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Application of Geographical Information Systems and Remote Sensing to Optimal Dumpsite Selection in Iseyin, Oyo State, Nigeria

James O. Ige[1*], John Ayankanmi[2] & Abiodun A. Mudashir[3]
[1]Department of Surveying and Geoinformatics
[2 &3]Department of Urban and Regional Planning,
Ladoke Akintola University of Technology,
Ogbomoso, Oyo State, Nigeria.

Corresponding author:* **joige@Lautech.edu.ng

Abstract

In Nigeria, existing studies on waste issues predominantly address the environmental challenges posed by open dumps with the gap that neglects crucial aspect of finding a suitable location for waste disposal, which is essential for effective and sustainable waste management practices, hence this study. This research sought to examine nature of waste generated, methods of waste disposal and dumpsite distribution pattern with a view to using geospatial techniques for finding suitable site for waste disposal in Iseyin. Primary data for this study were collected through questionnaire administration and GPS receiver to obtain coordinates of dumpsites while secondary data used were a Google earth imagery of the study area. One per hundred ($1^0/_0$) of the total 11,710 households in Iseyin town which approximately amount to 117 households constituted the sample size interviewed. Descriptive statistics was used to summarize findings and nearest neighbour analysis to determine pattern and arrangement of dumpsite in relation to their neighbours. From findings, nature of waste generated was mainly bio-degradable. Open disposal was the main waste disposal method. Recycling was said by majority (37.3%) as main method. From the analysis, the nearest neighbour ratio (Rn) from complete spatial randomness of 18 existing dumpsites was 0.098122 with a p-value of 0.0000 that typically suggested strong evidence against null hypothesis. In this context of a dump site distribution, the nearest neighbour ratio of 0.098122 indicated that the dumpsites were clustered closer together than expected in a random distribution. The study concluded that existing dumpsites were not evenly distributed in the area. Multi-criteria were used in GIS environment to propose two suitable dumpsites for the study area. The study therefore underscores the needs for geospatial techniques as it plays a crucial role in providing valuable insights and tools for decision making in waste collection and siting dumpsites

Keywords: Waste, Dumpsite, GIS, Recycling, biodegradable

Introduction

In Nigeria, open dump is one of the most notable threats to rural liveability and urban development, and has all day long become a hydra-headed environmental monster pervading every dimension of human survival and stable life style. The issues of waste management are a globally environmental issue particularly in developing countries of the world such as Nigeria, India, Rwanda, Argentina, China and Tanzania that are characterized with increased urbanization, poor planning and lack of adequate

resources (Abolade et al,.2019; Mwanthl and Nyabola, 1997; Nigeria Environmental Study/Action Team (NEST), 1991).

Neglect of finding a suitable location for waste disposal which is essential for effective and sustainable waste management practices is a major public concern and an important factor affecting the quality of the environment (Asian Institute of Technology (AIT), 2004; Stun Van Ewijk and Julia Stegemann, 2023). One is reminded of environmental risk everywhere one goes in Nigeria (Abolade et al., 2019). It is not just the warning signs on open dumps that indicate rampart menace but the increased heaps of waste materials in the neighbourhoods and the presence, day and night, of sanitation law enforcement agents patrolling the streets and major roads (Ige and Atanda, 2013).. The issue is even becoming more complex and alarming with the increasing rate of urbanization. Increasing population both within cities and their surrounding areas without adequate planning to improve the living condition of the teeming masses and provide amenities and essential services has been associated with increased poverty and environmental challenges (Muili et al., 2020). While poverty is being addressed by different governmental initiatives and policies, environmental pollutant continues to be demonstrated by occasional increase in the number of sanitation law enforcement personnel without proper understanding and analysis of finding a suitable location for waste disposal. Dumpsites have been the most organized common methods of waste disposal and remain so in many places in the world (El-Fadel *et al.,* 1995). In developing countries like Nigeria, the prevailing practice of municipal solid waste disposal is to dispose of the solid waste in dumpsites (Weiss 1974; Kent & Vujakovic 2020; El-Fadel *et al* 1995). The issues of this waste in Nigerian cities have caused a lot of health hazards and city disfiguration due lack of proper waste management and adequate provision of dumpsites where waste could be managed to avoid spreading of epidemics diseases in the environment.

In recent times, the management of waste in cities with the scientific approach has incorporated both technologies of reuse and recycle as an efficient means of resources recovery, but the adoption of Geographic Information System (GIS) by some developing countries has really helped to strengthen the management system (Johnbosco *et al.*, 2014). Geographic information system (GIS) is a conceptualized framework that provides the ability to capture and analyze spatial and geographic data (Ige et al 2020). GIS applications are computer-based tools that allow the user to create interactive queries (user-created searches), store and edit spatial and non-spatial data, analyze spatial information output, and visually share the results of these operations by presenting them as maps (Alexander James *et al* 2020). It is commonly initialized as GIS, (Goodchild, 2010). Geographic information systems are utilized in multiple technologies, processes, techniques and methods. They are attached to various operations and numerous applications that relate to transport and logistics, insurance, telecommunications, and business (Grigonis *et al*., 2011). In Africa, especially in Nigeria, the use of GIS as a tool for waste and dumpsite management is very rare. This is partly because of the inadequate funding of City Waste Management Agency that makes procuring of GIS tools difficult and more importantly there is dearth of GIS experts in the agencies. Society is advancing in technology and the waste management agencies, like any other organization have to adapt to the new challenges of the environment they are in, and move with the trend or they will be unable to meet the demands of the society. The correct use of Geographic information system is a very critical success for optimum functioning of an organization. There exists a positive correlation between the quality of information and the quality of decision making (Paresi, 2000). Dumpsite and waste are a topical issue in environmental management especially in the area of generating early warning system for preparedness against indiscriminate waste disposal. In the context of waste management in urban areas of Nigeria, the existing studies predominantly address the environmental challenges posed by open dumps and there is a glaring oversight in the investigation of optimal dumpsite selection. The gap neglects crucial aspects of finding a suitable location for waste disposal which is essential for effective and sustainable waste management practices, because

designated dumpsites can serve as the remote centres of gravity used as transhipment points for selection waste for recycling. This importance of this study underscores the needs to address the critical gap in waste management studies by leveraging GIS and Remote Sensing technologies. By focusing on dumpsite siting in a Nigeria city, the study endeavors to provide valuable insights into the strategic placement of waste disposal facilities. This not only contributes to mitigating environmental risks associated with haphazard dumping but also facilitates the development of a comprehensive waste management framework tailored to the specific needs and challenges of urban centers in Nigeria. Ultimately, the objectives of this study are to examine nature and types of waste generated, method of waste disposal and management practices, dumpsite distribution pattern, with a view to suggesting suitable site for waste disposal in Iseyin, Oyo State, Nigeria

Materials and Methods

Study Area

Iseyin town is located within Iseyin Local Government Area in Oke-Ogun Region of Oyo State. It lies between Latitudes $7^{0}56^{I}05^{11}$N and $8^{0}0^{I}30^{II}$N and Longitude $3^{0}33^{I}20^{II}$E and $3^{0}37^{I}49^{II}$E. Iseyin Local Government Area (LGA) covers a total land mass of 1380.84 km^2 and Iseyin town covers about a total built up area of 86.48 km^2 with total population of 236,000, per a United Nations 2006 estimate. Iseyin LGA·bounded in the North by Itesiwaju and Kajola Local Government Areas, in the South by Ibarapa East and Ido Local Government A|reas, in the West by Ibarapa North local government areas, and to the East by Oyo West and Afijio Local Government Areas, (see Figure 1 and Figure 2). The terrain of the study area ranges between 300m and 500m above sea level and has two important rivers namely Odo-Ogba and Ikere gorge dam which serve as irrigation for farming. It has a tolerable climate, immense and opportunities for socio-economic and agricultural activities (Oyo affairs.com).

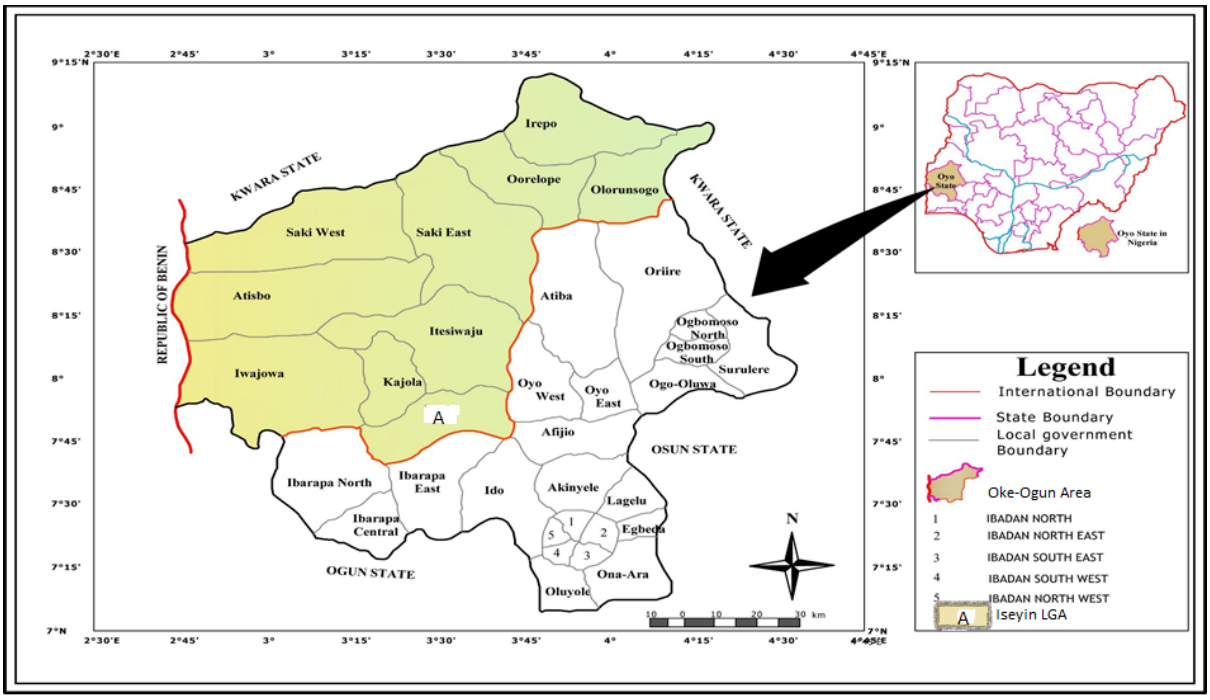

Figure 1: Iseyin LGA in the Context of Oke-Ogun, Oyo State and Nigeria.
Source: LAUTECH URP GIS Laboratory

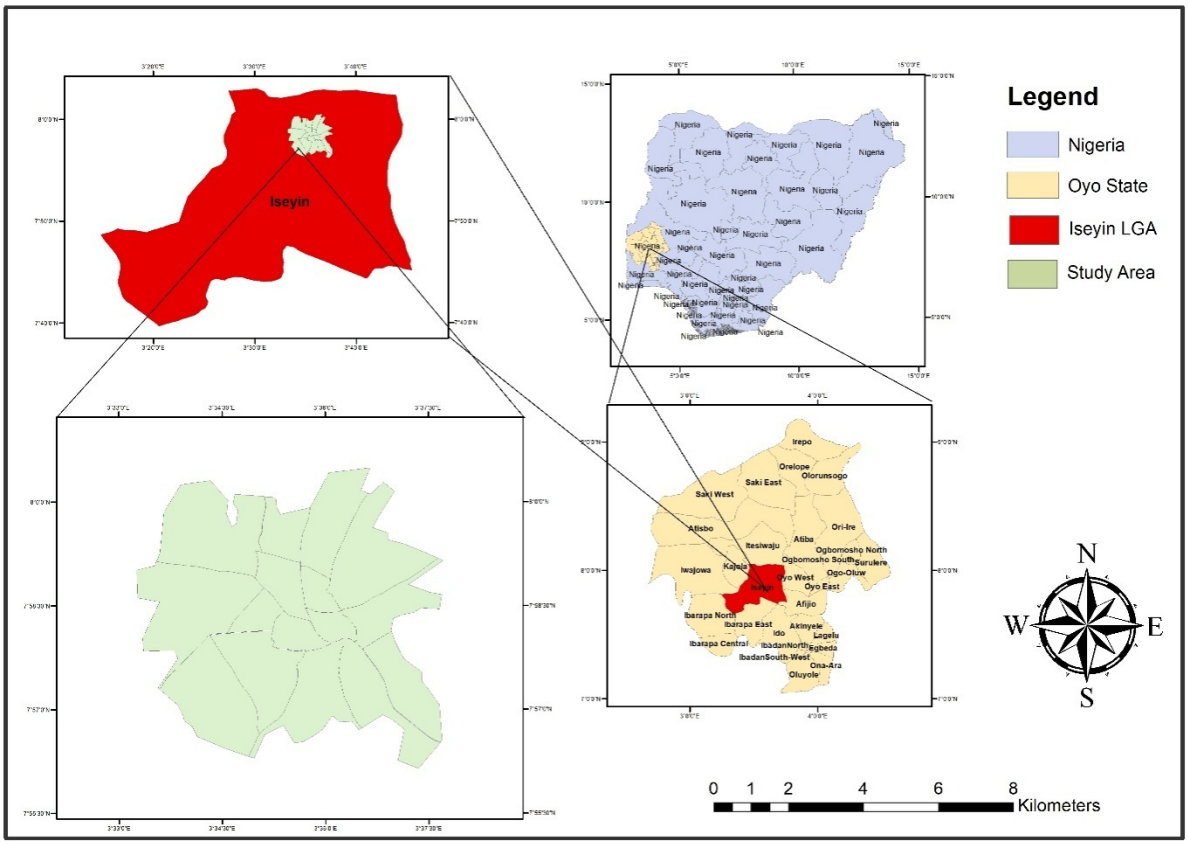

Figure 2: Iseyin Town in the context of Iseyin LGA, Oyo State, Nigeria
Source: LAUTECH URP GIS Laboratory (2023)

Method of Data Collection and Analysis

The primary and secondary sources of data were used for this study. Reconnaissance survey and ground truthing were carried out in order to identify the existing locations and situations of the dumpsites in the study area. Primary data sources include direct observation of the existing dumpsites and administration of questionnaire to obtain useful information from residents in the study area. The study identified eighteen (18) existing dumpsites in the study area and they were all considered for direct observation. All households in Iseyin town constituted the sample frame. Total households of Iseyin town as extracted from 1991 National Population Census were 4,839 however, with its projection from 1991 to 2023 using growth rate of 2.8%, total households of Iseyin town in Iseyin Local Government Area were 11,710. The use of 1991 National Population Census for projection was premised on the fact that it is the only census that recorded number of households per given area. To arrive at the sample size, sampling ratio of 0.5% of the total households was used. The decision for the choices of 1% of all household was premised on assertion of Neuman (1994) that large population that is in its thousands permits smaller sampling ratio for equally good samples. Neumann's argument is that, as population size grows, the returns in accuracy for sample size shrinks. Also, Adigun (2012) suggested 0.05 percent as a good proportion for sample survey of larger population of 20,000. All 11,710 households in the area constituted the sample frame, and 1% of the total households, which approximately amount to 117 households constituted the sample size. Hence, the copies of questionnaires administered in Iseyin were 117. A multi-stage sampling procedure was used to collect primary data through questionnaire administration. In the first stage, the numbers given to housing units in Iseyin town for enumeration area demarcation for 2006 population census by National Population Commission, and a good proportion of newly

constructed buildings that were outnumbered were updated, and both compiled. From the compiled lists, required housing units were randomly selected. In the second stage, one of all matured persons aged 18 years and above was purposively interviewed in household of selected buildings from every selected residential building, one household was selected and one matured person from the household. There was, however, an exceptional case like multi-household buildings (more than one household occupying only one building): the household with longest stay in the residential building was selected. In a multi-building single household (a single household occupying more than one building), this is a common feature of the traditional Yoruba settlements as a result of the polygamous and extended nature of Yoruba families. If two or more residential buildings randomly selected were of multi-building single household, only one housing unit was used while others were skipped. In this case, only one questionnaire was used just like any other household, while the remaining questionnaires were used for the nearest unselected residential building(s) from a compiled list of housing units. It is equally noteworthy to mention that there were some cases where housing units selected were empty (either unoccupied or households not at home) such housings units were skipped to the nearest unselected residential building. Secondary data employed for this study includes using of GPS receiver to obtain the coordinate of existing dumpsite. Google Earth pro was used to extract the image of the study area and ArcGIS10.7 was used to carry out the spatial analysis of the existing dumpsite. Also, useful information about waste management was obtained from Local Government Authorities and also from Internet and Newspapers. Descriptive statistics was mainly used and tis included frequency and percentage to summarize findings and nearest neighbour analysis to determine pattern and arrangement of dumpsite in relation to their neighbours. Database design was created to take into consideration all the objects and their interrelationship within the spatial unit (Iseyin LGA) being considered. The design was carried out in such a way that maximum benefit could be derived from the result of database. The database design was taken through four different levels of abstraction as mentioned. Having designed a generic data structure and procedures, actual database implementation follows first by inculcating the designed data structure into the internal data model of the GIS software. Then database created was populated by inputting data collected. Phases through which database was taken are diagrammatically adapted after Kufoniyi's (2004) model as shown in Figure 3 with the explicit explanations thereafter to each level on how database was created and implemented to achieve the aim of this study

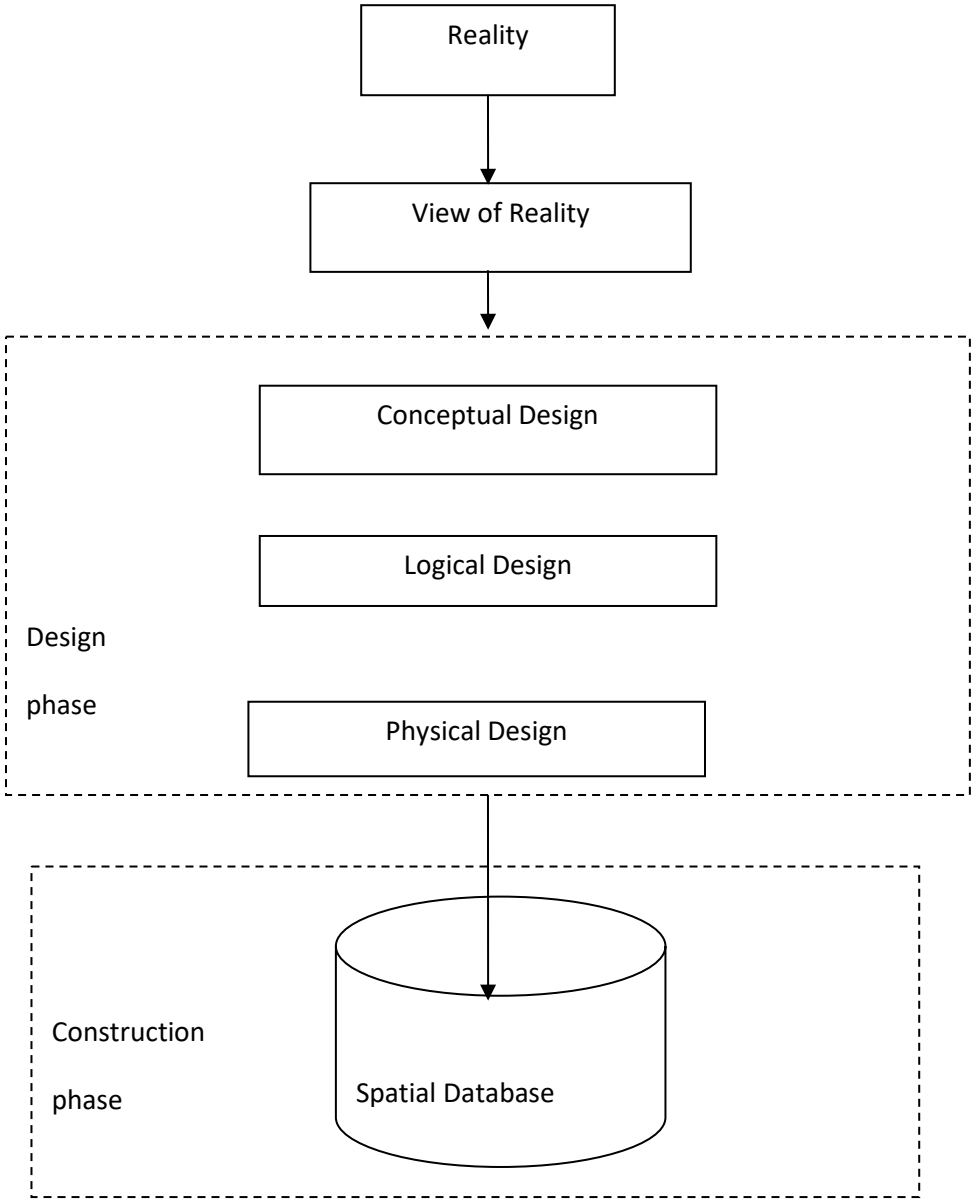

Figure 3: Phases of a Geo-database Construction (Kufoniyi, 2004)

View of Reality

After a careful thought of the problems for which the system was required and identifying all entries that take up the spatial unit of interest, the following entities will be identified as actual reality' i.e. as they exist on Iseyin town. A road was viewed as roads, locality as locality, boundary as boundary and dumpsites as dumpsites.

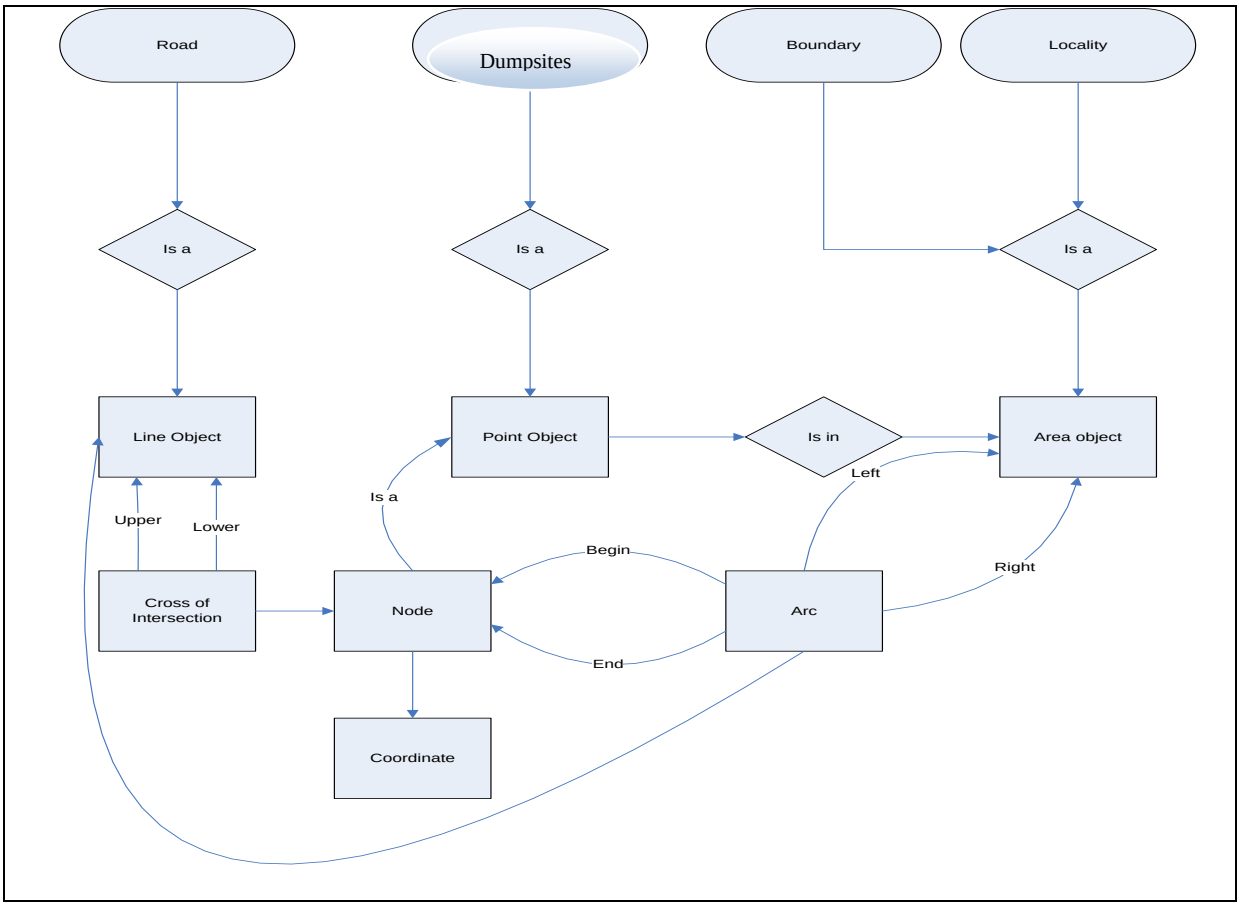

Figure 4: Geometric Representation of Spatial Entities in the Study Area
Source: Authors' work, (2023).

Conceptual Design

Here, the view of reality was represented in a simplified form. This is the human representation of the various views of reality. The entities identified were laid out and all their inter-relationship mapped out by using the extended entity relationship (E-R) diagram. E-R diagram is a modelling technique in the framework of Relational Database Management System (RDMS). Figure 2 shows an example of conceptual design of a waste management database using E-R diagram, based on a vector (topologic) data model. In the E-R diagram, rectangle represents entity and diamond represents relationship. Relationships were linked to their constituent entity types by arcs and the degree of relationship is indicated on the arc.

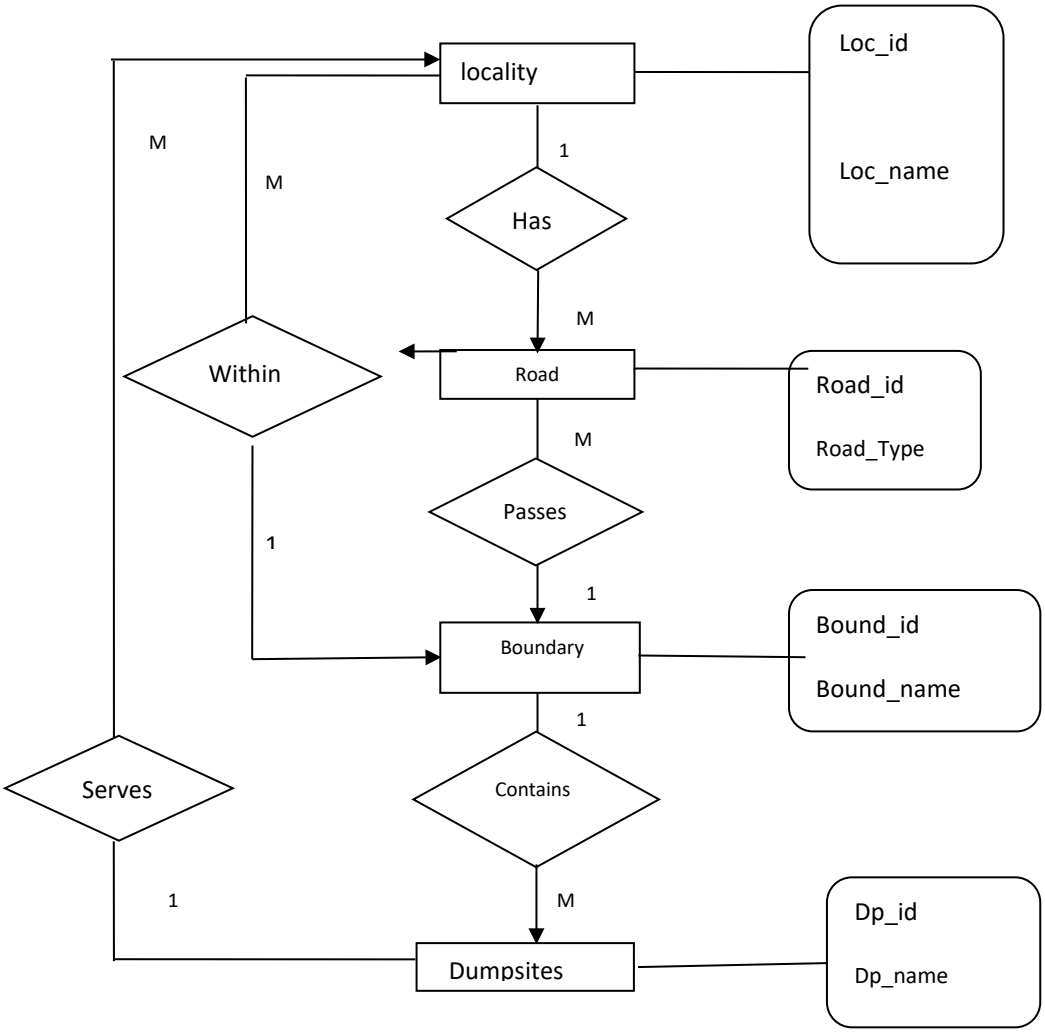

Figure 5: Entity Relationship Diagram
Source: Authors' work, (2023).

Definition of Entity

Boundary*:* A line which marks the limits of an area, in this context, it is the political unit under jurisdiction of local Government Area.

Locality*:* A distinct population cluster under jurisdiction of local government in which the inhabitants live in neighbouring set of living quarter or that has a name or a locally recognized status.

Enterprise Rules

Enterprise rules define the relationship between the entities and these rules are derived from the legislation, regulations and rules of best practice (Paresi, 2000). These rules are also derived from the norms of the organization, dumpsites serve as place for managing wastes in a society. Enterprise rules are the underlying rules governing how data elements in a system work together. These rules are usually determined from an in-depth understanding of how the data elements relate in the real world and these define how the data is going to be managed. For this waste analysis database, the enterprise rules are given below.

Spatial Enterprise Rules

A boundary must contain a dumpsite.

A boundary has many localities.

A locality has one or more roads passing through it.

One or more roads may pass through the boundary.

One locality has one or more dumpsites.

One dumpsite serves one or more localities

Logical Design

The conceptual data model was transformed into a data structure (tabular and spatial) upon which the data base system was implemented. The relational data model was used. A relational data model represents the data base as a collection of relations. A relational data model is one in which facts (real-world concept) are represented at a logical or abstract level. When relation was created, it was given a name. The type of attributes it has and what their respective domain was also indicated. This type declaration of a relation is known as relational schema. From entity relationship diagram, skeleton tables of the relational data structure are derived. The logical design stage was defined during physical design. The structure of these tables is presented below in Table 1. In the skeleton table drawn in the table 1 below the symbol * refer to primary key while ^{F} refers to foreign key.

Table 1: Skeleton Table

Boundary	bound_id*	bound_name	Bound_Lga	
Road	Road_id*	Road_type	Road_name	Bound_id^{F}
Locality	Loc-id*	Loc_Name	Road_id^{F}	
Dumpsites	Dp_id*	Dp_Coordinates	Dp_name	locality_id^{F}

Source: Authors' work, (2023).

Physical Design

At this stage, the data structure presented in logical design was presented in the language of the implementation software. The attribute tabular structured data generated in the logical design stage was actualized in the format of the implementation software. This includes definition of fields (numeric, text and string), record, length and type of record, etc., and setting some integrity rules that must be obeyed before data are acceptable into the records. This aspect also includes the data preparation and actual population of the database. The map data was geo-referenced and digitized in ILWIS 3.0 for the creation of different required layers. The spatial products of data format in ILWIS were thereafter converted to the ArcView (ESRI) shape file for using and adding database. Spatial acquisition of this research depicted in the table 2 below.

Table 2: Collection of Dataset and their Format Type

Feature	Spatial type	Format
Lga boundary	Polygon	Shape file
Locality	Polygon	Shape file
Road	Line	Shape file
Dumpsites	Point	Shape file

Multi-criteria for Identification of potential dumpsites.

To archive the objectives of this research, these formulated criteria were considered in selecting suitable site for waste disposal in the study area.

Table 3: Criteria for Optimal dumpsite Selection

Criteria	Least Suitable	Moderately Suitable	Highly Suitable
Distance to Water Body	160m - 480m	480m - 960m	> 960
Slope	10-15 degree	5-10 degree	0-5 degree
Distance to Residential Areas	> 2000m	1000m - 2000m	100m - 1000m
Distance to Road	300m - 500m	500m - 800m	> 8000m
Soil	-	Alisols	Nitsols
Geology	Quartzite	Migmatite-Gness Complex	Charnock /Granite

Source: Environmental Protection Agency (EPA) Landfil Manual 2006

Results and Discussion

Types and Nature of waste generated

The result from analysis revealed that, the common types of waste being generated in the study area were food waste 39(33.9%), Leaf/paper/sawdust waste account for 34(28.8%), cans/tins/bottles are 25(22.9%). From the result it can be affirm that majority of the waste generated by household in the study were food waste because it is more perishable than other types of waste, and it likely to rot and attract pest which can cause health hazard. See the summary in Table 4. Results from the analysis in Table 5 depict the classifications of waste generated in the study area. Out of 117 respondents in the study area, 61(51.7%) of respondents' waste are Biodegradable waste, followed by non-biodegradable waste which were 50(42.4%), while semi-Biodegradable waste being generated by respondents in the study area accounted for 6(5.9%). The study conducted in the study area fully asserted that, the most common classes of waste generated in the study area are mainly Biodegradable waste as it accounted for the highest percentage 61(51.7%).

Table 4: Types of Waste Generated

Variables	Frequency	Percentage (%)
Food waste	39	33.9
Cans/tins/bottles	25	22.9
Leaves/paper/sawdust	34	28.8
Nylon	7	7.5
Others	10	8.5
Total	117	100.0

Source: Authors' fieldwork, (2023).

Table 5: Nature of Waste

Variables	Frequency	Percent (%)
Biodegradable	61	51.7
Non-biodegradable	50	42.4
Semi-biodegradable	6	5.9
Total	117	100.0

Source: Authors' fieldwork, (2023).

Method of Waste of Disposal

There were different methods of disposing waste in the study area and included open dumps, large bin, compost, as illustrate in table 6; 56(47.9%), of the respondent dumps their collected waste on open dumpsite 37(31.7%) of the respondent dispose their collected waste on Waste bin, 21(17.9%) dispose their waste on water body while others dispose their waste on nearby bush and burn them in the night times. From this study it can be assert that respondents that was on opinion of open dump site has the highest percentage of 56(47.9%). According to some respondents, they complain that they don't have access to proper waste disposal facilities which made them to dispose their waste on open dumpsite.

Table 6: Method of Waste of Disposal

Variables	Frequency	Percent (%)
Waste bin	37	31.6
Open dumps	56	47.9
Inside water body	21	17.9
Others	3	3.4
Total	117	100.0

Source: Author's Fieldwork, (2023).

Waste Management Practice

There are different methods of managing waste which includes Compost, Landfill, Recycle, Reduce and Reuse. Analysis in table 7 reveals different method adopt for managing waste in the study area. Out of 117 respondents in the study area, 44(37.3%) of the respondent adopted Recycling method in managing their waste, Followed by Reuse method which account for 32(27.9%), 16(13.6%) of the respondent adopted compost making (conversion of wastes to manure or organic fertiliser) method to manage their waste, while 25(21.2%) of the respondent adopted landfilling (Getting rid of large amounts of waste by burying it) method in managing their waste. Based on the survey of this study it can be deduced that, the predominant method adopted by households for managing their waste are Recycling method 44(37.3%). See the analysis in table 7.

Plate 1: Evidence of Open Dumpsite at Atoori Area, Iseyin LGA
Source: Authors' fieldwork, (2023)

Table 7: Method of managing waste

Variable	Frequency	Percent (%)
Recycling	44	37.3
Reuse	32	27.9
Compost making	16	13.6
Landfilling	25	21.2
Total	117	100.0

Source: Authors' fieldwork, (2023).

The Distribution Pattern of Dumpsite using Geo-Spatial Techniques.

In this section, attempt was made to reveals the spatial distributions of existing dumpsites. Geographic information system was used to show the distribution of existing dumpsites in different locations in Iseyin town. These locations include; Oke-adeta, Isale-ogunbado, Odo-olowo, Itan, Ekunle among others. The coordinates of the existing solid waste dumpsites collected during fieldwork were imported from Microsoft Excel into the ArcGIS 10.1 as a text file then converted to shape file to show the location of the dumpsite. The points were over laid on the result. This assisted in finding out if the existing dumpsites within the study area were properly sited or not. From the result derived in Figure 1.2, it could be deduced that none of the existing dumpsites within the study area was properly located. In order words, none of them met the stipulated standard and criteria for sitting of dump site, for example: some of the existing dumpsites were located near environmental sensitive area, such as hospital, schools and abattoirs among others. The description of the location, Coordinates of each existing dumpsite within the study area were shown in Table 8, while the Nearest Neighbour analysis result was presented on Table 9.

Table 8: Distribution of Geometric Location of Existing Dumpsites in Iseyin town.

Dumpsites Point	Location Description	Latitude	Longitude
DP1	Opp. Iseyin to okeho road Bolajoko, Iseyin	562353.45 m E	882628.19 m N
DP2	OgbakutaIseyin	562977.62 m E	882504.59 m N
DP3	Along Iseyin to Saki Road, Custom, Iseyin	564220.05 m E	882300.60 m N
DP4	At the back of Anwarulprysch. Ori-Eeru, Iseyin	565125.73 m E	881951.45 m N
DP5	OkeAdeta.	565243.00 m E	882029.00 m N
DP6	Along oluwole market road, Oke-adeta, Iseyin.	565236.40 m E	882022.13 m N
DP7	Irawote area, isaluiseyin	565232.81 m E	882231.69 m N
DP8	Beside Agbeniga house, OdoOlowoIseyin.	565174.45 m E	882473.99 m N
DP9	Along Iseyin to ikere road Isale-OgunbadoIseyin.	565543.96 m E	882402.53 m N
DP10	Opp. Itanroad,Iseyin	565678.62 m E	882022.13 m N
DP11	At the back of Itan sacred area, ItanIseyin.	565868.63 m E	882044.45 m N
DP12	Along barrack road, AtoriIseyin	566654.67 m E	881450.08 m N
DP13	Ansarudeen, primary sch. AtoriIseyin	566659.59 m E	881063.86 m N
DP14	Ode Basorun area	566649.30 m E	880604.22 m N
DP15	Along Iseyin to Oyo Road Anglican Iseyin	566920.57 m E	880507.08 m N
DP16	Within Ebedi market premises.	567639.26 m E	879828.35 m N
DP17	Ekunle area	565293.42 m E	880155.25 m N
DP18	Oke-oja along sagbo-ilado road	565539.38 m E	880931.97 m N

Source: Authors' fieldwork, (2023).

Table 9: Complete spatial randomness of dumpsites in the study area

Results	
The size of the area (A)	1380835691.7sqm
Number of Dumpsites (n)	18
Observed Mean Distance	429.7075
Expected Mean distance	4379.3006
Z- score	-7.320061
P.value	0.0000
Nearest neighbor Ratio (Rn)	0.098122

Source: Authors' fieldwork, (2023).

Note: Rn= 2d√n/A

Rn= the nearest neighbour index

A= the size of the area

d = mean distance between dumpsite

n= the number of dumpsites

Rn= nearest neighbour Ratio value=0.098122*0*

A p-value of 0.0000 typically suggests strong evidence against null hypothesis. In this context of a dump site distribution, the observed pattern is significantly different from what was expected by random chance alone. The nearest neighbour ratio of 0.098122 indicates that the dumpsites were clustered closer together than expected in a random distribution.

Suggest Suitable site for Waste disposal

Proposed dumpsite

In carrying out optimal dumpsite selection, multi-criteria for Identification of potential dumpsite obtained from 2006 Landfill Manual of Environmental Protection Agency (EPA).is used. See Table 3. Two (2) final dumpsites were created in the study area, the first final dumpsite was proposed at paago along Iseyin-Okeho road with 500m distance away from the major road link Iseyin-Okeho town. Coordinate: Latitude (564167.02mE, 876671.76mN).

Second final waste disposal was proposed at Paanu along Akinwumi-Osoogunroadwith500m distance to the major road that link Iseyin-AkinwumiOsoogun town. Coordinate: Longitude (557676.54mE, 886577.80mE.).

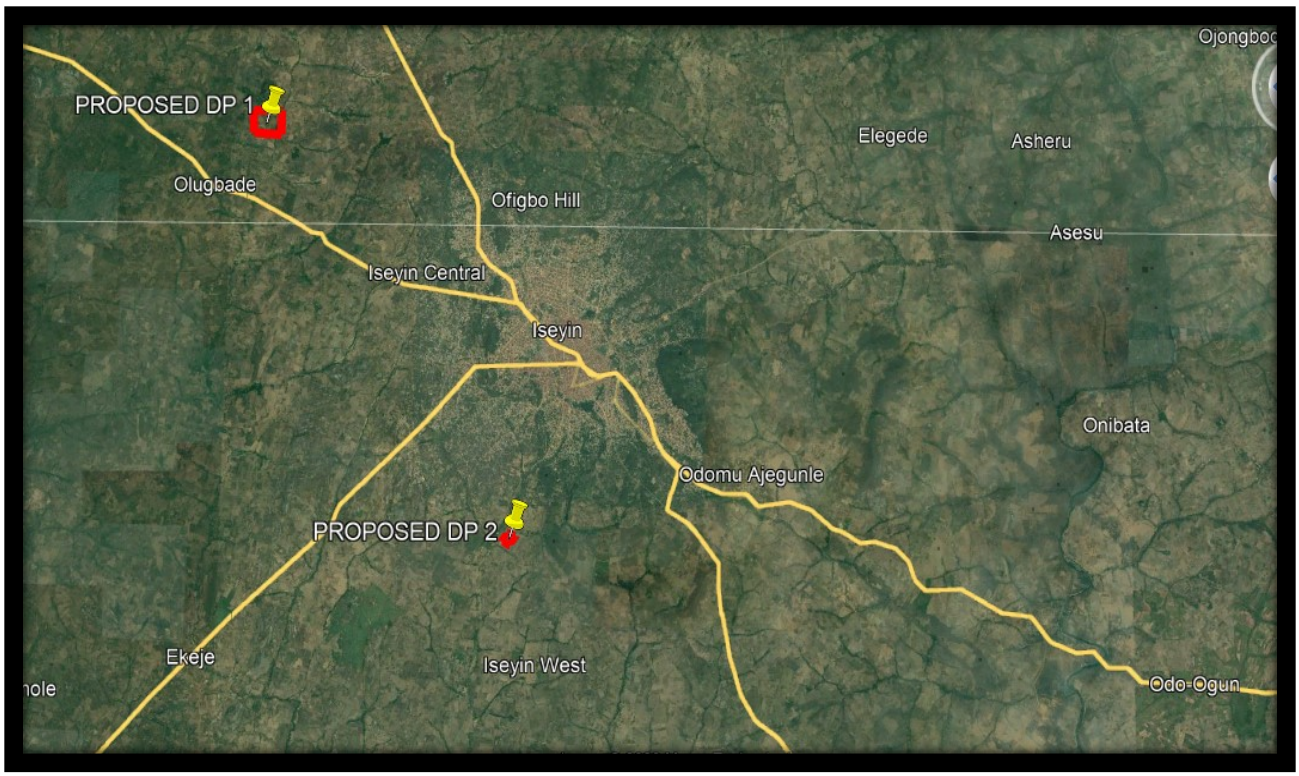

Figure 6: satellite Imagery showing location of proposed dumpsite 1 and 2 in the Study Area
Source: Authors' Fieldwork, (Google Earth pro, 2023).

Terrain Consideration for the Proposed Dumpsite 1 and 2

Generally, the elevation of a dump site is determined by the terrain and geography of the area. For example, if the dump site is located in a valley, it may have a lower elevation than if it were located on a hill or mountain. The elevation of the dump site may also be affected by the presence of any nearby bodies of water, such as a lake or river, as these can affect the local topography. From the field survey and analysis that was carried out on ArchGIS in respect to Elevation of the proposed site, the result show that 20% of the study area is most suitable for location of final dumpsite, while remaining 80% of the area is unsuitable due to rugged relief pattern of the study area. The lowest elevation of the proposed site 1 is 200m above sea level while the highest elevation is 337m above sea level and the elevation of the final waste disposal site 2 is ranging from 250m-257m. The slope of the proposed dumpsite 2 is more gentle in nature and that its degrees ranges from 0^0--10^0. It should be noted that the altitudes of places above sea level vary. The highest altitude of area A may be the lowest for Area B. Attitude therefore has no direct relationship with degree of slope.

Slope analysis

A slope can be defined as an inclined surface of a hill, mountain, plateau, valley, plain or any part of the earth surface. Slope of a map is typically represented by the ratio of vertical change (elevation) to horizontal distance. It can also be expressed as the difference in elevation between two points divided by the horizontal distance between them It is a remarkable and fundamental feature of the earth's surface form. Apart from being an important component of the landscape, slopes impart the geometrical qualities which determine the characteristics of the landform complexes or regional landscapes (wikipedia.com). Moderately, steep slopes range from 10^0 to 15^0 and can only be used with difficulty, at greater cost and only by manual labour of land excavation and cutting. Figure 7, 8, 9 and 10 reveals the slope analysis of proposed dumpsite 1 and 2 in the study area. While Figure7 and 8 reveal the slope analysis for proposed

dumpsite 1 while Figure 9 and 10 reveals analysis for proposed dumpsite 2. The higher the gradient the thicker the colour as depicted for the analyses. When analysing the topography map, the slope ranges from 0^0 to 15^0 is said to be gentle and above 15^0 is steep. Proposed dumpsite 2 is considered to be more suitable than dumpsite 1 because it has lower gradient. The reason for chosen these particular locations is that, it will help in prevention of contaminant run-off as being stated by Erkurt and Moran, (1991). The proposed location for dumpsite 1 is gentle slope in nature as shown in figure 8 while proposed location for dumpsite 2 is more gentle and very flat in nature which means it is more suitable for locating dumpsite compare to proposed location 1 in the study area.

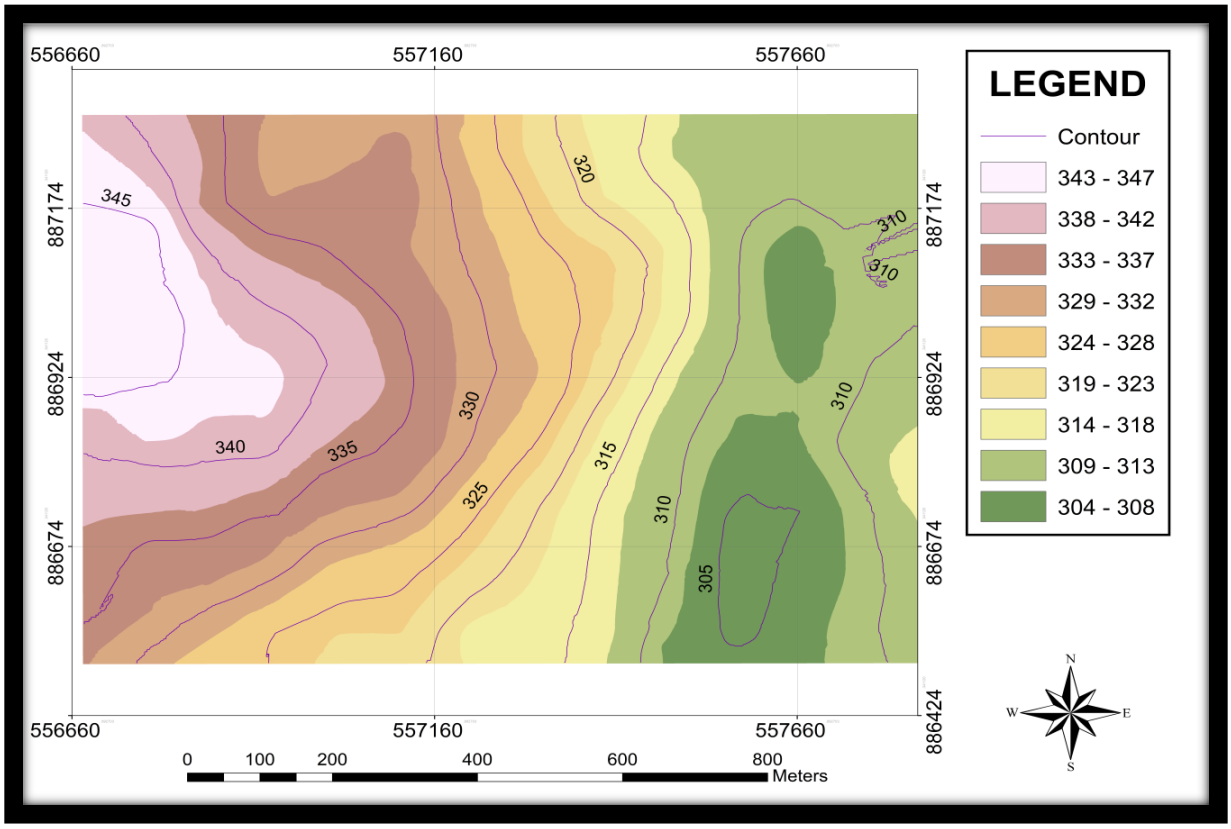

Figure 7: Elevation analysis of Proposed Dumpsite 1
Source: Author's Fieldwork, (GoogleEarthpro,2023).

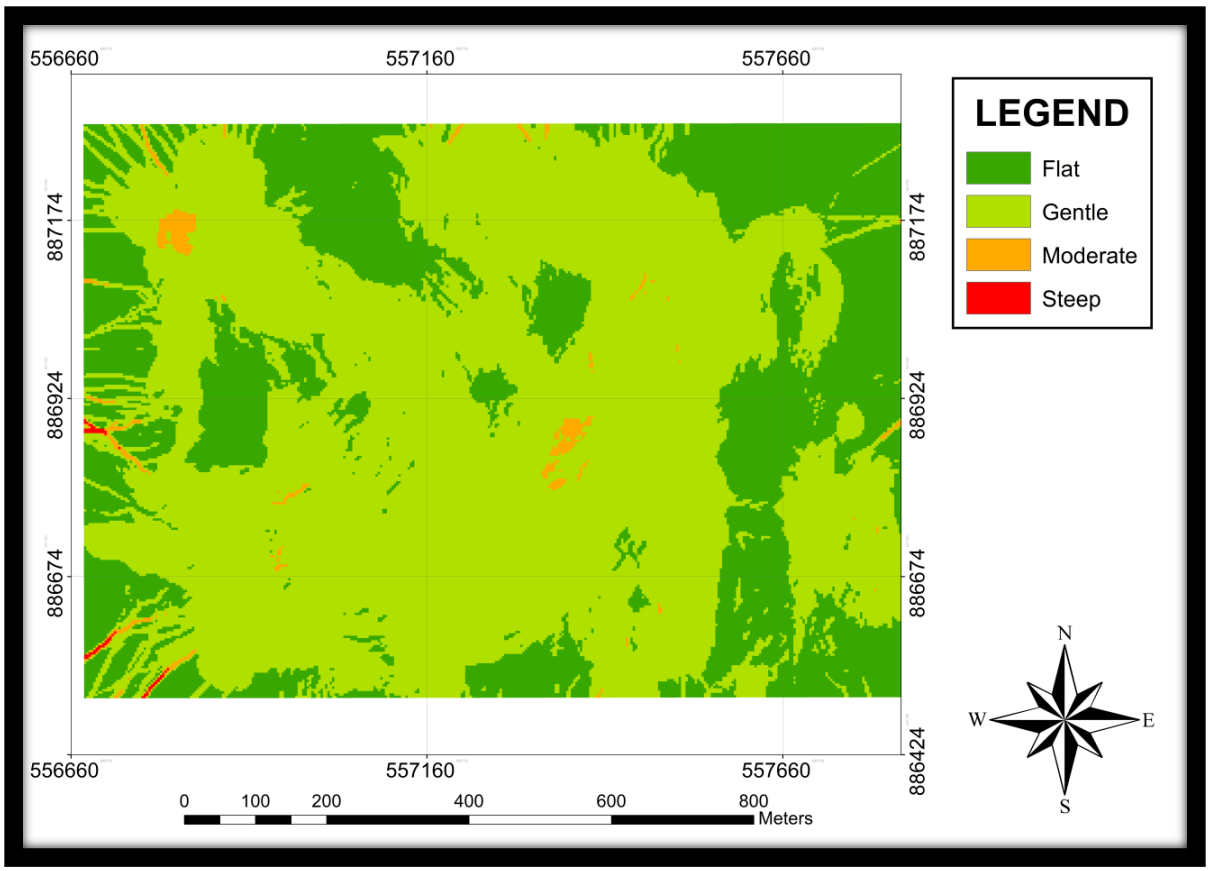

Figure 8: Slope analysis of Proposed Dumpsite 1
Source: Author's Fieldwork, (GoogleEarthpro,2023).

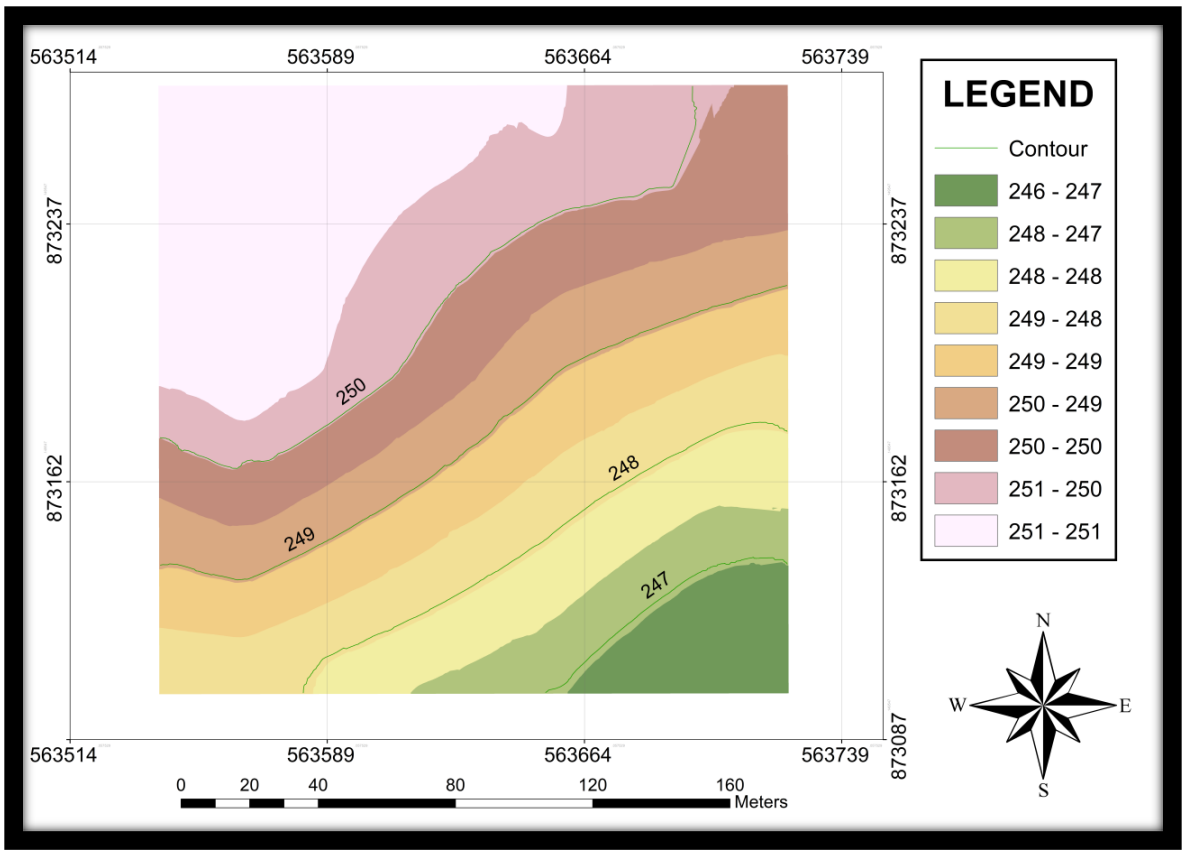

Figure 9: Elevation Analysis of Proposed Dumpsite 2
Source: Author's Fieldwork, (GoogleEarthpro,2023).

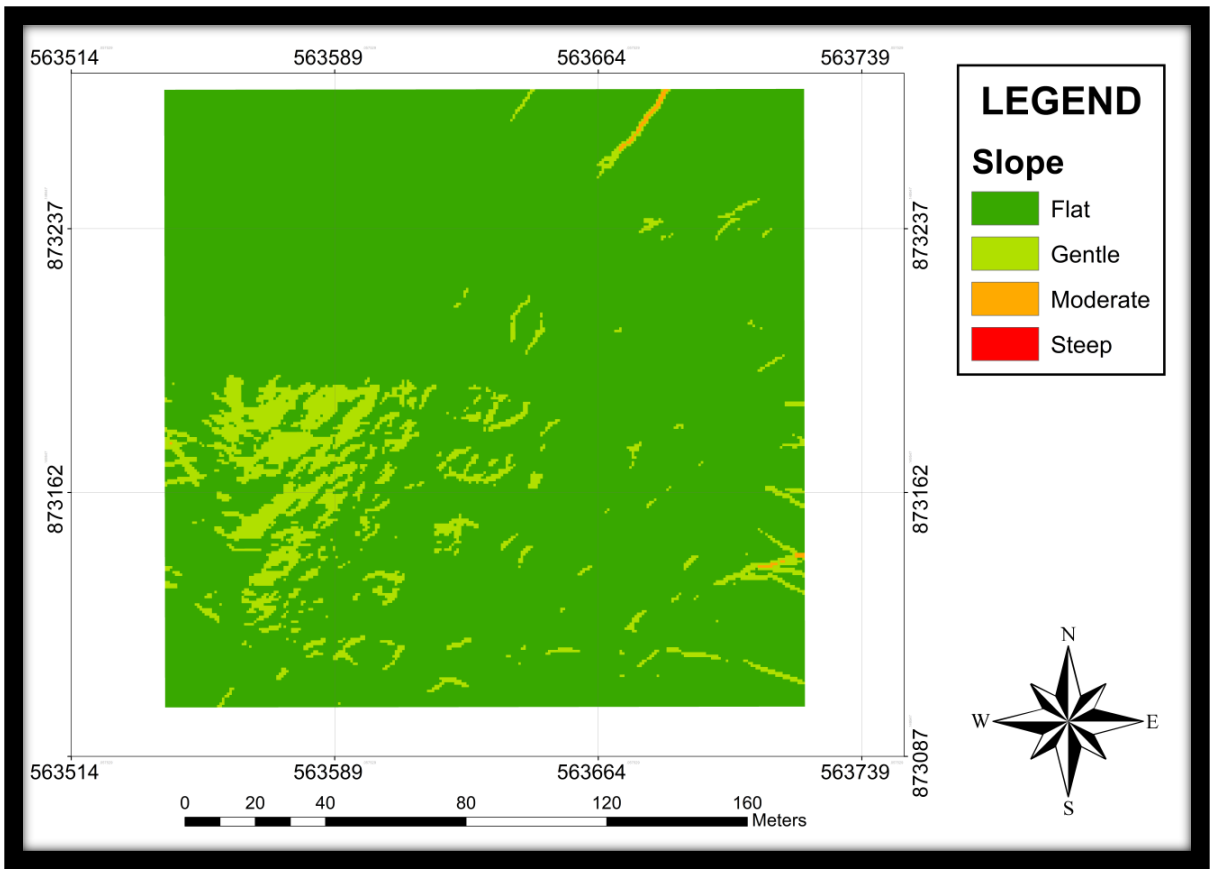

Figure 10: Slope Analysis of Proposed Dumpsite 2
Source: Author's Fieldwork, (GoogleEarthpro,2023).

Soil Properties for Proposed Dumpsite 1 and 2

Soil properties of the proposed final dumpsite is clay soil in nature, one of the major reasons for chosen clay soil is that it has high retention capacity to the extent that when waste like sludge waste is disposed on it, it will retain it and provide ground water protection against waste contamination and it is also economically cheaper in term of construction. Though the amount of clay that present in the proposed site is not adequate but it is recommended that clay can be transported to the site in order to maintain water quality according to Erkut& Moran (1991) and Dorhofer& Siebert (1998).

Proximity toWater SourceConsideration

From the research, it was observed that there are two major rivers in the study area namely: Odo-ogba River and Odo-ogun River which flow southwards direction of the study area, for this reason the proposed final dumpsite was sited 1000m away from the water body in accordance with dumpsite location criteria. It can also be deduced from Erkurt and Moran (1991) that dumpsites create noxious gases and leakage that make them unsuitable for to be in proximity to water surface. So therefore, the proposed site for final waste disposal was carefully selected for sustainability of the people. According to previous study and dumpsite location standard, 20% of the study area is suitable for final waste disposal and the proposed site is more than 400m to Odo-ogba River, and other irrigational canals.

Land ValueConsideration

As being reviewed from Baban and Flannagan, (1998), made it understood that public opinion is of paramount important in order to create avenue for community or association to express their mind. From the research and field survey, the site is free from land uses such as agricultural land use or Industrial land uses, the land is of low economic importance.

Distance from Population Centre/ Residential Areas Consideration

According to Ekurt and Moran (1991), and Lober (1995), and Kao lin (1996), final waste disposal must be sited far away from population centre. The proposed final dumpsite is 5km (5000m) away from town centre, see Table 3 depicting EPA multi-criteria. The road network in the study area comprises of two categories of road in the study area, the first category of road includes Major Road that comes from Oyo town and Ibadan and intersect each other at Kilometre 1 of the study area and then passes through core area of the town which then divide and at Oja-oba and later link Iseyin –Abeokuta, Iseyin- Saki, Iseyin-Ikere, Iseyin - Okeho township. The breadth of the major road is 18m wide with little or no drainage cover. Second category of road in the study area is access road or secondary road and it is 8-9m wide. This road passes through different locality in the study area as shown in figure 11. These two categories of road serve important function in the study area in terms of their socio-economic characteristics and other social life. The primary road or first categories of road were linked to proposed Dumpsite to ensure proper management of dumpsite in the study area. Buffer zone for the dumpsite was proposed in order to prevent pollution that may emanate from waste disposal to the nearby villages.

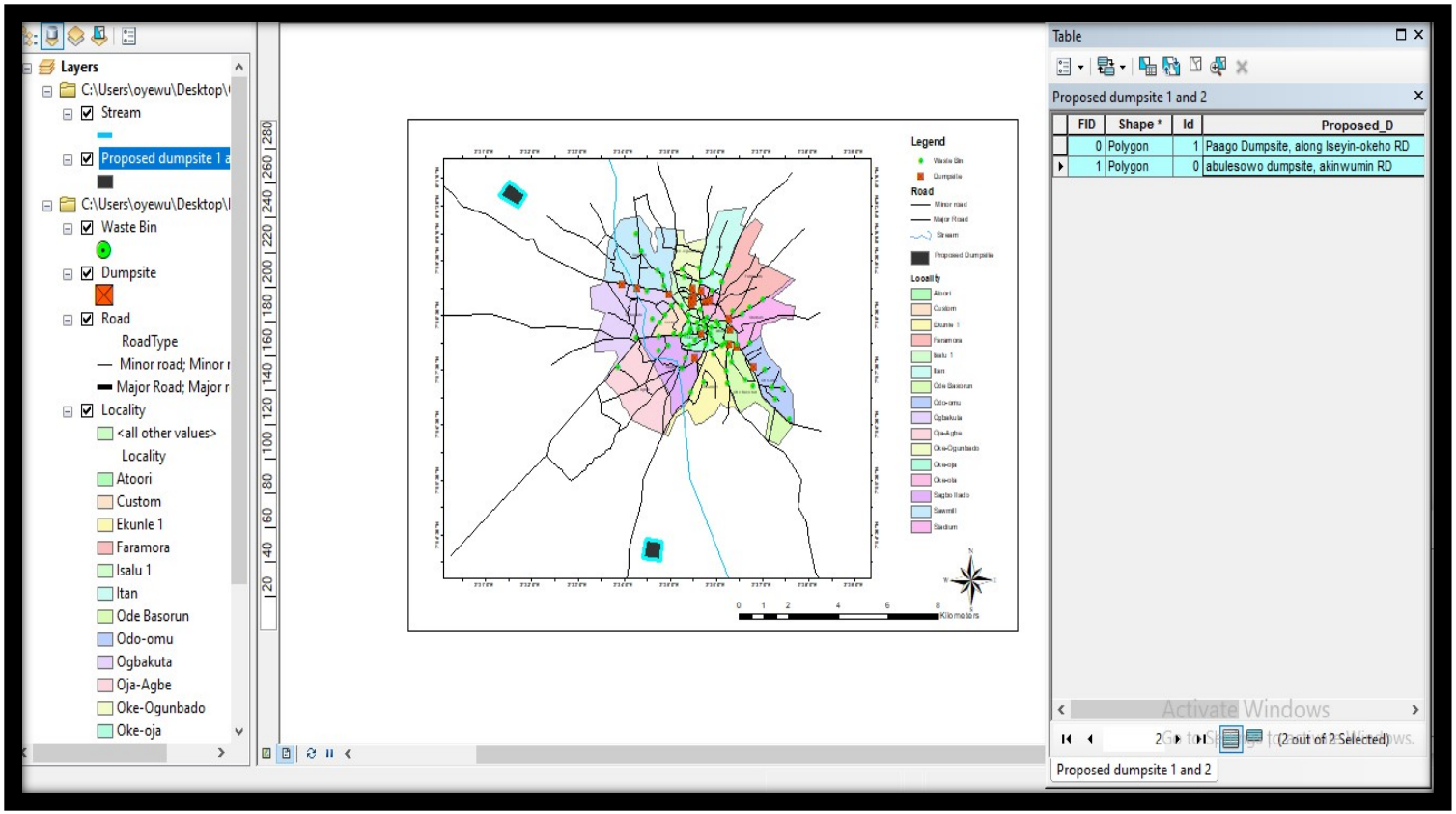

Figure 11: Query result showing Proposed Dumpsite 1and 2 for the study area
Source: Author's Fieldwork, (ArcGIS, 2023).

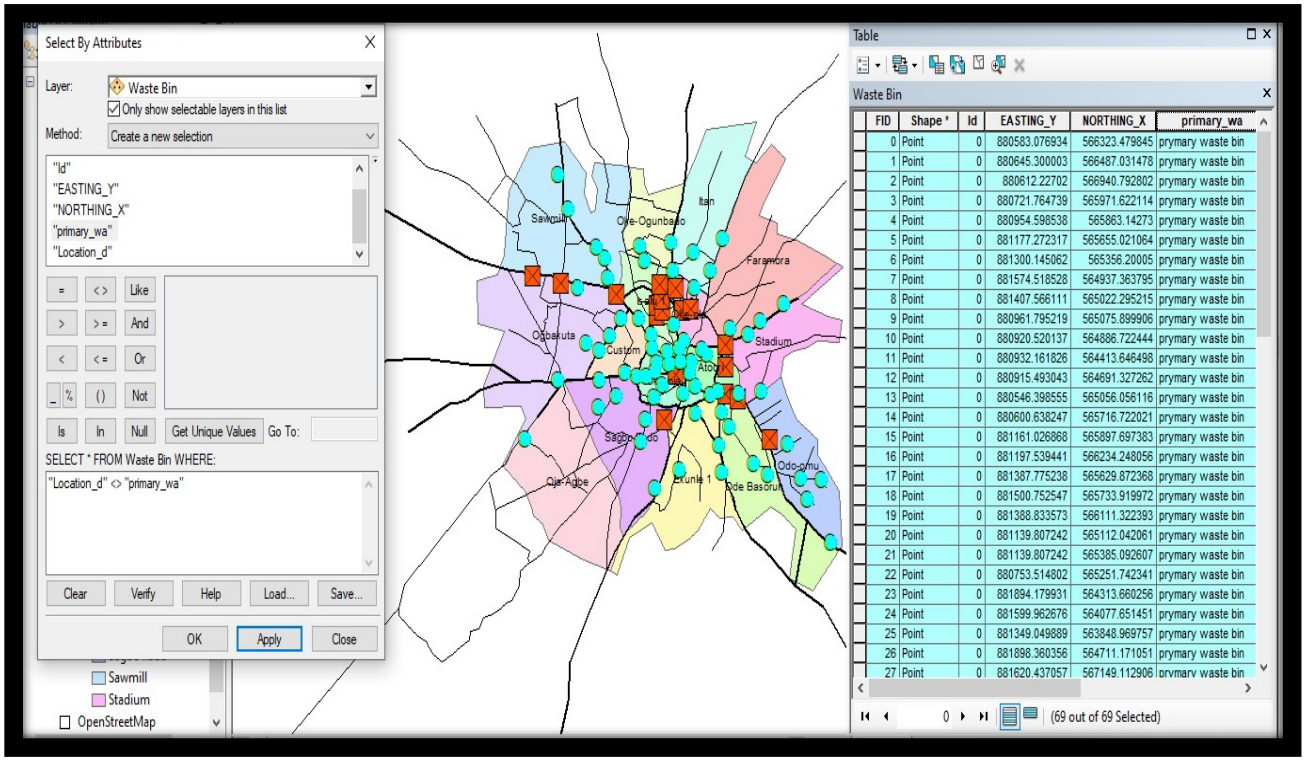

Figure 12: Query result showing proposed waste bin within the built-up area of Iseyin town

Source: Authors' fieldwork, (2023).

Figure 10 reveals the query result of primary waste disposal unit within the study area. In addition, each waste bin is located 100m away from environmental sensitive area such as water bodies, hospitals, and school etc. this is necessary as waste bin situated close to water bodies aids in pollution of the water bodies. Therefore, waste bin is discouraged from being positioned near sensitive area.10m away from road side and 20m away from waste producing areas. The purpose of proposed waste bin for the study area is to discourage illegal disposal of waste on environment, to increase the aesthetics value of the environment of the study area, to reduce health hazard and other environmental relating problems associating with waste disposal.

Furthermore, this proposed waste bin will also make the proposed dumpsite as discussed earlier to thrive well and it will make the management of the dumpsite a unique one because it will easy for waste collector to transport it to the final disposal unit which Dumpsite.

Conclusion

From findings 33.9%, 28.8%, and 22.9% of households attested respectively to food waste, leaves/paper/sawdust and can/tin/bottles, as the common types of waste generated and they were mainly (62.7%) bio-degradable in nature. The prevalent methods of disposing waste as mentioned by households in the study area were open disposal (47.9%), followed by usage of waste bin (31.6%), while disposal on water bodies were (17.9%). Waste disposal methods in the area were characterised with recycling, reuse, compost making and landfilling and recycling was said by majority (37.3%) as main method. From the analysis, the nearest neighbour ratio (Rn) from complete spatial randomness of 18 existing dumpsites was 0.098122 with a p-value of 0.0000 that typically suggested strong evidence against null hypothesis. In this context of a dump site distribution, the nearest neighbour ratio of 0.098122 indicated that the dumpsites were clustered closer together than expected in a random distribution. The study concluded that existing dumpsites were not evenly distributed in

the area. Enhancing the integration of machine learning algorithms withn GIS and Remote Sensing is considered for future studies for more accurate and efficient site selection. Additionally, the socio-economic impact of the chosen sites has to be explored to ensure sustainable development.

Planning Policy Remark

Based on the results, the study therefore underscored the needs for application of geospatial techniques for both public and private waste management agencies (contractors and organization involved) as it plays a crucial role in providing valuable insights and tools for decision making in waste collection and siting dumpsites. Also, it recommended that the Environmental Department of the Local Government Areas within the study area and the Town Planning Authority to 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. This study also remarks to prioritise community engagement to gather local knowledge and establish transparent criteria for site selection. It also emphasises the need for adaptive policies that account for changing environmental conditions and encourages regular monitoring to address any unforeseen challenges to the selected sites.

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