2
	>69m	Highly suitable	8		6
Slope	0-2°	Highly Suitable	8	1	8
	2-4°	Moderate Suitable	6		6
	4-10°	Least Suitable	4		4
	>10°	Not Suitable	2		2

4.8 Suitability Assessment

Presently, the existing dumpsites are not compliant with the required standards of environmental protection. A number of soil criteria determining the landfill site evaluation have been created to varying extents and weighted appropriately. It was found that variation exists among the criteria in terms of their impact on the site selection process. For this aim, seven of the most important criteria were selected. To weight each criterion fairly, multi-criteria decision analysis (MCDA) techniques were applied in the suitable modeller of ArcGIS. To complete the rank projection along with topology creation elevation transportation networks lithology soil land use/land cover LULC and slope were used and all factors were converted to individual rasters with given weights and scores assigned to each. The rasters for each layer were prepared, with different scores, and aggregate over the layers in the site suitability analysis using the raster calculator tool in the GIS package, and the resulting scores combined. The resulting scores were then classified again into 4 categories to come up with a landfill suitability map as shown in Figure 12. In this study, areas suitable for landfill sites were identified. The site suitability analysis revealed that 13.36% of the area was found to be unsuitable for landfill siting, 54.8% was classified as least suitable, and 30% as moderately suitable. Only 1.19% of the area was determined to be most suitable.

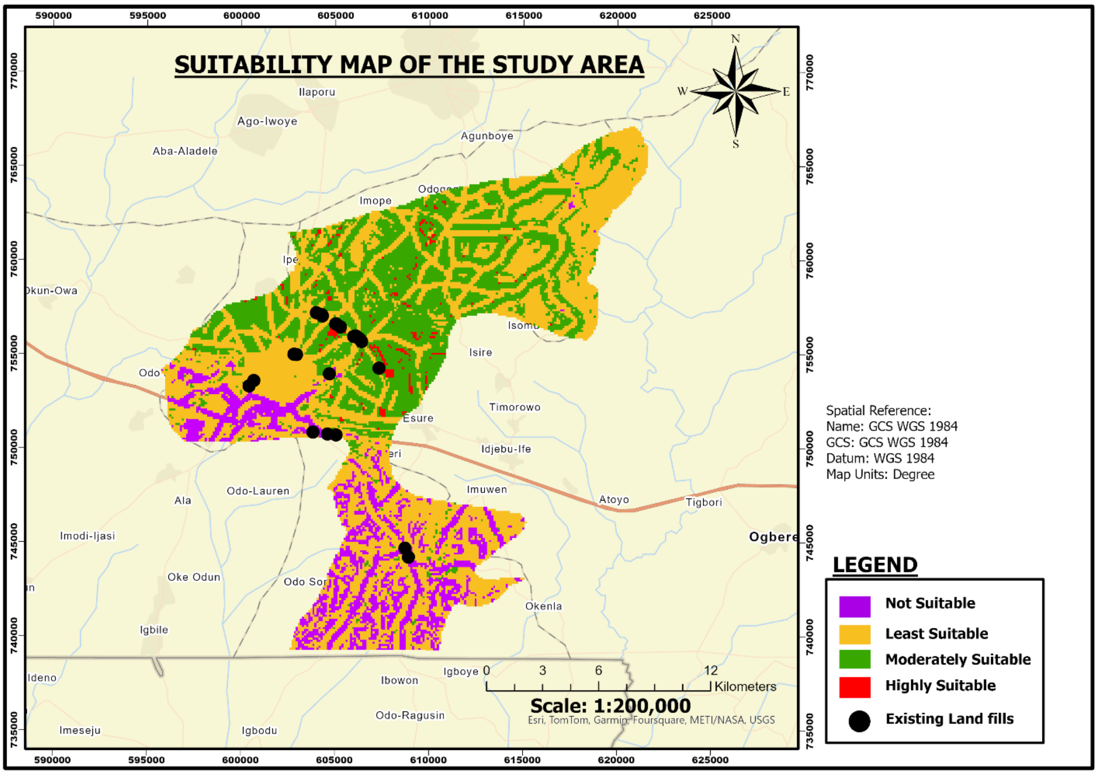

Figure 12: **Suitability Map for Landfill Site Selection**

Based on Figure 12, most of the existing dumpsites are in close proximity to urban areas, creating a risk to the health of the residents in the vicinity. The selected locations have adequate area to provide for the projected accumulation of solid waste over time. Nevertheless, the current landfill sites are inadequately designed and operated contrary to the environmental and scientific standards which adversely affect the health of the people. In the process of choosing a landfill site, it is important to consider the validity of the various techniques used to determine the best possible site.

4.9 Discussions

Geospatial technology is well suited for site selection studies due to its capacity to handle and evaluate highly diverse spatial data which are in excess in the environment [1]; [10]. All the studies which discussed the site selection and evaluation of landfills or other waste disposal facilities as the case studies were deterministic in nature with the majority of the articles concerning MCDA and GIS overlay studies [2]; [13]; [20]. The assessment models used for the landfill site selection proved to be successful in this study as well [18]. Various parameter ancillary data were collected and after some descriptive analysis, studies were then placed under six different categories in a GIS environment. The multicriteria decision analysis was then used to rank the importance of those criteria and land suitability was determined using the weighted linear combination WLC method. All of the study area maps, along with other documents such as the topographical maps, were projected in WGS84. Also, in the GIS environment, suitablity analysis was done by Multi-Criteria Decision Analysis (MCDA) and six positive landfill site windows were obtained for overlay analysis.

4.0 CONCLUSIONS

According to the research, geospatial perspective combined Weighted Linear Combination (WLC) is effective for landfill sites selection. It allows an assessment of several criteria in a systematic manner and generates a suitability map to assist in locating appropriate sites for landfills. Even with some limitations, for instance, the unavailability of some data or the challenge of weight assignment, this technique extends a framework for making reasonable and ecological choices.

REFERENCES

[1]. Alkaradaghi, K., Ali, S. S., Al-Ansari, N., Laue, J., & Chabuk, A. (2019). Landfill site selection using MCDM methods and GIS in the Sulaimaniyah Governorate, Iraq. *Sustainability*, *11*(17), 4530.

[2]. Al-Hanbali, A., Alsaaideh, B., & Kondoh, A. (2011). Using GIS-based weighted linear combination analysis and remote sensing techniques to select optimum solid waste disposal sites within Mafraq City, Jordan. *Journal of Geographic Information System,* *3*(4), 267-278. https://doi.org/10.4236/jgis.2011.34023

[3]. Anifowose, Y. B., Omole, K. E., & Akingbade, O. O. (2012). Waste disposal site selection using remote sensing and GIS: a study of akure and its environs, Southwest-Nigeria. *COLERM Proceedings*, *2*, 526-533.

[4]. Eastman, J. R., Kyem, P. A. K., Toledano, J., & Jin, W. (1993). *GIS and decision making*. Geneva, UNITAR.

[5]. Hassan, Q. K., Ali, A., & Ali, M. (2018). A GIS-based approach for landfill site selection: A case study in Gujranwala district, Pakistan. *Environmental Earth Sciences, 77*(8), 318.

[6]. Hopkins, L. (1977). Methods for generating land suitability maps: A comparative evaluation. *Journal of the American Institute of Planners, 34*(1), 19-29.

[7]. Kharat, M. G., Kamble, S. J., Raut, R. D., & Kamble, S. S. (2016). Identification and evaluation of landfill site selection criteria using a hybrid fuzzy Delphi fuzzy AHP DEMATEL based approach. *Modeling Earth Systems and Environment, 2*(98), 1-13.

[8]. Li, X., Zhou, Y., Wang, W., & Zhang, J. (2016). GIS-based multi-criteria evaluation for landfill site selection: A case study in a rural area of China. *Environmental Earth Sciences*, 75(4), 289. https://doi.org/10.1007/s12665-016-5223-0

[9]. Mahmood, A., Ahmad, S., Ahmad, F., & Batool, N. (2018). Landfill site selection using multi-criteria evaluation and GIS suitability analysis in Kohat District, Pakistan. *Journal of Geographic Information System, 10*(5), 611.

[10]. Malczewski, J. (1996). A GIS-based approach to multiple criteria group decision making. *International Journal of Geographical Information Systems, 10*(8), 955-971.

[11]. Malczewski, J. (1999). *GIS and multicriteria decision analysis*. New York: John Wiley & Sons.

[12]. Moeinaddini, M., & Khorasani, N. (2018). A GIS-based approach for landfill site selection using fuzzy AHP: A case study in Iran. *Environmental Earth Sciences, 77*(3), 1-17.

[13]. Moeinaddini, M., Khorasani, N., Danehkar, A., Darvishsefat, A., & Zienalyan, M. (2010). Siting MSW landfill using weighted linear combination and analytical hierarchy process (AHP) methodology in GIS environment: Case study in Karaj, Iran. *Waste Management, 30*(2), 912-920. https://doi.org/10.1016/j.wasman.2010.01.015

[14]. Multaniya, A. P., Verma, S., & Beg, M. K. (2021). Assessment of suitable landfill site using geospatial techniques: a case study of Raipur Urban Region, Chhattisgarh, India. *Int J Res-Granthaalayah, 9*(3), 132-148.

[15]. Okecha, S. A. (2000). *Pollution and conservation of Nigeria's environment*. T'Afrique International Associates (WA).

[16]. Olanibi O. A & Emmanuel A. A., (2022). Site Suitability Analysis of Solid Waste Disposal in Ilesa, Nigeria. *European Journal of Development Studies, 2*(2), 49 – 59. DOI:10.24018/ejdevelop.2022.2.2.60

[17]. Olayiwola A. M. & Salau W. O., (2022). Evaluation of Land Cover Dynamics and Landscape Fragmentation in Ijebu Ode, Nigeria. *Journal of Geoinformatics and Environmental Research, 3*(2), 34 –45. doi: 10.38094/jgier30249

[18]. Poorna, C. A., & Vinod, P. G. (2016). Solid waste disposal site selection by data analysis using GIS and Remote sensing tools: A case study in Thiruvananthapuram corporation area. International Journal of Geomatics and geosciences, 6(4), 1734-1747.

[19]. Rezapour, S., Valizadeh Kamran, K., & Kaboudvandpour, S. (2019). A GIS-based approach for landfill site selection in an arid region, central Iran. *Modeling Earth Systems and Environment, 5*(1), 77-89.

[20]. Saeed, M. O., Hassan, M. N., & Mujeebu, M. A. (2009). Assessment of municipal solid waste generation and recyclable materials potential in Kuala Lumpur, Malaysia. *Waste management*, *29*(7), 2209-2213.

[21]. Solaja O. M., Omodehin A. O. & Badejo B. A., (2017). Socio-ecologies of solid waste in Ijebu-Ode, Ogun State, Nigeria. *Recycling and Sustainable Development 10*, 1-8. doi: 10.5937/ror1701001S

[22]. Wilson, D. C., Rodic, L., Modak, P., Soos, R., Carpintero, A., Velis, C., & Simmons, G. (2015). *Global waste management outlook*. UNEP.