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Suitability analysis of solid waste dumpsites in Igabi LGA, Kaduna State

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ABSTRACT

Efficient management of solid waste is one problem that environmentalists, health workers, and city planners face in Nigeria. This problem caused by the generation of over 80 million kilograms of solid waste per day requires adequate and modern facilities to guarantee a healthy environment. So far, there is no efficient system to manage the existing refuse dump in Igabi LGA. Residents in the area are attacked by disease and unhealthy conditions. Large quantities of waste materials are being disposed of and burnt without collection thereby creating pollution and environmental uncertainties. That is why this study seeks to evaluate the suitability of the study location for the sitting of a landfill in the area. From the analysis carried out in this project, it shows that a total area of 95.3015km^2 is unsuitable, 39.4806km^2 is least suitable, 9.7741km^2 is moderately suitable and 1.6364km^2 is highly suitable. All the dumpsites identified within the study area fall under unsuitable areas. Therefore, it is recommended that they should be moved to highly suitable places.

1. Introduction

The rapid growth of population increases the non-renewable resources and disposal of effluent and toxic waste indiscriminately, are the major environmental issues posing threats to the existence of humans (Allen, 1997). The most common problems associated with improper management of solid waste include diseases transmission, fire hazards, odor nuisance, atmospheric and water pollution, aesthetic nuisance, and economic losses (Jilani, 2012).

There has been a significant increase in solid waste generation in Kaduna over the years from 100gm per person per day in small towns to 500grams per person per day in large towns. Presently most of the municipal solid waste in Kaduna is being disposed of unscientifically (KEPA, 2019).

Generally, municipal solid waste is collected and deposited in a sanitary landfill, such unscientific disposal attracts birds, rodents, and fleas to the waste dumping site and creates unhygienic conditions. The degradation of the solid waste results in the emission of carbon dioxide (CO2), methane (CH4), and other trace gases. The unscientific landfill may reduce the quality of the drinking water and causes disease like jaundice, nausea, asthma (Busu, 2010)

The present study intends to find out a suitable site for the disposal of solid waste generated from Igabi LGA municipality and surrounding areas with the help of GIS techniques.

2. Method

The methods used in this work are shown in Figure 1. Each of these criteria is generated as a layer in the GIS Environment (ArcGIS 10.4.1) using a number of data acquired from different sources. The information compiled from the literature (EPA, 2006) about the safe distance to a dump site was used to determine the buffer zones and varying degrees of suitability within each layer.

3. Results

3.1 Mapping of existing solid waste dumpsites

To achieve the first objective of this project, coordinates of the existing dumpsites were collected using hand-held Garmin GPS. The obtained coordinates were used to create a geodatabase for solid waste dumpsites in the study area. The Study area base map was digitized from the SAS planet satellite imagery. A total of 41 dumpsites were identified within the study area. The coordinates of the existing dumpsites obtained from fieldwork were keyed into the Microsoft excel 2013 software and imported into the ArcGIS software as an excel file then converted to shapefile to show the location of the dumpsites, and to present a Geo-database map for the dumpsites within the study area. Figure 2 below

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shows the geo-database map of the existing dumpsites within the study area.

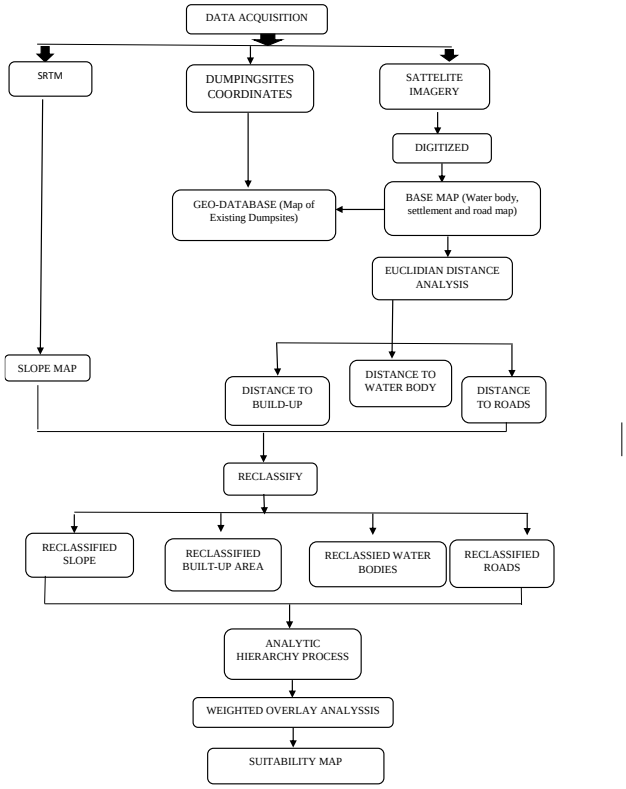

Figure 1: workflow diagram illustrating the steps adopted for the project**. Source: (**Author, 2019)

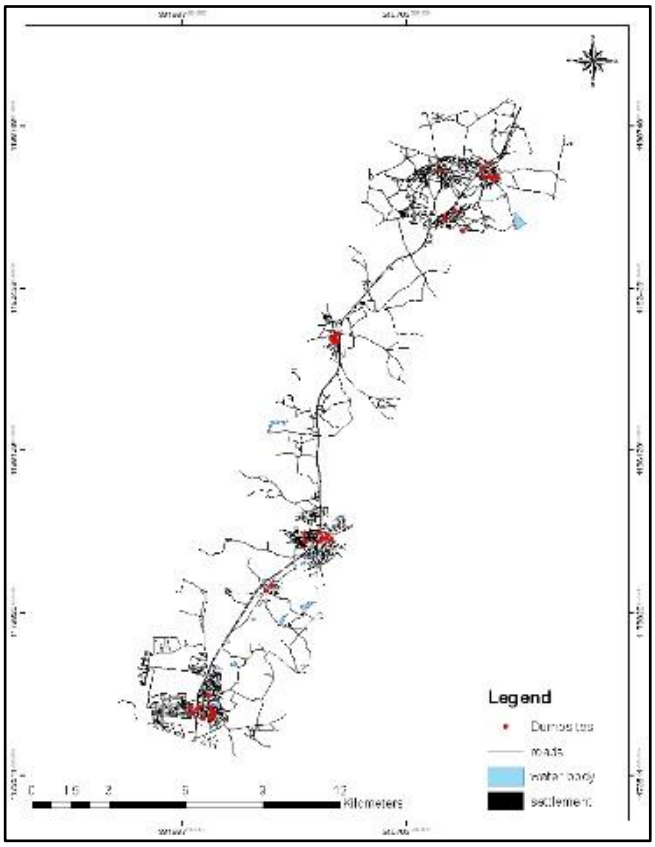

Figure 2. Showing the spatial location of the existing dumpsites

All the dumpsites identified within the study area, are located at unsuitable places. Table 1 & 2 below shows the minimum distance required for the dumping of solid waste according to the Environmental Protection Agency, 2006.

Table 1. Showing constraints criteria **Source:** (EPA, 2006)

S/N	Criteria	Unsuitable area
1	Distance to water body	Less than 160m
2	Slope	Area with slope greater than 15°
3	Distance to settlement	Less than 300m
4	Distance to roads	Less than 100m

Table 2. Showing factors criteria **Source**: (EPA Landfill manual 2006)

S/N	Criteria	Least suitable	Moderately suitable	Highly suitable
1	Distance to water body	160m – 480m	480m– 960m	>960m
2	Slope	10°- 15°	5°- 10°	0°- 5°
3	Distance to roads	100m-1000m	1000m–2000m	>2000m
4	Distance to settlement	300m – 500m	500m– 800m	>8000m
5	Soil	-	Alisols	Nitisols

3.1.1 Euclidean distance result

The Euclidean distance output raster contains the measured distance from every cell to the nearest source. The distances are measured as the crow flies (Euclidean distance) in the projection units of the raster, in meters and are computed from cell to cell. Below in figure 3. shows the results of the Euclidean distance result for the settlement, road network, and waterbody respectively with respect to the proposed dumpsite.

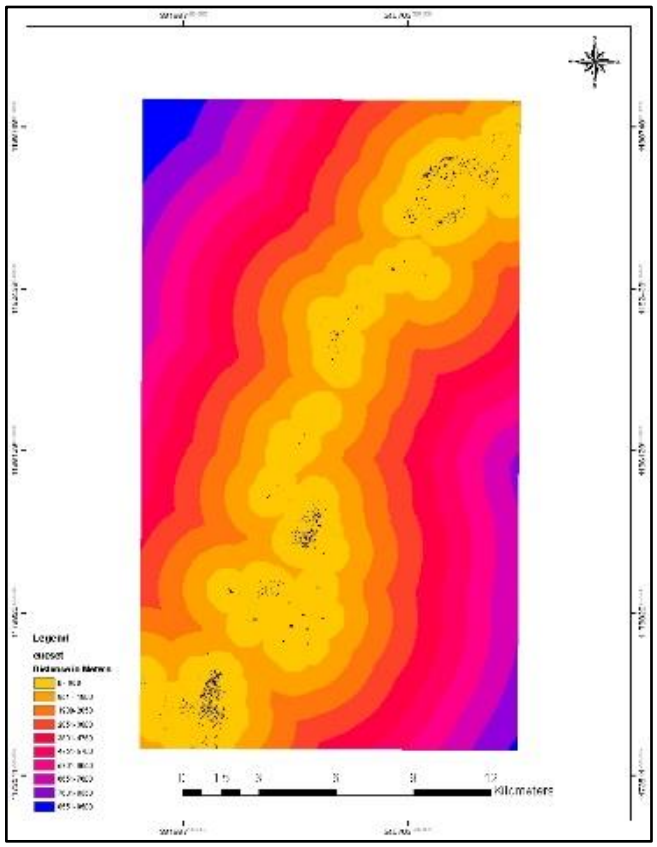

Figure 3. Euclidean distance analysis for settlement map

3.1.2 Reclassification of result

To create a single ranked map of potential areas to site solid waste dumpsite the value of classes between layers are compared by assigning numeric values to classes within each map layer. It is called reclassification. Having all measures on the same numeric scale gives them equal importance in determining the most suitable locations, hence all data map layers will be reclassified into new numeric values scoring as 10 to 1 (MC, 2011). The scores of 10 to 1 are used to identify the differences among areas of suitability. The slope dataset is reclassified at a score of 1 to 10 in order of priority (i.e. the lesser the slope the more suitable the area). Figures 4 and 5 show the reclassified datasets

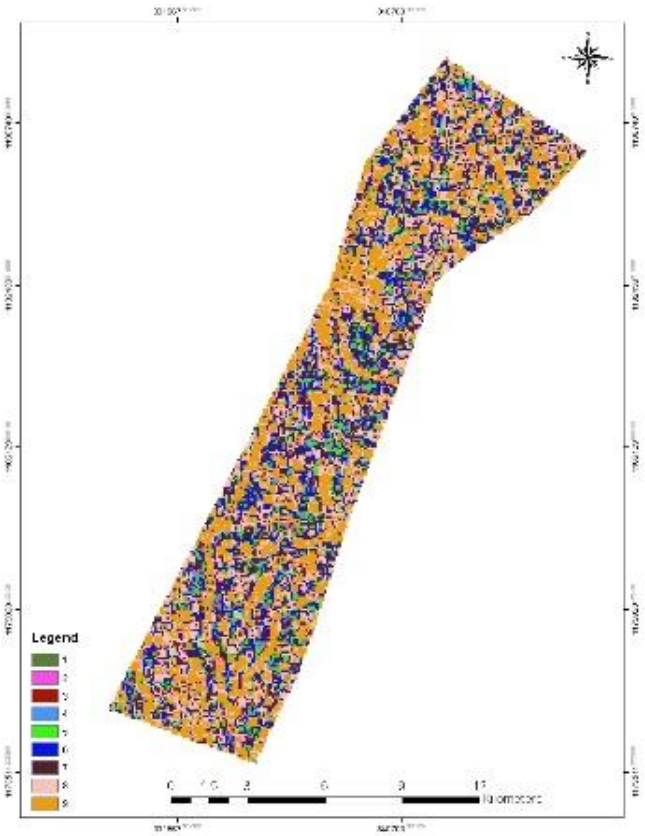

Figure 4. A map showing reclassified slope

3.1.3 Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) is a structured technique for organizing and analyzing complex decisions, based on mathematics and psychology. It represents the most accurate approach for quantifying the weights of criteria (Saaty, 2000). The magnitude of each factor was estimated through pair-wise comparisons. After all pair-wise comparisons are formed, the vector weights are calculated based on Saaty's eigenvector method. Then, this eigenvector is normalized and then the weights and consistency ratio are computed.

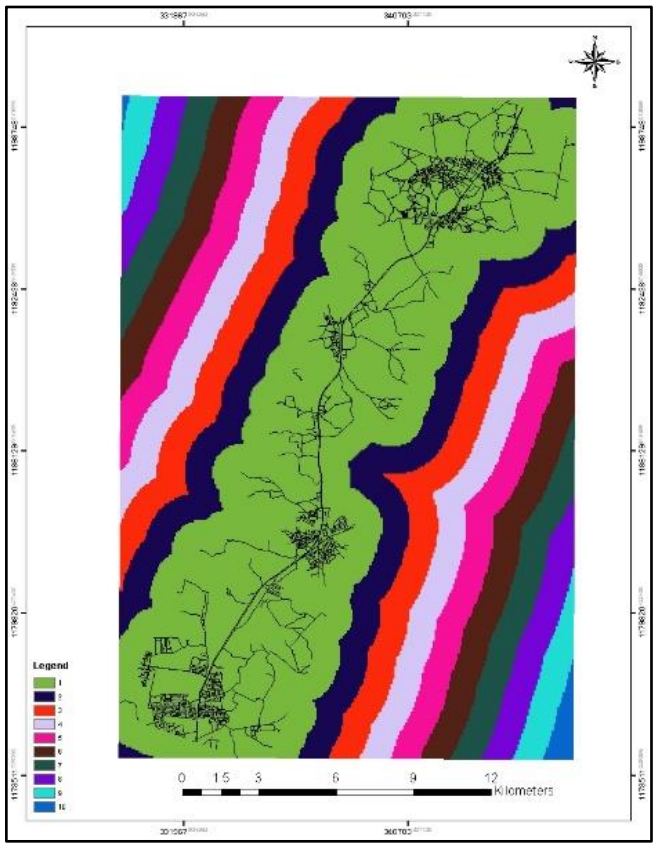

Figure 5. A map showing reclassified road networks

Table 3. pair-wise comparison of the criteria

S/N	Settlement	Water	Road	Slope
Settlement	1.00	2.00	6.00	9.00
Water	0.50	1.00	3.00	7.00
Road	0.17	0.33	1.00	3.00
Slope	0.11	0.14	0.33	1.00

Table 4. Shows the normalized matrix

S/N	Settlement	Water	Road	Slope	Eigenvector weights
Settlement	0.56	0.58	0.58	0.45	0.54
Water	0.28	0.29	0.29	0.35	0.30
Road	0.10	0.10	0.10	0.15	0.11
Slope	0.06	0.04	0.03	0.05	0.05
Total	1	1	1	1	1
Consistency ratio	1.6%				

3.1.4 Weighted overlay result

The final suitability map for locating solid waste is effected with the weighted overlay tool for each map layer using the weights computed from the AHP method. Then finally, all data map layer is ready to be overlaid by using the weighted overlay method to create a single rank map of suitability analyses, five rasters are ranked for developing suitability on a map of 1 to 10. And the weighted overlay results are further reclassified to a scale of 1 to 4 the result from figure 6 shows the area that is not suitable depicted as white, areas that are least suitable depicted as red, areas that are moderately suitable depicted as brown, and areas that are highly suitable depicted as green.

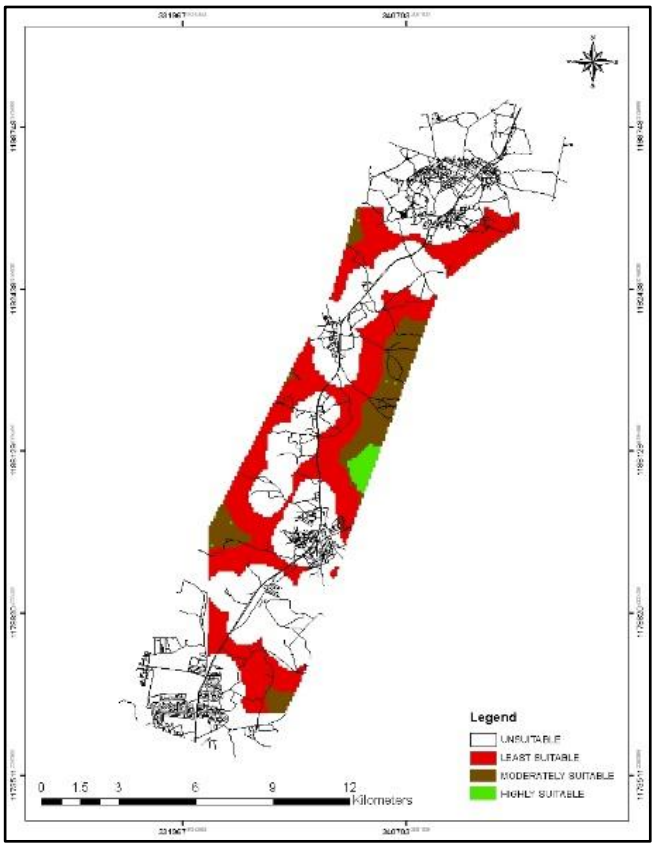

Figure 6. Suitability Map of Solid Waste Dumpsites

From the above analysis, it shows that an estimated total area of 95.3015km^2 is unsuitable, 39.4806km^2 is least suitable, 9.7741km^2 is moderately suitable and 1.6364km^2 is highly suitable.

4. Discussion

The project has shown the capability of GIS in capturing, storing, processing, and analyzing spatial data as well as creating a spatial database for solid waste dumpsites in Igabi LGA. Datasets for the work include road network, elevation, and Land use of study area, existing solid waste dumpsites, and water body within the study area. The coordinates of the existing dumpsites were captured with the handheld GPS and entered into an excel spreadsheet and exported to ArcGIS 10.4.1. Spatial analyses were carried out which include slope, Euclidean distance, reclassification, and weighted overlay analyses in other to actualize the aim and objectives of the study. The criteria as related to the siting of a solid waste dumpsite according to the environmental protection agency.

5. Conclusion

The aim and objectives of this project have been achieved through the acquisition of the necessary dataset and the 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 rapid increase in population growth in Igabi LGA, is directly affecting the amount of waste generation in that area. This study will serve as a catalyst in that area for the proper management of dumpsites in that area.

Acknowledgement

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