ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 10, Issue 7 , July 2023

Thematic Maps from Geographic Information System to Identify the Most Suitable Site for Sanitary Landfill in Owerri, Imo State Nigeria

UKACHUKWU O.C., DIKE B.U., NWOKE H.U.

DEPARTMENT OF CIVIL ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY OWERRI, IMO STATE NIGERIA.

ABSTRACT:

This study is aimed at identifying the most suitable site for establishing a Sanitary Landfill in Owerri (Owerri West, Owerri North and Owerri Municipal) Imo state, Nigeria by producing thematic maps from spatial analysis using Geographic Information System. This study was divided into three major themes viz: Environmental theme, Economic theme and social theme. Specifically different base data were identified and used for this analysis. For the social theme, point features were identified and used. These include hospitals, Motor parks and Markets. These features were imported to the ArcMap software all the points were automatically spread within the Owerri administrative area. The Euclidean distance tool was used to calculate the proximity of the point features to the boundary of the entire study area. Therefore, the Euclidean distance tool generated a 10-class float-point Raster dataset for the market, hospital and Motor Park point features. The reclassify tool was used to convert the float-point raster to an integer raster, using the natural breaks method. This distributed the 10-class float-point raster into 5 class integer raster's. Furthermore, the weighted sum tool was used to estimate the influence of each of these base data (Markets, Hospitals and Motor Parks) with respect to the entire Owerri. The base data were assigned equal number of weight (1). This helped to generate a thematic map for the social theme. For the economic theme, the following base data were identified, Roads, Rivers, Settlement, Drainage Network and Slope. The slope was estimated using the slope tool from the spatial analyst tool of ArcMap software. The slope tool generated a 10-class float-point raster, which was further reclassed into a 5-class integer raster. The Euclidean tool was used to create a float-point raster for the other vector type base data (roads network, river, drainage network and settlement).The reclassify tool was used to convert the float-point raster to a 5 class interfere raster. Furthermore, the weighted sum tool was used to generate a thematic map for the economic theme. For the Environmental theme the Landsat 9 (OLI) data was used. Three major bands were extracted from the Landsat scene which are: Band 4, Band 5 and Band 3.The extract by mask tool was used to clip out the study area (Owerri) from each of the bands. Therefore, the raster calculator tool was used to estimate the Normalized Difference Vegetation Index (NDVI) and the Normalized Difference Water Index (NDWI) for the entire study area (Owerri). In addition, the weighted sum tool was used to estimate the weight of the (NDVI) and (NDWI) having equal weight (1).This helped to generate a thematic map for the environmental theme.

KEYWORD: Thematic Maps, Geographic Information System, Environmental theme, Economic theme, Social theme and Euclidean Distance.

I. INTRODUCTION

In any discussion related to waste management, one of the key issues that comes into mind is that of the location where the waste disposal facilities would be sited. These facilities includes landfills, sewage treatment plants, waste treatment plants, incinerators and a lot more. Among all these facilities, landfills have been shown to be the best facilities for the efficient handling and management of wastes in developing nations (Egun, 2011). Judging by their high risks to human health and the environment hazards that are posed by wastes, waste management has been identified as one of the critical challenges facing the modern day society in most developing nations (Olorunfemi, 2011).

The desire to protect the environment and natural resources is increasingly becoming a great concern to many countries through environmentally sustainable waste management program (Kumar, Balaram and Binod, 2017; Ugwu, Echiegu

ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 10, Issue 7 , July 2023

and Okonkwo, 2018).As opined by Babalola and Busu (2010), there is a high growth of cities in third world countries in recent years and Nigeria itself is not left out of this. Many urban communities worldwide are experiencing increasing volumes of waste, resulting mainly from high population growth, industrialization, increased consumption of manufactured goods and agricultural produce (Pan, Yu and Yang, 2019). Nigeria is one of the Sub-Saharan countries battling with the management of wastes. Despite different policy interventions in the past three decades, most towns in the country experience poor waste management. All the towns, without exception, are saddled with the proliferation of waste dumps on open lands, farmlands, river banks, major roads and streets, which provide breeding grounds to disease vectors and vermin, but also contaminate surface and groundwater (Ike, Ezeibe, Anijiofor and David, 2018). Available statistics shows that Nigeria has a population growth rate of 2.8% per annum (Davidson, 2011). This figure is higher for that of the urban areas of the nation which is estimated at 5.5%, with each individual generating an average of 0.58 kg solid waste per day (Ogwueleka, 2009). In Imo state, large volume of solid waste is generated daily (Adogu 2015), and the quantity varied according to the period of the week. The average quantity of solid waste generated in Owerri municipality in 2013 as obtained by Nwoke (2013) is 0.00974m^3 per capita per day.

Thematic maps are an important output of spatial analysis in GIS (Geographic Information Systems). They are maps that represent specific themes or topics, such as population density, land use, or vegetation cover, and are used to visually display patterns and trends in the data. Spatial analysis in GIS involves the manipulation and analysis of geographic data, including spatial relationships, distances, and patterns. Thematic maps are created by applying different analytical methods to these data, such as interpolation, clustering, classification, and overlay analysis. Interpolation methods are used to estimate values for points where data is missing or not available. For example, if you have data for air pollution at certain monitoring stations, interpolation can be used to estimate pollution levels for other locations. Clustering methods are used to identify groups of similar features or patterns in the data. For example, you can use clustering to identify areas with similar land use patterns. Classification methods are used to categorize data into different classes based on certain criteria. For example, you can use classification to group areas into different levels of population density. Overlay analysis involves combining different layers of data to create a composite map. For example, you can overlay data on land use, soil types, and topography to create a map of suitable areas for agriculture. Thematic maps are a powerful tool for visualizing spatial data and communicating information to others. They can be used to identify patterns and trends, make comparisons, and highlight areas of interest or concern. Geographic Information Systems is initialized as GIS(Goodchild, 2010).The first computerized GIS was developed by Roger Tomlinson who also coined the word GIS(Tomlinson, 2014).GIS is a computer system that combines hardware and software to link non-spatial features with Geographically linked data ,allowing users to layer multiple types of data together to manipulate and analysed at a bases to create new maps and tabular data (Clarke, 1986).Euclidean space is named after the ancient Greek mathematician Euclid (Zhang, 2007). In ArcGIS Spatial Analyst, the two primary methods for carrying out distance analysis are known as the Euclidean distance and the cost distance. The Euclidean distance features determine the distance, in terms of a straight line, between each cell and the nearest source. You are able to not only determine location, but also measure the distance and determine the direction to the source that is the closest to you. The Euclidean distance is modified by the cost-weighted distance function, which determines the distance between two points by equating it with the cost to move through any given cell. For instance, it might take less time to reach the destination by ascending over the mountain than it would by going around it using the circumnavigation route. The function for allocating costs figures out which source cell is the least expensive based on the total amount spent on travel.

II. MATERIALS AND METHODS

The materials utilized for the suitability analysis for a Sanitary Landfill areArcMap 10.7, Microsoft office package 2016, Google Earth Pro., GPS Navigation App, HP Laptop 15-bs0xx, Techno Camon 19 and Microsoft Mouse.

A. Methods

The ArcMap10.7 tool was used to analyse the spatial dataset (Digital Elevation Model, Shape files and Lands at 9).The Euclide an distance tool, reclassify tool, and weighted sum tool were used to delineate the suitability sites from the ArcGIS model builder.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 10, Issue 7 , July 2023

B. Thematic Map for Environmental theme

For the Environmental the Lands at 9(OLI)data was used. Three major bands were extracted from the Landsat scene which are: band 4, band 5 and band 3.The extract by masktool was used to clip out the study area(Owerri) from the each of the bands. Therefore, the raster calculator tool was used to estimate the Normalized Difference Vegetation Index (NDVI) and the Normalized Difference Water Index (NDWI) for the entire study area(Owerri).The NDVI was calculated using this formula

$$(Band5 - Band4)/(Band\ 5 + Band4) \text{ Eqn1}$$

Where; Band 5 represent the Near Infrared Band (NIR) having a resolution of 30m.Band4 represent the RED bandwith a resolution of 30m.The NDVI calculation helped us to quantify the presence of green vegetation using theNIR and RED bands of Lands at 9 (OLI). The Interface for calculation is shown in Fig 1 below.

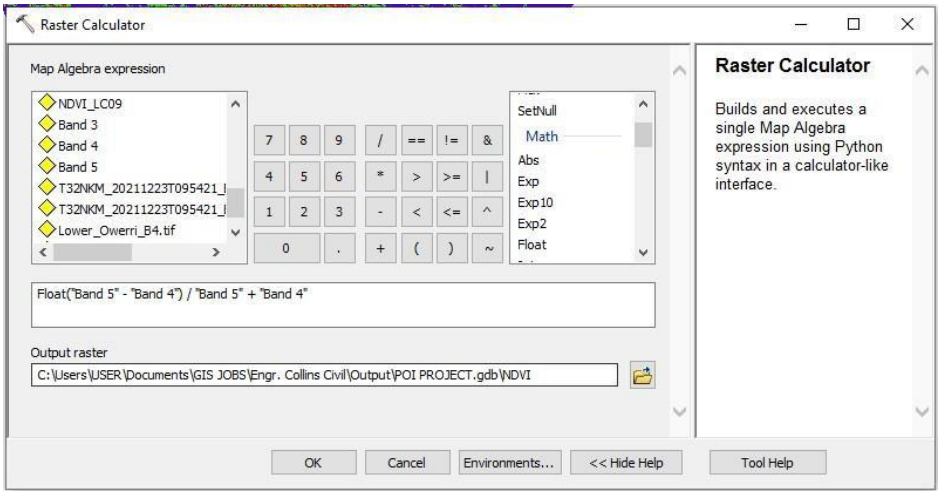

Figure 1:Interface for calculation of NDVI

The NDWI was calculated using this formula

(Band3-Band5)/(Band 3+Band5)Eqn 2

Where;

Band3 represent the Green bandwith are solution of 30m.

Band5 represent the Near Infrared Band having a resolution of 30 m.

The NDWI method is an index for delineating and monitoring content change in surface water on the earth surface. It is computed with the NIR and Green bands of Lands at 9(OLI).

From the result of the NDWI calculation, the values ranged from – 0.3824 to 0.1192.The Interface for calculation of NDWI is shown in Figure 2 below.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 10, Issue 7 , July 2023

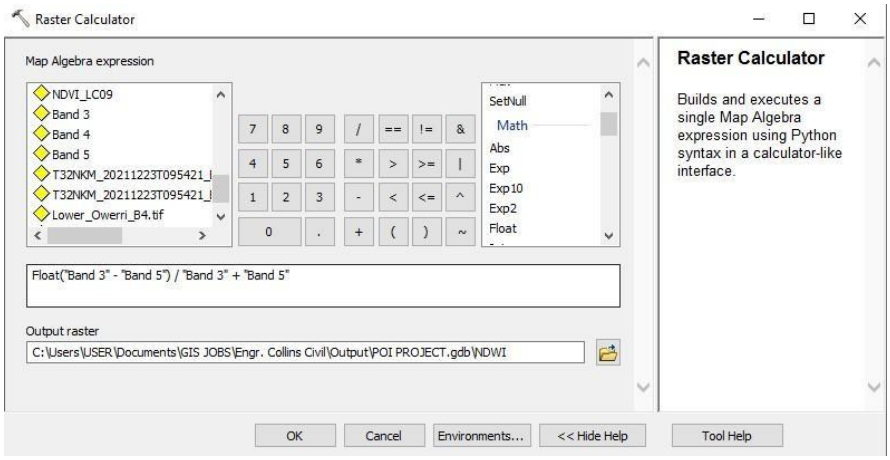

Figure 2: Interface for calculation of NDWI

The weighted sum tool was used to estimate the weight of the (NDVI) and(NDWI) having equal weight (1). Fig 3 shows the interface for the weighted sum of environmental theme.

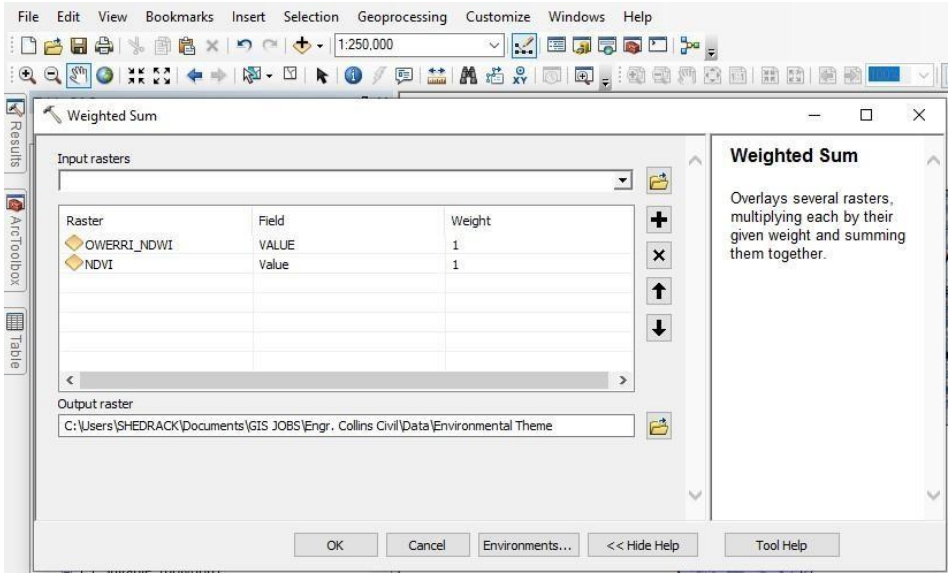

Figure3: Weighted sum for Environmental Theme

C. Thematic Map for Social theme

For the social theme point features which include hospitals, Motor parks and Markets. The global positioning system (GPS) of the hospitals, motor parks and markets were imported to the ArcMap software. The Euclidean distance tool was used to calculate the proximity of the point features to the boundary of the entire study area. The Euclidean distances of each source is then reclassified into five major classes representing the suitability of the social theme. The weighted sum tool was used to generate the thematicmap.Fig4 shows the interface for the weighted sum of social theme.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 10, Issue 7 , July 2023

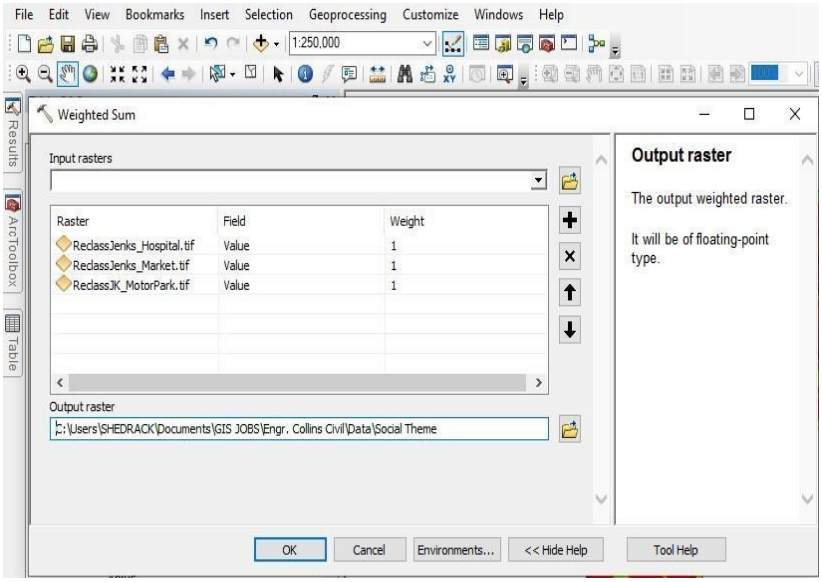

Figure4: Weighted sum for Social theme

D.Thematic Map for Economic theme

For the economic theme, Settlement, Road, Slope, Drainage Network and Rivers are the data used.

The economic theme also took into consideration the intensity of the inhabitant within the study area. There were 582 records captured in the settlement dataset, it consists of Built-up Area with 5 records having an average population of 1,191,720,Hamlet has 546 records with an average population of 2,427 and Small Settlement area have 31 records with an average population of 35.These populations include males and the female population.

The slope was estimated using the slope tool from the spatial analyst tool of ArcMapsoftware. The slope tool generated a 10-class float-point raster, which was further re-classed into a5-class integer raster.

The River and Drainage Network indicated the flow of water within the study area.

The Euclidean tool was used to create a float-point raster for the other vector type based at a Rivers, Drainage Network, Settlement , Road and Slope respectively.

The reclassify tool was used to convert the float-point raster to a 5 class interfere raster. Furthermore, the weighted sum tool was used to generate a thematic map for the economic theme.Fig5 shows weighted sum interface for Economic theme.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 10, Issue 7 , July 2023

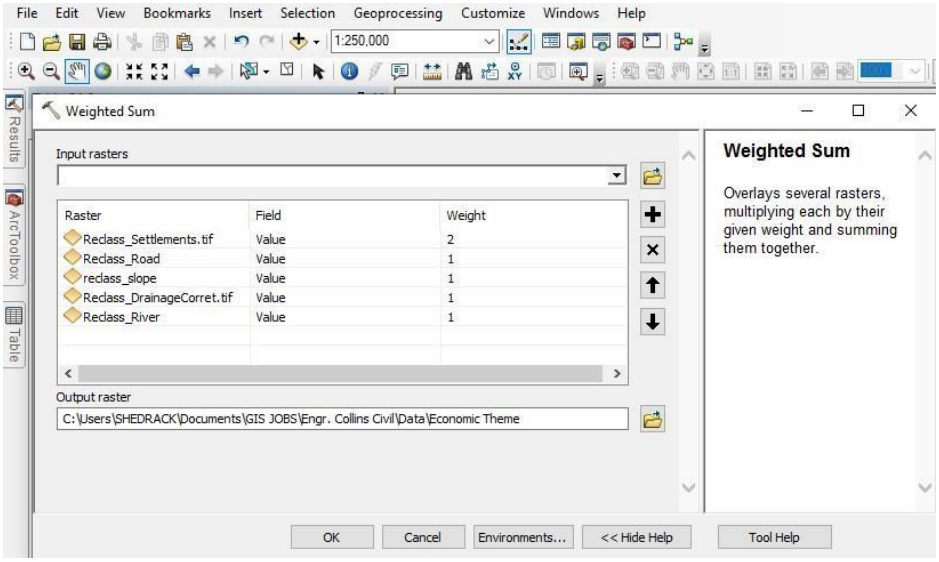

Figure5: Interface for weighted sum for economic theme.

III.RESULT

A. Result on Thematic map of Environmental theme

The Environmental theme had the following area coverage per class in the study area (Sq. Km). Table 1 shows the attribute table for the thematic map of environmental theme.

Table1 Attribute table for thematic map of environmental theme

Suitability Level	AreaSq.km
Highly Unsuitable	55
Unsuitable	127
Moderately Suitable	141
Partially Suitable	106
Suitable	122

The thematic map for environmental theme was produced. Fig6 shows the thematic map for environmental theme.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 10, Issue 7 , July 2023

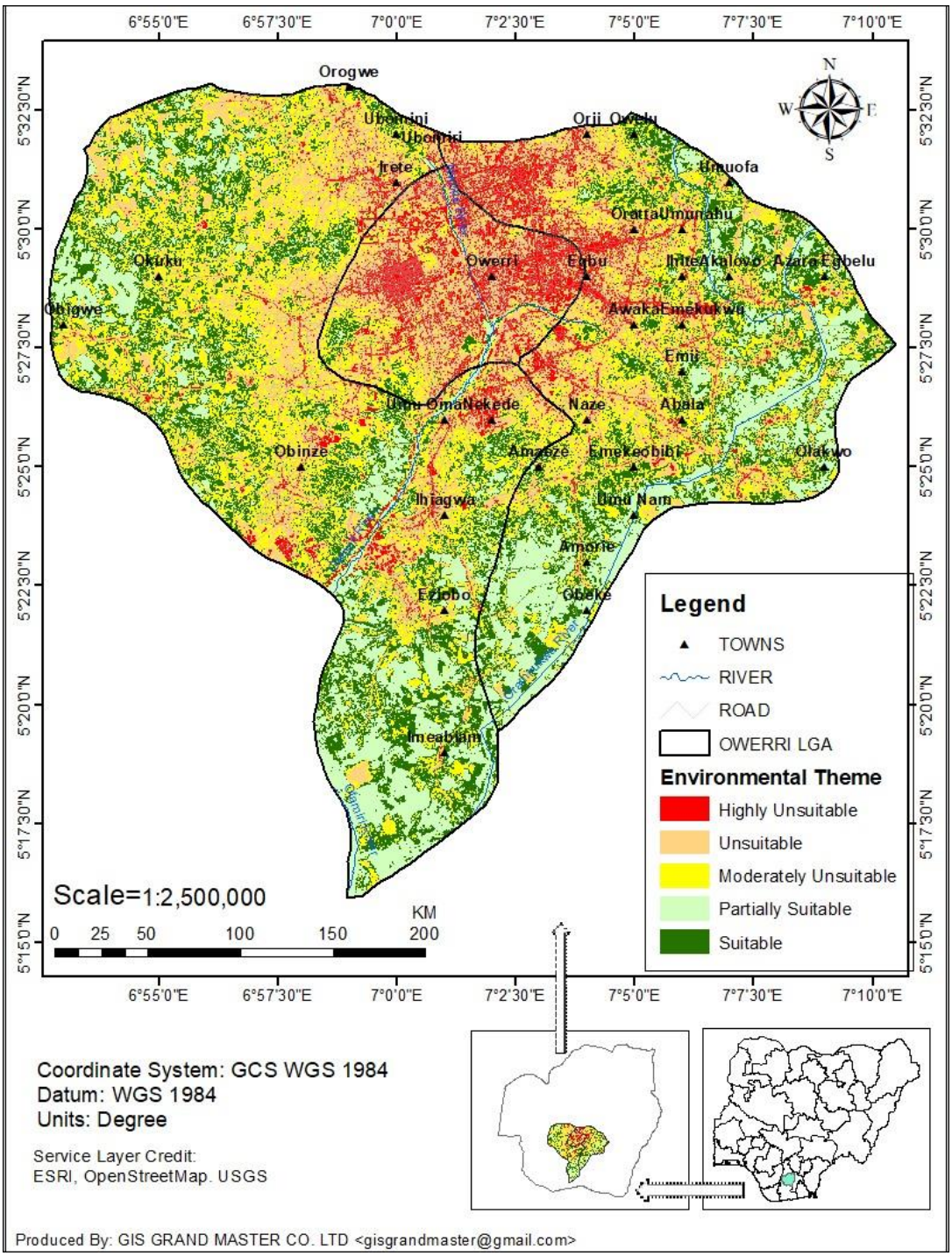

Figure 6: Thematic map for environmental theme

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 10, Issue 7 , July 2023

Thematic map for environmental theme shows that 55sqkm of the study area is highly unsuitable for siting Landfill. Locations on the map that represents this highly unsuitable

areas include Egbu, Douglas road, Orji, Wetheral road. These places are situated in the municipal of the study area. The environmental thematic map shows 127sq km of the study area is unsuitable for siting landfill. Locations on the map that represents these unsuitable areas include Amaeze,Naze,Ihiagwa, Irete, Abala. These places can be located in the municipal, north and west of the study area. The environmental thematic map also shows that 141sq-km of the study area is moderately unsuitable. Location on the map that represents these moderately unsuitable areas include Eziobodo, Umuofa, Ubomiri. These places are situated in the north and west of the study area. Furthermore, the map also shows that 106 sq km of the study area is partially suitable for siting landfill. Locations on the map that represent these partially suitable areas include Emeabiam, Umunam, AzaroandEgbelu. These places are situated in the west of the study area. Lastly, the map shows that 122sqkm of the study area is suitable for siting landfill. Location on the map that represent these suitable areas include Okuku, Emebiam, and Obigwe. These places are situated in the west of the study area.

B. Result on Thematic Map of Social Theme

The Social theme had the following area coverage per class in the study area (Sq. Km).Table2shows the attribute table for the thematic map of social theme.

Table2 Attribute table for thematic map of social theme

Suitability Level	AreaSq.km
Highly Unsuitable	87
Unsuitable	163
Moderately Suitable	158
Partially Suitable	80
Suitable	62

Thematic map for social theme shows that 87 sq km of the study area is highly unsuitable for siting Landfill. Locations on the map that represents this highly unsuitable areas include Egbu,Douglasroad,Orji,Wetheralroad. These places are situated in the municipal of the study area. The environmental thematic map shows 163 sqkm of the study area is Unsuitable for siting landfill. Locations on the map that represents these Unsuitable areas include Amaeze,Naze, Obinze,Ihite, Eme, Ubomiri,Irete, Abala. These places can be located in the municipal,north and west of the study area. The environmental thematic map also shows that 158sqkm of the study area is moderately unsuitable. Location on the map that represents these moderately unsuitable areas includeEziobodo, Umuofa,Amorie,Umunam,Emekeobibi,Azara,Egbelu,Orogwe.These places are situated in the north and municipal of the study area. Furthermore, the map also shows that 80 sq km of the study area is partially suitable for siting landfill. Locations on the map that represent these partially suitable areas include Obeke,Okuku,Olakwo, These places are situated in the west and north of the study area. Lastly,the map shows that 62sqkm of the study area is suitable for siting landfill. Location on the map that represent these suitable areas include Okuku,Emebiam,Offorola,Obigwe. These places are situated in the west of the study area. The thematic map for social theme was produced. Fig 7 shows the thematic map for social theme.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 10, Issue 7 , July 2023

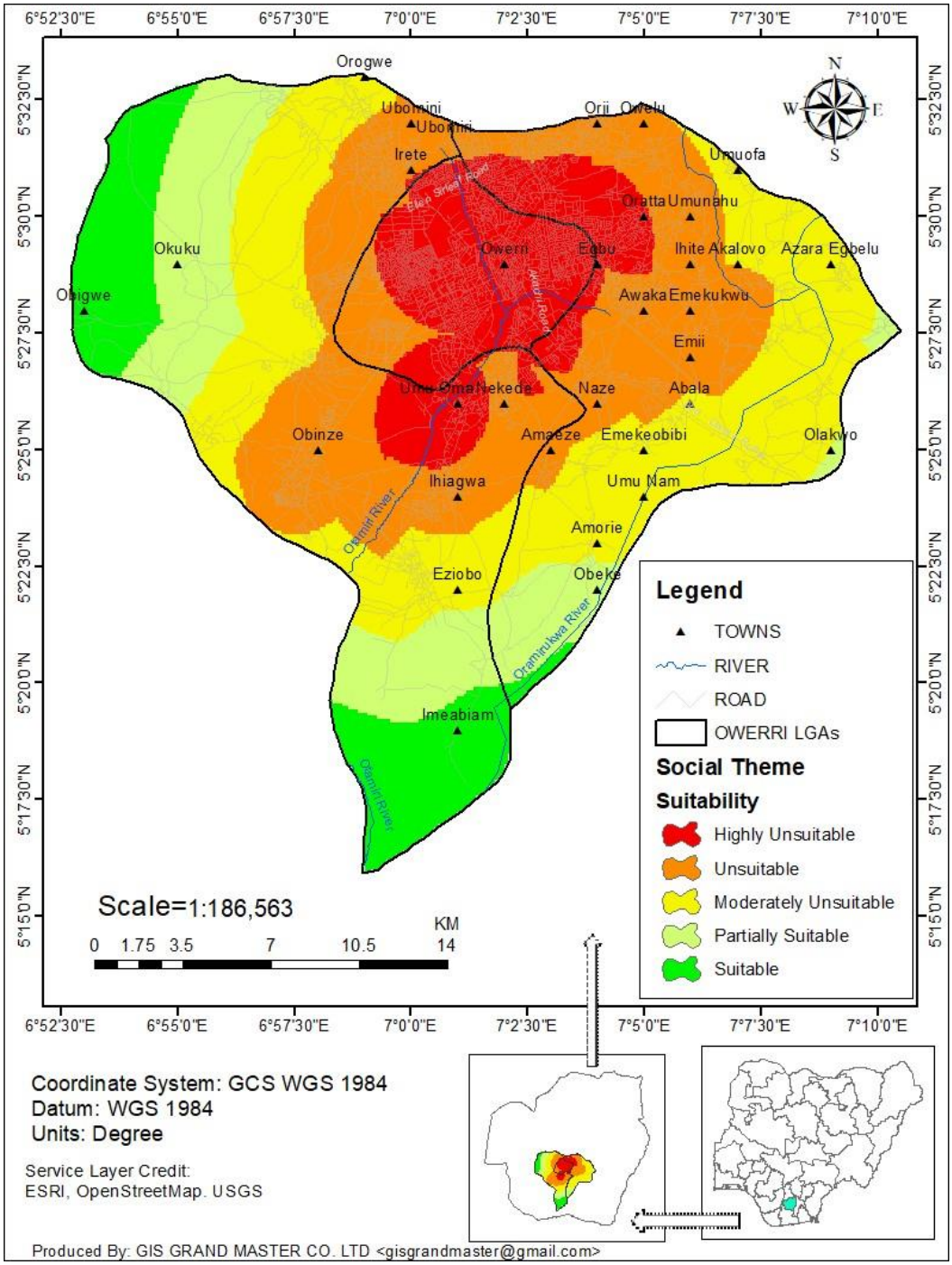

Figure7: Thematic map for social theme

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 10, Issue 7 , July 2023

C.Result on Thematic Map of Economic Theme

The Economic theme had the following area coverage per class in the study area (Sq. Km).Table3 shows the attribute table for the thematic map of economic theme.

Table3 Attribute table for thematic map of economic theme

Suitability Level	AreaSq.km
Highly Unsuitable	198
Unsuitable	209
Moderately Suitable	85
Partially Suitable	38
Suitable	21

Thematic map for economic theme shows that 198 sq km of the study area is highly unsuitable for siting Landfill. Locations on the map that represents this highly unsuitable areas include Egbu, Douglas road, Orji, Wetheral road. These places are situated in the municipal of the study area. The economic thematic map shows 209 sq km of the study area is unsuitable for siting landfill. Locations on the map that represents these unsuitable areas include Amaeze,Naze,Obize, Ihite, Eme, Ubomiri, Irete, Abala. These places can be located in the municipal, north and west of the study area. The economic thematic map also shows that 85 sq km of the study area is moderately unsuitable. Location on the map that represents these moderately unsuitable areas include Eziobodo,Umuofa,Amorie,Umunam,Emekeobibi,Azara,Egbelu,Orogwe.These places are situated in the north and municipal of the study area. Furthermore, the map also shows that 38 sq km of the study area is partially suitable for siting landfill. Locations on the map that represent these partially suitable areas include Obeke,Okuku,Olakwo, These places are situated in the west and north of the study area. Lastly, the map shows that 21sqkm of the study area is suitable for siting landfill.Location on the map that represent these suitable area include kuku,Emebiam,Offorola,Obigwe. These places are situated in the west of the study area.

The thematic map for economic theme was produced. Fig8 shows the thematic map for economic theme.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 10, Issue 7 , July 2023

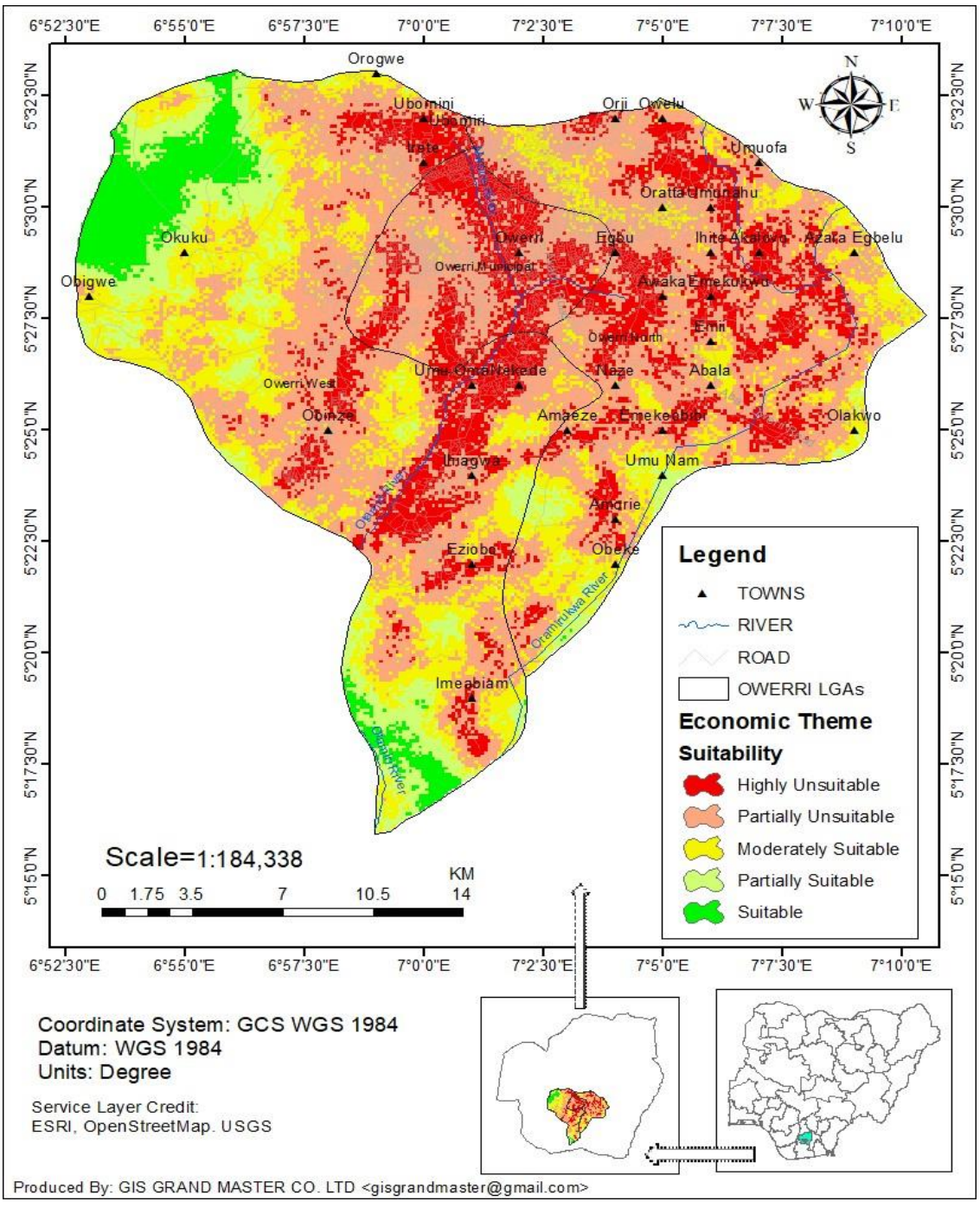

Figure8: Thematic map for economic theme

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 10, Issue 7 , July 2023

IV. CONCLUSION

Thematic maps are a powerful tool for visualizing spatial data and communicating complex patterns and relationships to a wide range of audiences. Geographic Information Systems (GIS) are often used to create thematic maps, as they allow for the analysis and visualization of spatial data.

The ArcMap 10.8 tool in the Geographic Information System (GIS) was used to perform spatial analysis in the study area. In the spatial analysis, the study was divided into three major themes, which are Environmental theme, Social theme and Economical theme respectively.

For the environmental theme the Landsat 9 (OLI) was used. A thematic map was produced for environmental theme after overlaying the Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index (NDWI) maps. The weighted sum tool was used to estimate the weight of NDVI and NDWI having an equal weight of 1. This produced the thematic map for the environmental theme. From the attribute table for the thematic map of Environmental theme, 55sq-km of the study are was highly unsuitable, 127sq-km was Unsuitable, 141sq-km was moderately suitable, 122 sq-km was partially suitable and 106sq-km was suitable. This shows that only about 19.24% of the study are was suitable for siting landfill considering the environmental theme.

For the social theme, base data of hospitals, markets and motors parks were collected randomly across the study area. A weighted sum tool was used to weigh these 3 (three) criterions and assigning each a weight of 1. This produced the thematic map for social theme. From the attribute table of the thematic map for social theme 87sq-km is highly unsuitable, 163 sq-km is unsuitable, 158sq-km is moderately suitable, 80sq-km is partially suitable and 62sq-km is suitable. This shows that only 11.27% of the total study area is suitable for siting landfill considering the social theme.

For Economic theme, the following base data was identified: Rivers, Drainage Network, Settlement, Road and slope respectively. Considering the importance of settlement in siting a landfill, a weight of 2 was assigned using the weight sum tool and other factors were assigned 1. This produced the thematic map for Economical theme. From the attribute table of the thematic map for economical theme 198sq-km is highly unsuitable, 209sq-km is unsuitable, 85sq-km is moderately suitable, 38 sq-km is partially suitable and 21sq-km is suitable. This shows that only 3.8% of the total study area was suitable for siting landfill considering the economical theme.

REFERENCES

Adogu, .P.O.U, Uwakwe .K. A, Egenti .N. B, Okwuoha .A. P, and Nkwocha I.B. (2015). Assessment of Waste Management Practices among Residents of Owerri Municipal Imo State Nigeria, Jr of EnvProt. 6 , 446-456

Babalola, A. and Busu, I. (2010). *Selection of landfill sites for solid waste treatment in Damaturu Town-Using GIS Techniques*, University Technology Malaysia, Johor state, Malaysia.

Clarke, K.C. (1986). Advances in geographic information systems, computers environment and urban systems, computers, environment and urban systems, vol. 10 :175-184.

Davidson, G. (2011). Waste management practices: literature review. Dalhousie University –office of sustainability.

Egun, N.K. (2011). Environmental Responsibility: Nigerians How Far? Journal of Applied Technology in Environmental Sanitation, No 2,pp 143 - 147.

Goodchild, M.F. (2010). Twenty years of years' progress: Geoscience in (2010). Twenty years of progress: Giscience in 2010. *Journal of spatial information science (1).*

Ike, C.C., Ezeibe, C.C., Anijiofor, S.C., Nik-Daud, N.N. (2018). Solid Waste Management in Nigeria: Problems, Prospects and Policies. Journal of Solid Waste Management 44(2) 163 -172

Kumar, B., Balaram, P., and Binod, K. (2017). An Analysis of Household demand for improved Solid Waste Management in Birendranager Municipality, Nepal. International Journal of Energy Economics and Policy, 7 (41), 83-89

Nwoke, H.U. (2013). Generation rate of Solid Waste in Owerri Metropolis, Imo state, Nigeria.*Continental J. Environmental Sciences*. Vol 7 (1), pp 8-10.

ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 10, Issue 7 , July 2023

Ogwueleke, T.C., 2009. Municipal solid waste characteristics and management in Nigeria. Iran *Journal of Environmental Health, Science Engineering*, 6(3): 173-180.

Olorunfemi, D.I.,(2011) Living with Waste: Major Sources of Worries and Concerns about Landfills in Lagos Metropolis, Nigeria, Ethopian Journal of Enviromental Studies and management

Pan, A., Yu, L., and Yang, Q. (2019). Characteristics and Forecasting of Municipal Solid Waste Generation in China. Journal of Environmental Sustainability, 11, 1433

Tomlinson, R. (2014). UCGIS Achieved from the original on 17 December 2015.Retrieved 16 December, 2015.

Ugwu, K.C., Echiegu, E.A., Okonkwo, W.I. (2018). Solid Waste Generation and Management in Nsukka Urban, Enugu State, Nigeria. World Journal of Engineering and Technology, 4(1), 21-34.

Zhang, Jin (2007), *Visualization for Information Retrieval*, Springer, ISBN 978-3-540- 75148-9