



International Journal of Engineering, Business and Enterprise Applications (IJEBEA)

(Open Access, Double Blind Peer-reviewed, Refereed and Indexed Journal)

www.iasir.net

Application of Geographic Information System (GIS) Technique in Mapping Election Polling Units: A Case Study of Ihitte Uboma Local Government, Imo State, Nigeria

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Abstract: Political scientists have embraced the GIS technology as means to address the spatial questions regarding the management of the election process. Management of polling units in cities and urban centers requires resource information of the locality. Local government offices and party and election managers need to have easy access to all types of public data for research and planning purposes. This project applied the Geographic information systems (GIS) approach in integrating various spatial components into a spatial database for the management of elections in Ihitte/Uboma LGA of Imo State, Nigeria. The result of this project demonstrated the ability of GIS in planning and managing elections in regards to spatial components of voters, polling units and vital requirements for the success of election processes.

Keywords: GIS, Polling units, Voters, Elections, Nigeria

I. INTRODUCTION

Geographic Information Systems (GIS) is an information technology that has found increasing application in public decision-making; particularly in environmental planning and management, Human resource management, logistic planning and management.. GIS is a “system of computer software, hardware, data, and personnel to help manipulate, analyze, and present information that is tied to a spatial location. GIS allows users to collate and analyze information far more readily than is possible with traditional research techniques. With GIS, investigators can map, model, query, and analyze large quantities of data all held together within a single database. [1]

In many countries, GIS is now used extensively in government, census, election, business, and research for a wide range of applications. Important uses include environmental resource analysis, land-use planning, locational analysis, tax appraisal, utility and infrastructure planning, real estate analysis, marketing and demographic analysis, habitat studies, and archaeological analysis. Over the past decade or so, international assistance agencies have been engaged in efforts aimed at helping developing countries, particularly in Africa, to adopt GIS technology. These efforts have encompassed acquisition of computer software and hardware as well as the development of human capacity to apply GIS technology in environmental policy development.[2], Inherent in any GIS application is the capability to enter data through actions such as scanning and digitizing maps, importing existing database information, or entering data directly into the system. What makes a GIS so powerful is its ability to layer thematic maps vertically [3]. GIS technology has been used in recent elections to model voter turnout and determine where politicians should focus their efforts. GIS technology also has the ability to give traditional gerrymandering a technological boost by combining demographic (e.g., Census) and geographic data within a single information system. [4]

New technologies have created a powerful paradigm shift in political campaigning [2],[5]. Elected officials are no longer merely pictures on a classroom wall or caricatures on a television screen. The convergence of the Internet, computers, and social media tools has made politics an immediate as well as interactive process. Candidates have an intimacy with their constituents on a large scale that would not have been possible without modern technology. One of the most significant tools is a geographic information system (GIS), which is a sophisticated mapping technology. Politicians can review political hot spots at a glance or determine which neighborhoods to focus their message. The diverse applications of GIS have made its use attractive to people in business, industry, government, and education[5],[2].

II. STUDY AREA

Ihitte/Uboma is a Local Government Area of Imo State, Nigeria. Its headquarters are in the town of Isinweke. It has an area of 104 km² and a population of 120,744 at the 2006 census. The postal code of the area is 472 and fall between latitude 5°34'56" – 5°41'56" and longitude 7°18'37" – 7°25'55". As the name implies, Ihitte/Uboma LGA, is made up of two separate independent clans, Ihitte and Uboma but which share common cultural backgrounds, and affinity. The two Communities usually congregate at the headquarters at Isinweke which has a great proximity to navigate to any part of the LGA. This they do for Sports, commerce, recreation

and social intermingling. The Isinweke council headquarters is located at the centre of the component clans along the Umuahia-Anara highway thus gives it a unique place in Imo politics. One striking thing about Ihitte and Uboma is that each of them has 5 political wards, giving them equal strength and capacity to elect their various representatives at the LGA, State and Federal levels. The inhabitants of Ihitte/Uboma are rich farmers who do not only engage in commercial farming but essentially produce all of their staple foods, Figure 1 below shows map of the study area.

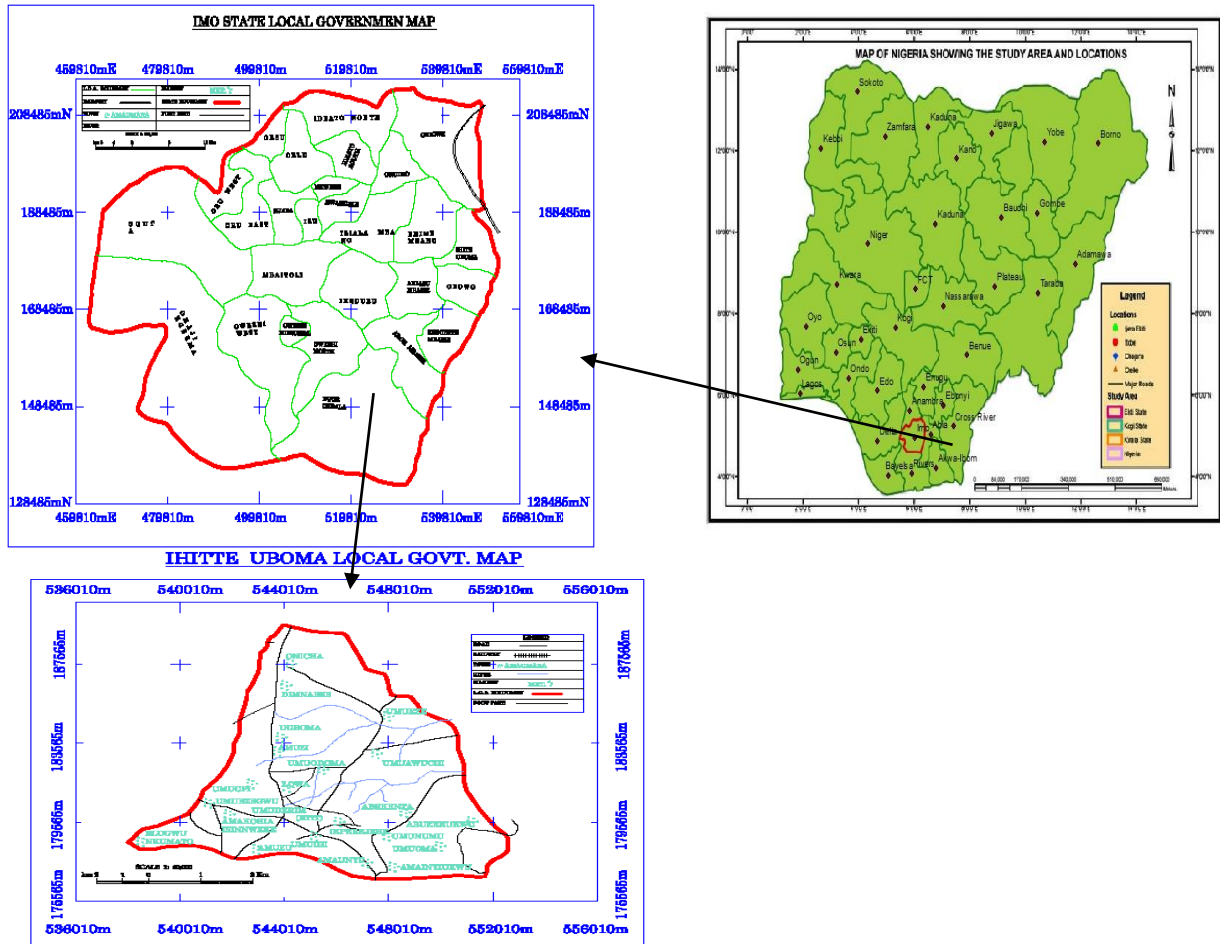


Figure 1: Map of Nigeria showing Imo State Showing the study area

III. METHODOLOGY

The methodology adopted for the project is shown in figure 2 below

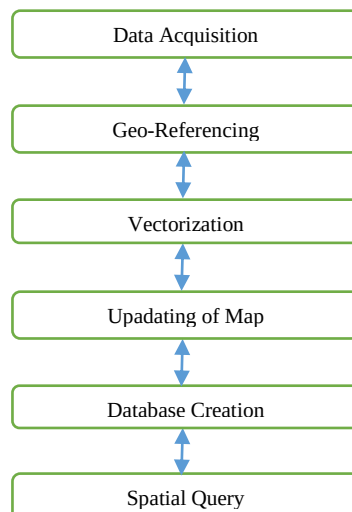


Figure 2: Flow chart of Methodology

A. DATA ACQUISITION

This is the process of acquiring (obtaining the data required on the site or office using various data acquisition techniques such as land surveying, photogrammetry, Vectorizing. All the data acquired on the site for this project are primary data while those acquired in office via (Vectorizing) are secondary data. The office data was the analog map of ihitte uboma collected from survey and urban planning office in owerri. While GPS was used for collecting data of the polling units, Inec office, road network update, Police station, Hospital and town hall. Below are the data acquired using Global positioning System (GPS).

S/N	NAME OF FEATURE	POLLING UNIT ID	EASTINGS	NORTHING
1	POLLING UNIT	432	316635.086	621605.058
2	POLLING UNIT	491	316873.211	621382.808
3	POLLING UNIT	583	317825.713	621430.433
4	POLLING UNIT	776	316333.460	621271.682
5	POLLING UNIT	672	316381.085	620970.057
6	POLLING UNIT	671	316777.961	620811.306
7	POLLING UNIT	670	316333.460	620668.431
8	POLLING UNIT	674	317190.712	621001.807
9	POLLING UNIT	719	317127.212	620239.805
10	POLLING UNIT	514	322270.722	622859.185
11	POLLING UNIT	527	322127.847	621716.183
12	POLLING UNIT	573	323302.599	620954.182
13	POLLING UNIT	541	323747.100	622224.184
14	POLLING UNIT	506	323318.474	623256.061
15	POLLING UNIT	519	322619.973	620096.930
16	POLLING UNIT	500	322334.222	620049.305
17	POLLING UNIT	509	321916.179	620377.389
18	POLLING UNIT	504	321799.763	620684.306
19	POLLING UNIT	578	320423.927	619996.388
20	POLLING UNIT	511	319280.924	618504.135
21	POLLING UNIT	509	321302.345	618885.136
22	POLLING UNIT	556	322111.972	616961.611
23	POLLING UNIT	458	322405.660	617009.236
24	POLLING UNIT	460	322358.035	617302.924
25	POLLING UNIT	544	321556.345	617326.737
26	POLLING UNIT	748	321675.408	617509.300
27	POLLING UNIT	1023	321913.534	617668.050
28	POLLING UNIT	528	321278.532	617699.800
29	POLLING UNIT	547	320064.092	617485.487
30	POLLING UNIT	579	320730.844	619644.492
31	POLLING UNIT	587	320595.698	619516.030

S/N	NAME OF FEATURES	EASTINGS	NORTHING
1	Etiti General Hospital	318906.948	620847.038
2	Emmanuel Misionary Hospital	318416.688	621269.988
3	Our Saviour Anglican Maternity	321111.419	619218.939
4	Abueke Health Ceneter	322658.771	621722.992
5	Ikperejere Health Center	320212.746	621517.499
6	Inec Office	319141.539	620802.990
7	Etiti Police Station	318337.204	620772.166
8	Ihitte	322800.990	626600.990
9	Imekalagwu Hall	317974.000	619613.990
10	Umuonyeche Village Hall	316411.000	620691.990
11	Uhuawushi Hall	317730.000	620421.990
12	Umumee Village Hall	315223.990	621984.990

13	Umumgburu Village Hall	314476.990	621956.990
14	Umuohoshia Hall	318547.990	624476.990
15	Umuebonu Hall	321529.990	624981.990
16	Ndibinuhu Village Hall	322021.000	621752.990
17	Umuezeala Hall	323290.000	623319.990
18	Umuoparaodu Hall	323783.990	622307.990
19	Umuehetu Hall	322073.000	617033.990
20	St Cyprian's Anglican Church Umuhi.	318350.000	621205.990
21	Umudim Civic Hall	317965.990	629343.990
22	Onicha	317300.990	629479.990
23	Isinweke	319227.990	624392.990
24	Ishinweke	318006.000	621439.990
25	Obowo	314122.990	619576.990
26	Okwuohia	315933.990	618968.990
27	Anainyi	321152.990	618954.990
28	Unuaweke	322970.000	617566.990
29	Abekenta	323341.000	621078.990
30	Ukwuokwe Hall	318321.000	620846.990
31	Function Hall	317746.000	621171.990
32	Nwankita Hall	317921.000	620586.990
33	Nwakpaka Hall	318519.990	620125.990
34	Umuezeokwa Hall	319127.990	619884.990
35	Kingdom Hall	320359.990	620034.990

B. GEO-REFERENCING OF IMAGE MAP

Georeferencing is the process of aligning spatial data (layers that are shape files: polygons, points,) to an image file such as an historical map, satellite image, or aerial photograph. The term is commonly used in the geographic information systems field to describe the process of associating a physical map or raster image of a map with spatial locations. Georeferencing may be applied to data sets that are related to a geographical location, such as points of interest, roads, places, bridges, or buildings. Geographic locations are most commonly represented using a coordinate reference system, which in turn can be related to a geodetic reference system such as WGS-84. The data set for this project (Ihitte Uboma analogue map) was georeferenced using ArcGIS.

C. VECTORIZATION OF IMAGE MAP

vectorization process is the generation of vector features. ArcGIS supports centerline and outline vectorization methods in automatic mode. The centerline vectorization method allows you to generate vector line features at the center of the raster cells. This method is the most common type of vectorization. The centerline vectorization method is the default setting. The outline vectorization method allows you to generate vector polygon features at the borders of the raster cells. Typically, automatic vectorization is performed for the entire raster layer, and therefore, it is the default technique. ArcGIS also supports tools that allow you to vectorize a user-defined portion of the raster. This provides flexibility in cases where you only need to convert a certain area of the raster. You can also take advantage of the cell selection tools and use them in concert with the Generate Features command to vectorize only the currently selected raster cells. ArcScan supports vector data creation for two layer formats: shapefiles and geodatabase feature classes. During this process layers were been created and all the features (roads, boundaries etc) in the Image map was digitized.

D. DEVELOPING AND UPDATING OF MAP

The map was updated using GPS data and satellite imagery. After complete vectorization of the map, the next step was to update the map. This is because during ground truthing we notice a lot of new developed roads and feature that were not included in the map meaning that the map had been outdated. GPS was used to acquire data on all the polling units, new roads, town hall, ward boundary, inec office etc and the data were used for updating of the map in Arc GIS10.1. During the field exercise the mapping unit gave every polling unit a unique identification number for easy identification. With the level of data generated, updating and producing of a new Ihitte Uboma map was possible, easier and faster. Using ARCGIS the boundary of each of the ward were mapped out. A number of ground truthing exercises were conducted to ensure proper demarcation of these boundaries.

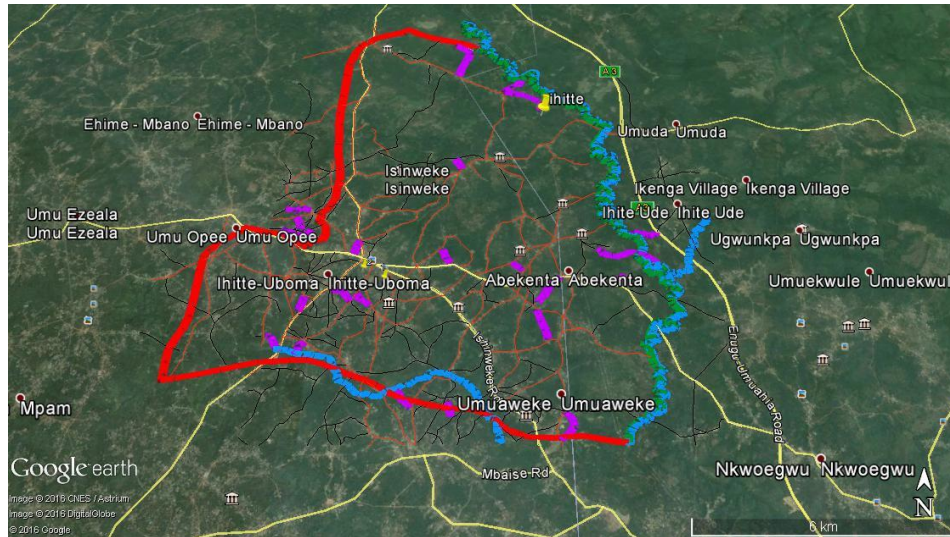


Figure 3: Map Updating using Satellite Imagery

E. DATABASE CREATION

Spatial database is the central force of GIS technology, according to [3],[6] described GIS data modeling as process by which the real world entities and their interrelationship are analyzed and modeled in such a way that maximum benefit are derived while utilized a minimum numbers of data. Reality refers to phenomena as they actually exist, including all aspects which may or may not be perceived by individuals. The view of reality is the mental abstraction of reality for a particular application (user requirements) or group of applications [7],[3]. In this study reality refers to road network, Polling Units, Inec Office, Ward / local govt / state boundaries, Stadium, Church, and Town halls within the study area.

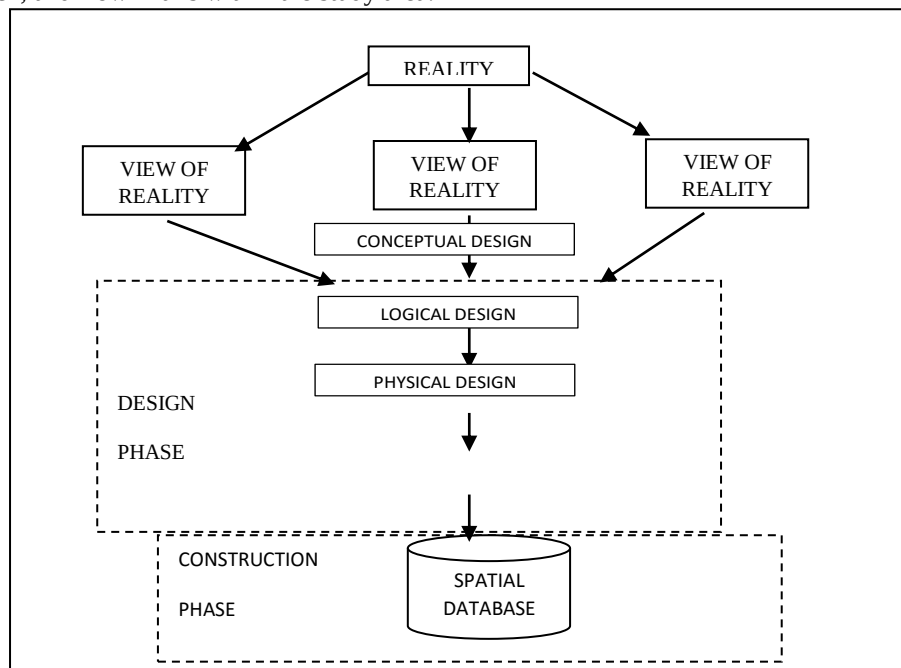


Figure 4: Showing structure of Reality

Database is an integral part of any decision support system (DSS) [6],[1]. Spatial decision support system used by GIS is a special kind of database with spatial database required in GIS for wide range of reasons including, reducing data duplication, ensuring data standard, and for efficient way of representing geographic data in the user's perspectives [6],[3]. There are two main phases in obtaining a GIS database; these are the design phase and construction or implementation phase otherwise known as data modeling, this consist of three stages and the construction phase is made up of spatial database proper, the three main phase of database design are:

- I. Conceptual design phases
- II. Logical design phases
- III. Physical design phases

Conceptual Design

Conceptual design is the arrangement of a human conceptualization of reality, how the view of reality will be presented in a simplified manner but still accommodate the information requirement for successful implementation of the project at hand. Abstraction of reality is the first step to be addressed before designing and creating a database. For this study, the reality stands as the spatial arrangement for political election in other to see their spatial relationship with other factors that interact with road network, Polling Units, Inec Office, Ward / local govt / state boundaries, Stadium, Church, and Town halls etc. The vector data model was adopted for the representation of the complex reality in this study. The vector data model represents the real word using points, line and polygons or area. The complex reality in this study will be represented as follows using vector data mode;

POINT: Polling units, Town halls, Inec office, stadium, church.

LINE: Roads, rives, boundaries or any liner feature

Polygons or Area: Wards

This study considered the following entities: road network, Polling Units, Inec Office, Ward / local govt / state boundaries, Stadium, Churches, and Town halls.

Logical Design Phase:

Representation of the data model designed to reflect the recording of the data in the computer environment; it may also be referred to as the data in the structure. Data can be structured using the hierarchical, network or relational approaches. For the purpose of this study the relational data model was adopted this choice was based on the available software, the data collected and most importantly the scale of operation both input and output, where all the entities are treated as object. In relational data structure, data are stored in simple records, which contain set of attribute values that are grouped together in a two-dimensional table know as relations. Each contains item of data called field about entities. The entities (objects) are found along rows while the column, contains attribute are fields.

POLLING UNITS (OBJ_ID, TRMSITE_NAME, TRMSITE_ADD, TRMSITE_FACI, TRMSITE_OWNER}
BUILDING (OBJ_ID, B_USE, B_NAME, B_ADDRESS, B_FACILITIES, B_OWNER}
ROAD (OBJ_ID, R_NAME, R_LENGTH, R_CLASS)

IV. RESULT AND DISCUSSION

Spatial Analysis

There are wide ranges of function for data analysis in GIS packages; this is what distinguishes GIS from other information system. GIS project will not be said to have been completed without carrying out spatial analysis on the created spatial database. Some of GIS capabilities are measurements techniques, spatial search, attribute queries, proximity analysis, buffering operations and analysis of models of surface and network analysis. The following spatial analysis was carried out in this project: Spatial Search, Query, Network analysis (Finding the shortest route to polling unit), Buffering to determine Polling unit with a define radius using the recommended criteria.

Queries

Single and multiple criterion queries were carried in the database, An Example of such query is: `SELECT* WHERE: "name"='polling unit'`. The result is seen in figure 5 below.

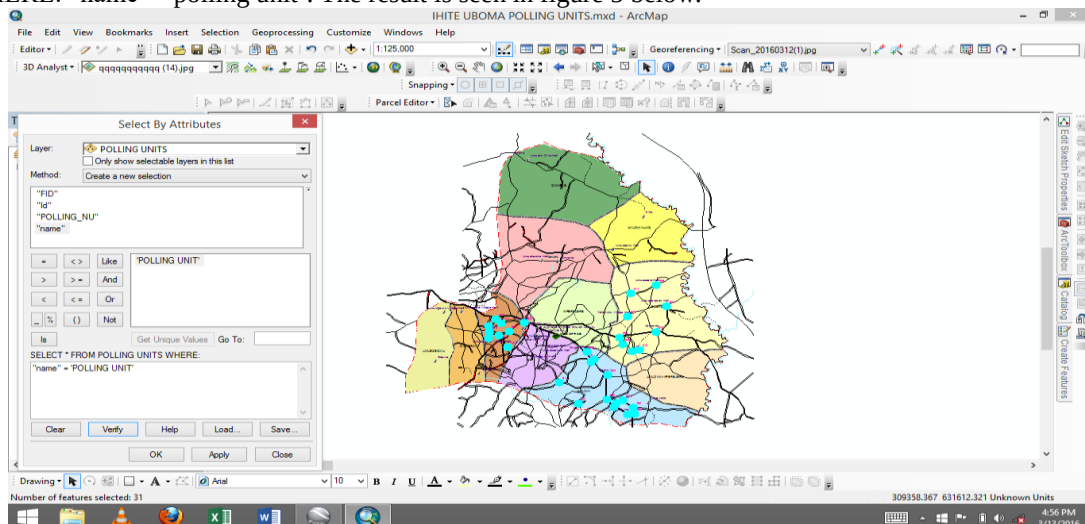


Figure 5 Result Of Query showing (All Polling Units Location)

Network Analysis

A network is a set of interconnected lines linking up a set of features through which resources can flow. Network with appropriate attributes can be used directly for finding road network, shortest path and measuring accessibility to closest facility. A network can also assist in solving location problems, and transportation planning for voters, Inec officials, security officers, Media, Foreign / Internal observers.

Analysis 1: Road network to polling unit

This analysis was used to find the shortest route from Inec office to Polling Unit 506 located at Umuezeala. This is highlighted in purple colour, which is the shortest route to access the polling station. It can be used for movement of voters, Inec officials, security officers, and Media, Foreign / Internal observers. This analysis can also be used to get the fastest route to police station, hospital, town hall, each ward etc.

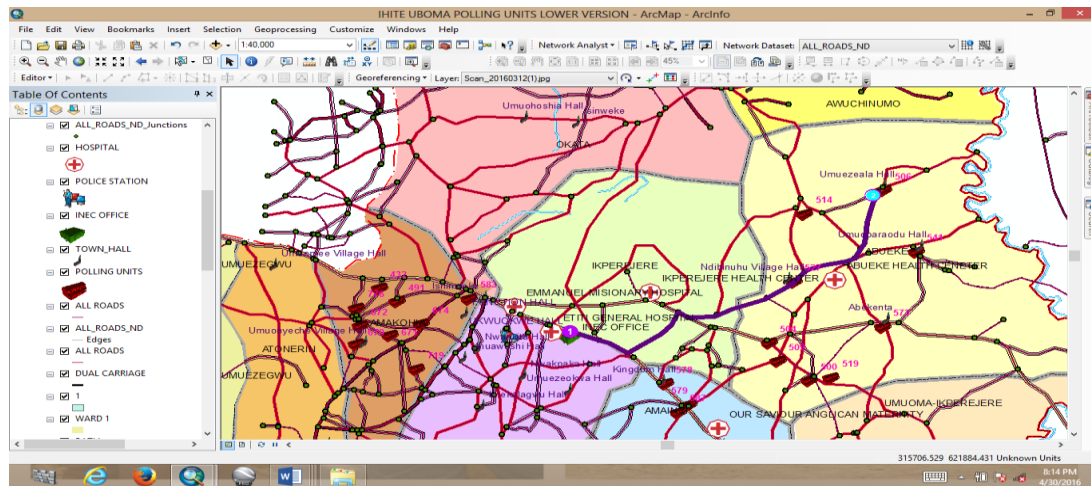


Figure 6: shortest route from Inec Office to Polling Unit 506

Buffering

In consideration of the distance from Inec office to Polling unit so as to enhance dispersion and returns of electoral materials, and also to be able to calculate the distance and time for travelling to these polling units, there was a great need to create a buffer zone of 5km radius. One important spatial operation in GIS is the determination of spatial proximity or nearness to various geographic features. Using the above criterion in the Arc GIS software, 5 KM radius was buffer from Inec office.

From the above buffering analysis, facilities that fall within the define parameter is said to be within the buffer zone that have met the above recommendation, all the polling units, hospital, police station, fell within the buffer zone.

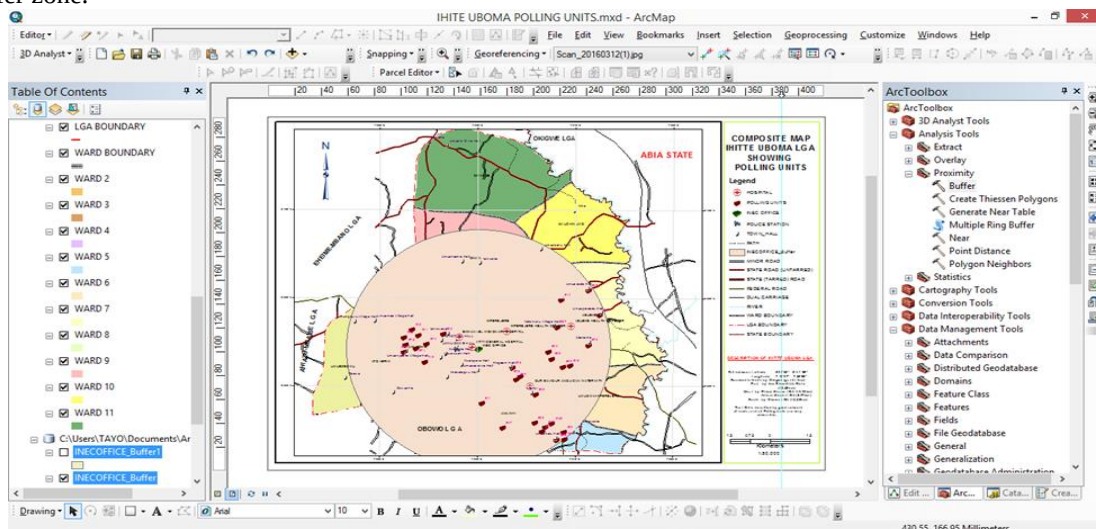


Figure 7: showing all polling units within 5km radius buffer zone from the INEC office.

V. CONCLUSION

This project has demonstrated the ability of GIS in planning election process. The GIS analysis implemented in this project will enable voters, inec officials and party officials to access information on the closest facility, query the database to get information on the type of polling units, services that are available for voters, proximity to polling units.

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