Journal of Physical Science and Environmental Studies
Vol. 4 (4), pp. 64-73, November, 2018
ISSN 2467-8775
Full Length Research Paper
http://pearlresearchjournals.org/journals/jpses/index.html

Spatial Analysis of Urban Flood Risks on Recreational Development in Oguta, Owerri - Imo State, South-Eastern Nigeria, West Africa

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Accepted 15 November, 2018

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ABSTRACT

Over the years, the population of Oguta has been on the increase which brought about expansion in human activities to meet with the varied needs of the local communities. This anthropogenic action has resulted to a level of environmental degradation of which the researcher has envisage the problem of flooding in Oguta lake in Oguta Local Government Area (LGA), Owerri, Imo State. For this assessment, Geographic Information System (GIS) and Remote Sensing (RS) were used as a tool for carrying out this research. The data used for the analysis were acquired through the United State Geologic Survey (USGS), Global Land Use Land Cover Facilities (GLULCF) and archived materials from National Center for Remote Sensing Jos (NCRS). The assessment revealed that the water bodies and settlement increased from 130 km^2 (26.80%) to 306 km^2 (36.11%) and 53 km^2 (10.93%) to 154 km^2 (31.73%) for 1986 and 2016 respectively. It equally shows a corresponding decrease in vegetative cover and bare surface which decrease from (37.32%) and 121 km^2 (24.95%) to (4.97%) and 1 km^2 (0.19%) from 1986 to 2016 respectively. The analysis also revealed that increase in paved surfaces and infrastructural development has resulted in displacement of vegetative cover and bare surface and as such block water from infiltration and recharging of underground water. These increase the rate of run-off into the adjacent water body within the Oguta lake which makes the surrounding region to be liable to flooding. The government of Oguta LGA should ensure that GIS is used in the monitoring of flood event and ensure that Town Planning Laws and Ordinances should be observed.

Keywords: Digital elevation model, flood incidence, flood-risk, GIS, image classification, runoff intensity, urban recreation and management.

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INTRODUCTION

Flood is a standing pool of water which remains on the land surface for a long duration after a heavy down pour. Flood as a global phenomenon that occurs when the amount of rainfall exceeds a certain amount normal for that region, sufficient to cause significant damage to lives and properties, traffic obstruction, nuisance and health hazards as they inundate them (Adeleke, 2015). Flood is one of the extreme geophysical events in the world that constitute hazard to man (Gillespie et al., 2017). It is a water related hazard that affects a wide range of human activities such as agriculture and transportation (Ademora, 2014). Flood is fast becoming a common environmental hazard in most towns in Nigeria of which Owerri is not an exception. A variety of climatic and non-climatic processes influence flood processes, resulting in river floods, flash floods, urban floods and coastal floods. These flood-producing processes include intense precipitation, snow melt, dam break or release of water from dam. In the tropical and subtropical regions, severe flood hazard resulting from heavy thunderstorms, torrential monsoon down-pours, hurricanes, cyclones and tidal waves surges in coastal and estuarine environments are becoming yearly occurrence and are linked to global warming which produced climate change (Akintola and Ikwuatu, 2016).

Owerri has witnessed increased flooding incidences during recent past of which no fewer than 30 buildings located in the densely populated works layout in Amakohia area, Owerri, were submerged by flood following a heavy down-pour on the 10th of September, 2016. Flood risks in Owerri urban areas are attributed to hazards accelerated by growth in terms of population, housing, paved-up areas/surfaces, inappropriate waste disposal in to drainage channels, water use, among others all contributing to high intensity of runoff leading to flooding to low land areas.

Urban flash flood associated with torrential rainfall is the major type of flood in Owerri. In Owerri, flooding affects people on annual basis more than any other form of natural disaster. The phenomena of flood hazard comprise structural damage, erosion damage, loss of life and property and disruption of social and economic activities (Akinyemi and Akinyemi, 2016). Axim (2016) described it as an environmental issue which remains threatening to man. Perennial flood has been associated with interruption of economic activities giving rise to loss of cultivable farmlands and property, and invariably retarding development. There is concern for flood because of the vulnerability of the people.

Flood damage has been extremely severe in recent decades as a result of change in the land use pattern which is expanding due to increasing population, leading to more housing and paved surfaces, loss of vegetative cover, excavation of earth materials among others. All these activities of man have shown a great foot print in form climate change, global warming, rise in sea level and it is evident that both the frequency and intensity of floods are increasing. To this end, it is increasingly important to resolve the issues relating to flood risk management using GIS and remote sensing.

More significantly**,** the disaster profile of Owerri and environment is dominated by flood events which are associated with property damage, interruption of movement of people, economic and social activities as well as recreational centers. All disaster reduction related activities are targeted at safety and sustainability of human lives and property. Safety is linked to avoiding human casualties and injury as well as safe guarding property assets. Since flood is a challenge, it is good to carry out flood risk assessment in the study area.

In Owerri and environs, flooding is becoming a regular annual phenomenon. Rainfall is the primary source of flood water in Owerri. In recent times, flood water has been associated with loss of properties, traffic obstruction, and health hazards. This has led to the blocking of drainage channels in urban areas. Poor drainage network and refuse disposal system in addition to lack of good tarred roads increase flood risk in informal settlements (Nwafor, 2006). Unpaved roads are washed away easily, hindering access. Floods are annual phenomena with the most severe occurring during the months of June, July and August. Flood frequently affect the area eroding the landscape thereby creating gullies plate.

Flood mapping will help to establish the site-specific nature of flood risk. Maps produced will help to develop and improve information management system to effectively handle all information relating to flood. Knowledge of activities going on in the environment is important for daily survival since some of these activities impact life negatively (Bartholomew and Michael, 2017; Benjamin and Charles, 2017).

A flood hazard map is a very crucial tool for monitoring flood risk. There are several methods for flood mapping based primarily on hydrologic, meteorological and geomorphologic approaches. Brooks and Nana (2013) investigated series of sites to explain how GIS could be used in manipulating and processing various forms and types of spatial data for strategic flood risk assessment. Their paper described the use of GIS in flood risk mapping by monitoring flood depth and velocity of floodwater flow. Flood defense data was analyzed and combined with other data such a land use, hydrological survey data, bathymetric data, and photogrammetric data to generate models. Brooks and Nana (2013) considered six combinations of water level, to produce a flood hazard map of the area showing the spatial distribution of different levels of flood risk and showed the effectiveness of the use of models in a GIS environment for mapping flood risk.

Harieth (2016) and Golden and Golden (2014) employed the methods of remote sensing and GIS in combination with Gumbel's extreme distribution model to estimate the extent of flood inundation in different flood return periods in Kaduna metropolis. The data used for the study included land use/land cover, flood stage data and digital elevation model. They concluded that areas lying close to River Kaduna floodplain were under threat of flooding in different return periods.

An understanding of these issues can contribute to appropriate urban flood risk management strategies. Ibeh (2017), Jesse (2016) and Ishmael and Ajibaje (2017) opined that the acceptance of risk should be studied from three different points of view in relation to the estimation of the consequences of flooding. The first point of view according to them is the assessment by the individual. This is translated as the probability of losing one's life due to participating in daily activities. The second point of view concerns the risk assessment by society on a national level related to the number of causalities due to a certain activity while the third has to do with acceptable level of risk due to economic cost-benefit analysis.

More importantly to this study, most of the papers reviewed

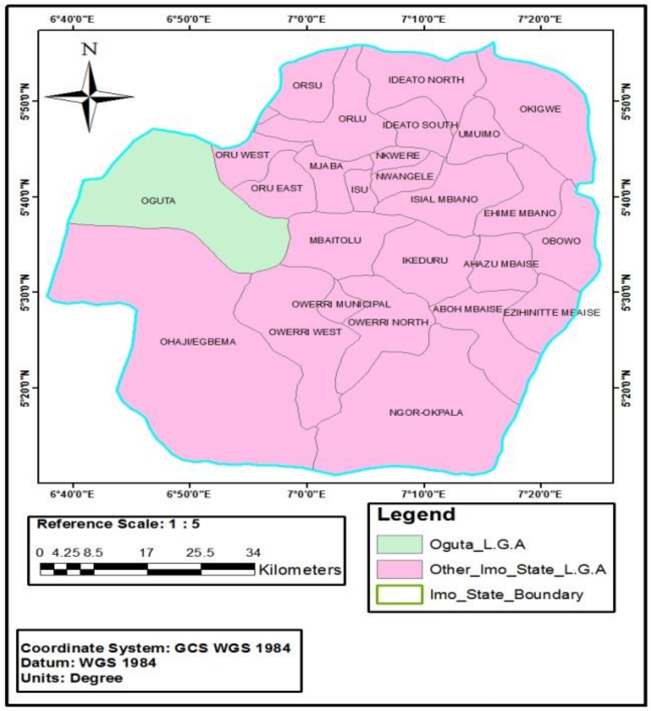

Figure 1. Location map of Imo State showing oguta.

focuses on the risk assessment and adaptation options to river flooding in some urban areas. To the best knowledge of the researcher, very few research works have taken a quantitative and holistic view of the factors responsible for flooding in Oguta LGA of all the papers reviewed, little attention is paid to run-off studies in Nigerian catchment area. It is therefore important to identify which areas that are at risk of flood hence security of life and property is involved. To combat effectively with the environmental factors, it is increasingly important to resolve the issues relating to flood risk management using GIS and remote sensing as it relates to Oguta Lake recreation center since no such work has been carried out in that area. Thus, the aim of this research is to investigate the risk of flooding on the infrastructural development within Oguta lake recreational center in Owerri, using GIS and remote sensing. The specific objectives are to identify the land use pattern as well as other geographic features using the satellite imagery of 1986 and 2016 of Oguta, to generate the contour/slope map of the study area using the DEM (Digital Elevation Model), to identify areas that is at risk of flood hazard, and to determine the cause of flood hazard.

MATERIAL AND METHODS

Study area

The study area (Oguta Lake) is one of the recreational centers in Nigeria is located in Oguta local government area of Owerri, Imo State (Figure 1). It is also one of the 26 LGA in Imo state which lies between latitude $5^{0}41'$ and $5^{0}44'$ N and longitude $6^{0}56'$ and $6^{0}45'$ E of Greenwich (NCRS, 2016). It is a natural lake with surface area of 1.8 km^2 at peak flood with a maximum depth of 7 m during raining season with mean depth of 5.5 m (Figure 2). The lake is fed mainly by Njaba and Obana Rivers and then empties itself into the River Niger drainage system through River Orashi by virtue of its location in relation to other existing water bodies. Oguta Lake is one of the largest lakes in the South Eastern Nigeria.

Data collection and analysis

The process of data acquisition relied on secondary data (methods of remote sensing and GIS) and field observation. The GIS methods included acquiring of spatial reference point using Global Positioning System (GPS) with projected coordinate system (universal transverse Mercator, 1984 Datum, zone 32) system. Image data for 1986 and 2016 were obtained from Land sat satellite imageries of thirty meters (30 m) resolution for Landsat 7 (GLCF) and the other one from Landsat 8 (USGS (ETM$^+$).

Contour map analysis (using Digital Elevation Model (DEM)) generates thematic maps over the temporal and spatial scale to understand the patterns on vegetative cover, settlement/buildup area, water bodies, bare

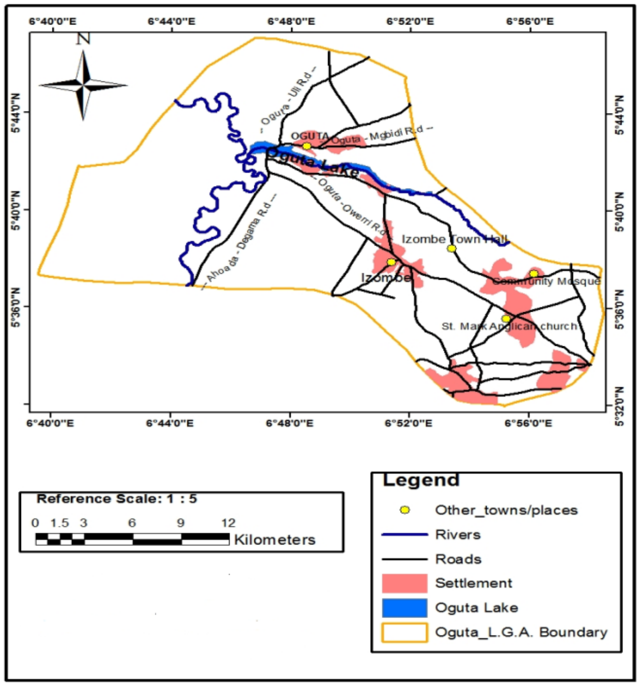

Figure 2. Location map of Oguta Lake identified within the study area.

surfaces and consequences on hydrological settings. These include the following: satellite imagery Global Land Cover Facility (GLCF) and GLULCF, digital camera, GPS, Application Software such as: Arc GIS 10.1 and Microsoft Pack (Microsoft Word and Microsoft Excel) were used. The methods employed for this data analysis which is geared towards achieving of the aim are stated below: In image analysis, two acquired images for which one is from Landsat 7 the other is from Landsat 8 (ETM^+) which are 1986 and 2016 images, with different bands, these bands of the two images were layer stacking using ArcGIS 10.1 for each particular epoch clipping of the study area was equally carried out using ArcGIS 10.1.

Nearest neighbor for district data were used for the resampling in a TIFF and each were rectified to Projected Coordinate System (PCS), World Geodetic Survey (WGS), Northern Hemisphere and Zone 32. This was carried out using ArcGIS 10.0 for all the images to ensure and also have the actual representation of the earth surface. Each of these images was classified using the same identifiable geographic features/land use pattern which is forest, farm land, bare surface, and settlement. Once the image area is rectified to specific coordinate system, this classification will help to effectively quantify the identified features for which it will be used for further analysis. Iso-cluster method of image classification was been used as it takes more consideration into the pixel image extraction/classification. This has been backed up with ground truthing which was carried out on the same period of data collection to ensure that what was on the image was exactly what it was reality. Materials like global positioning system (GPS), Google Earth are equally used for this process (Figure 4). The people of the area were equally asked questions on what have been in existence in a given area before and during the research, and how as well as when the change might have taken place. Using ArcGIS 10.1 software, the unsupervised classification system, was carried out using iso-cluter algorithm to perform the classification on the images. Data collected during field trips using global positioning system (GPS) served as reference data and google earth was also used for image verification. The unsupervised classification is used, instead of supervised classification, because it will effectively and accurately detect the smallest change for effective analysis.

Analysis on Digital Elevation Model (DEM) was done to reveal the topography of the study area using contour lines as this will effectively help to identify the flood prone area. Different quantified/classified image of different epochs was engaged as statistical representation to carry out the study in a statistical manner, using graph and table format, in addition to Microsoft Excel.

These quantification/classification analyses of these images were carried out using ArcGIS 10.1 which produces the area covered by the identified features in count. Since the research was carried out using Landsat image of 30 meters resolution (30 by 30 m in terms of pixel size), and the area of a square is L^2, therefore, the area of each pixel will be $30^2 = 900\ m^2$. Therefore, each count that covers a given classified feature in terms of quantification, is been multiplied by $0.0009\ km^2$ to get the area covered

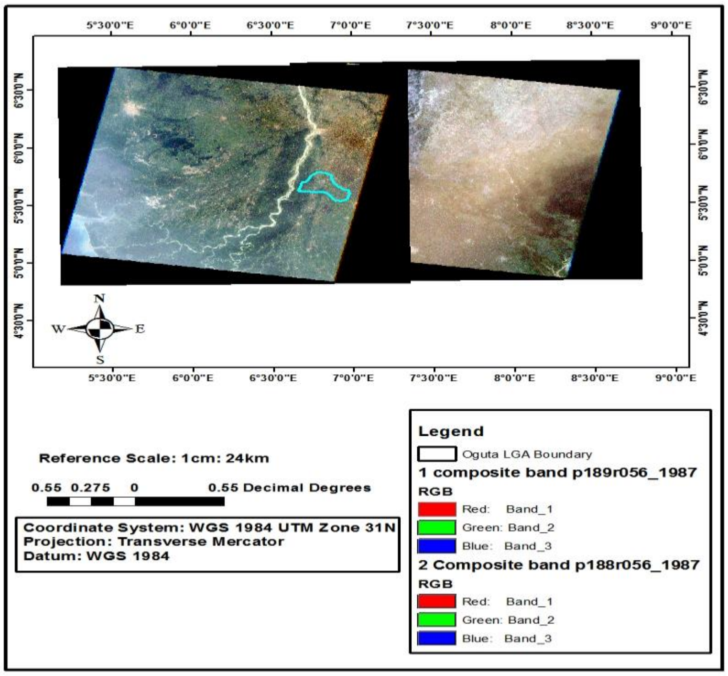

Figure 3. Combined landsat images of Oguta for 1986 and 2016.

directly in square kilometers square (km²).

Descriptive and analytical methods of data analysis were adopted. GIS technology was used for the production and presentation of risk information. GIS played a central role in integrating, organizing, processing and visualizing spatial data. GIS was used to interpret and analyze remotely sensed data. It was used to establish spatial variation of slope, land use pattern and relief information through appropriate maps. Risk was presented in the form maps. For every geographic data, the attributes and geometric characteristics were highlighted and assessed. Types of spatial analysis employed include overlay analysis and geostatistical analysis. Maps of the study area covering different themes were produced. Each map layer represents a single geographic feature. To achieve the aim of the study, various maps were produced.

The two images acquired were classified using ArcGIS 10.1 and the steps adopted are as follows: import the already clipped image (ensuring that the image classification tool is checked). On the image classification tool bar, ensure that it is the name of the image that you want to classify that is highlighted, click on the classification drop down button and select Iso-cluster; fill up the menu that appear and click ok, and then the image will be classified. The image classification process was carried out for the 1986 and 2016 image as indicated in Figure 3.

The topographic map of the study area is been generated using the digital elevation model (DEM). This helps to show the height/elevation/slope of the study area which helps to reveal the direction of flow after rainfall or heavy downpour. This was also carried out by launching ArcGIS 10.1, then importing the map of the study area. Afterwards, import the DEM of Nigeria, and then clip the DEM of the study area to reduce the time spent during the analysis. From Arc tool box --- Spatial analysis --- Surface analysis --- Contour analysis, specify the interval (for this work, the study made use of 5 meter interval) of the contour line and fill the storage location among others. Then this forms the map as shown in Figure 5.

In assessing risk of flooding in an urban recreational development, the study utilized primary and secondary data. Relevant environmental factors were mapped and analyzed. The attributes and geometric characteristics of every geographic data collected were highlighted. Data were collected from physical survey through the administration of 200 questionnaires using a random sampling technique. The data collected for each objective, the method of data collection, the analytical frame work and the conclusion drawn, all contributed in accomplishing the philosophy of the study.

RESULTS

The Oguta Lake is located at a very low area which will make the settlement around there prone to flooding as the lake drains the rain within its catchment area and increases in volume after any rain fall.

The classified image of 1986 shows the land use pattern

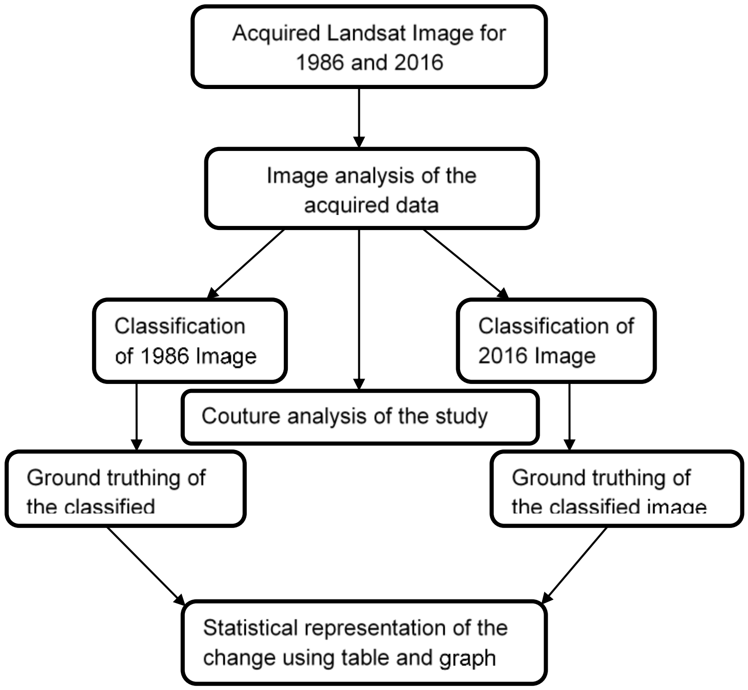

Figure 4. Stages of data acquisition and processing.

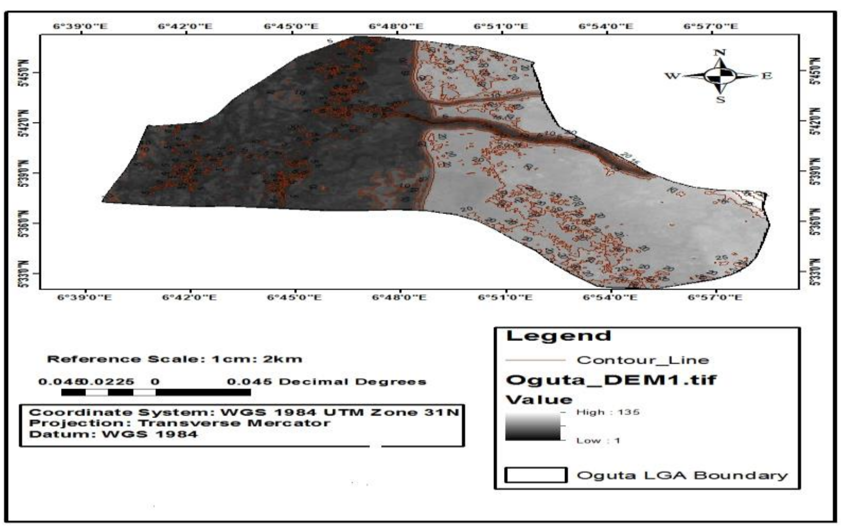

Figure 5. Showing the contour/elevation of the study area for 2016.

of the study area and it reveals that 26.8% of the area is covered by water bodies, 37.32% is covered by vegetation, 10.93% is used by settlement while 24.95% is covered by bare surface (Figure 7).

The classified image of 2016 as shown in Figure 9 the land use pattern of the study area equally reveals that 63.11% of the area is covered by water bodies, 4.97% is covered by vegetation, 31.73% is used by settlement while 0.19% is covered by bare surface. Settlement is increasing, while the water bodies is decreasing, which is as a result of high rate of run-off which will bring about flooding in the Oguta lake recreation center. The map in Figure 6 shows a buffer distance of 0.5 km and any settlement or development within this buffer distance are at risk of inundation as delineated in the map.

From the flood risk on Oguta recreational development map produced (Golden and Golden, 2014), it was discovered that the area with the highest flood risk is located at Oguta Lake and Government College Teacher's quarter. Imo state University Staff School as well,

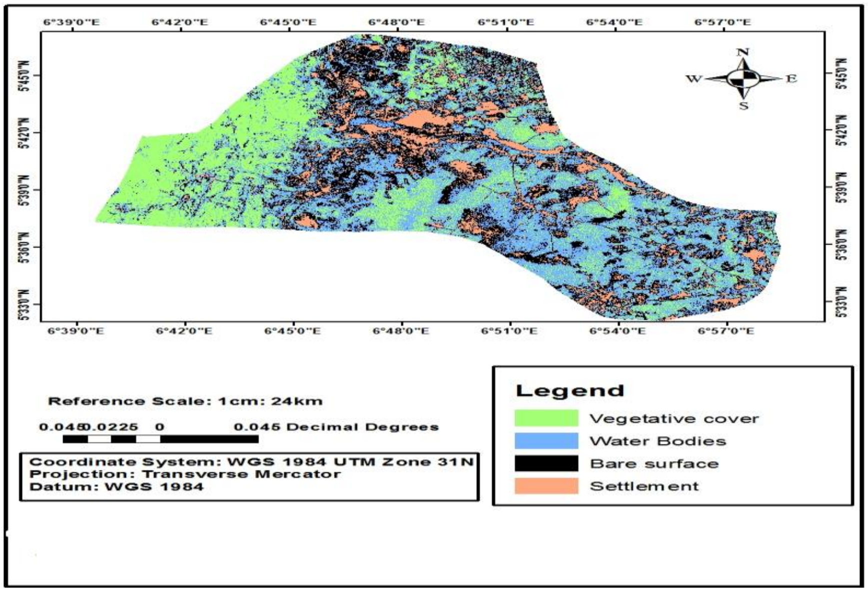

Figure 6. The classified image of Oguta for 1986 epoch.

experiences slight risk of flood hazard as the area lies within 0.5 km buffer distance identified as Oguta Lake buffer distance in Figure 6.

DISCUSSION

GIS was used to interpret and analyze remotely sensed data. It was used to establish spatial variation of slope, land use pattern through appropriate maps as shown in Figures 3, 4, 5. From the image classification analysis, it was discovered that susceptible/vulnerable to the risk of flooding resulting from its location and environmental factors. It is observed that the area usually experiences annual increase in the volume of water as a result of annual increase in rain fall. The Oguta Lake serves as an inland water body, which drains the run-off from the surrounding catchment areas within its water shade.

Pointer to flood hazard mapping assessed shows that physical location, poor waste management practice, inadequate/poorly constructed road and drainage, rainfall and poor development control practices. The causes of flood are linked to land use, soil, climate features and lack of good governance. This result is in agreement with the assertion by Jesse (2016) that flood in urban areas is linked with rainfall, urbanization, indiscriminate waste disposal, poor development control practice and poor drainage facility.

Flooding was man's modification of the basic drainage network and channels characteristics during the process of settlement development on the flood plain. He noted that natural surfaces were replaced by more impermeable roads and concrete, which have very low infiltration capacity. The hydrological consequences of this was that water, which should normally infiltrate into the ground, or be intercepted by vegetation and then delayed for some time before running, would be immediately available for runoff (Adeleke, 2015; Brooks and Nnana, 2013).

With the increasing number of urban dwellers, the number of people at risk to flood hazard in Owerri most especially the recreation centers (Oguta Lake) is increasing such that it has been identified as a serious threat to sustainable development of Owerri (Ibeh, 2017). Adeleke (2015) has reported that the high amount of sediment yield in a river is directly related to the amount, duration and intensity of rainfall, as well as stream discharge, which often increases the river water level and finally causes flooding in Ilorin. Considering the fact that mapping is the cornerstone for meaningful development there is need for flood risk management.

It is therefore important to identify which areas that are at risk of flood hence security of life and property is involved. To combat effectively with the environmental factors, it is increasingly important to resolve the issues relating to flood risk management using GIS and remote sensing as it relates to Oguta Lake recreation center. All environmental problems are associated with space and time.

The classified Land Use Land Cover (LULC) pattern of 1986 and 2016 as shown in Figures 6 and 8 respectively revealed that water bodies occupied 130 km^2 (26.80%) and 306km^2 (36.11%) respectively (Table 1 and 2 above with a graphical representation as well). This shows that there is an increment in the volume of water bodies by 176 km^2. This point to the fact that flooding will occur most especially with the low land areas as identified with the

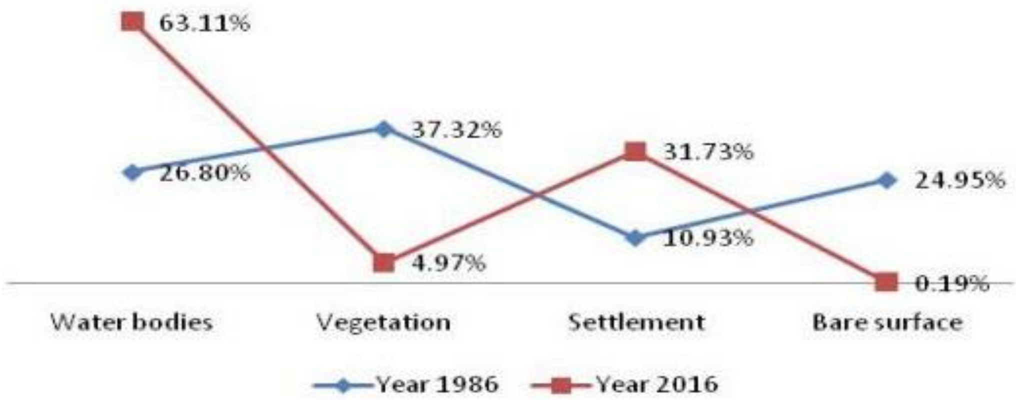

Figure 7. Quantified value of the 1986 classified image.

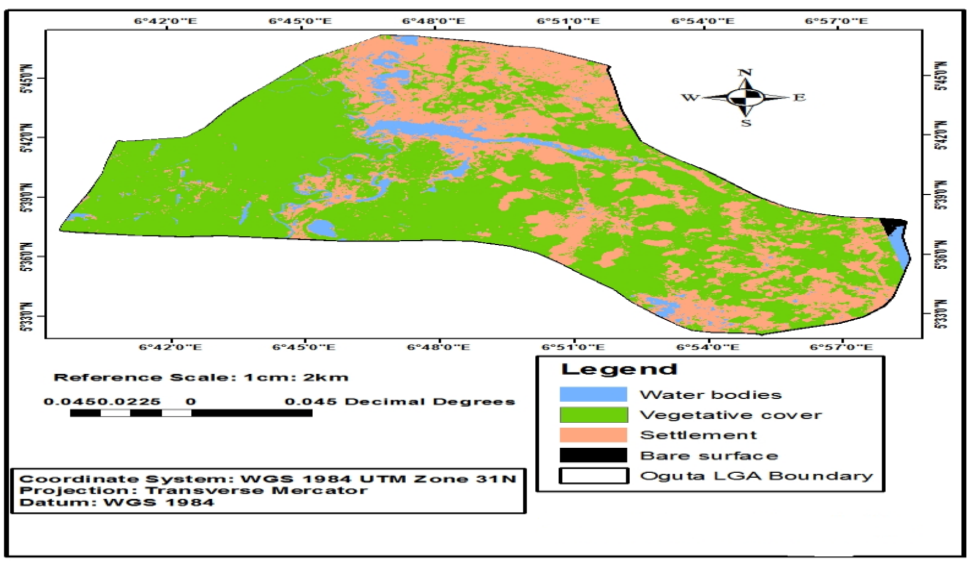

Figure 8. Showing the classified image of the study area for 2016

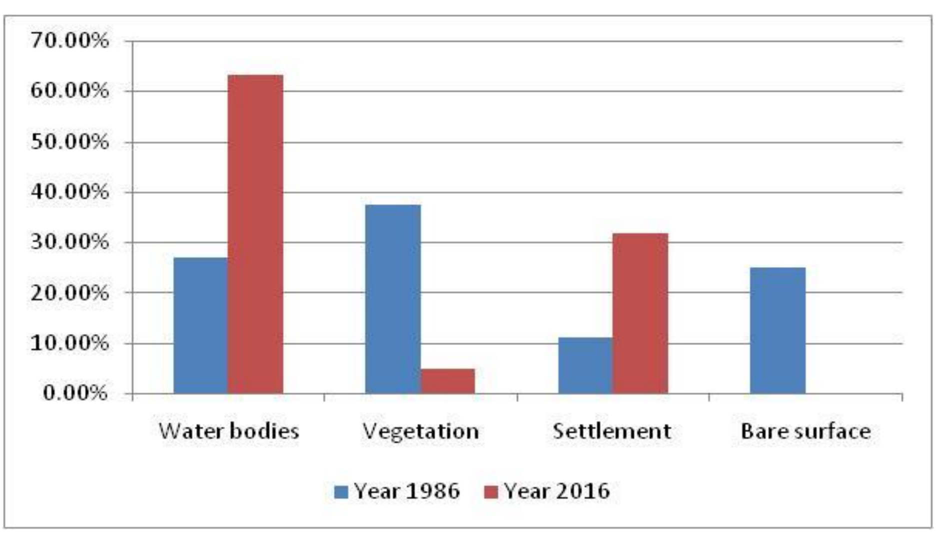

Figure 9. Quantified value of the 2016 classified image.

Table 1. Showing the values of the 1986 classified image.

Objects	Land use	Count	Quantity in Km^2	Percentage
1	Water bodies	144129	130	26.80%
2	Vegetation	200773	181	37.32%
3	Settlement	58660	53	10.93%
4	Bare surface	134869	121	24.95%
Total		538431	485	100.00%

Table 2. Showing the values of the 2016 classified image.

Objects	Land use	Count	Quantity in KM^2	Percentage
1	Water bodies	339782.5	306	63.11%
2	Vegetation	26786.62	24	4.97%
3	Settlement	170835.2	154	31.73%
4	Bare surface	1026.77	1	0.19%
Total		538431	485	100.0%

contour map in Figure 3 above of which Oguta lake and it environ is not an exception as water will always take lowest contour based on the topography of the study area.

The LULC pattern resulting from image classification has it that settlement occupied an area of 53 km^2 (10.93%) and 154 km^2 (31.73%) for 1978 and 2016 respectively. This shows that there is an increment of 101 km^2 area covered by settlement from 1986 to 2016. This is as a result of increase in population which will bring about increase in dowelling place for man. This action of man in the environment today has greatly increase the rate of buildings and paved surfaces which blocks the point of recharge of sub-surface and ground water, coupling with the slope of the study area, during rainfall, instead of infiltrating into the soil, water percolate and run-off and the velocity of this run-off increases with increase in slope, paved surface and the amount of rainfall and empties into the adjacent larger water body, thereby increasing the volume of the river and causing inundation of the adjacent settlement to the river. Herieth (2016) observed that residence contributes greatly to flood problems of their area and their act jeopardizes the environment which attracts many people for economic, social and recreational facilities.

Vegetation and bare surface decreased from 181 km^2 (37.32%) and 121 km^2 (24.95%) in 1986 to 24 km^2 (4.97%) and 1 km^2 (0.19%) in 2016 respectively. This also reveals that in a spatial environment where the study area of 485 km^2 is fixed, it indicates that the loss of vegetative cover and that of bare surface is gained by the increasing settlement and water bodies. This equally increases the risk of flooding, because the point of underground recharge and infiltration are been blocked by paved surfaces and settlements. All environmental problems are associated with space and time. In order to appreciate the magnitude of the problem, their quantum and spatial relationship need to be known. Attempt has been made to x-ray the philosophy of the study. Relevant maps were produced to achieve the aim of the study.

Conclusion

All environmental problems are associated with variation in space and time and in order to appreciate the magnitude of the problem, their qualitative nature and spatial relationship need to be known. Relevant maps were produced to direct achieve the aim of the study. In assessing envisage risk of flooding in Oguta lake recreational center. The study analyzed different flood hazard indicators that contribute to the vulnerability of the people. The data were integrated in a GIS to perform the flood risk. GIS was used to evaluate the interaction of environmental factors in a spatial dimension to locate areas that would be given priority in implementing remedial measures. GIS application ranges from storing and retrieving of data to manipulating data with a view to producing a flood hazard map. Land use pattern map were generated data set helped the researcher to understand the drainage behavior of the area. Therefore, once life, man will continue to deteriorate the environment to meet up with his unending needs and as such, and history will continue to recur itself. This has made GIS and remote sensing an inevitable tool to be used in the data collection, assessment and monitoring of the environment.

In view of the envisaged problem identified by this study and the comments made on the sources of flood risk, assessment of impact on infrastructures and properties. To this end, it will be of interest to make some recommendation for the sustainable growth and development of this Oguta Lake recreational center and they are as follows:

1. Appropriate infrastructural investments in the construction of good quality roads with drainage should be made likewise bridge/fly over to help provide assess when the issue of flooding commence.
2. There should be proper layout of drainage systems to

ensure that excess water finds a smooth pathway to flow out from the land surface.

3. A layout plan should be developed on the contour map (Figure 3) produced such that consideration of the topographical features highlighted will aid proper orientation of the drainages during construction.

4. The residence or infrastructures within the 0.5km buffer distance delineated in figure 6 should evacuate to avoid loss of life and properties when flooding will occur.

5. For a better cultural and natural environment to be achieved, the environmental laws and order need to be obeyed. Therefore, the Urban and Regional Planners should be given the opportunity to practice their profession to the best of their knowledge without bottom neck approach.

6. On the side of the masses, they should obey the environmental laws stated by the Town Planning Authority.

7. Measure should be put in place to ensure that communities will have the knowledge and understanding of their risk environment to enable them to cope better with hazard impacts.

8. Environmental education and monthly clean up exercises of drains and surroundings should be enforced.

9. Further research on flood risk using GIS and remote sensing data should be carried out on yearly bases to ensure proper monitoring and data base creation is created for effective environmental management.

10 .Finally, a mechanism should be worked out and fully supported by the government to assist those carrying out studies using GIS and remote sensing methods to obtain the required satellite imagery because of the cost implication. This will help to give the future researchers the courage to engage in any sort of research using such method as it is fast more accurate and precise.

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