



## ACCESSING AGULU LAKE THROUGH THE APPLICATION OF REMOTE SENSING AND GEOSPATIAL INFORMATION TECHNOLOGY

I. C. Ezeomodo<sup>1</sup> & J. I. Igbokwe<sup>2</sup>

<sup>1</sup>Department of Environmental Management, Chukwuemeka Odumegwu Ojukwu University, Uli Campus, Anambra State, Nigeria

<sup>2</sup>Department of Surveying & Geoinformatics, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria  
ic.ezeomodo@coou.edu.ng, ji.igbokwe@unizik.edu.ng

### Abstract

*The widespread availability of satellite imagery makes it possible to access and map even an inaccessible area by looking at it from space. Agulu Lake, a natural feature has so many mysteries surrounding its existence which make effective ground based research virtually impossible. The objective of this paper is to access Agulu Lake through the application of Remote Sensing. Mapping of Agulu Lake was carried out using IKONOS (2015) satellite image; the method adopted was digital image processing and cartographic procedures. The georeferenced and classified map was validated using Confusion Matrix Statistical tool after ground-truthing, acquisition of coordinates of selected Ground Control Points (GCPs) and field completion. It was also possible to map buildings and roads using the imagery and this was done to depict some development around the lake during the onscreen digitization. The acquired data were processed using ArcGIS 10.1 and ILWIS 3.3. The image classification was tested using Box Classifier and Minimum Distance Classifiers respectively and the Maximum Likelihood Classifiers result gave the best result with the Average Accuracy of 83.46 %, Average Reliability of 81.56 %, and Overall Accuracy of 86.49 %. The perimeter of the Lake is found to be 965,062.083 square metres and longest side of the Lake is 2,622.848 metres. The coordinate list of the lake perimeter was produced based on the WGS1984 UTM Zone 32N coordinate system. A buffer zone with a fixed distance 30 m which specifies a constant buffer distance was applied to the boundary line of the Lake and result showed that a building of the Idemili Cultural centre was the only infrastructure inside the buffer zone. The project recommends among others that the relevant institutions/government concerned, should use this information as a base map for monitoring the developments that affect the water quality and good tourism potentials of the lake and environs.*

**Keywords:** Satellite Imagery, Inaccessible Area Mapping, Digitization, Buffering & Base map

### INTRODUCTION

Surveying and Geoinformatics is an applied science and a professional discipline. As an applied science it involves an integrated approach to the measurement, analysis, management, and display of geographic and other spatial data. Fortunately, remote sensing which is proven to be a fast and reliable means of acquiring data about the environment without physical contact with the features, is very significant and cost effective in data mapping real world problems (Jensen, 2005; USGS, 2012). High resolution satellite imagery such as IKONOS, Quickbird and GeoEye-1 have served as useful means of monitoring the environment and the state of its features. They also provide the tool to constantly map natural and man-made features and even plan for new ones. This capability is made more versatile with the use of the Geographic Information System (GIS); a computer based information system that is used to input, store, retrieve, manipulate, analyse and output geographically referenced data,

The integration of remote sensing and Geographic Information System (GIS) techniques in mapping and updating, allow for the integration of data from different sources as well as the interpretation, analysis and accurate representation and automation of the map-making and revision processes (Okpala-okaka, 2008). Remote sensing data processing deals with real-life applications with great societal values. For instance urban monitoring, fire detection or flood prediction from remotely sensed multispectral or radar images have a great impact on economic and environmental issues (Camps-valls, 2008).

Up-to-date and accurate base maps, are basic tools for any meaningful planning, systematic development and effective management of the natural resources of any nation, (Ejikeme, Igbokwe, Igbokwe & Ezeomede, 2014). However, the Agulu lake map produced in topographical map of 1964 by the Federal survey is outdated and thus not very suitable for effective planning, monitoring, environmental management and sustainable development (Ufuah, 2003). In the past, traditional survey technique had been the process used for mapping and revision of maps. This method is tedious, time consuming, inefficient for mapping large areas and most times difficult for mapping inaccessible and dangerous areas. Later, in nineteenth century, aerial photographs were used to extract data for producing and revising maps. This method had also proven to be inefficient since most of aerial photographs available in the country were acquired between 1956 and 1972, hence outdated and cannot be used in this kind of assessment and mapping.

Agulu Lake has gone through a lot of changes in the recent past if compared with the available long-standing data of the area, like the Topographic map of 1964, SPOT-5 (2005) and LANDSAT ETM + image of (2006) available to the researcher (see Figure 3, Plate 2 and Plate 3) and there is need to update land database continuously, to meet the rapid changes in the environment. To achieve this, the study tends to map Agulu Lake via Remote Sensing and Geospatial Information Technology. Remote Sensing and Geographic Information System (GIS) as a computerized technique provides the capability for land use/cover mapping with improved accuracy, which can be done repeatedly, that is, continuously at regular time intervals. It is upon this background that the study set out to use IKONOS (2015) satellite image covering the area to map the “sacred and inaccessible” Agulu lake with a view to produce a digital base map that will be a future reference tool for evaluation, monitoring, planning and management of this potential tourist zone.

## **Conceptual framework**

Remote sensing is the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by sensors that are not in physical contact with the object under investigation (Jensen, 2007). Remote sensing is the field of science studying and modelling the processes occurring on the Earth's surface and their interaction with the atmosphere. Generating different maps from remotely sensed data can be so effective and valuable. A classification of sensing elements and methodologies to generate these remotely sensed models are essential for mapping. The major concepts of geoinformatics used in this research are data (pre-) processing, training of area of interest, image classification, accuracy assessment and digitizing process.

Remote sensing provides valuable information for policy and decision makers, as well as for tourism or defence applications (Camps-Valls, 2008) The term Remote sensing means the sensing of the earth's surface from space by making use of the properties of electromagnetic wave emitted, reflected or diffracted by the sensed objects, for the purpose of improving natural resource management, land use and the protection of the environment. It is the collecting and interpretation of information about a target without being in physical contact with the object. Aircrafts and satellites are the common platforms for remote sensing observation. According to United Nation (as part of the general assembly resolutions A/RES/41/65, 95<sup>th</sup> plenary meeting, 3 December, 1986), This involves the utilization at a distance of any device for gathering information pertinent to the environment, such as measurements of force fields, electromagnetic radiation or acoustic energy for air craft, space crafts or ships. The technique employs such devices as cameras, lasers, ratio frequency receivers, radar systems, sonars, seismographs, gravimeters, magnetometers and scintillation counters (Jenson, 2007).

The processes in remote sensing involve an interaction between incident radiation and the targets of interest. Electromagnetic energy has been classified by wavelength and arranged to form the electromagnetic

spectrum. As electromagnetic energy interacts with the atmosphere and the surface of the earth, the most important concept to remember is the conservation of energy (i.e, the total energy is constant). As electromagnetic waves travel, they encounter objects (discontinuities in velocity) that reflect some energy like a mirror and transmit some energy after changing the travel path. The instruments used to measure the electromagnetic radiation reflected/emitted by the target under study are usually referred to as remote sensors. There are two classes of remote sensor. Sensors which sense natural radiations, either emitted or reflected from the earth are called passive sensors and the sun as a source of energy or radiation. The sun provides a very convenient source of energy for remote sensing. The sun's energy is either reflected, as it is for visible wave lengths, or absorbed and then re-emitted as it is for thermal infrared wave lengths. Sensors which carry electromagnetic radiation of a specific wave length or band of wave lengths of illuminate the earth's surface are called active sensor. Active sensors, on the other hand, provide their own energy source for illumination. The sensor emits radiation which is directed toward the target to be investigated. The radiation reflected from that target is detected and measured by the sensor. Advantages of active sensors include the ability to obtain measurements any time, regardless of the time of day or season. Active sensors can be used for examining wavelengths that are not sufficiently provided by the sun, such as microwaves, or to better control the way a target is illuminated.

## **Literature reviewed**

Petrie (2007) used remote sensing to map inaccessible lands between Pakistan and Afghanistan, the research concluded that although much of the borderlands are almost completely inaccessible for archaeological research on the ground, it is still possible to carry out research from space by using the readily available satellite imagery from NASA, such as the Landsat 7 and SRTM data that can be downloaded for free from the internet. Toju and Okoduwa, showed the application of GIS to map flood risk zones in Benin city, Nigeria in 2000), the resultant map was a raster map showing variation in soil strength across the study area. While (Carmelo, et al 2014) used a combination of remote sensing data and mapping information from different sources to create the land cover map. USGS (2012) carried out analysis of potential future land cover change in the United States, where an approach of scenario construction and spatially explicit land cover modeling was adopted. (Babalola, et al 2014) analyzed the Land Use/Land Cover of Girei, Yola North and South Local Government Areas of Adamawa State, Nigeria Using Satellite Imagery. The study showed that land use/land cover change was better captured and monitored through the use of satellite imagery that served as a means of efficiently updating digital databases. (Ohlhof, et al 2015) the article was on the "Semi-Automatic Extraction of Line and Area Features from Aerial and Satellite Images" were the researchers developed an operational system for the semi-automatic extraction of line and area features in 2D and 3D based on an existing software platform. The complete system was delivered to the Geo-Information Office (AGeoBw) of the German Federal Armed Forces and has been in practical use since May 2003 for the update of VMap Level 1 data and the generation of the military basic vector database. (Iovan, et al 2008) presented a complete image analysis system, from which high-resolution colour infrared (CIR) digital images, and a Digital Surface Model (DSM), extracts segments and classifies vegetation in high density urban areas, with very high reliability, Such that, Detection, Characterization and Modelling of Vegetation in Urban Areas from High Resolution Aerial Imagery was be carried out.

## **The study Area**

Agulu Lake lies within Latitude 05° 15' 00" N and 5°55' 00" N and Longitudes 06° 06' 00" E and 07° 03' 00" E, see Figures 1, 2 and 3. The climate zone of the area is within the tropical rain forest belt of Nigeria, with an average temperature of 26.8° C and about 1,897 mm of precipitation of rainfalls annually. The rainforest vegetation has been reduced to open vegetation type as a result of urban and rural growth. The intense rainfall in the area enhances soil erosion and gully thereby indenting the ground surface and hill slopes. The area is predominately filled with sediments of poorly consolidated sandy units with litho-stratigraphic thickness of up to 2,500 m. These include Nkporo shale, Mamu formation, Ajali sandstone, Nsukka formation, Imo shale, Nanka/Ameke formation, Nsugbe formation and Ogwashi Asaba formations, (Egboka, et al, 2006).

Agulu is the biggest town in Anaocha Local Government area of Anambra state in terms of square miles, number of villages (20) and population. It is one of the biggest towns east of the Niger. It occupies an area of about 49 sq. miles, and lies within the state capital territory. The town is bounded to the North by Nanka and Aguluuz'igbo, to the East by Ogbu and Mbaukwu, to the South by Nise and Agu-Ukwu (Nri) and to the West by Adazi-Nnukwu and Obeledu. In the extreme North West of Agulu lays Agulu Lake, the largest lake in Anambra State located in Umuowele village along Awka road in Agulu. Anambra state is one of the States that has traditional attractions such as Ogbunike Cave, River Niger, Ikenga Virgin forest, Omashi-iyi cave, Akpu, Odo River and Obutu Lake Omogho, iyi-ocha Lake Amaokpala town, Ekwuluimili botanical and herbal garden, Nanka natural springs amongst others all situated in different parts of Anambra State. These areas have potentials for investment and tourism development of which Agulu Lake is one.

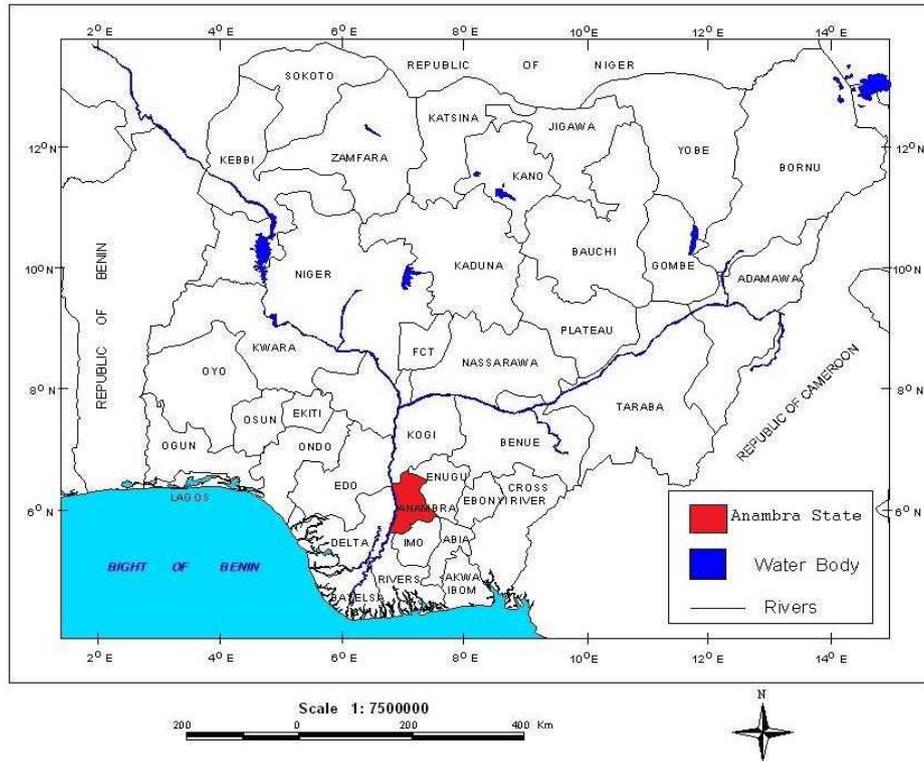
The lake is also the source of Idemili River which serves different communities of Anambra state (see Plate 1). It has a vast area which is roughly estimated to cover 200 acres and about a mile long. Satellite imagery shows that the lake empties itself into the River Niger through Idemili stream of Obosi. The Lake also promotes the community economy through the fund generated from tourists and local healing practices. The extent of the study area is 2220 lines x 4800 Columns satellite image submap model of the project area with following edge coordinates (To: 679488.557 mN, Left: 279989.875 mE, Right: 284789.875 mE and Bottom: 677268.557 mN).



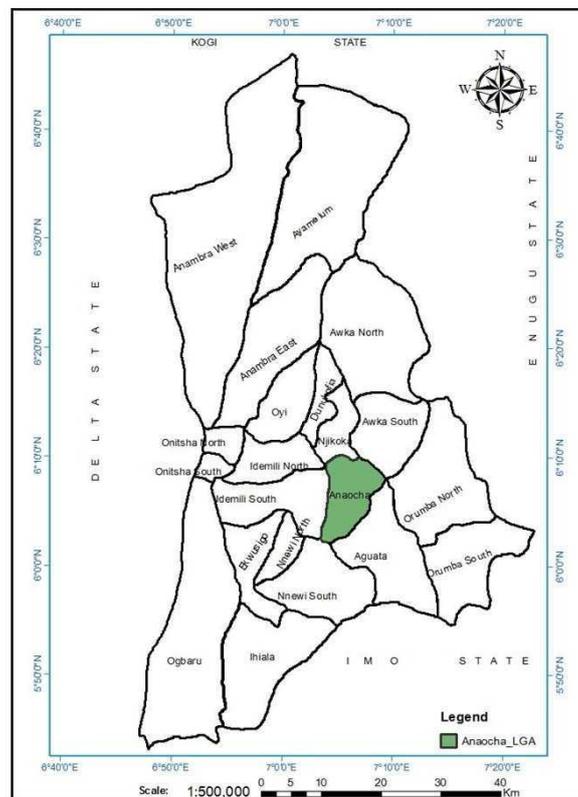
**Plate 1: View of Agulu Lake**

Source: anambrastate.gov.ng (2018)

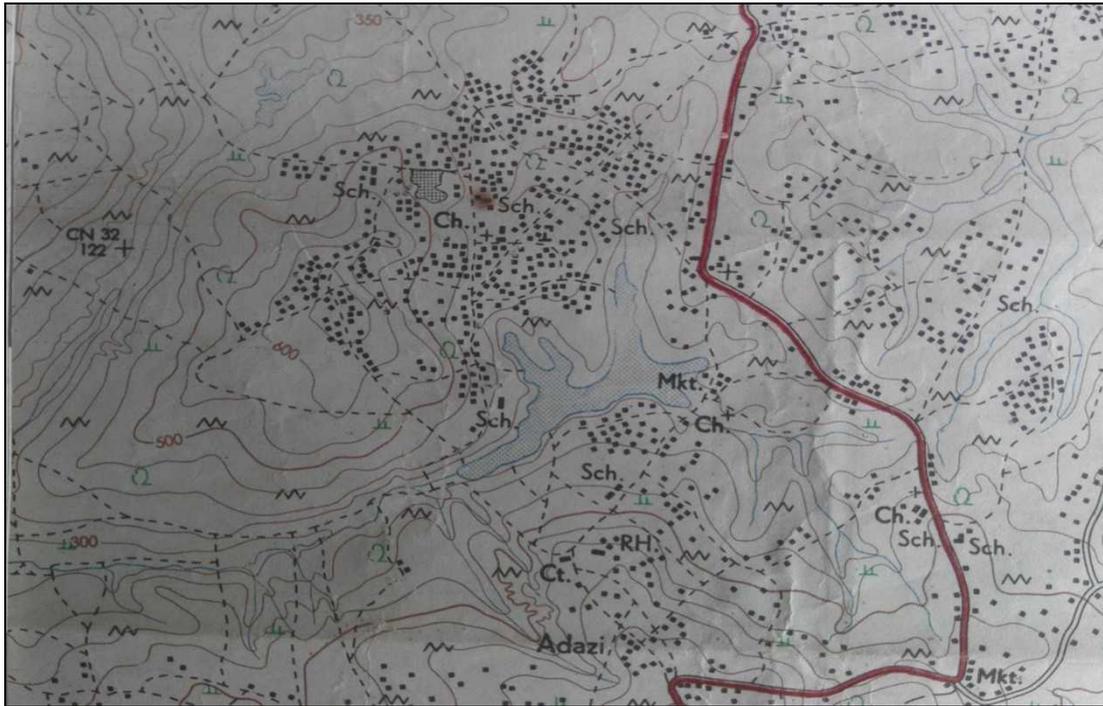
The elements of water budget equation were analysed for the Agulu lake area and underlying aquifers. The water budget implications for soil and gully erosion were evaluated in relation to the geological formations and hydrogeotechnics. Results show that rainfall constitutes the main source of precipitation. It ranges from 1714.04 mm to 1995.53 mm annually. The potential groundwater aquifer volume is  $1.5 \times 10^7 \text{ m}^3$ . Discharge from aquifers contributes  $7.4 \times 10^7 \text{ m}^3$  water annually. The amount of  $1.72 \times 10^5 \text{ m}^3$  (60% of precipitation) is lost to evaporation; 17 to 21% to infiltration, (Egboka, et al, 2006).



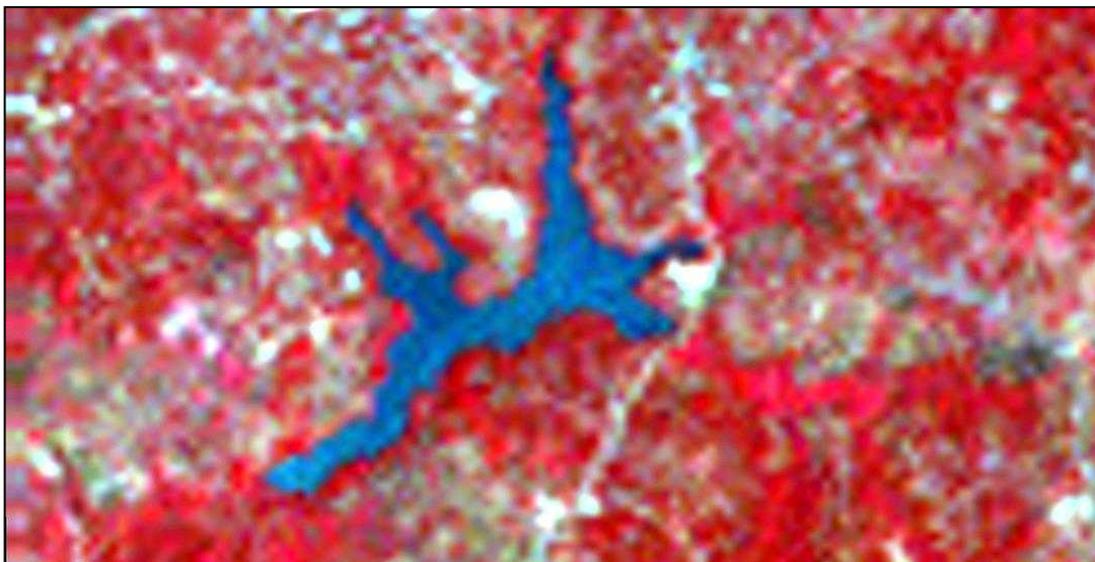
**Figure 1: Map of Nigeria showing Anambra State**  
Source: Ezeomodo (2016)



**Figure 2: Location of Anaocha in the map of Anambra State**  
Source: Ezeomodo (2015)



**Figure 3: Location of Agulu Lake in Topographical Map of 1964**  
Source: Ministry of lands, survey and town planning Awka, Anambra State (A2015).



**Plate 2: Location of Agulu Lake in LANDSAT ETM + (2006)**  
Source: Department of Surveying and Geoinformatics, NAU Awka (2015).



**Plate 3: Location of Agulu Lake in SPOT-5 Satellite image of 2005**  
Source: Department of Surveying and Geoinformatics, NAU Awka (2015).



**Plate 4: Location of Agulu Lake in Satellite image of IKONOS (2015)**  
Source: Department of Surveying and Geoinformatics, NAU Awka (2015).

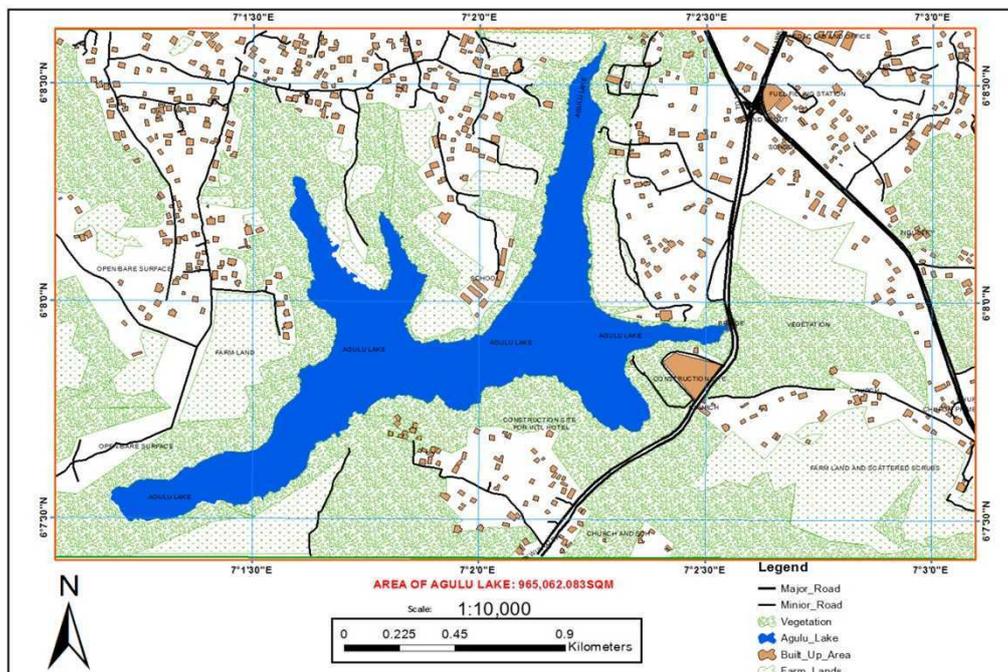
## MATERIALS AND METHOD

The methodology adopted in this project is survey method involving the use of Remote Sensing and Geospatial Information Techniques. This integrated and conceptualized approach consisted of digital image processing and cartographic procedures. Mapping of this sacred lake was carried out using IKONOS (2015) satellite image covering the area. The image was geo-referenced into the UTM coordinate frame and classified using Supervised Maximum likelihood and two other classifiers. The georeferenced image and classified map were digitized and validated using Confusion Matrix Statistical tool after ground-truthing, acquisition of coordinates of selected Ground Control Points (GCPs) and field completion. It was also possible to pick up buildings and roads from the imagery during the image onscreen digitization process. This was done to depict some development around the lake. The acquired data were processed using ArcGIS 10.1 and ILWIS 3.3. The Maximum Likelihood image classification was tested using Box Classifier and Minimum Distance Classifiers respectively. The Maximum Likelihood Classifiers result was the best. The coordinate list of the lake perimeter was produced based on the WGS1984 UTM Zone 32N coordinate system.

The data used were obtained as follows:

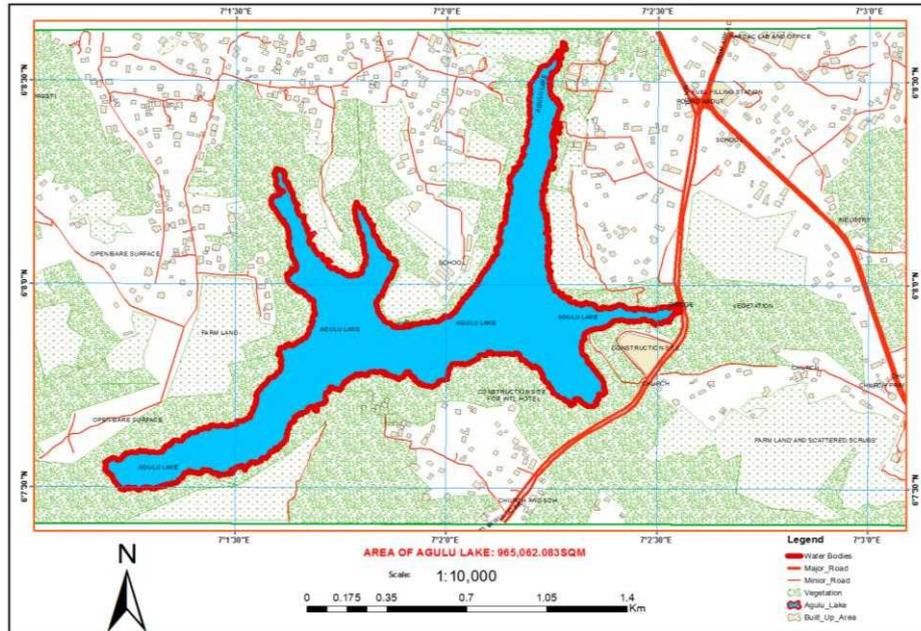
- i. The existing 1:50,000 topographic map of 1964 covering the project area was obtained from the Ministry of lands, survey and town planning Awka, Anambra State.
- ii. The IKONOS (2015) imagery of Agulu Lake and its environs, with 1m spatial resolution, SPOT-5 image (2005) and LANDSAT ETM + (2006) was obtained from Archive of the Department of Surveying and Geoinformatics, Nnamdi Azikiwe University Awka, Anambra State.
- iii. Coordinates of positions of features and control points used were obtained using Garmin, Handheld GPS.

The correct attributes of the various map objects such as names of roads and villages, rivers and other kinds of labelling information required for the completion of the map were obtained. The scheme was designed in such a way that simple features such as road widths and other spot checks were ascertained for their correctness. The coordinates of some landmark features such as schools, churches, markets, within the site for example were validated using GPS (See figure 4).



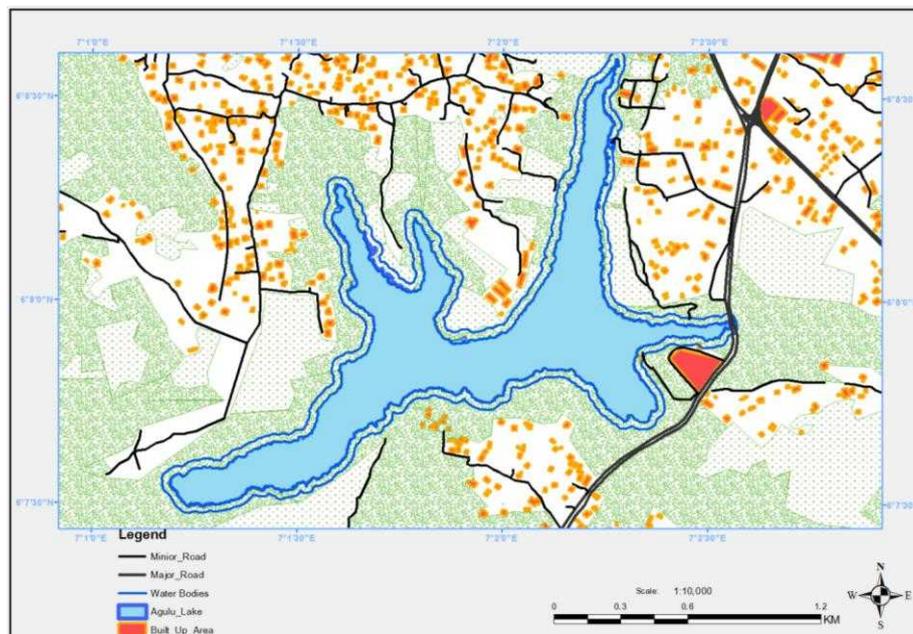
**Figure 4: A thematic map of Land use and Land cover, showing features around Agulu Lake**  
Source: Fieldwork (2015).

This study used a vector conceptual scheme where roads were classified as linear, facilities and roundabouts as polygon and bridges as line features. For the logical design stage, the relational data model which separated data into tables was adopted for each of the entity type. This was followed with the physical design. The database created shows attributes of the different layers (See figure 5).



**Figure 5: The perimeter of Agulu Lake (in Red found to be 965,062.083 square metres)**  
Source: Fieldwork (2015).

A buffer zone with a fixed distance of 30m which specifies a constant buffer distance was applied to the boundary line of the Lake and the result showed that only one building was affected, i.e. the Idemili Cultural center (See figure 6).



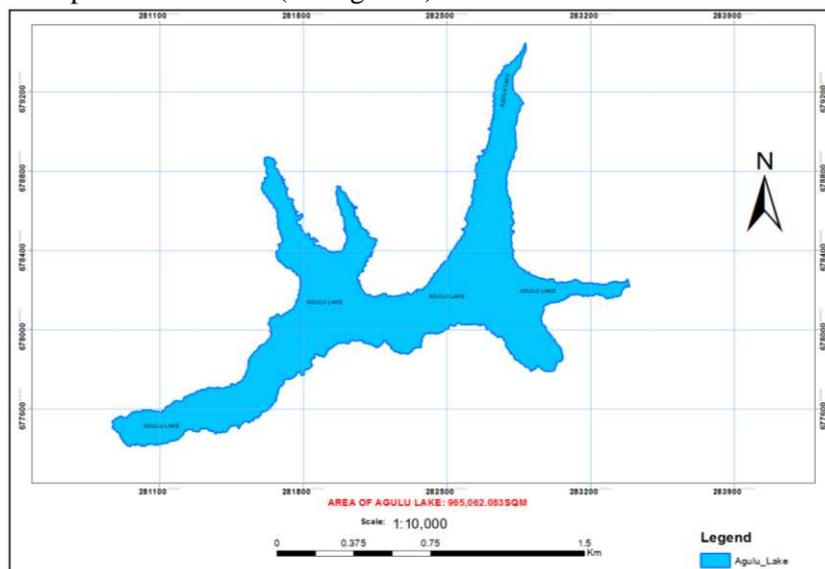
**Figure 6: Buffer zone (30m) around Agulu Lake.**  
Source: Fieldwork (2015).

## RESULTS AND DISCUSSION

The research was centred on the processing of IKONOS image (2015) of Agulu and its environs and other ancillary data. This has resulted in the mapping and production of information about Agulu-Lake and its environs. The Classification and the ground truthing carried out during the course of this project showed several developments which had taken place since the last available map was produced and the perimeter of the Lake determined. The coordinates of the points or edge of nodes around the Agulu Lake and any feature of interest can therefore be accessed and used for various analyses. In this study, the relative accuracy of the map was tested by comparing the measured length of roads in the field with their corresponding length measured on the digital map using the “Calculate Geometry” tool of the ArcGIS 10.1.

Accuracy assessment is a process used to estimate the accuracy of image classification by comparing the classified map with a reference map and hence “Confusion Matrix” analysis was used to achieve that which is critical for a map generated from any remote sensing data. This is considered as an integral part of any image classification. This is because image classification using different classification algorithms may classify pixels or group of pixels to wrong classes. The obvious types of error that occur in image classifications are errors of omission or commission. Overall, in this work, producer’s and user’s accuracy were considered for analysis. The Kappa coefficient, which is one of the most popular measures in addressing the difference between the actual agreement and change agreement, was also calculated. Hence, the overall accuracy for the map was 86.49 %. It is noted that a minimum accuracy value of 85% is required for effective and reliable land cover change analysis and modelling, the overall result of the producer’s accuracy was 83.46%. However, the lowest producer’s accuracy exists in the land cover classes “Vegetation” and “Open/barren Land”. This is probably attributed to the similar spectral properties of some of the land cover classes (e.g. bare land with urban areas, green urban areas with forest cover, arable during dry season with bare land). The User’s accuracy of individual classes ranges from 76.91% to 100%. From user’s accuracy point of view, urban areas and bare land presented low accuracy for the land cover map. The urban class, and open/bare land were, to some extent, misclassified as “vegetation” and urban areas, respectively. This is probably caused by the spectral signature of the features. And the Kappa coefficient was calculated to be 83.38% and was considered to be a good result and in conformity with Congalton (1991).

The image classification was tested using Box Classifier, Minimum Distance and Maximum Likelihood Classifiers and the result shows that the Average Accuracy = 83.46%, Average Reliability = 81.56%, and Overall Accuracy = 86.49% respectively. The perimeter of the Agulu Lake was found to be 965,062.083 square metres and the longest side of the Lake was 2,622.848 metres. An on-screen digitizing tool was used to produce a digital base map of the environs (see figure 7).



**Figure 7: Digital map of Agulu Lake.**

Source: Fieldwork (2015).

## CONCLUSION AND RECOMMENDATIONS

A digital base map was created for various geospatial analyses, the classification of land use and land cover of the area of Agulu Lake and its environs and the coordinates of its perimeter were generated using IKONOS (2015) based on the WGS1984 UTM Zone 32N coordinate system. The acquired data were processed using ArcGIS 10.1 and ILWIS 3.3. The image classification was tested using Box Classifier and Minimum Distance Classifiers respectively and the Maximum Likelihood Classifiers result gave the best result with the Average Accuracy of 83.46 %, Average Reliability of 81.56 %, and Overall Accuracy of 86.49 %. The perimeter of the Lake was found to be 965,062.083 square metres and the longest side of the Lake is 2,622.848 metres. A buffer zone with a fixed distance 30m which specified a constant buffer distance was applied to the boundary line of the Lake and result showed that one building (the Idemili Cultural centre) was the only infrastructure inside the buffer zone.

The result of this project shows that, the perimeter of an irregular shape like that of Agulu Lake can be adequately determined through the application of Remote Sensing and Geospatial Information Technology techniques. Moreover, areas that are considered inaccessible can be reached through modern method of geospatial technology, which means that even dangerous terrain can be accessed. A larger area or extent of land can be mapped and accurate data collected with ease and great speed, and also the base-map of non-existing places can be created and periodically updated with minimal cost. The result will be a base map for monitoring the developments that affect the water quality and good tourism potential of the lake and its environs. It is recommended that government should enforce developmental limit around the lake to prevent encroachment. The follow-up work of this research shall be monitoring of the site using Unmanned Aerial Vehicle (UAV), thus, the future research will use LiDAR or an Unmanned Aircraft like drone to map the configuration and depth of the lake.

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