International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

The Use of Geoinformatics Techniques in Site Selection for Solid Waste Dump: A Case Study of Warri and Environ

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Abstract: ***The study portrays the potentials and efficiency of Geoinformatics techniques in accessing the most suitable site for solid waste disposal. The study area is Warri and its environ in Delta State, Nigeria. The data set used for the study include; Satellite imagery (Landsat) covering Warri at 30 meter resolution of 2010, road Map of the study area, facility and topographic maps of the study area. The layers created include those for roads, water bodies, residential areas and the slope map of the study area to determine the degree of slope. The various created layers were subjected to buffering, overlay and query operations using ArcGis 9.3 alongside the established criteria for solid waste site selection. The result shows that only three out of twenty five identified open spaces in the study area met the criteria for solid waste dump site***

Keywords: Waste, Geoinformatics, Dump site, Selection, Leachate,

1. Introduction

Solid waste is a major public health issue and a vital factor that has led to environmental problems facing us today.Heaps of various sizes of solid wastes dumps are seen on the streets roads, blocking drainage channels, backyards of residences, undeveloped plots, and open spaces in front of commercial area. Modern refuse collection facilities are needed across the country and in the study area in particular for effective solid waste management. These range from hauled-container system known as drop boxes to stationary container system.

The selection of a dumping site (landfill) is a big question that faces local authorities because it represents a point of confluence of science, social science, and planning (Habital, 1987). Urban planners and city managers throughout the world are now confronting this issue within a much broader social development context. "Not in my backyard" may be the mantra facing decision makers as the volume of solid waste generated in rural and urban areas increases (UNEP, 1996; Nishanth et al 2010).

According toNigerian Environmental Study and Action Team (NEST) (1991), waste is divided into three; gaseous, liquid and solid. Gaseous waste can be said to be any uncontained airborne emmissions and effluents that may consist of particulate matter, dust, fumes, gas, mist, smoke or any combination. Liquid waste means the discharge of wastewater from any residential or commercial unit; liquid waste includes without limitation to human excreta and waste carried from plumbing fixtures, including but not also limited to waste from toilets, sinks and floor drains.

This study limits itself to solid waste alone which are materials or objects discarded as worthless or unwanted human economic productive activities. Among the factors governing the selection of the dumping site are:

- Institutional factors such as restrictions by local authorities for dumping due to other priorities.
- Economical factors such as dumping site should be at minimum distance from roads so that collection vehicles can travel through the optimum route.
- Environmental factors such as noise contamination due to trucks movement; soil, surface water, and groundwater contamination due to leachate; and atmospheric contamination due to emission of carbon dioxide (CO_2) and methane(CH_4).

There are few or no collective household receptacles for tenants and landlords to use for regular waste control disposal likewisethere are very few or no designated zones along neighborhood streets to dispose household wastes in the study area.In the emanating confusion, regardless of the impact of infrequent environmental sanitation exercises, urban residents in the study area dump solid wastes carelessly or haphazardly – anywhere they deem fit. Such controversial tendencies and attributes would seem incomprehensible; if we desire to live in beauteous environments. Rapid urbanization has increased the amount of wastes produced and the incessant pressure on the environment with the externalities of the development undoubtedly poses threats to sustainable development of the people and economy (Geoffrey, 1999; Olawepo, 2000)

Issue of site selection of activity is a recurrent one in spatial field or environment. One of the objectives of selecting a suitable site for any project is to reduce capital required for site development. The choice of the best site for an activity such as solid waste dump in Warri, Delta State will be well defined criteria using Geoinformatics techniques would support cost effective and environmentally sound site development based on the criteria proposed by Star and Estees,(1991).

Geographic information system (GIS), as a spatial decision support tools (Onosemuode et al, 2010 and Eastman et al. 1993), can be used to select the appropriate and best site for location for solid waste dump for Warri. Geographic information system (GIS) is a spatial based information

system that provides a means to model real-world objects through their geographic location linked to database providing attributes information (Davidson, 1996, **Onosemuode et, al.,** 2013).

The increase in the volume of range of solid waste generated daily in Warri due to domestic, commercial, industrial and administrative activities and unsanitary condition in which the solid waste is disposed off on streets, streams, behind residences, on the path way, etc has contributed greatly to the environmental degradation of the town, so there is an urgent need for selection of proper site for solid waste disposal in Warri using GIS and remote sensing. It is this urgent need for proper solid waste disposal site that has necessited this research work.

2. Materials and Methods

Data Acquisition

The data set used for this study were mainly secondary and are;

- Satellite imagery (Landsat) covering Warri at 30 meter resolution of 2010
- Road Map of the study area
- Facility map of the study area
- Topographic map of the study area
- Existing literatures and journals.

ConceptualDesign

The view of reality is the mental abstraction for a particular application or group of application.

It is the representation of a human conceptualization of reality. In this study, vector representations were widely exploited. The basic entities and attributes were residential area, road and water body, each entities have its attributes. And data sets were shown on different layers for example; boundary, road, residential area, water body and suitable sites for solid wastes dump.

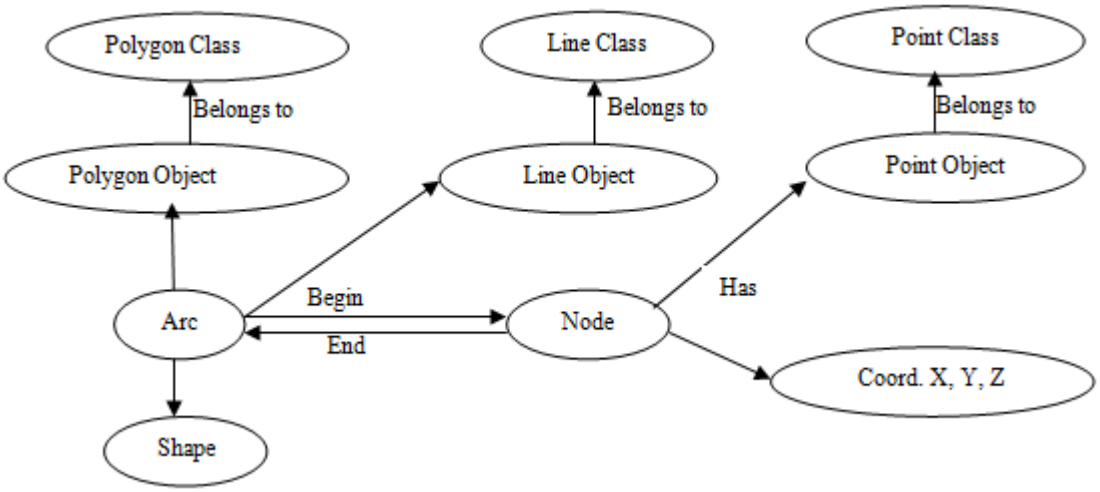

Figure 1: Data Model for Value Vector Map

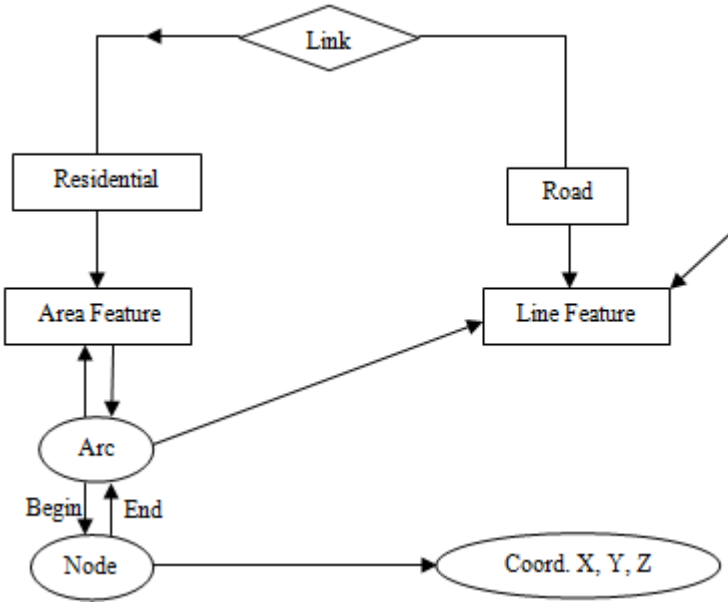

Figure 2: Entity Relationship Diagram

Data Processing Procedures

The data processing procedure is based on the cartography model on figure 3. Cartographic model is a graphic representation of the data and analytical procedure used in a study. It is the process of linking or organizing basic analysis operation in a logical sequence such that output from one is the input to the next.

Cartographic model is the use of basic GIS manipulation functions in a logical sequence to solve complex spatial problem.

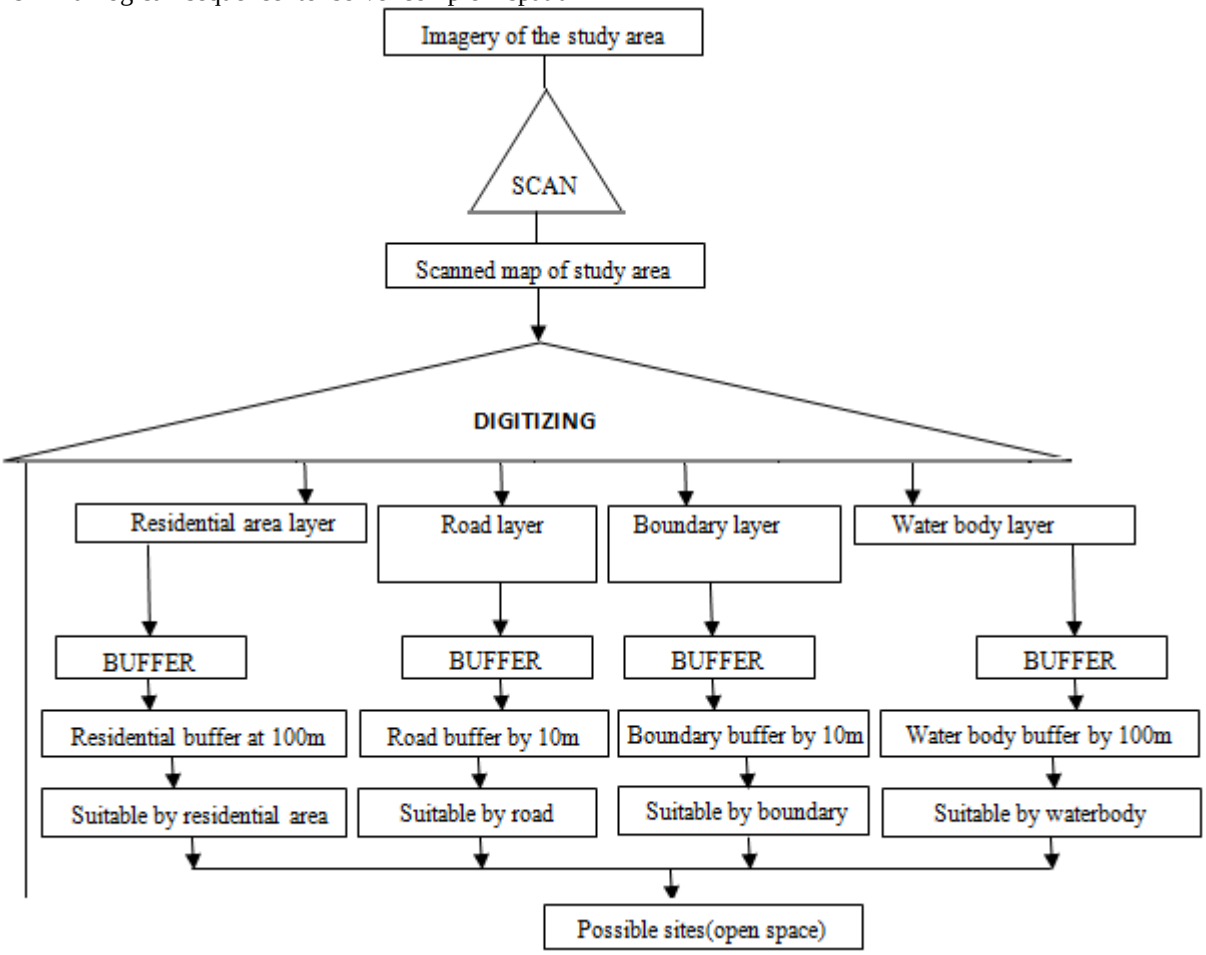

Figure 3: Cartographic model illustrating the task sequence.

Presentation and Discussion of Results

Criteria for Site Selection

The following criteria are set for the fulfillment of site selection for solid waste dump

1) The preferred land use is an open space.
2) The site must be at least 10m from existing road.
3) The site must be at least 100m from Residential, Educational and Administrative areas.
4) The site should be located on a terrain with a slope less than 20°to prevent erosion and insecure accessibility.
5) The waste dump should be greater or equal to0.5 hectares
6) The site must be at least 100m from water sources.

Buffer Operations

Buffer operation is a spatial operation that is concerned with the determination of spatial proximity of various spatial features. In this study, application of buffering for analysis of area that are greater than 100m from Residential, Academic, Recreational,Religious and Administrative areas,10m from all existing roads, and 100m from existing water sources. The results obtained were displayed in figures1 to 3below.

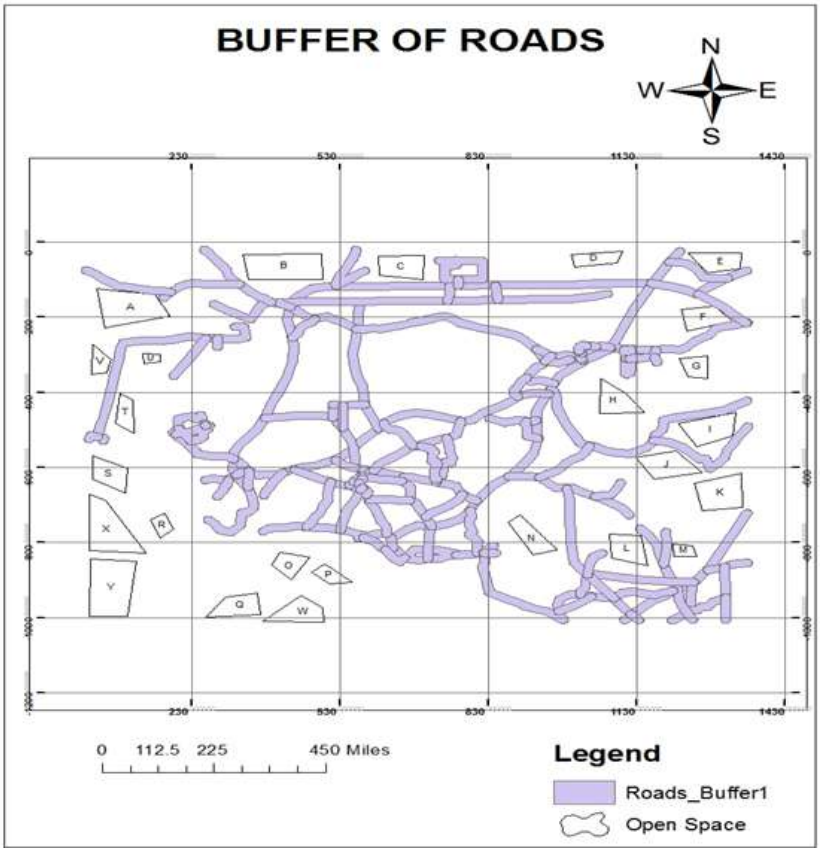

Figure 1: Map showing buffer operation on existing roads at 10m buffer distance

From the resulting map in figure 1 above, it can be observed that all the open spaces meet this creterion (site should be 10m away from existing roads).

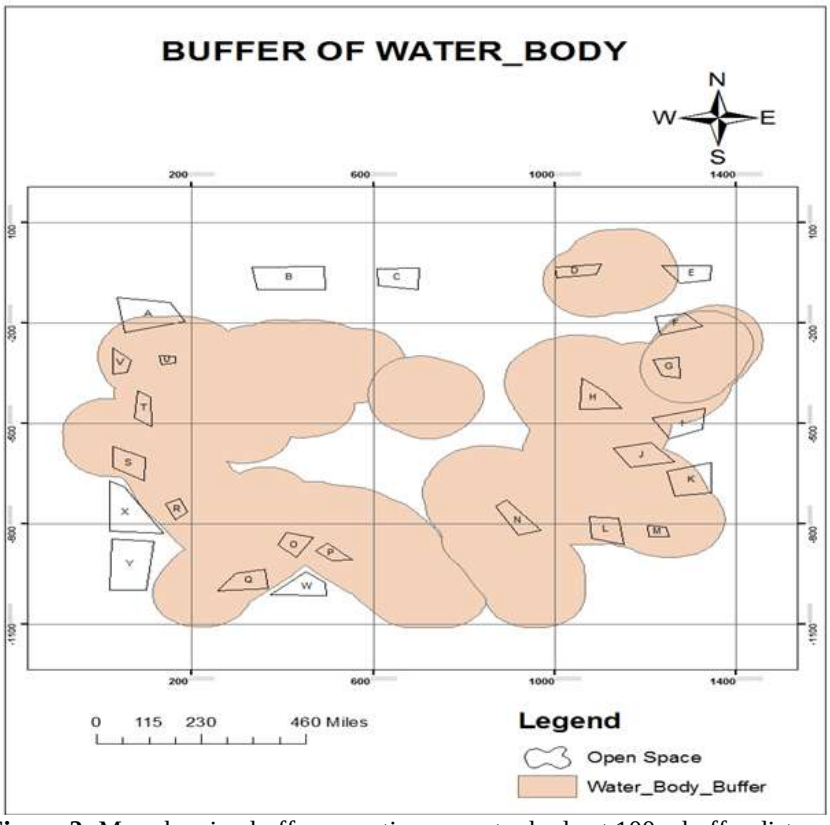

Figure 2: Map showing buffer operation on water body at 100m buffer distance

From figure 2 above, only open spaces **B, C, W, X** and **Y** met the creteria that dump site should be 100m away from existing water bodies.

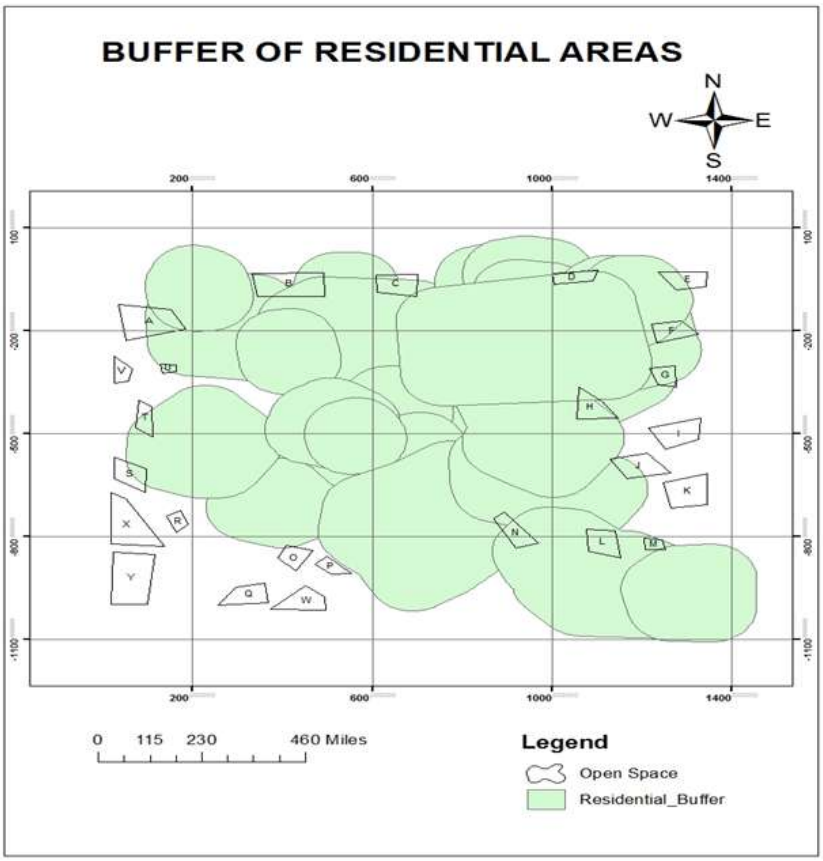

Figure 3: Map showing buffer operation on residential area at 100m buffer distance

Figure 3 above shows that open spaces **I, K, W, Q, V, X** and **Y** met the creteria that sites should be 100m away from residential areas.

Slop Generation

Arc GIS 9.3 version of GIS software was used to generate the slope map from the existing raster image of the study area. Draping in of colour was introduced to enhance visualization and location of suitable site in the study area as shown in figure 4.

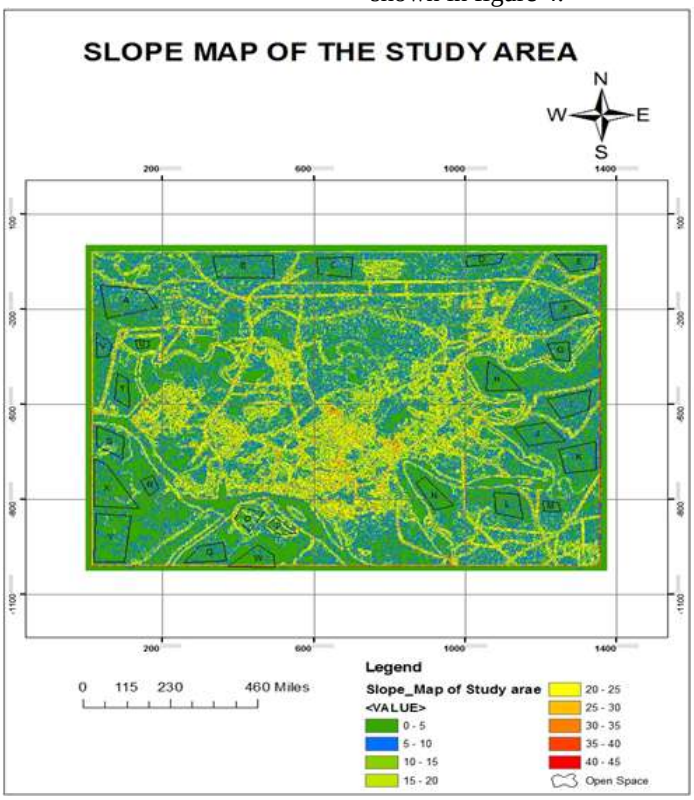

Figure 4: Map showing the slope of the study area

The map in figure 4 above shows the different slope area and their value in degrees for the study area. Values ranging from 0^0 to 20^0 are those that are acceptable for the location of dump site. Values ranging from 20^0 to 45^0 are not suitable for the siting of dump sites. Open space was virtually overlaid on the slope map to see areas that has slope of less than 20^0 and these include open spaces; Q, S, W, X, Y (Figure 4). This was done so that the sites would be prevented from erosion and insecure accessibility. The open spaces were hollowed to allow visual inspection of sites that meet the slope creteria.

3. Overlay Operations

Overlay operation allows combining two different layers by applying the set theoretic operation of intersection. In this study, overlay operations was carried out with the use of Arc GIS 9.3 software, and following erase functions were carried out;

1) The layer containing buffered residential area was overlaid on the layer containing the boundary to giveboundary_erase layer. (See fig. 5).
2) The layer containing buffered water body was overlaid on the result above (i.e. boundary_erase layer) to giveboundary_erase_erase layers. (See fig. 6).
3) The layer containing buffered roads was overlaid on the result from above (i.e. boundary_erase_erase) to give boundary_erase_3. (See fig. 7).
4) The layer containing buffered boundary was then overlaid on the result above (i.e. boundary_erase_3) to giveboundary_erase_4 layer. (See fig. 8).

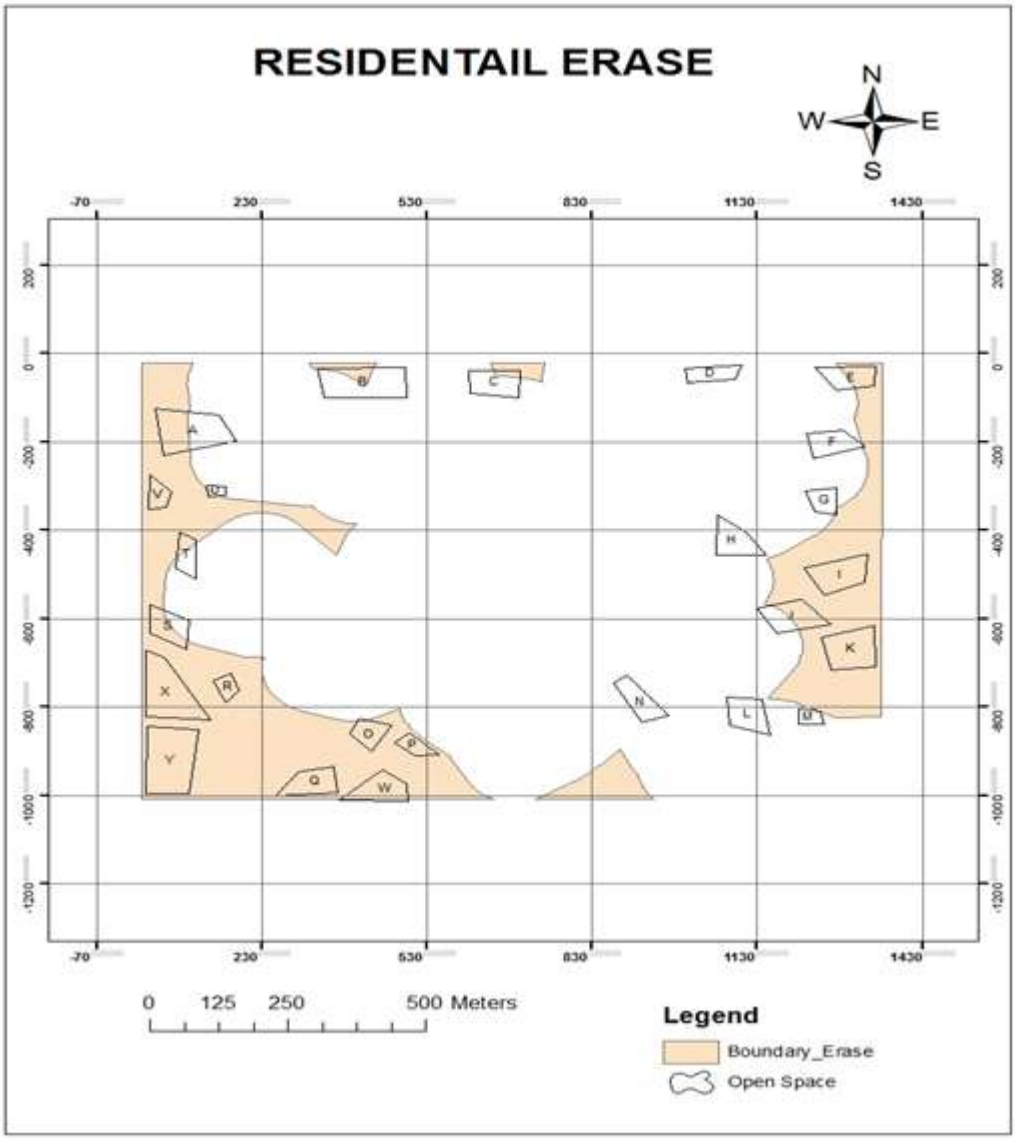

Figure 5: Buffered residential areas was overlaid on the layer containing the boundary to giveboundary_ Erase layer

In figure 5 above shows the overlay of buffered residential area on the boundary of the map of the study area to give boundary _erase layer. The coloured part of the map i.e the unerased part, shows the part remaining after erasing the buffered residential area from the map. The open space that fell inside the coloured part are areas where dump sites can be sited.

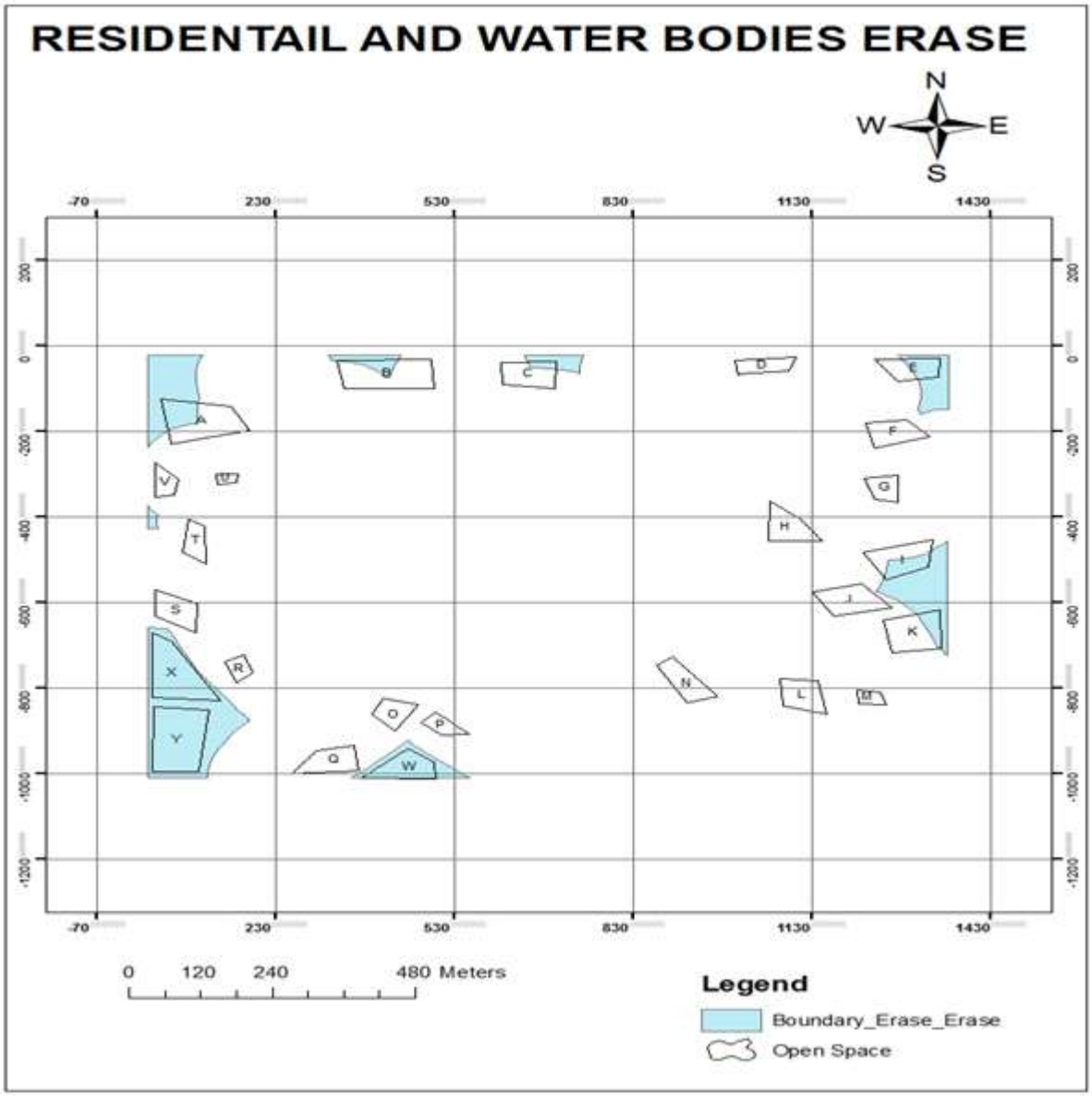

Figure 6: Buffered water bodies was overlaid on the result above (i.e. boundary_erase layer) to give Boundary_Erase_Erase

Figure 6 above shows the overlay of buffered water bodies on boundary_erase layer of the map of the study area to give boundary _erase_erase layer. The coloured part of the map i.e the unerased part, shows the part remaining after erasing the buffered water bodies from the map of boundary_erase. The open space that fell inside the coloured part are areas where dump sites can be sited. The open space outside the coloured part of the map shows areas that are not suitable for dump sites.

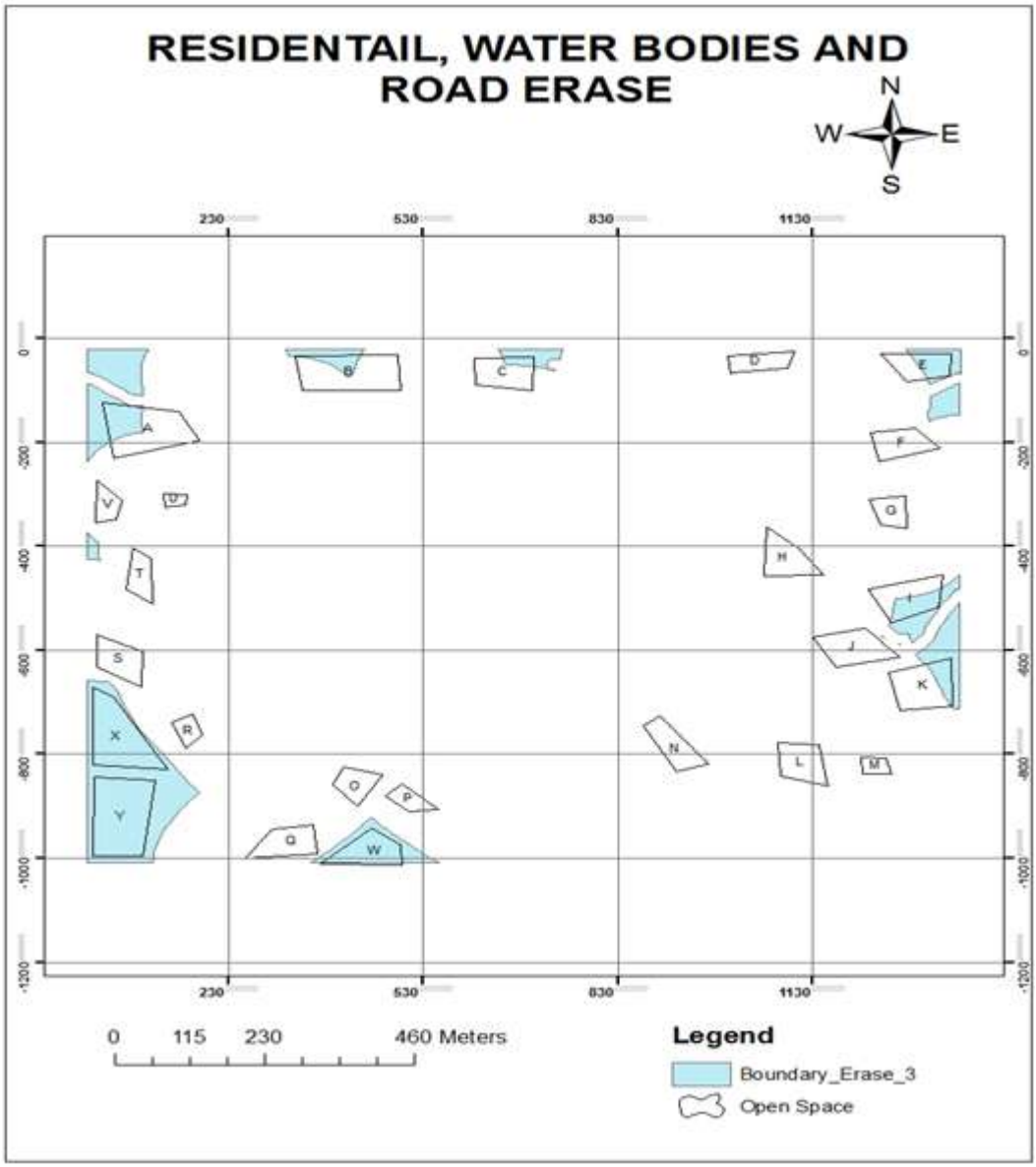

Figure 7: Buffered roads was overlaid on the result from above (i.e. Boundary_Erase_Erase layer) to give Boundary_Erase_3 layer

Figure 7 above shows the overlay of buffered roads on boundary_erase_erase layer of the map of the study area to give boundary _erase_erase_3 layer. The coloured part of the map i.e the unerased part, shows the part remaining after erasing the buffered roads from the map of boundary_erase_erase. The open space that fell inside the coloured part are areas where dump sites can be sited. The open space outside the coloured part of the map shows areas that are not suitable for dump sites.

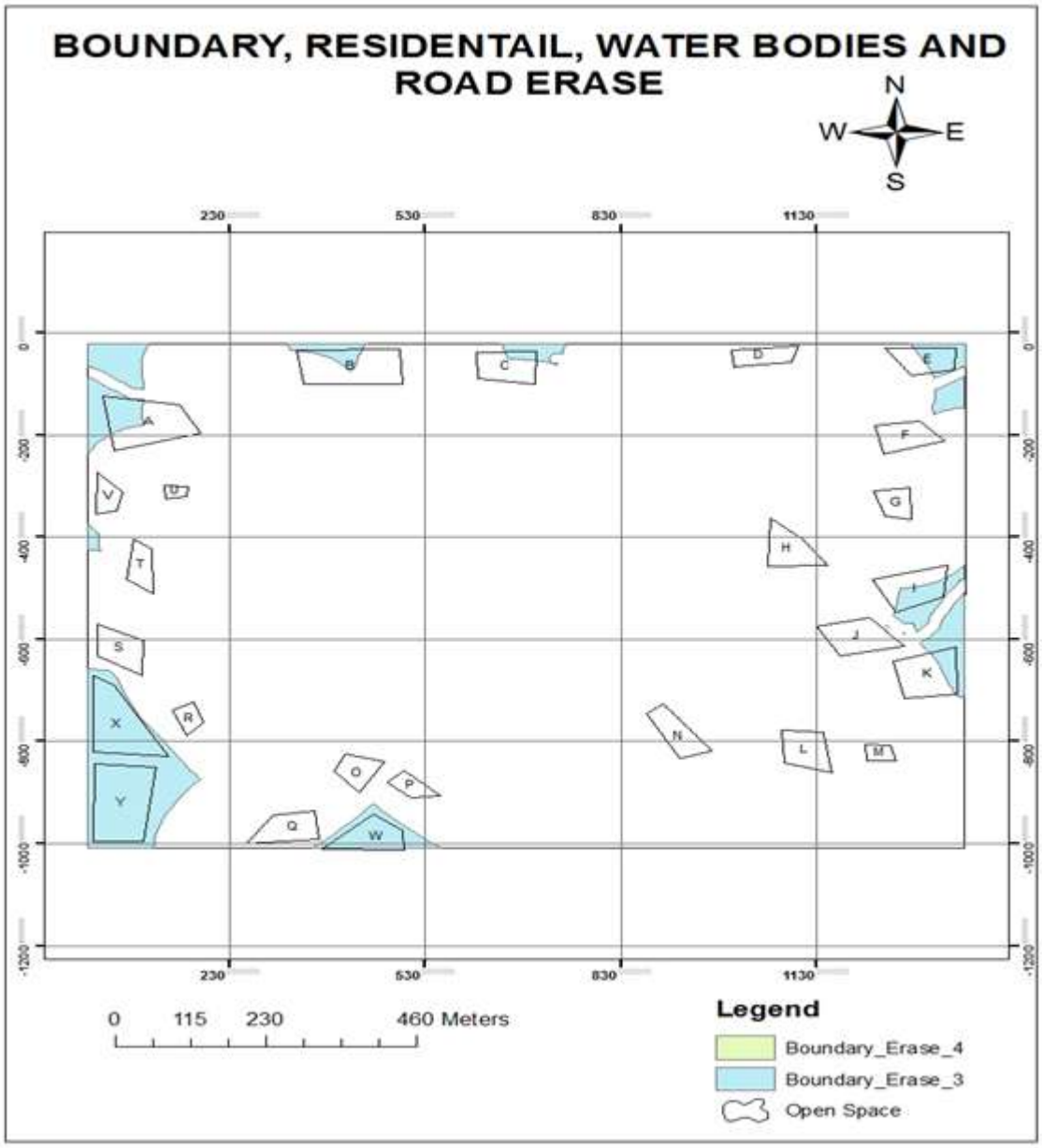

Figure 8: Boundary was then overlaid on the result above (i.e. Boundary_Erase_3 layer) to give Boundary_Erase_4 layer

Figure 8 aboveshows the overlay of boundary on boundary_erase_3 layer of the map of the study area to give boundary _erase_4 layer. The coloured part of the map i.e the unerased part, shows the part remaining after erasing the boundary from the map of boundary_erase_3. The open space that fell inside the coloured part are areas where dump sites can be sited. The open space outside the coloured part of the map shows areas that are not suitable for dump sites.

Spatial Search Query

Spatial search was applied to the attribute data to yield the suitable sites with greater than or equal to 0.5 hectares

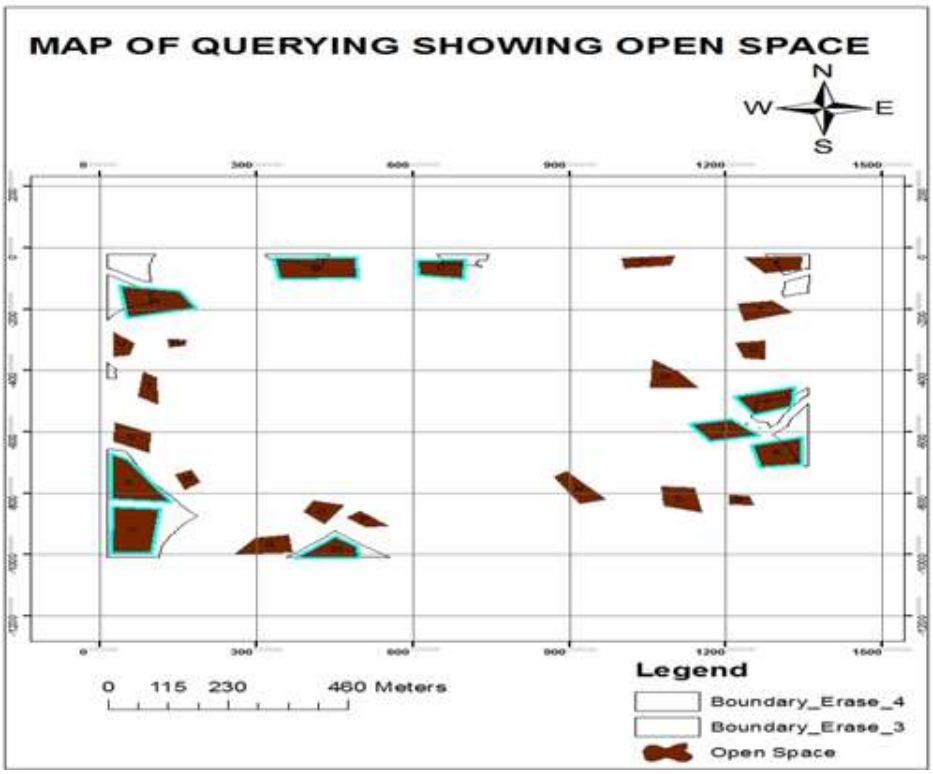

Figure 9: Map of open space showing querying result

Figure 9 shows open spaces that met the creteria that dump sites should be equal or greater than 0.5 hectares. The open spaces; A, B, C, I, J, K, W, X, and Y met the creteria while the other open spaces contravened this creteria. The open spaces that met this creteria are the suitable sites where solid waste dump sites can be located, but some of these open spaces contravened other set creteria and as such only open spaces W, X, and Y (Figure 10) met this creteria without contraving other set creteria. These open spaces are the most suitable sites that met all the creteria for the sitting of waste dump in the study area.

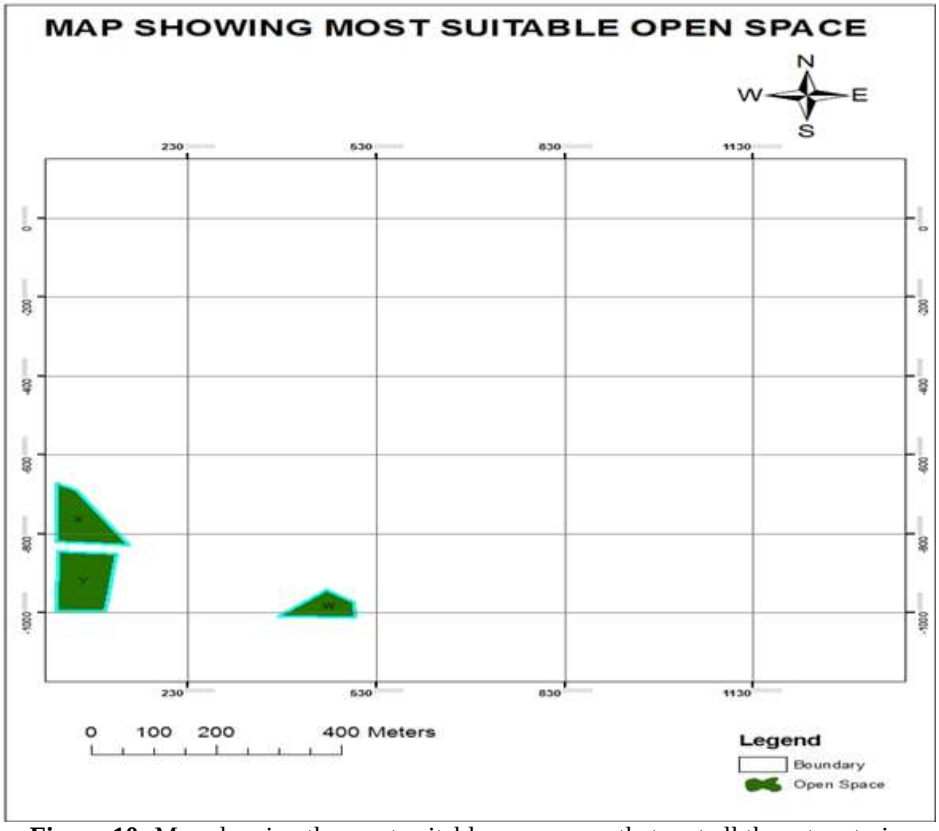

Figure 10: Map showing the most suitable open space that met all the set creteria

4. Conclusion

It is obvious that Geoinformatics technique is a better way of decision making on complex issues related to earth surface and the people residing in it.All suitable sites selected were in line with the purpose and the criteria for the selection of the most suitable site for solid waste disposal. Also, the result of the queries and the analyses generated from the database shows that GIS is the only decision-supporting tool that could be used to obtain that most suitable site for solid waste disposal within and around Warri, Delta State.

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