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Assessing the Impact of Urbanization on Dumpsite Suitability Criteria in Benin City, Nigeria

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ABSTRACT: The fast growing economy has created different criteria in dumpsite selection as the challenge to manage the increasing rate of solid waste produced is still present. This research took Benin City as a case study obtaining data from an open-source database which are from remote sensing, Edo State open-data platform. Benin City just like most urban areas in other developing countries faces the challenge of solid waste management of which about thirty-four percent (34%) of waste generated are left at the point of generation and only sixty-six percent (66%) of waste generated are regularly collected for disposal. The challenges of municipal solid waste management include insufficient policy and legal framework, poor environmental planning and implementation, inadequate infrastructure, budgetary and operational constraints, inadequate environmental education, and overpopulation.

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Keyword: Benin City, municipal solid waste, remote sensing and open-data platform.

Population growth, industrialization and urbanizations possess as major driving factors for waste generation in most developing countries in the World. According to the World Bank, urban population of low and middle-income countries is expected to double from 2 to 4 billion between 2000 and 2030 (World Bank, 2013) and the UNDP further predicted that nearly all of the expected growth of the world population will be concentrated in the urban area of the less developed regions up until 2050 (UNPD, 2012). Many environmental threats have surfaced due to the increase in developing trends of modernization and industrialization which in turn generates tons of municipal solid waste of different categories such as biodegradable: food and kitchen waste e.t.c and degradable: cans, bottles, plastics e.t.c (Siva and Prasada, 2016). Hauster and Schnore, 1965, stated that an urban area can be known via the population density, the number of residents in that area, the availability of public utilities and services as electricity and education, and the percentage of people not dependent on agriculture. He also went on to state that the term urban is used by some countries on areas whose population is 2,500 or more and also, other countries have set of criteria for distinguishing urban areas. Benin City just like most urban areas in other developing countries faces the challenge of municipal solid waste management. Thirty-four percent (34%) of generated waste are left at the different point of generation and sixty-six percent (66%) of the remaining waste generated in the city is then regularly collected for disposal. Several research conducted have shown that the poor waste management practices carried out in Benin City comprises mostly of open waste disposal which then exposes the population in that environment to potential public health hazards and environmental pollution. This increase in waste is expected to continue and this may lead to competition between land for human activities and dumpsite location (Igbinomwanhia and Ideho, 2014; Akujieze and Irabor, 2014). Solid waste is a term which is used to describe non-liquid (biodegradable and degradable) waste gotten from agricultural, trade, commercial, industrial activities, and domestic environment (Aibor

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and Olorunda, 2006). The problem of refuse disposal (properly or not properly) is basically from rapid growth of urbanization, of which Nigeria is still in its infancy. Due to location issues on dumpsites, illegal disposal of municipal solid waste have been introduced. Municipal solid waste continues to increase in different cities of Nigeria on a daily basis leaving the dumpsites to become perfect ground for breeding of both flies, insects, rodents and other vectors. These have resulted to health hazards, increase obstruction of traffic flow, general unsightliness, air pollution and environmental degradation (Hauwa, 2003). In Nigeria, Waste Management Policies are formulated at the Federal and State Government Levels, while the implementation is executed at the Local Government Level (Environmental Law Research Institute, 2011). This makes the Edo State Environmental and Waste Management Board and the Local Government Authorities to be responsible for the selection and establishment of waste collection points, and dumpsite location (Asikhia M. O. and Olaye D., 2011). Hence, the objective of this paper is to evaluate the impact of urbanization on dumpsite suitability criteria in Benin City, Nigeria.

MATERIALS AND METHODS

Study Area: Edo State is located in the Southern region of Nigeria, and it is bordered by Kogi State in the Northern part, Ondo State in the South Western part and Delta State in the South Eastern part. The State consists of eighteen (18) Local Government Areas (L.G.A) and Benin City is the Economic Centre which also doubles as the Capital. Benin City is made up of three LGAs which are Oredo, Egor, Ikpoba-Okha LGAs. Edo State covers a land area of about 17,802km^2 with population of about 3,233,366 people (Information Communication Technology Agency, 2016) and a growth rate of 2.7% (Commission N. P., 2006). The rate of waste generation in Benin City is estimated to be about 0.5kg per person per day thereby has the potential of generating 1,616,683kg per day in total.

Data and Materials: The data used in the study were acquired primarily from open-source database which are from the remote sensing, open geospatial data portals and the Edo State open-data platform. The local government area land size and population were obtained from Edo State Open Data Portal, through the weblink: www.data.edostate.gov.ng (Information Communication Technology Agency, 2016). two dumpsites were used for this research which are Otuoken and Ikhueniro dumpsite in Benin City. These sites were chosen as a result of the spatial location towards urban areas and because of data availability. The administrative data of Edo State and local government boundaries were downloaded from the Diva-GIS database (http://www.diva-gis.org/) (Asikhia and Olaye, 2011), while road network data was acquired from the Trimble data Market Place (https://www.market.trimbedata.com). Digital elevation model was extracted from the Shuttle Radar Transmission Mission (SRTM) which was downloaded from the United States Geological Survey (USGS) explore database (https://earthexplorer.usgs.gov). Table 1 shows a summary of the data sets used for the study and their corresponding characteristics.

Table 1: Data sets and their corresponding characteristics

S/N	Data	Source	Year	Resolution	Remark
1	Land Use Map	ESP CCI	1992 – 2015	300m	Land use changes will be analyzed within this range.
2	SRTM DEM	SRTM	2002	30m	Digital Elevation model will be used to generate slope
3	Soil Map	HWSD			To extract the soil type for the area.
4	Administrative map	BBBite			To extract road Network and towns.

Land Use Land Cover Analysis: The land use/cover map was extracted from the European Space Agency Global Land Use map under the initiative of climate change initiative (CCI-LC). The CCI-LC project provides a consistent global Land Cover maps at 300m spatial resolution on an annual basis from 1992 to 2015. This map uses the UN-Land Cover Classification System to define land use type which is quite compactible with the pant functional types used in many models. The land use/land cover changes for Edo State for the various years of interest were extracted from the ESA CCI-LC map. An interval of 5 years was adopted so as to give reasonable change difference in the analysis. This gave a total of 6 land use map for Edo State which are 1992, 1995, 2000, 2005, 2010 and 2015. The land use map legend was generated using the gradient method so as to easily identify urban areas while the percentage of land use type on each map was presented in a tabular format.

Spatial Data Analysis of Dumpsite: The study area for the solid waste analysis was reduced to five local governments in Edo State which are Oredo, Ovia and Ovia. The downscaling of the study area was done as a result of the available dumpsite data and in order to get a higher resolution. The data set used for this analysis and their corresponding criteria are given in tables 2 and 3 while figures 1 and 2 shows the study area for assessing urbanization impact on dumpsite in Edo State and satellite imagery of Benin City and surrounding environ

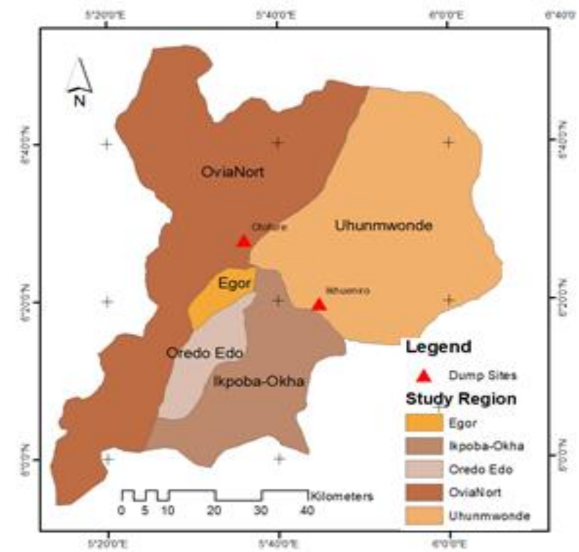

Fig 1: Study Area for Assessing Urbanization Impact on Dumpsite in Edo State.

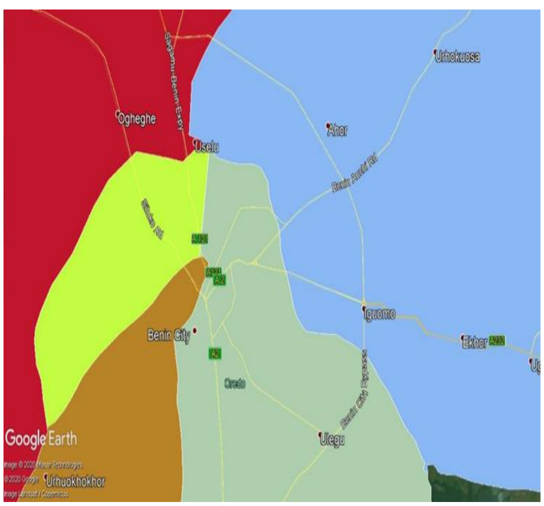

Fig 2: Satellite Imagery of Benin City and Surrounding Environ

Identification of Potential Solid Waste Dumpsites using Multi-Criteria Analysis Approach: The data were processed using the Arc GIS software. Land Use map, Digital Elevation Model, road networks and river networks were re-projected to the same coordinate system. The criteria for setting distance to water body was adopted using the moderately suitable range in Table 2, this was done so as to eliminate extreme conditions that may occur during the analysis process. The slope, distance to road and soil type were also selected in same manner. The analysis made use of the spatial analyst toolbox, which provide desktop with a more sophisticated analysis process which consist of to create, query and analyze raster data set at cell level. This it does by generating new information from existing data, query information across multiple data layers, fully integrate cell-based raster data with traditional vector data source and create sophisticated spatial models. This process becomes very lugubrious and tedious when performed manually as such a model builder was adopted. The Model builder is a tool for creating and managing automated ad self-documenting spatial models. It enables the creation of flow process diagrams and scenarios to automate the modeling process. The flow diagram is as shown in figure 3. The model builder enables the automation of a set of spatial processes such as buffering, classification, reclassification and overlay. The road network and river network were first processed by computing the minimum distance criteria from every cell measured to the nearest source and converted to raster format. The Euclidean distances are measured as the crow files in the projection units of the raster i.e., meters, computed from the cell center to cell center. Each layer was computed based on the adopted criteria as stated in table 3. These criteria give the adopted safe distances to road and river bodies. These distances were further reclassified in order to place level of priority to the various cell distances for both road and river. The elevation data was used to generate slope for the study area and then reclassified. This process created a single ranked map of potential areas to site dumpsite and was used to compare the values of the classes between layers by assigning numeric values to the various cells within the layer maps. Since all measurement are on the same coordinate system and in same numeric scale, it therefor provides equal importance in determining the most suitable locations, thus all data map layers were reclassified into new numeric value or scoring as 10 to 1. The slope dataset was reclassified at a score of 1 to 10 in order of priority i.e., the lesser the slope the more suitable the area as such the scaling was reversed, such as road dataset are reclassified at a score of 10 to 1 as distance father from the road less suitable it is.

Table 2: Factor Criteria Table Formulated from EPA Landfill Manual 2006

Criteria	Least Suitable	Moderately Suitable	Highly Suitable
Distance to Water Body	160m – 480m	480m – 960m	> 960m
Slope	10^0 - 15^0	5^0 - 10^0	0^0 - 5^0
Distance to Road	> 2000m	1000m – 2000m	100m – 1000m
Soil	-	Alisols	Nitisols

Table 3: Adopted Criteria for Dumpsite Analysis Extracted from the EPA Landfill Manual of 2006.

Criteria	Moderately Suitable
Distance to Water Body	720 m
Slope	5^0
Distance to Road	300m
Soil	Alisols

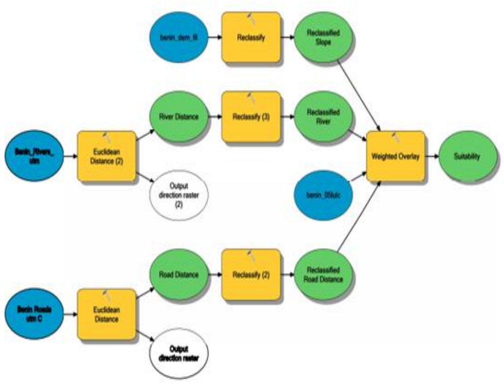

Fig 3: Flow Diagram for Suitability Analysis on Model Builder

RESULTS AND DISCUSSION

Land Use/ Land Cover Map: The Figures below 4a to 4f represents the corresponding land use changes over the years for Edo State. The legend on the various figures is shown in table 4.

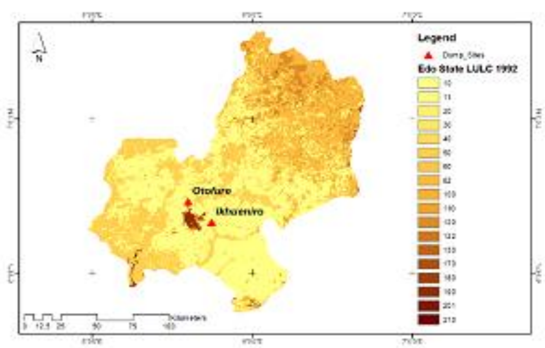

Fig 4a: Land Use / Land Cover Map for 1992

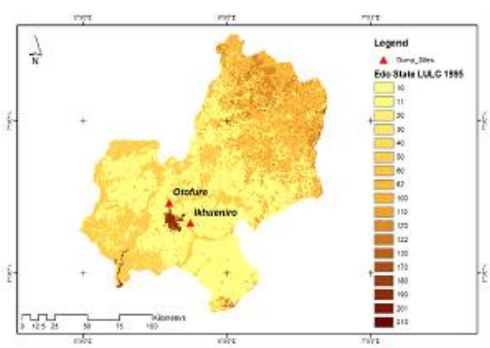

Fig 4b: Land Use / Land Cover Map for 1995

In order to get a proper understanding of the land use type changes over the years the pixel values for the land use type were identified and the corresponding area for each land us type were presented in in table 5. Specific land use types were analyzed and the changes over the years were plotted in a graphical format as shown in figures 5 to 7.

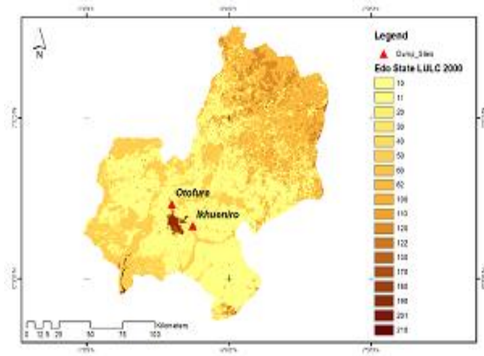

Fig 4c: Land Use / Land Cover Map for 2000

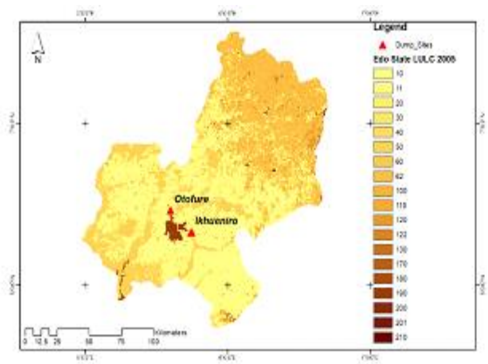

Fig 4d: Land Use / Land Cover Map for 2005

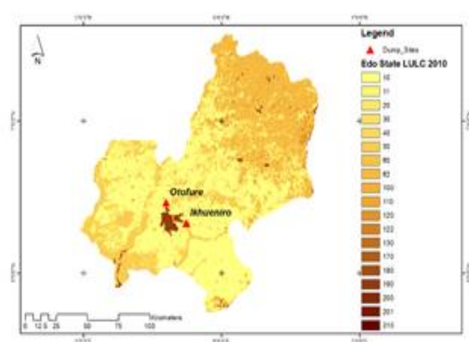

Fig 4e: Land Use / Land Cover Map for 2010

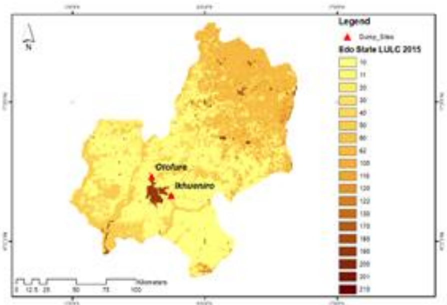

Fig 4f: Land Use / Land Cover Map for 2015

Table 4: Land Use Land Cover Legend

LANDUSE_ID	LULC_CODE	LABEL
10	AGRR	Cropland, rainfed
11	RNGB	Herbaceous cover
20	AGRR	Cropland, irrigated or post-flooding
30	AGRL	Mosaic cropland (>50%) / natural vegetation (tree, shrub, herbaceous cover) (<50%)
40	AGRL	Mosaic natural vegetation (tree, shrub, herbaceous cover) (>50%) / cropland (<50%)
50	FRSE	Tree cover, broadleaved, evergreen, closed to open (>15%)
60	FRSD	Tree cover, broadleaved, deciduous, closed to open (>15%)
62	FRSD	Tree cover, broadleaved, deciduous, open (15-40%)
100	FRST	Mosaic tree and shrub (>50%) / herbaceous cover (<50%)
110	FRST	Mosaic herbaceous cover (>50%) / tree and shrub (<50%)
120	RNGB	Shrubland
122	RNGB	Deciduous shrubland
130	RNGE	Grassland
170	WETF	Tree cover, flooded, saline water
180	WETL	Shrub or herbaceous cover, flooded, fresh/saline/brakish water
190	URBN	Urban areas
200	BARR	Bare areas
201	BARR	Consolidated bare areas
210	WATR	Water bodies

Table 5: Land Use/Land Cover Changes from 1992 to 2015 of Edo State

LANDUSE_ID	LULC_CODE	1992	1995	2000	2005	2010	2015
10	AGRR	45.8762	46.31786	47.05381	48.25261	48.22371	48.05177
11	RNGB	0.686337	0.715717	0.779293	1.880804	2.760278	2.859496
20	AGRR	0.001927	0.001927	0.001927	0.001927	0.001927	0.001927
30	AGRL	3.751011	3.78569	3.869013	4.06793	4.11176	4.020248
40	AGRL	3.460101	3.226987	2.801218	2.443841	2.146187	2.052749
50	FRSE	17.46137	17.24656	16.76685	14.09326	13.14973	13.16322
60	FRSD	0.053944	0.050091	0.080916	0.395908	0.517281	0.570262
62	FRSD	22.062	22.01865	22.33075	25.20951	25.40988	25.53896
100	FRST	0.092475	0.092475	0.092475	0.098736	0.099699	0.098736
110	FRST	0.030343	0.030343	0.030343	0.009151	0.00578	0.004816
120	RNGB	4.988826	5.012908	4.691654	1.827342	1.617828	1.446846
122	RNGB	0.520653	0.514873	0.505722	0.441182	0.428178	0.423361
130	RNGE	0.274535	0.272608	0.270682	0.09103	0.075617	0.072728
170	WETF	0.135822	0.094401	0.08236	0.082842	0.082842	0.082842
180	WETL	0.000482	0.000482	0.000482	0.000482	0.000482	0.000482
190	URBN	0.436847	0.451297	0.475379	0.935345	1.200728	1.443475
200	BARR	0	0	0	0.000482	0.000482	0.000482
201	BARR	0.00289	0.00289	0.00289	0.003371	0.003371	0.003371
210	WATR	0.164239	0.164239	0.164239	0.164239	0.164239	0.164239

Changes in Urban Area of Edo State: There have been some changes that have occurred over the years in urban areas of Edo State as shown in tables 6 to 8.

Changes in Grass Land of Edo State: The changes also occurred in the grass land aspect of Edo State and below are the table which gives a breakdown of these changes from 1992 to 2015.

Changes in Scrublands in Edo State: The changes also occurred in the shrub land aspect of Edo State and below are the table which gives a breakdown of these changes from 1992 to 2015.

Table 6: Changes in Urban Area of Edo State from 1992 to 2015

Years	Urban areas	Rate of Change
1992	0.436847378	
1995	0.451296575	1.444919662
2000	0.475378569	2.408199437
2005	0.935344662	45.99660926
2010	1.20072824	26.5383578

2015	1.443474743	24.27465033
Average		20.1325473

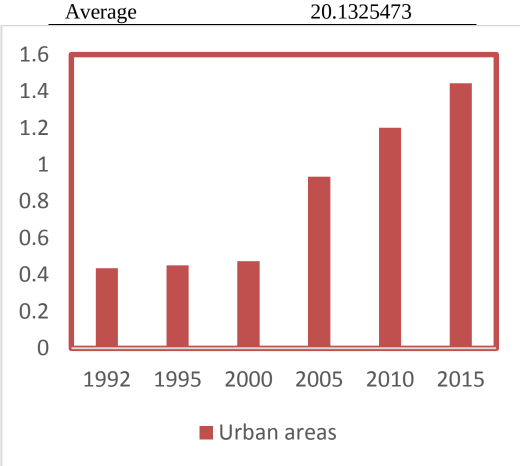

Fig 5: Graphical Representation of Changes in Urban Area of Edo State

The Land use land-cover change estimation as presented in the respective figures and tables revealed that Urban areas around Benin City is increasing at a high rate of about 20.13%, while of land covers like the grassland is experiencing a decrease at a rate of 4.04%. The Shrub lands are seen to be experiencing the high depletion rate of about 70.84%. Also, Bare Land development was observed from the year 2005 to 2015 of about 0.01% of the entire land area.

Table 7: Changes in Grass Land of Edo State from 1992 to 2015

Years	Grassland	Rate of Change
1992	0.274534736	
1995	0.272608176	-0.192655955
2000	0.270681617	-0.192655955
2005	0.091029939	-17.9651678
2010	0.075617462	-1.54124764
2015	0.072727623	-0.288983932
Average		-4.036142257

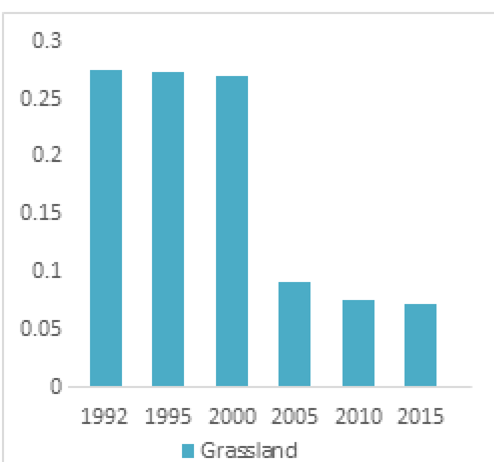

Fig 6: Graphical Representation of Changes in Grassland in Edo State

Table 7: Changes in Shrub lands in Edo State from 1992 to 2015

Years	**Shrubland**	**Rate of Change**
1992	4.988825955	
1995	5.012907949	2.408199437
2000	4.691654144	-32.1253805
2005	1.827341733	-286.4312411
2010	1.617828382	-20.95133511
2015	1.446846222	-17.09821601
Average		-70.83959465

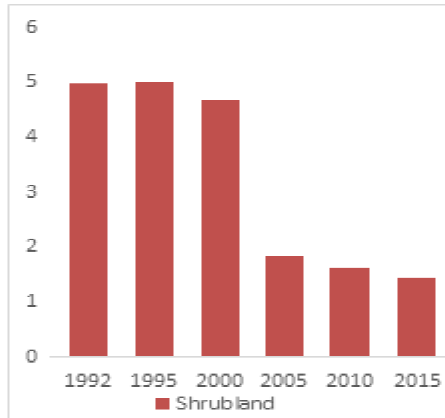

Fig 7: Graphical Representation of Changes in Shrub lands in Edo State

Spatial Analysis of Urbanization on Dumpsite: The spatial analysis of road network and river network are presented in the figures below. The digital elevation model (DEM) is presented in figure 6. The DEM was used to generate the slope of the area and then reclassified to present regions with gentle slope of 5 degree Celsius is given high priority while more steeper regions are given less suitable. The DEM revealed an elevation range of 0 as the lowest elevation which is typical of the lower portion of the basin while a high elevation ranges of 348m as in red in the map. The Euclidean distances for river and road are presented in figure 9 and 10 respectively.

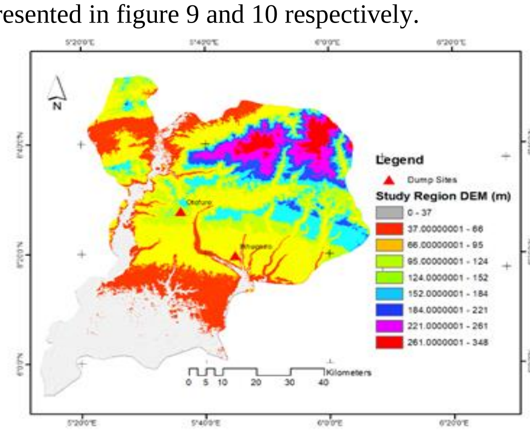

Fig 8: Digital Elevation Model for the Study Area.

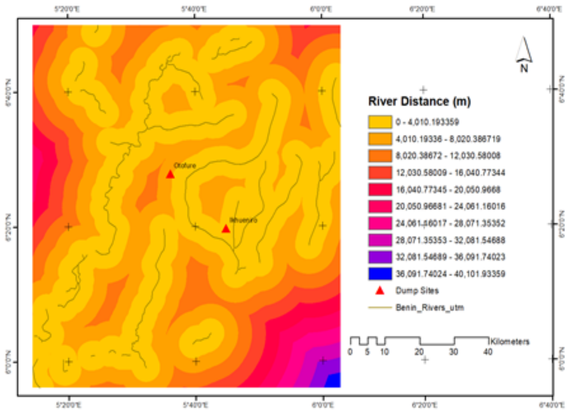

Fig 9: Euclidean Distance for River Networks in the Study Area.

The Euclidean distance for river measured distance range of about 0m from the river to as far as 40km from the river while the Euclidean distance for road measure proximity to suitable site from 0m to as far as 30.5km. Figure 11 and 12 presents the reclassified map for both river and road respectively. In order to create a single ranked map for identifying potential areas for siting solid waste dumpsite, the map layers were assigned numeric values and compared between these classes. The numeric value assigned to the map layers range from 10 to 1, which were used to identify the differences among area of most suitable to less suitable.

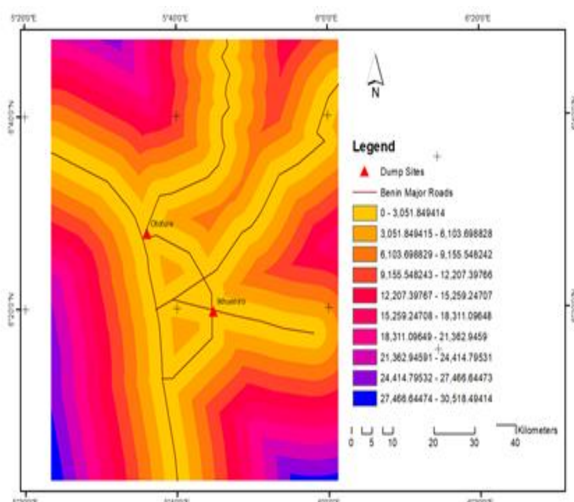

Fig 10: Euclidean Distance for Road Networks in the Study Area.

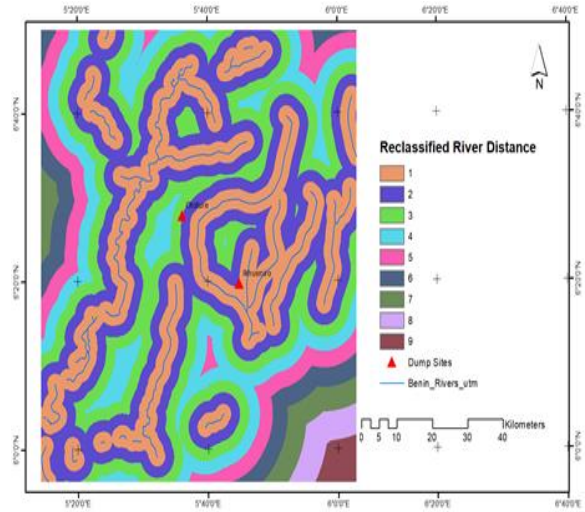

Fig 11: Reclassification Model for River Networks in the Study Area.

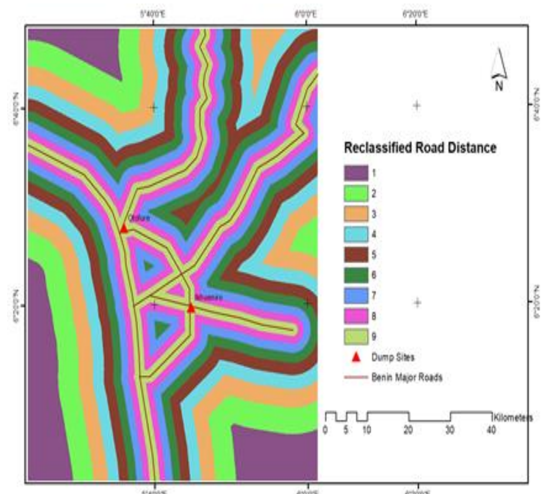

Fig 12: Reclassification Model for Road Networks in the Study Area.

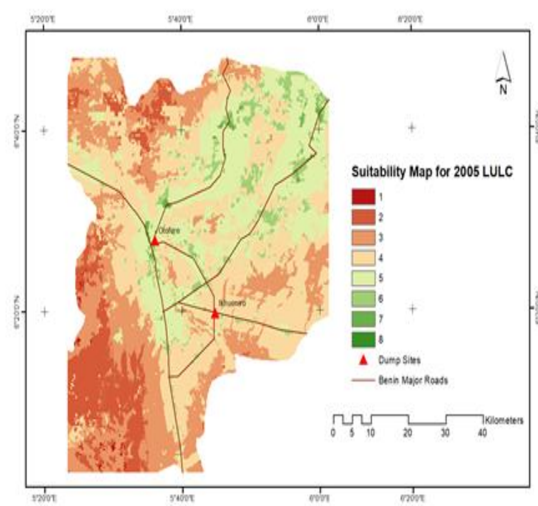

Fig 13: Suitability Map for Siting Dump Site in Edo State for 2005

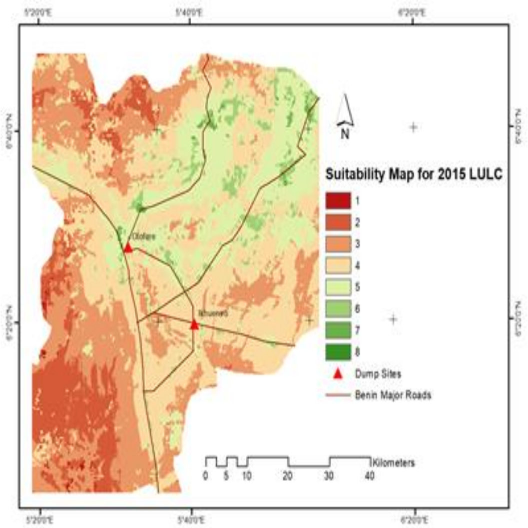

Fig 14: Suitability Map for Siting Dump Site in Edo State for 2015

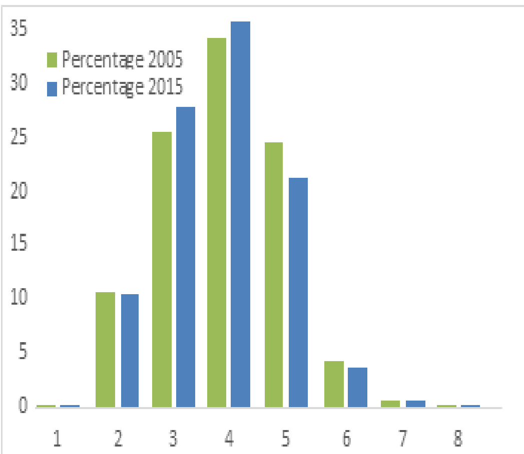

Fig 15: Percentage Changes for Available Suitable Land Type for Siting Dump Sites in Edo State from 2005 to 2015.

The identified areas of great importance to this research are presented in figure 13 and 14. Figure 13 present the region suitable for siting a dumpsite as at 2005 while figure 14 presents regions suitable for siting dumpsite in 2015. The areas suitable for citing dumpsite were then extracted from the map and presented in a tabular format and are presented in figure 15. It was observed that there is a significant decrease in the area available for siting dumpsite as the year go by this can be ascribed to rate of urbanization in the study area.

Conclusion: The available area of land for siting a dump sites in Edo State showed a significant reduction due to increase urbanization. With an average of about 20% increase in urban areas, and severe reduction in grassland and shrubs of about 4% and 70% respectively, it is seen that there is rapid increase in the rate of urbanization in the study area. The available land mass for siting dumpsite as at 2005 is drastically reduced as at 2015, which can be inferred that Edo State will face serious dumpsite inundation as residential building and activities would have taken up suitable land for sitting dumpsites. This may in turn affect the public health and should call for a proactive measure to curb this almost invisible challenge in the future.

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