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SITE SUITABILITY ANALYSIS OF SOLID WASTE DUMP IN ALIMOSHO LOCAL GOVERNMENT AREA, LAGOS STATE

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ABSTRACT

The solid waste materials in cities are the natural outcome of human activities, in cities and municipalities of most developing countries. In Nigeria, it is a major concern of the government due to the health problems associated with improper disposal of waste. Due to the different parameters involved, deciding upon a suitable location is very complicated, costly and time consuming. Geographic Information System (GIS) allows users to view, understand, query, interpret and visualize spatial and non-spatial data in many ways that reveals relationships, patterns and trends in the form of maps, reports and charts. This study determined the most suitable site(s) for waste disposal in Alimosho L.G.A, Lagos State. Suitable disposal site must follow some safety criteria that will enable the wastes to be isolated so that there is no unacceptable risk to people or the environment. The Criteria for site selection used for this study includes physical characteristics, socioeconomic, and land-use factors.

Keywords: - Solid Waste Materials, Suitable Location, Health Problems, GIS, Land-Use Factor

INTRODUCTION

Man, in an attempt to satisfy his daily needs, engages in the production of goods and services. In the process, waste is generated. (Beede and Bloom, 1995). The need to improve sanitation has been necessitated by an increase in solid waste generation due to factors like population increase, industrialization, urbanization, the alteration of urban consumption pattern towards packaging and economic growth, Zurbrugg, 2002. It is estimated that in 2006 the amount of municipal solid waste (MSW) generated globally reached 2.02 billion tons, representing a 7% annual increase since 2003 (Global Waste Management Report, 2007).

According to Audu (2007), waste is simply a used item waiting for re-use or disposal. Dumpsites have been the most organized common methods of waste disposal and remain so in many areas in the world (EL -Fadel, 1995). In developed countries like Nigeria, the prevailing practice of municipal solid waste disposal has been to dispose solid waste in dumpsites (Weiss et al., 1974; Asian Institute of Technology(AIT) 2004). Arimah and Adinu (1995) in their work observed that location of dumpsites in urban areas is beneficial in that they provide the most cost efficient and safe means of disposal of generated waste; however, the perceived environmental and health related implication, social and economic impact on households and businesses of waste dumpsites are often confined to the immediate zone of influence and extends up to a few kilometers.

Lagos – the most populous city in the continent of Africa is also grappling with the management of waste disposal, this comes as no surprise as the rate of solid waste generation is on the increase even beyond what the city system can absorb, in which the aforementioned factors have all played a part. According to a former managing director of Lagos state Waste Management Authority, LAWMA, Engr. Ogunbiyi, waste in form of paper, cardboard, plastic, metal, food and other materials is generated by over 23 million residents running into 13,000 metric tons daily.

Due to this staggering rate, the Lagos State waste management authority had planned to increase its municipal solid waste evacuation from tenements and commercial facilities to approved dumpsites from 500 trips daily to 850 in 2020 to enable it cope with the 13,000 metric tons of waste generated daily, (This day, 2020). However, in spite of the effort of the state and local authority, this continues to be a major environmental concern as streets are littered with plastics and drainages blocked as a result of the unsanitary attitude and indiscriminate dumping of wastes by some locals in the metropolitan city.

The LAWMA notwithstanding, has continued its relentless effort in making sure it fulfils its responsibility of waste management in the Lagos environ; providing homes with refuse bins for refuse collection, and these are evacuated periodically using hydraulic rear – load refuse packer compactor trucks (LAWMA, 2011).

PROBLEM STATEMENT

Eze (2008) in a report on environment sanitation trend analysis in the African region, classified solid waste management as one of the three major factors affecting public health and environmental degradation. Most times, the heaps of waste gathered at the initial waste storage points in neighborhoods are not evacuated as at when due, which lead to wastes exceeding the carrying capacity of waste bins. Other times, residents indiscriminately indulge in open dumping of solid waste in places that are prohibited for refuse disposal thereby leading to littered streets and blocked drainages.

There are three major landfill sites serving the Lagos Metropolitan area. They are Abule-Egba, Solous dumpsite at Igando and Olusosun landfill. According to Mr. Adedayo, LAWMA's Desk Officer at Mosan - Okunola Local Council Development Area, the LCDA mainly utilizes the Solous dumpsite due to its close proximity while Abule-Egba dumpsite is preferred as an alternative.

However, according to research done by Jude et. al., (2012) on existing dumpsites in Lagos, distances of the Abule – Egba and Solous landfills to residential areas are less than 250m which is not in line with the world Bank criteria standard for establishing landfill sites. The major concern is the health risk these landfills pose to hospital patients, business owners and residents around the environs as certain studies have discovered that toxic substances especially heavy metals from landfills can descend into soil profile and contaminate adjacent surface water and groundwater system (Christensen *et al., 2001*). Hence, residents depending on such contaminated sources of water could be at the risk of a plethora of diseases.

The research by Jude et. al., (2012) subsequently identified that the 280-meter distance of Abule -Egba landfill from the Lagos/Abeokuta express way may not be environmentally friendly as the system of burning landfill covers which produces smoke thereby causing visibility challenge to the motorists plying the road.

Based on the problem statement, this study unravels alternative areas suitable for potential sanitary landfills in accordance with regulations of the Federal Environment Protection Agency and past research on landfill site selection.

AIM

Establishing an appraisal blueprint to identify suitable landfill sites in the study area.

OBJECTIVES

The key objectives of this project was

a. Accessing the Suitability of the Current Landfill Sites
b. Determining criteria that influences the siting of location of waste disposal in Lagos State.
a. To map the potential areas suitable for dumpsite in Alimosho Local Government Area of Lagos using Weighted Overlay to determine the suitable sites for waste disposal.

SIGNIFICANCE OF STUDY

The rapid economic growth and population increase in Lagos state have led to increased waste generation, according to Lagos State Waste Management

Authority, an estimated 13, 000 metric tons of municipal solid waste is generated every day. Parcels of land in areas with close proximity with the traditional landfills (controlled dump) are being purchased and utilized for different land-use purposes due to the rapid increase in the city's population and limited land space with town planners doing little or nothing about it. Hence, this study is crucial since a sanitary and well – engineered landfill will reduce the negative impact of municipal solid waste on the environment and health of surrounding residents.

STUDY AREA

Location

Alimosho is a Local Government Area in the Ikeja Division, Lagos state, Nigeria. It is the largest local government in Lagos state with geographic coordinates of latitude 6° 36' 38" N and longitude 3° 17'45" E with a UTM reference of 730737.539 Northing and 532732.133 Easting on zone 31N. It has a total land mass of 185km^2 and an average density of 713 persons per square kilometer approximately.

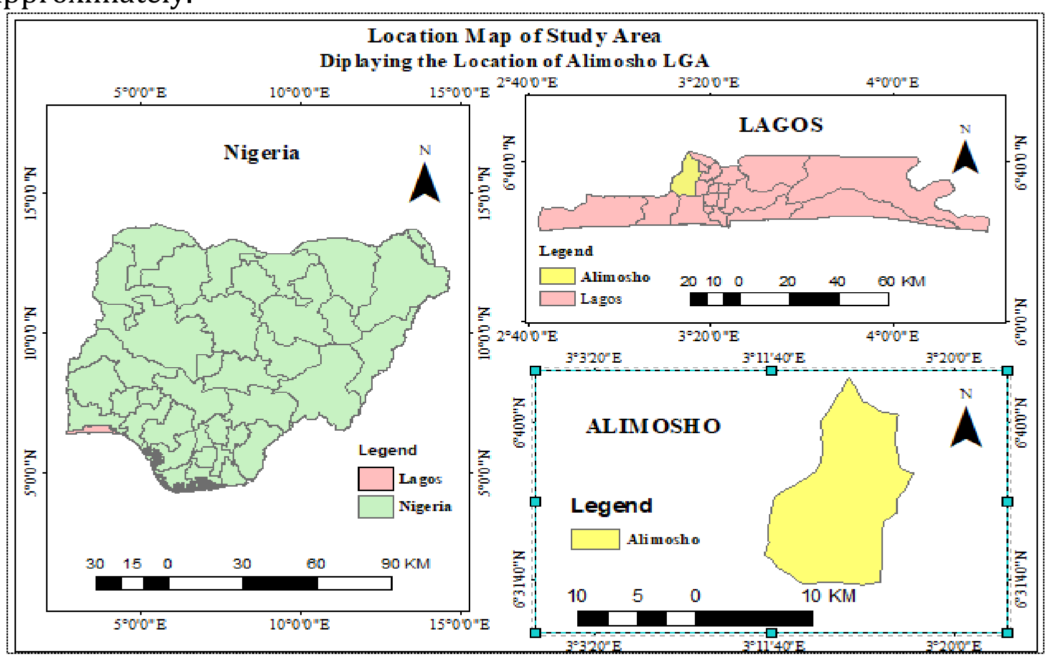

Figure 1: Image of the study area

DATA AND METHODOLOGY

The method employed for the research involved consideration of important criteria for sitting solid waste dumpsite. Four criteria were identified namely: Slope, Land-use, Roads, and Water body.

Each of these criteria was generated as a layer in GIS Environment (ArcGis 10.7) using a number of data acquired from different sources. The information compiled from literature (EPA Landfill Manual 2006) about the safe distance to a dump site was used to determine the buffer zones and varying degree of suitability within each layer. See Figure 2 for the workflow diagram adopted for the work.

Due to the nature of rapid development and land unavailability in Lagos, the whole Alimosho sub-divisions (Agbado/ Oke- Odo LCDA, Ayobo/Ipaja LCDA, Alimosho LG, Egbe / Idimu LCDA, Ikotun/Igando LCDA and Mosan Okunola LCDA) were all considered.

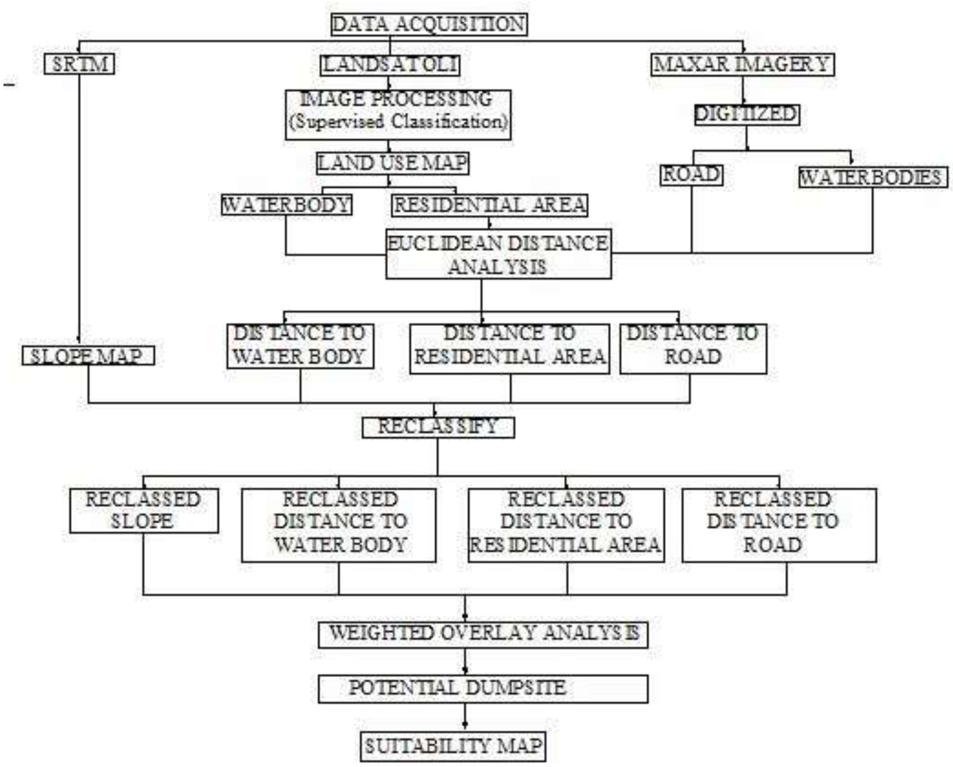

Figure 2: Methodology Workflow

The data and materials used for this research are the LANDSAT OLI, the SRTM DEM of (30m resolution) covering the study area was used in the research to generate elevation and slope of the study area. Maxar satellite imagery of the study area was used to extract the road network and also verify water bodies within the study area. The geometric data of the existing dumpsites within the study area was acquired through field survey using a Global Positioning System

(GPS). Landsat image and SRTM DEM were downloaded from the USGS website and the Maxar satellite imagery was captured from Global Mapper 23.0 for the purpose of extracting the terrain elevation and roads respectively.

Table 1: Adopted Data and their attributes

S/N	DATA	SOURCE	YEAR	RESOLUTION	RELEVANCE
1	LANDSAT OLI	United States Geological Survey (USGS) website.	2021	30m	To extract the Land-use types of the study area.
2	SRTM DEM	United States Geological Survey (USGS) website.	2021	30m	For elevation and to generate slope
3	Maxar Imagery	Global Mapper 23.0	2021	0.6m	To extract the road network and also verify the water bodies within the study area
4	Administrative Map of Alimosho L.G.A, Lagos State	grid3.gov.ng/dataset/lagos-local-government-administrative-boundaries	2021		To derive boundary information.
5	GPS Coordinates	Field Survey	2021		For the geometric data of the existing solid waste dumpsites within the study area

ASSESSMENT OF THE EXISTING SOLID WASTE DUMPSITES

To achieve the first objective in this research, work the data needed to perform the spatial analysis is the X Y coordinates of the existing solid waste dump sites. The coordinates of the existing solid waste dumpsites were collected through field measurement/ field survey method. Hand-held GARMIN 76CX GPS was used to obtain the coordinates. These coordinates are shown in the table below:

Table 3.4: Coordinates of the Existing Dumpsites

Name/ location	**X (m)**	**Y (m)**
Solous Landfill	527852.08	726361.29
Abule – Egba Landfill	533465.68	733942.06

Figure 3: Google Image of Abule Egba Land Fill Site (Source- Google Earth)

Figure 4: Google Image of Solous Land Fill Site (Source- Google Earth)

The coordinates of the existing solid waste dumpsites collected during fieldwork were imported into the ArcGIS 10.7 as a text file then converted to shape-file to show the location of the dumpsites. The points were superimposed on the result derived from the identification of potential solid waste dumpsites using multi-criteria analysis. This was to determine whether the existing dumpsites within the study area met the stipulated standards. Above are the images of the existing dumpsites downloaded from google earth.

LANDSAT IMAGE PRE-PROCESSING AND LULC CLASSIFICATION

In this study, digital remote-sensing data of the Landsat image was used to map various LULC classes in Alimosho L.G.A, Lagos State. Bands 5, 4 and 3 for Landsat OLI_TIRS image was used to create false colour composite image for the year studied and the study area extent was extracted by mask (administrative map of Alimosho L.G.A).

The classification of Landsat imagery was carried out with ArcGIS 10.7 software based on supervised maximum likelihood classification where each pixel was classified in one of the following classes: built-up land, tree cover, shrubland, grassland, cropland, bare/sparse vegetation, water bodies and herbaceous wetland.

MAXAR IMAGE PROCESSING AND DIGITIZING

The Maxar imagery downloaded from global mapper 23.0 was obtained with its projection properties and as such, it has been geo-referenced. The exact coverage of the study area was extracted from the rectangular shaped imagery downloaded, Road, important locations and water bodies were then located on the imagery and digitized accordingly using ArcMAP 10.7. shapefile was created for each theme with polyline selected as the geometry type, digitizing tool was activated and each of the features were traced and saved in their appropriate layers.

IDENTIFICATION OF POTENTIAL SOLID WASTE DUMPSITES USING MULTI-CRITERIA ANALYSIS.

To achieve the second objective in this research work, the following data were used to perform the spatial analysis: SRTM DEM, land-use map and Maxar satellite imagery. The data were selected based on the criteria that must be satisfied to determine the most suitable location for a dumpsite in the study area according to the Environment Protection Agency Landfill Manual 2006. All the maps were digitized to convert the raster map to vector format useable in the GIS software. water body, residential area, road layers were derived. The various criteria that were created as layer in the GIS environment are:

Table 2: Constraint Criteria Table Formulated from EPA landfill manual 2006

Criteria	Unsuitable Area	Less Suitable Area	Moderately Suitable	Suitable	Highly Suitable
Distance to Water	Less than 160m	160m-480m	480m-700m	700m-960m	>960m

Slope	Slope greater than 15o	8o – 15o	6o – 8o	5o – 6o	0o – 2o
Distance to Residential Areas	Less than 300m	>1500m	1000-2000	100m-1000m	50m-400m
Distance to Road	Less than 100m	300m-500m	500m-800m	800-1500	>8000

Figure 5: The Cartographic Model

All the criteria were mapped using both remote sensing and GIS techniques. They were created as GIS layers and structured in a geo-database to ensure consistency of the data during spatial analysis. GIS analysis such as: slope analysis, Euclidean distance analysis, reclassification, rasterization and weighted overlay were performed. Supervised image classification was carried out to derive the landuse/ landcover types required for the analysis on the Landsat OLI imagery using ArcGIS 10.7 application. Slope analysis was carried out on the ASTER DEM to generate the slope of the terrain. Furthermore, Euclidean distance output raster was generated showing the measured distance from the nearest source (road network, residential area and waterbody). The slope map, Euclidean distance raster of road network, residential area and waterbody were reclassified and ranked from 1 (the least suitable) to 5 (the most suitable). Finally, weighted overlay was done using equal level of influence for all the factors in the GIS environment to determine suitable dumpsite areas. All the analysis was accompanied using geo-processing module of ArcGis 10.7 software.

WEIGHTED OVERLAY (SPATIAL ANALYST)

A suitability model was applied using weighted overlay analysis to capture all aspect of decisions. According to AL-Hanbali *et al*. (2011), It is one of common methodologies used for site selection in general, and for selecting solid waste disposal sites in particular. Therefore, in this study, the method was used for site selection criteria, with some variations in the selected parameters based on local conditions of the study area. This method can avail the decision makers a variety of options for selecting appropriate locations of landfill sites, since using this method will produce a final output map which will range from the “most suitable” to “not suitable”.

All the attributes of input data were given scores. The scores represent land constraints for siting a landfill that range from 1 -5. A score of 1 indicates not suitable, and a score of 5 indicates suitable.

ANALYSIS OF EXISTING SOLID WASTE DUMPSITES

Solous Landfill

The Solous landfill is situated at Igando along the Lagos State University – Iba in Alimosho Local Government Area of Lagos State. It commenced operation in the year 1996 with a projected lifespan of between 5 and 6 years (LAWMA, 2010). As a result of urban development, this dumpsite is now surrounded by residential, commercial and industrial activities.

The existing landfill covers about 10.8 hectares of land and receives an average waste of about 2,250 m^2 per day. According to Longe and Balogun (2010), soil stratigraphy of Solous landfill is intercalated with lateritic clay that is capable of protecting underlying confined aquifer from leachate contamination.

Abule – Egba Landfill

This landfill is located in the northern part of Lagos along the Lagos – Abeokuta express road and occupies an area of about 10.2 ha in Alimosho Local Government. The major concern about this landfill is its shared fuzzy boundary with the vibrant market commonly known as 'Super'. According to LAWMA (2012), a total of 2,628,726 metric tons of waste was deposited in the Abule -Egba landfill as of its closing in 2009.

Additionally, there are no sufficient cover materials in this site. As a result, wastes dumped into this site are sometimes not covered at all. This has increased the amount of odour and the number of flies within the area. There is no provision for ponding the leachate generated from the site and therefore, groundwater contamination is inevitable.

ANALYSIS OF POTENTIAL SOLID WASTE DUMPSITES

First of all, all data map layers were converted from vector form to raster form. A raster consists of a matrix of cells (or pixels) organized into rows and columns (or a grid) where each cell contains a value representing information. For several data map layers, this first step proceeded further with Euclidean distance analysis to apply the safe distance between dumpsites to several criteria that has been set up as indicators mentioned in suitability criteria. The Euclidean distance output raster contains the measured distance from every cell to the nearest source. When all data map layers already set up in certain prerequisite for safety distance through Euclidean distance analysis, the values of classes have to be compared between layers by assigning numeric values to classes within each map layer so they have equal importance in determining the most suitable location. Then finally, all data map layers were ready to be overlaid by using weighted overlay method to create single rank map of suitability analysis.

EUCLIDEAN DISTANCE RESULT

Figure 4.1, 4.2 and 4.3 shows the result of Euclidean distance. The Euclidean distance output raster contains the measured distance from every cell to the nearest source.

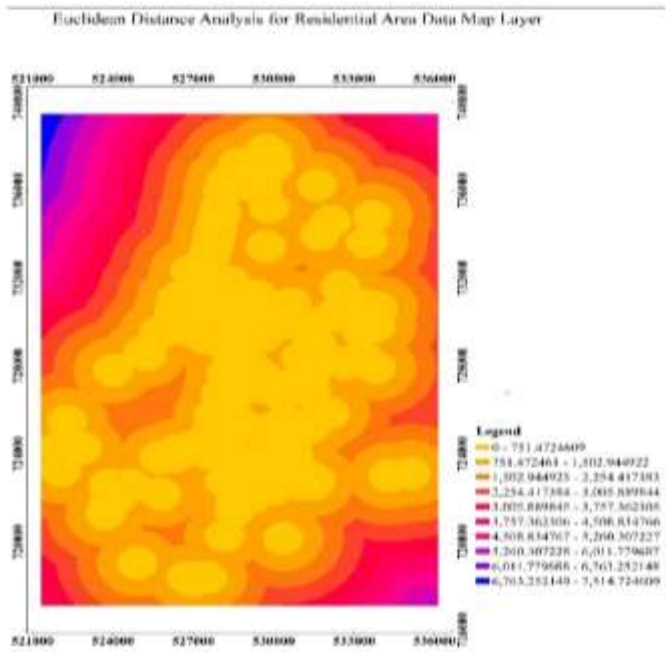

Figure 6: Euclidean Distance Analysis for Residential Area Data Map Layer

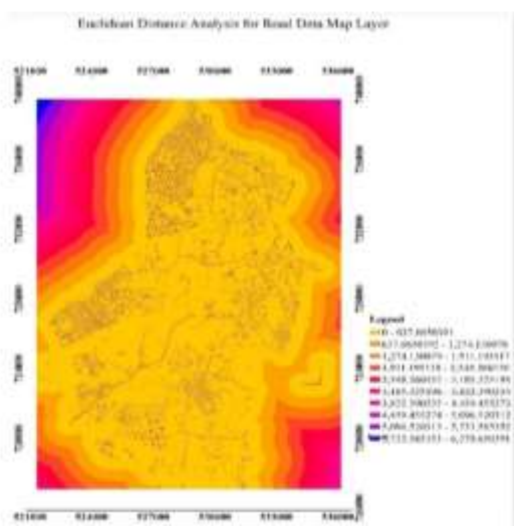

Figure 7: Euclidean Distance Analysis for Road Data Map Layer

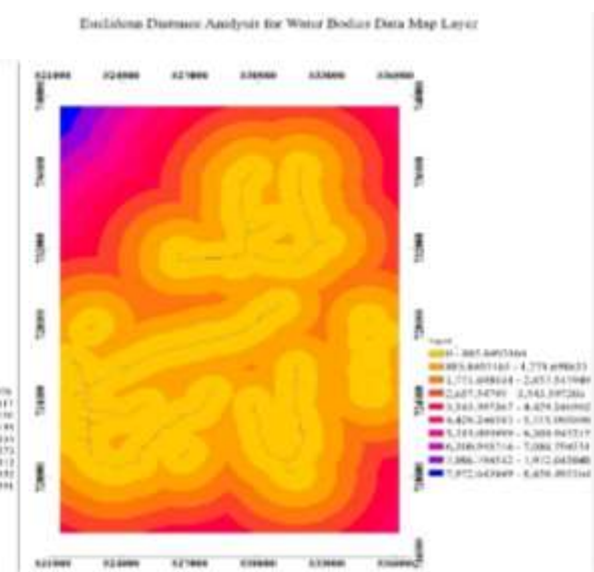

Figure 8: Euclidean Distance Analysis for Waterbody Data Map Layer

RECLASSIFICATION RESULT

To create a single ranked map of potential areas to site Solid waste dumpsite we had to compare the values of classes between layers by assigning numeric values to classes within each map layer, it is called reclassifying. The scores of '5 to 1' are used to identify the differences among areas of suitability. The slope dataset is reclassified at a score of 1 to 5 in order of priority (i.e. the lesser the slope the more suitable the area) so the scaling was reversed. The figures below show the reclassified datasets

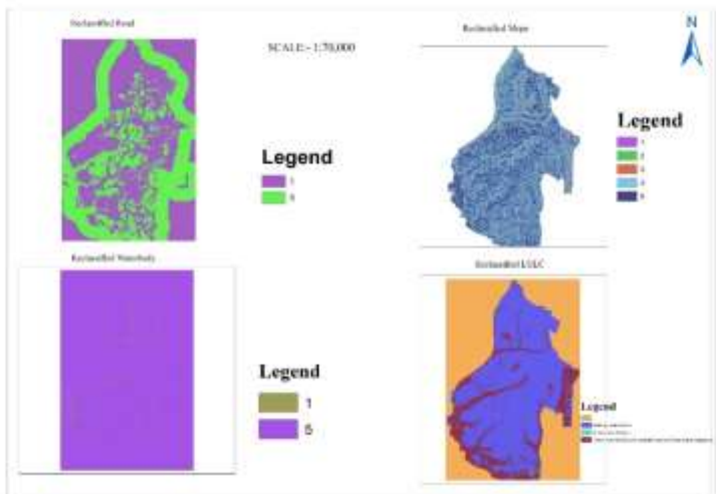

Figure 9: Reclassified Maps

a) Reclassification of distance for road at a range of 1 (the least suitable) to 5 (the most suitable). This ranking is based on the criterion which addresses required distance from road.
b) Reclassification of degree of slope of the terrain at a range of 1 to 5. 1 (the least suitable) to 5 (the most suitable). This ranking is based on the criterion which addresses the degree of slope suitable for the location of a dumpsite. The plainer the better.
c) Reclassification of distance from water body at a range of 1 to 5. 1 (the least suitable) to 5 (the most suitable). This ranking is based on the criterion which addresses required distance from water body. The farther the better.
d) Reclassification of distance from residential areas at a range of 1 (the least suitable) to 5 (the most suitable). This ranking is based on the criterion which addresses required distance from a residential Area.

WEIGHTED OVERLAY RESULT

The Weighted Overlay tool lets you implement several of the steps in the general overlay analysis process within a single tool.

The tool combines the following steps:

a. Reclassifies values in the input raster into a common evaluation scale of suitability or preference, risk, or some similarly unifying scale
b. Multiplies the cell values of each input raster by the raster's weight of importance
c. Adds the resulting cell values together to produce the output raster

The final suitability map for locating solid waste dumpsites is seen in figure 10. Four raster layers are ranked for development suitability on a scale of 1 to 5.

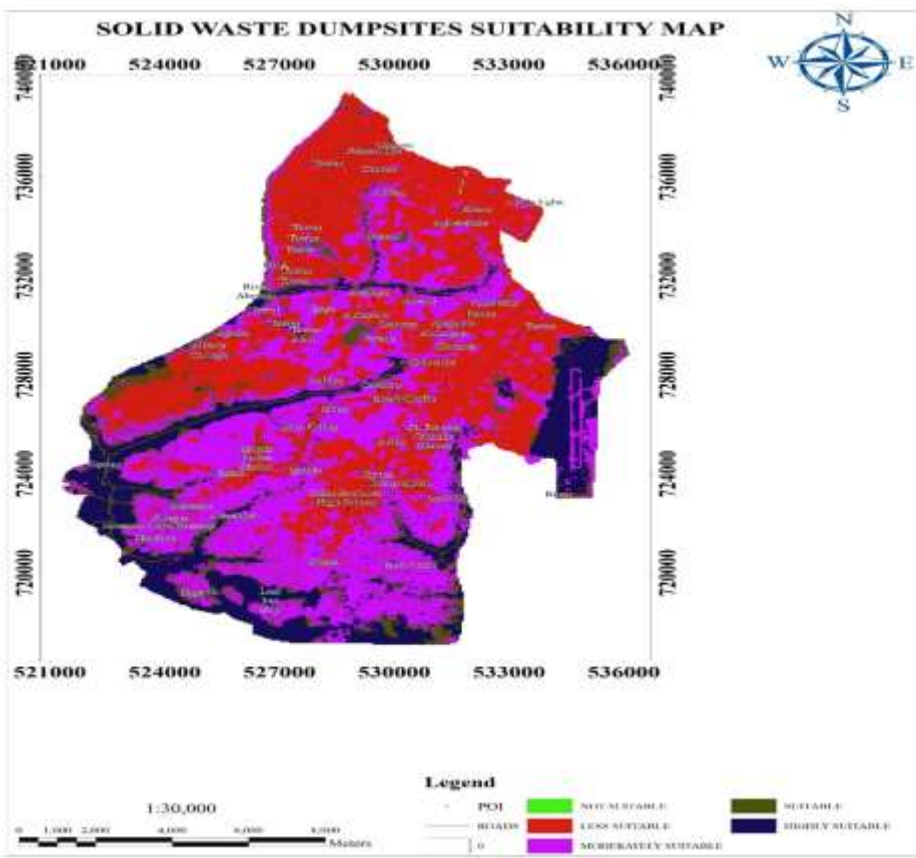

Figure 10: Solid Waste Dumpsites Suitability Map

CONCLUSION

The results Shows suitable area for Dumpsites in the study area, by the use of Geoinformation technique realizing that citing of Solid Waste Dumpsites is a big issue in Alimosho L.G.A. Specifically, this project shows Spatial Modeling Analysis to build the area suitable for citing dumpsite using multi-criteria analysis within the GIS environment. The considered criteria included distance from water bodies, distance from major roads, residential areas and the slope.

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

RECOMMENDATION

Having identified the area best for sitting dumpsites, in their levels of suitability using a Suitability Analysis Model Builder, it is recommended that the Environmental Department of the Local Government Areas within the study area and the Town Planning Authority have the site suitability analysis model in their finger-tips so that it will serve as a guide before a site can be approved for dumpsite, since it has taken care of all the criteria as regards suitable locations for dumpsite in its analysis. A step can still be taken further to incorporating within the model a procedure to enable identification of optimum site for locating a Solid waste dumpsite.

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