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Research Paper

Road Network Mapping and Analysis of Ado-Ekiti Township Roads using Remote Sensing and GIS Techniques

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Abstract
Nigeria has the highest road network in West Africa and the second vastest south of the Sahara. The transport sector is the backbone to the economic growth of any nation and road network remains the basic and critical component of transport system in the nation. This research aimed at mapping accessibility to facilities within Ado Local Government Area using Remote Sensing and GIS Techniques. Road network analysis using Remote Sensing & GIS techniques to extract road network map from satellite imagery (Google Earth pro) shows the streets map category and their corresponding names. The objective is to digitize all the roads and notable features, categorize them accordingly and update information about the road extraction and extent of each road located within the study area. The methodology employed involves the extraction of road networks using OpenStreetMap (OSM) as the base map and modify from the satellite imagery (Google Earth Pro). The result of this study which is a map showing a network of roads can serve as a basis for a number of other projects and analysis that requires the name of place and position within a community e.g., emergency response analysis, crime mapping and accessibility analysis.

Keywords- *GIS, Road network, Road accessibility, Connectivity, Extraction and High-Resolution Image*

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I. Introduction

Nigeria has the vastest road network in West Africa and the second vastest south of the Sahara, with the national network currently evaluated to be 194,200km in which 34,120km (17.6%) are federal roads, 30,500km (15.7%) are state roads and 129,580km (66.7%) are local and rural roads (newnigerian.blogspot.com). However, 70% of the freight in the country is carried by federal roads. Road network have the most essential function than other transport means, it is the overall transportation network system in the world. Importantly, they provide us with access to home, offices, recreational areas, agriculture land, important buildings and other locations. Often they also carry our basic amenities such as power, water and telecommunications (Mansouri et. al., 2008). Transportation service is one of the vital urban and rural amenities, which influence and impact on regional pattern of development, economic efficiency, environmental impact and helping to maintain socially acceptable level of life in an area (Murray et al., 1998). This type of map can serve as a base map for various other projects and analysis that needs the name of place and position in

a community e.g. mapping of crime, emergency response analysis, and accessibility analysis. In this setting a Geographic Information System (GIS) and Remote Sensing method is a highly favoured method for the productive management of road accessibility in the nation. Social science issues applicable to remote sensing exist, like urban growth and development, quality of life, and urban population density and structure. Identified areas where a road network map is useful like enumeration areas planning by demographers, tourists' navigation, salesmen, firemen, security agents, tax collectors, postal services etc. These improvements have allowed the development of more sophisticated analytical applications in accessibility field, (Nicholls, 2001). Over the past ten years, GIS technology has been employed by researchers for accessibility analysis. Maps are specially designed to serve various purposes and answer specific questions like street maps, utility maps etc. (Idowu et. al., 2016).

The transport sector is the backbone to the economic growth of any nation and road network remains the fundamental and crucial component of transport system in the country. Nigeria has the unsafe roads in Africa and has followed an ambitious road expansion policy in the past decade (WHO, 2015). Nigeria's road networks are badly maintained and worn out as alternative modes of transport are poorly developed. After several failed interventions to address the need for the maintenance of the federal roads, the Federal Roads Maintenance Agency (FERMA) was established in November 2002 (Establishment Act, 2002) to maintain and monitor the federal roads network. Overloading the Highway Code says how much load is allowed for various types of vehicles, the road worthiness of vehicles and who is qualified to drive on the road, among others. Many trunk roads in Nigerian are designed to carry 30 tons maximum axle loading. Roads of lesser capacity, such as state and local roads are incapable of bearing such weight. The broad aim of the programme is to protect the road, prevent bad habits and abuses, such as drainage blockage, illegal excavations, spillage of destructive chemicals on bituminous surfaces, building on road shoulders, abandoning of damaged vehicles, vehicle repairs on the carriage ways driving on kerbs among others.

II. The study Area

The study area (Fig. 1) is located in the north-western part of the Benin-Owena River Basin Development Area. The present population of the study area is 561,000 according to the United Nations Population (United Nation – World population Prospects, 2022). The city lies between latitude 7° 34' and 7° 44' north of the equator and longitude 5° 11' and 5° 18' east of the Greenwich meridian. The study area has a number of Satellite towns around it. To the North is Iworoko, which is about 16 kilometers away from the city; in the east are Are and Afao, about 16 kilometers; to the West are Iyin and Igede, about 20km and to the South is Ikere, about 18 km. Ado-Ekiti enjoy the privilege of being a nodal town and located at the center of the state; hence roads leading to other parts of the state converge in the city. This development, no doubt, will have some effects on the land use pattern of the city and its road network connectivity. The study area enjoys two major seasons, which are the wet and the dry seasons. The wet season is between March and October while the dry season is between November and March.

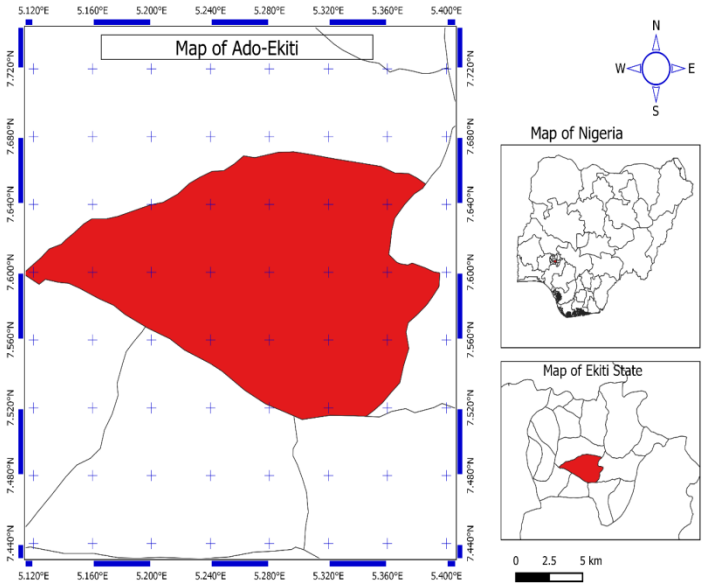

Fig. 1 Map showing the study Area.

III. Materials And Methods

The data utilized in this study were generated from secondary source only.

Secondary Data and sources

The secondary data used in this research were Remotely Sensed Data: Google Earth Data (Satellite imageries), Web Collected Data and GIS Datasets (Which consists of data derived from remote sensing). They are described in details in the following sub-sections:

Remotely Sensed Data (Google Earth Data)

Google earth data is a freely and easily accessible data source worldwide. This Paper is a pilot research and free data is used for the work.

Web Collected Data

Data from web sources were utilized for this research. Mainly places of interest, street names, villages and road extents have been taken out from the web resources.

GIS Data

As a result of the cross disciplinary nature of the methodology, a diverse variety of data sources were examined. A brief explanation of the datasets is given below:

- **Road Network Dataset-** Digitization of road network was done with the help of web collected data and basic imagery.
- **Network Dataset-** With the help of network data tool option and its attributes in QGIS toolbar catalogue, network dataset was created.

c. Understanding the road network

The function of the road network is to permit the movement of goods, services and people. A network consists of road corridors that perform distinct functions, known as the road hierarchy. The function of each road corridor in the hierarchy is determined by the type of service it provides.

Major Roads: They serve neighbouring states transport movements and carry longer distance traffic through the area. They serve as primary freight and dangerous good routes. For example: Ado-Akure Road.

Minor Roads: They carry the majority of traffic movements to, from and within urban areas. They serve as major public transport and freight routes and have limited intersections with local connectors. These allow the movement of traffic in a local area. They are generally located in a suburb and do not serve as a 'through traffic' route.

Residential Roads: Lane ways and streets that serve the local neighbourhood.

Data Processing Technique

This stage involves converting data acquired on OSM and Google map to suite each other in other not fall in different projection and creating new shapefile for them. The projection used was EPSG: 4326 WGS84. This involves:

i. Creating projection: To ensure all data set are in the same projection
ii. Creating shapefile: In order to edit attribute table from KML file a new shapefile should be created.
iii. Restructuring: Creating new attribute table to reclassify data

Digitizing

This is the process of converting data into digital format. In this case, the map was digitized on Google earth using pathway, polygon and point. The banks were digitized with points, roads with pathway and the area with polygon. This involves:

1. Create folder: for line add pathway, for points (settlement) add point
2. Carry out the procedure for other details
3. Export file as KML
4. Import it to QGIS

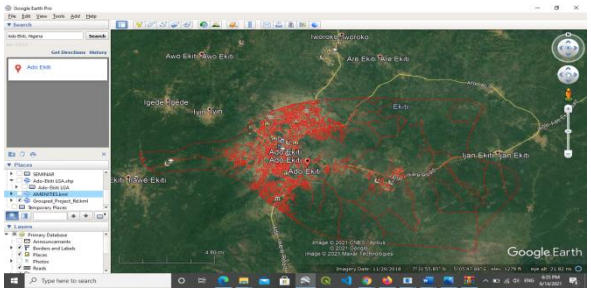

Fig 2: Digitized image

Data Preparation

This stage includes downloading the study area base map, preparation of the road network data, healthcare service provider's data downloading, and preparation of the historical traffic data. The base map of the study area was downloaded from OpenStreetMap (OSM). OSM can be accessed as a QGIS Online Service that provides free read-only access to OpenStreetMap as a base map for GIS work in ESRI products such as QGIS Desktop It is shown in Figure 3

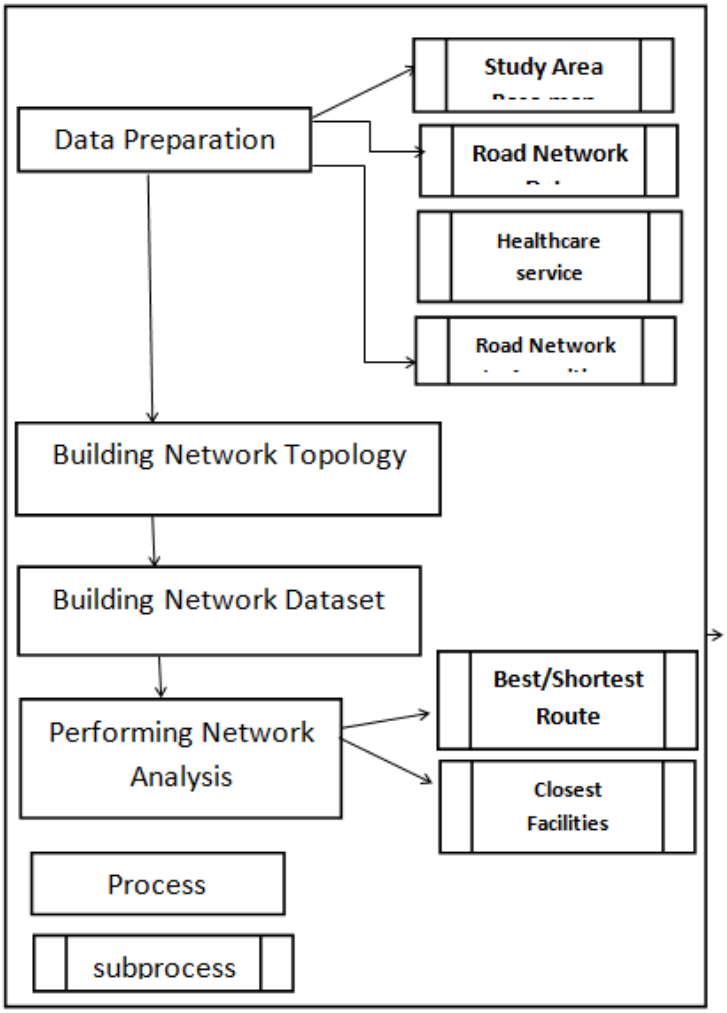

Fig 3: Enhanced Network Analysis Process Flow Diagram

Map Making

The road network data for the study area were downloaded using the QGIS Online Service as shown in Figure 3. The data contain an attribute (Meters) to save the length of each road segment in the roads network, an attribute (Direction) to save the bearing of each segment, and an attribute (Name) to save the name of each road segment. The healthcare service providers' data were downloaded from the OpenStreetMap. The data contain an attribute (Name) to save the name of each healthcare service provider, and another attribute (Type) to save the type of this healthcare service provider.

QGIS was opened and the data was opened as a vector file on this platform. The lines and polygons were modified to improve the data acquired. The map was produced on QGIS map composer. The procedure is stated below;

i. QGIS was open and new page was selected.

ii. Necessary plugins were installed (Digitizing tools, Open layers plugin, OSM place search, OSM downloader, Quick map services and Quick OSM).

iii. On the menu bar click on Web → Openlayersplugin → OpenStreetMap to search for Ado-Ekiti, Nigeria boundary place search and zoot extract to download the lines, polygons features using the OSM downloader plugin (using a selection by rectangle). The plugin also automatically loads the OSM files into QGIS in a transparent way.

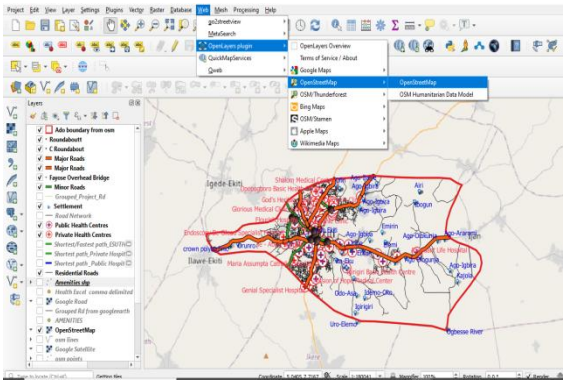

Fig 4: Base map of Ado Ekiti from OSM.

iv. On the tool bar and "Add new layer" was selected in other to load the kml file that was digitized on Google Earth Pro

v. The polygons and lines were converted to shapefile from kml and were later modified. (Geo-community, 2012)

vi. On the menu bar, project was clicked and new print layout was selected.

vii. On the tool bar of the map layout, add new map was selected, left click and drag the mouse on the lay-out page in other to add the map.

viii. Features like scale, legend, north arrow and text was added to the map.

IV. Results and Discussions

Road Network Analysis

The best route connecting two locations was generated on the basis of travel time which depends on the traffic conditions available on the network at a particular time of the day. Figure 5 shows the best route connecting a start location (FPA health centers) and end location (EKSUTH).

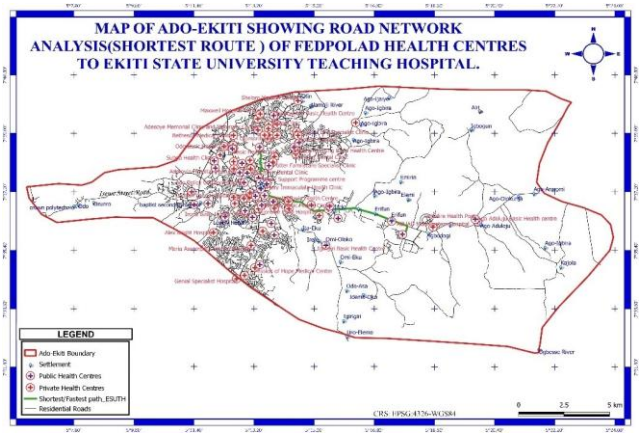

Fig 5: Best route analysis of FPA health centre to EKSUTH

Closest Facilities Analysis

This was done so as to determine the nearest facilities that can be reached in a specific period from an incident location on the basis of travel time and traffic information available. This will assist in emergency situations to know the nearest facilities that can be reached from the incident location, which in turns reduces time, effort, resources and saving peoples' lives. The nearest facilities to the location of an incident can be found as shown in the figures 6 and 7 between a start location (FPA health centers) and end location (Public and Private Health Centers).

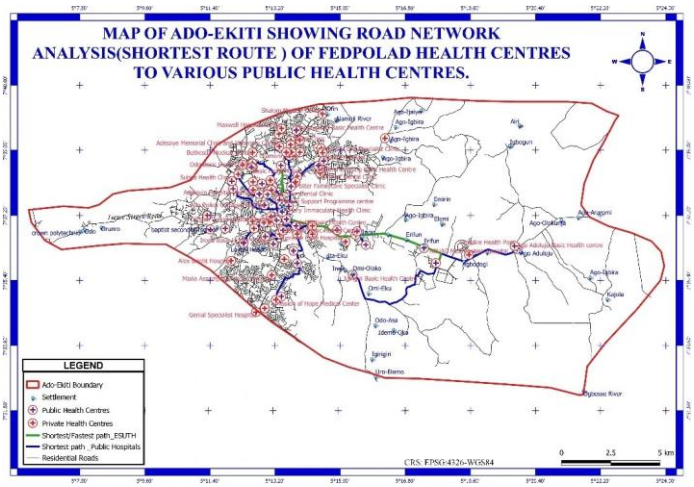

Fig 6: Shortest route analysis of FPA to various public health centers

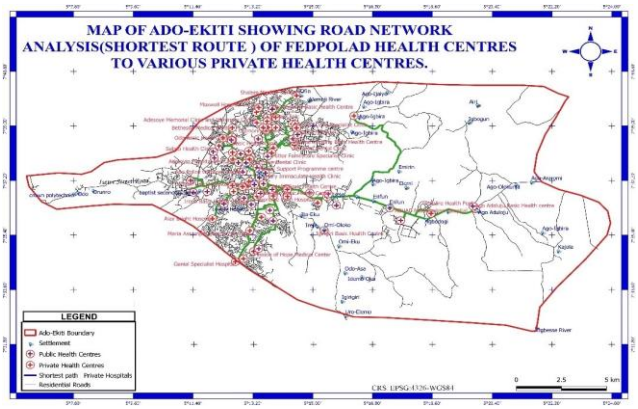

Fig 7: Shortest route analysis of FPA to various private health centers

V. Conclusion

Due to the findings of this study, it is therefore concluded as follows:

i. The study revealed the shortest possible routes to various health amenities within Ado-Ekiti thereby saving peoples' lives in case of emergency.

ii. The results of the study will serve as a decision support system for solving problems both presently and in the future in Ado Local Government Area of Ekiti State.

iii. The research also revealed area with non-functioning health facility. This area should be visited by the government in so as to resurrect the non-functioning health facility thereby reducing the long distance people travel to other functioning health facilities.

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