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Research Article

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Mapping of Infrastructures of Sectional Area at Auchi, Nigeria

Izah, N.L, Ikharo, I.B., Eshiemokhai, I.T.

Department of Surveying and Geoinformatics, Auchi Polytechnic, Auchi, Nigeria

Abstract: The study focuses on mapping the infrastructural amenities of sections of Auchi. Several steps were adopted for evaluating and monitoring through the application of Geospatial Information System (GIS). To do this, geometric data from the infrastructures in the study area was obtained and downloaded from satellite imagery with the use of Terra Incognita. Updating the current map of the area with georeferencing and digitizing the map. Attribute data was collected via physical observation and oral interviews. A relational database management strategy and buffering operation were used to design and create a database for the study area's infrastructure. Geometric and attribute databases were linked using ArcGIS 10.3, which was also used for spatial analysis and information presentation. A series of spatial queries were made to solve problems to determine the effectiveness of the system. Spatial analysis was carried out to solve spatial problems such as getting the locations of the infrastructures, identifying where problems were, and aiding in decision-making for proper record keeping.

Keywords: Spatial, Geographic Information System, Geometric, Infrastructures, Auchi

1. Introduction

According to Osunde, Ekhosuehi, & Imogie (2018) , infrastructure mapping is the surveying of all utilities, both above and below ground, as well as related structures situated within the project boundary. It is the mapping of the fundamental systems and services required for a nation or organization, such as buildings, transportation networks, administrative systems, water and power supplies, solar energy installations, electrical power systems, hospitals, and so forth. But generally speaking, mapping is the process of creating maps using cartographic, photogrammetric, or land surveying techniques. As a result, the end result of infrastructure mapping is an infrastructure map that depicts the locations of utilities as they are found on Earth.

Infrastructure is defined as a collection of interconnected structural components, utilities, and services that support various aspects of society and the economy, including transportation, irrigation, health care, education, and other essential services that support people's day-to-day activities. According to the Adeyemi & Olasoji (2022), infrastructure generally refers to the fundamental technological, organizational, soft, and physical structures, facilities, and systems needed for an economy, business, community, city, society, or country to exist and operate effectively. It consists of soft, technological, organizational, and physical structures like water supply, waste disposal networks, highways, bridges, airports, seaports, railroads, dams, and digital communication equipment, power supply systems, broadband equipment, Internet access, schools, and health facilities. The town of Auchi, located in Edo State, Nigeria, has witnessed a remarkable transformation characterized by rapid urbanization and exponential population growth over the past few decades. This phenomenon has been propelled by a myriad of factors, including rural-to-urban migration, economic opportunities, and infrastructural development. As Auchi evolves into a bustling urban center, the imperative for efficient infrastructure management becomes increasingly pronounced to ensure sustainable growth and enhance the overall quality of life for its expanding population. (Ezemonye & Ajokeiye 2019)

Olasoji & Adeyemi (2020) Against this backdrop, the adoption of Geographic Information Systems (GIS) and Remote Sensing (RS) technologies emerges as a pivotal strategy in addressing the multifaceted challenges associated with urbanization. Geographic Information Systems (GIS) and Remote Sensing (RS) offer sophisticated tools and methodologies for mapping, analyzing, and managing intricate infrastructure networks within urban landscapes (Adedeji, A., Adegbile, M., &Ayedun, 2020). By leveraging these technologies, stakeholders can gather comprehensive data on infrastructural assets, visualize spatial relationships, and derive actionable insights to inform evidence-based planning and decision-making processes. One of the primary advantages of GIS lies in its ability to integrate diverse spatial datasets, ranging from satellite imagery and aerial photographs to ground-based surveys and census data. Through this integrative approach, GIS facilitates the creation of comprehensive infrastructure inventories that capture the spatial distribution, attributes, and interconnectivity of various elements such as roads, buildings, utilities, healthcare facilities, and educational institutions. These datasets serve as invaluable resources for urban planners, policymakers, and community stakeholders seeking to understand the dynamics of urban infrastructure and formulate effective strategies for its development and management Chen, Sun, & Yang, (2018).

The facility information service offers infrastructure mapping (maintenance of positions and description information for buildings, roads, and center line data; utilities; and other systems), as well as the collecting and maintenance of spatial data pertaining to the built and human surroundings. Infrastructure utility administration and upkeep have grown in importance for a variety of business and public sector organizations. Thus, having an up-to-date map and record will facilitate effective maintenance and management. The absence of a map illustrating the area's infrastructure makes it difficult to adequately monitor and manage the facilities. The project's outcome would include data for use in engineering, surveying, urban planning, and other land-related fields. It also provides a mechanism for stakeholders, students, and the general public to learn about facility placements. This infrastructure map will also serve as the foundation for future planning.

2. Research Methodology

Study Area

The Auchi administrative center of the Etsako West local government area in Edo state, Nigeria, which is the study area, is Auchi. It is located between longitudes 6.014”1 East and 6.0 43”1 East of the Greenwich Meridian and latitudes 7.014”1 North and 7.034”1 North of the equator. Auchi is bordered to the east by Jattu, to the south by Aviele, to the west by Warrake, and to the north by Iyuku. Its centrality has been credited with its quick growth. This town is in transit and is situated along the Benin-Okene-Abuja highway. For those from the Eastern and Southern regions of Nigeria, it serves as a gateway to the country's Northern region. The town is located in a low-lying area with few valleys, making it particularly vulnerable to the impacts of erosion. It is known that the Auchi people are descended from the old Bini kingdom. Auchi is situated at an elevation of roughly 300 meters above sea level on gently sloping ground. Auchi has a tropical climate with the rainy and dry seasons being the two distinct seasons. Its location notwithstanding, it receives 800-1500 mm of rainfall annually on average. Its southerly location at the base of Akoko-Edo Hill (Kukuruku Hill) has a significant impact on the local climate, which explains why it receives less annual rainfall than other towns at the same latitude (Oguntoyinbo, 1983). The rainy season, which lasts from April to October, peaks in August and has 150 cm of rain on average. November through April is considered the dry season, with a chilly harmattan period occurring in December and January. During the rainy season, the average temperature is roughly 25°C, whereas during the dry season, it is 28°C. In Auchi, the climate is subhumid. The Guinea Savanna section of the town's vegetation cover sustained lush vegetation, the kind that is discovered in tropical rainforests but had been uprooted and agitated by farming, urbanization, and construction activities.

The town has witnessed tremendous changes in the inward plan. Omuta (1983) pointed out that the quick metropolitan conspicuousness growth in the town, which extended from 35,000 in 1979 to an estimated worth of 68,000 in 1991, verifiable necessity, came about from changes in the real environment of Auchi. Figure 1 shows the study area. This study used geospatial technique in mapping the spatial distribution, distribution pattern of the existing infrastructures in the study area. The frame work for the methodology is presented in Figure 2.

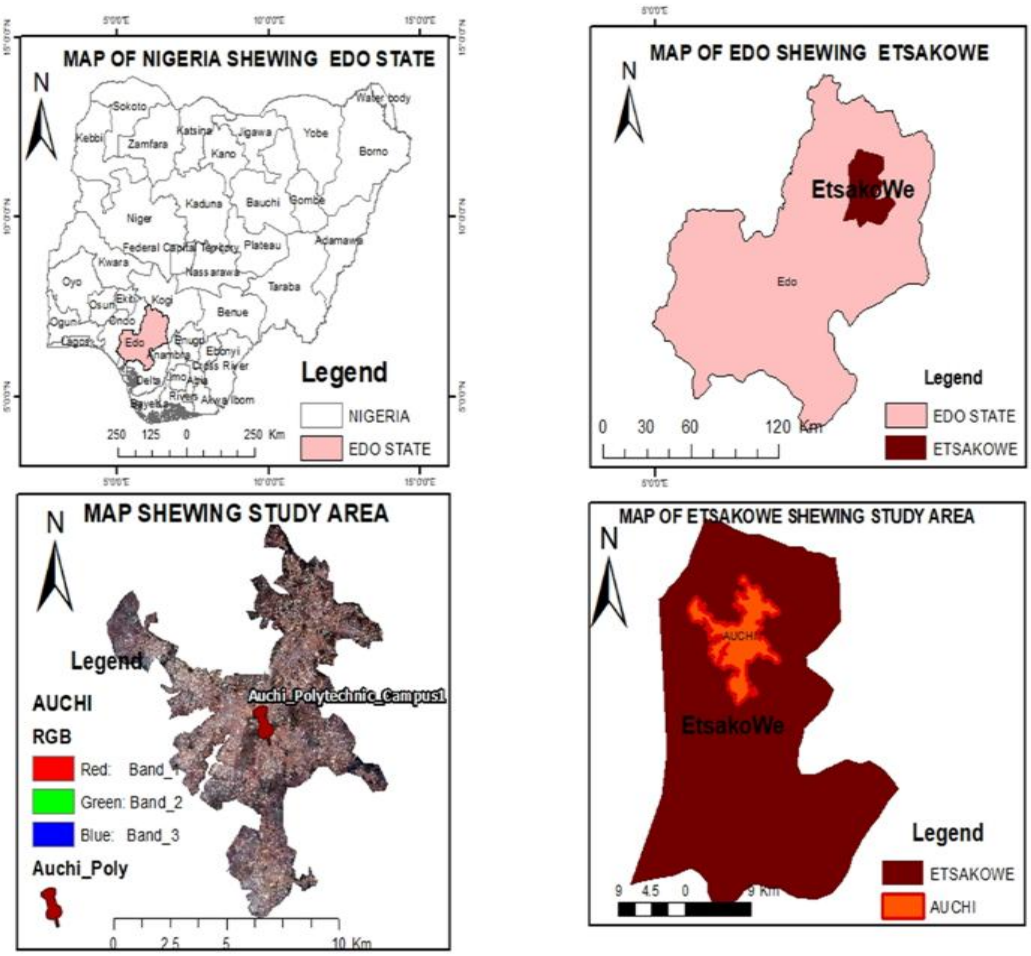

Figure 1: The study area

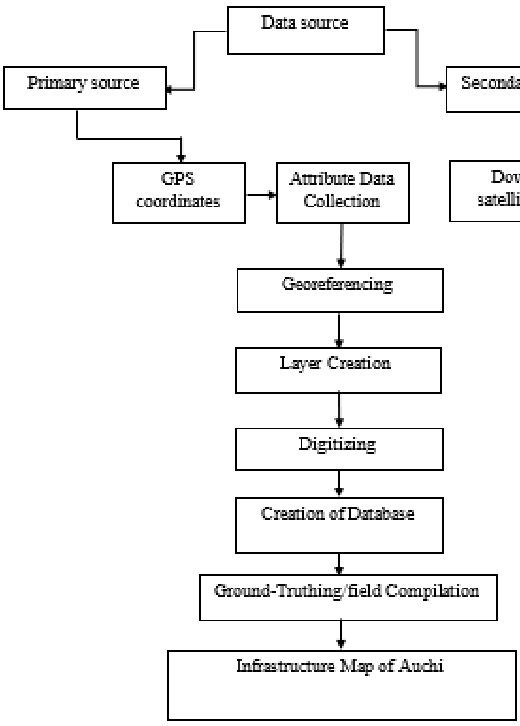

Figure 2: Methodology flow chart

Data acquisition

The data assembly process was used to compile the list of infrastructures (both private and public) in Auchi, starting from the polytechnic and expanding to the rest of the infrastructure within the study area. This was done using the handheld GPS, a satellite map of the study area, and questionnaires to enquire with facilities operators. The primary data source was the satellite imagery of Auchi, which served as a guide during the spatial and attributes data acquisition and a Global Positioning System (GPS) Garmin 60csx. The GPS was employed in capturing the locational data (coordinates). Attribute data, such as names of infrastructures, street names leading to this infrastructure, addresses of each facility, and their categories (public or private), are the major information that has been sourced during the field exercise. In a case where a route leading to an infrastructure is not on the Google image map, then questionnaires were made to infrastructure administrators for the purpose of updating the map, which was then imported into ArcGIS 10.3 software as a raster image as shown in Figure 3.

Figure 3: Raster Image

Reconnaissance and Planning

Reconnaissance is one of the important preliminaries of research study of this nature. It involved taking into account the method to be used, instrumentation, procedure to follow, and the software to be used for presentation. However, the office reconnaissance, which formed a fundamental phase of the study, was undertaken to take a critical look at the study area with a view to identifying the key features, patterns, and potential of areas of interest. Field reconnaissance carried out involved the validation of the boundary data extracted from the goggles image. The social survey was adopted for collecting and extracting attribute data over the study area.

Validation of GPS Data

The validation of extracted data was necessary to check the reliability of the extracted boundary data before their use; five already established boundary points were identified on the ground, and a GPS was used to pick coordinates compared with the existing ones (Makarand & Goodman, 2018). As it is a regular practice in the surveying profession, in-situ checks and instrument tests were carried out on the controls (AUP12 and AUP13) stations and on the instrument, respectively, and were both reliable for measurement and observations. Table 1 and 2 show the coordinates of control and validated GPS datasets.

Table 1: Coordinates of controls used for validation of extracted boundary data

Control Station	Coordinate	
	E(m)	N(m)
Aup 12	198868.992	781481.507
Aup 13	198843.592	781452.402

Table 2: Some validated GPS data

Station	Extracted Coordinate		Observed Coordinate		Difference
	E(m)	N(m)	E(m)	N(m)	Distance(m)
Aup01	199315.051	781249.906	199315.141	781249.908	0.09
Aup2	199210.417	781035.188	199210.407	781035.168	0.02
AB03	199178.203	781004.053	199178.233	781004.023	0.04
AB04	199051.014	780889.315	199051.034	780889.300	0.03
AB05	199051.445	780886.950	199051.477	780886.976	0.04

Attribute data acquisition

A handheld GPS device was used to acquire the data in the field, and surveying involved combining spatial information (coordinates) with non-spatial or descriptive information about the features being surveyed as indicated in Table 3. The general steps we use to acquire attribute data using a handheld GPS device were as follows:

i. First, we handheld the GPS device, which was properly charged and ensured sufficient memory for data storage.
ii. Identification of all the infrastructures in the study area.
iii. GPS device used to capture accurate spatial data. This included selecting the appropriate coordinate system and adjusting settings for accuracy and use the GPS device to navigate to each survey point.
iv. Spatial data by captured the GPS coordinates at each location was recorded and stored.
v. The data was ensured that it was stored.

Table 3: Sample of infrastructures and their coordinates

INFRASTRUCTURES	EASTING[M]	NORTHING[M]
EDUCATIONAL INSTITUTION		
IYEHKEI GIRLS PRIMARY SCHOOL	198188.11	781640.471
IYEHKEI GIRLS SECONDARY SCHOOL	197654.643	780633.144
BRAIN BRUSH SCHOOL	197624.643	780634.124
USOKWILI PRIMARY	197720.975	780107.025
IKELEBE SECONDARY SCHOOL	198330.156	781973.613
AKPEKPE MODEL PRIMARY SCHOOL	198523.209	782018.236
AUCHI POLYTECHNIC	199342.395	781237.735
OSENI ELAMAH ICT INSTITUTE	198115.125	781686.118
HEALTHCARE FACILITIES		
PRIMARY HEALTH CARE IYEKHEI	197736.608	780112.109
DR IMOMOH'S CLINIC	197716.611	779777.236
REHOBOTH CLINIC AND MATERNITY	199117.391	781910.089
OSIGBEMHE HOSPITAL	199156.736	781974.016
FILLING STATIONS		
AMA FILLING STATION	198237.354	762162.642
RAIN OIL FILLING STATION	198335.264	782168.523
FORTE FILLING STATION	199336.436	772165.655
PECJOE PETROL STATION	197756.050	779859.302
WIN OIL FLLING STATION	198337.833	782165.674

HAMAZ FILLING STATION	198885.964	781961.444
NNPC FILLING STATION	199345.661	781829.97
DAN OIL FILLING STATION	199376.732	781560.236
COMMERCIAL FACILTIES		
UCHI MARKET	198030.241	781679.333
AFEAKHUYE MODERN MARKET IYEKHEI	197758.531	779675.03
IGBE MODERN MARKET	199001.766	781951.895
INDOMIE COMPLEX	199337.834	792165.774
PMS TABLE WATER IYEKHEI	197735.182	778890.153
S. S BREAD BRAKERY	197825.349	778986.696
MOTORCYCLE DEPO	199336.735	773162.233
MOUKA FOAM	189235.832	772165.765
BIG TASTE	198039.532	781689.303
BOURDILLON MALL	198061.414	781690.017
SKP GAS STATION	199235.832	773165.762
CHOSEN GAS STATION	197857.122	779359.42
FINANCIAL INSTITUTIONS		
UBA BANK	197368.883	792077.340
GT BANK	197987.935	781659.492
ACCESS BANK	198011.26	781670.195
UNION BANK	198213.784	781657.165
FIDELITY BANK	198239.046	781650.542
ECO BANK	198769.311	781985.420
HOTELS / GUEST HOUSE		
GEE INTERCONTINENTAL HOTEL	197595.252	780478.859
STERLING EMBASSY HOTEL	197620.815	779713.365
VALCHI HOTEL AND SUITE	197880.292	779134.005
HABEEBMOORE HOTEL	197506.385	778963.641
JEEDEE HOTEL AND SUITE	197652.478	778855.422
RECREATIONAL FACILITIES		
WEALTH FOOD AND BAR	197733.824	779952.974
LUX BAR	197756.893	779739.091
MOBILUXE	197369.882	792078.346
OMODADA EMPIRE	197723.794	780135.514
S S RESTAURANT	197826.226	781577.548
PUBLIC FIELD	198369.885	782078.445
IKB CASTLE	198341.748	782136.499
FUN HOUSE	198681.58	782014.161
VEGAS CLUB	199393.626	781905.528
DANISCO	199430.607	781813.399
VALCHI	199358.48	781692.026
MAT ICE	199368.405	781634.648

Acquisition of satellite imagery

The satellite imagery was downloaded from Google via terra incognita. Terra Incognita is a program capable of downloading and saving maps from Google, Bing, and other sources supporting GPS and waypoints. It is written on NET technology and works on every computer with this platform integrated. With this online-based software, rectified satellite imagery of any area of interest can be downloaded to even a zoom level of 5m. The satellite imagery of the study area was downloaded using this software as shown in Figure 2.

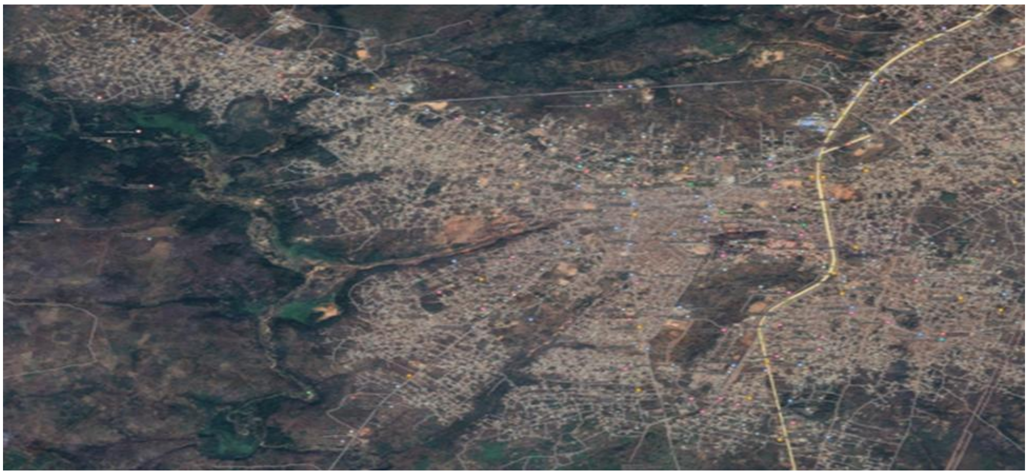

Figure 4: The satellite imagery of Auchi

3. Results and Discussion

GIS analysis

These comprise various analyses performed in order to show the spatial distribution and route that lead to these infrastructures. The attribute table that was created during ground truthing was used to query to provide solutions and answers for questions about some specific entity in the study area extracted from the database created. Basic queries could be either single or multiple criteria. A single query brings out one field result, while multi-criteria bring more than one field. Figure 4 presents the production map of Auchi.

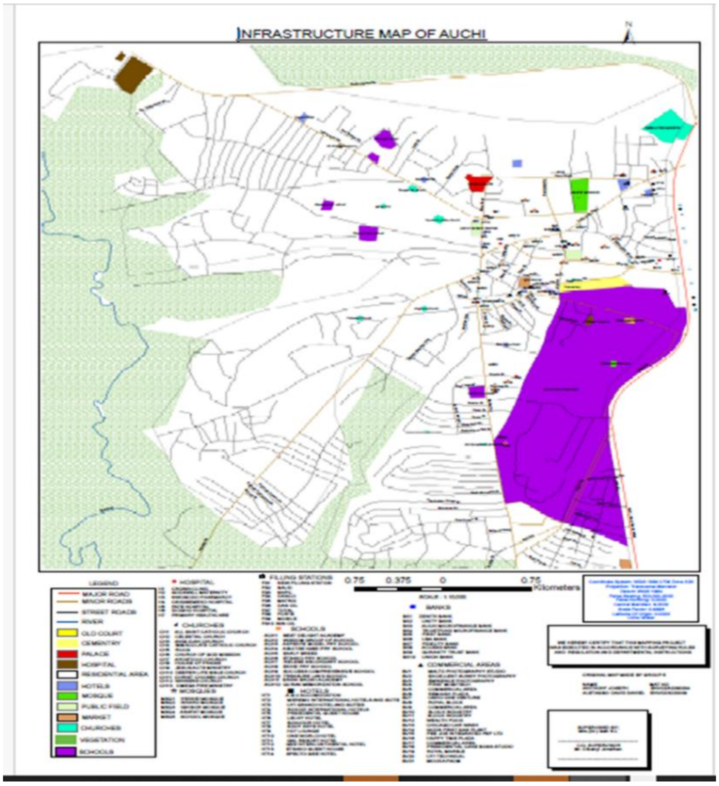

Figure 5: Production of map

Querying by attribute

This kind of query tends to define from a given attribute a specific layer of concern. For instance, the name of a specific health care facility can be queried from the attribute name to check if it exists. This can be done within most GIS environments, like ArcGIS, which was used for this purpose as shown in Figure 5.

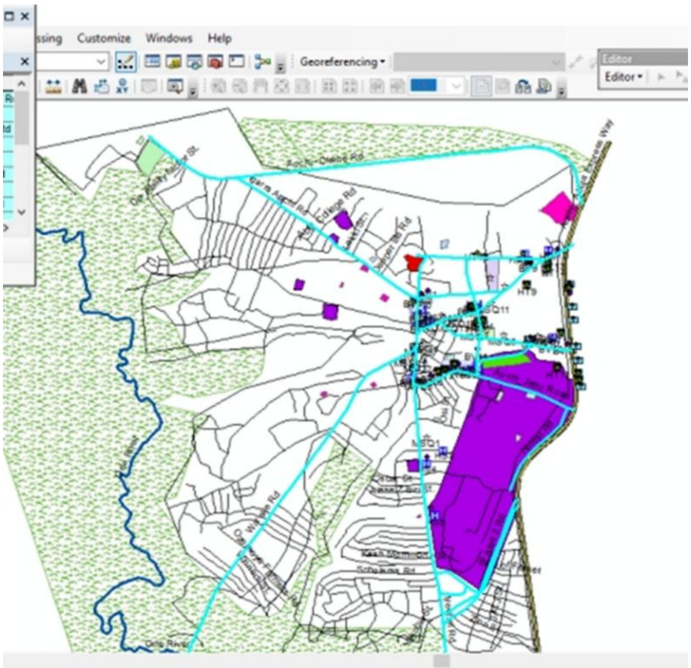

Figure 5: Minor roads in Auchi.

Figure 5 shows a query selecting all the private infrastructure facilities within Auchi. By this analysis, it can be seen that the majority, if not all, of the infrastructure's facilities are owned by private individuals. This is to show the level of negligence on the part of the government toward the welfare of people (Ibokwe, 2008). It was discovered that most people in Auchi were not able to access some of the government and private infrastructure, like schools, hospitals, and more, which are expensive, so this caused some hazards in the community. Figure 6 shows infrastructures that are contained within the 150 m major road buffer zone; based on this analysis, it was discovered that most of the infrastructures in Auchi are located within 150 m along the main road. It was also observed that some of the infrastructures were not well distributed, especially for those living around some specific locations such as Igbira Camp and Warake. Areas were deprived because of distance, although the road leading to Auchi main town was good, but at certain periods of the day (evening), there is heavy traffic. It is hereby advised that the authority should establish infrastructures closed to people living around these locations.

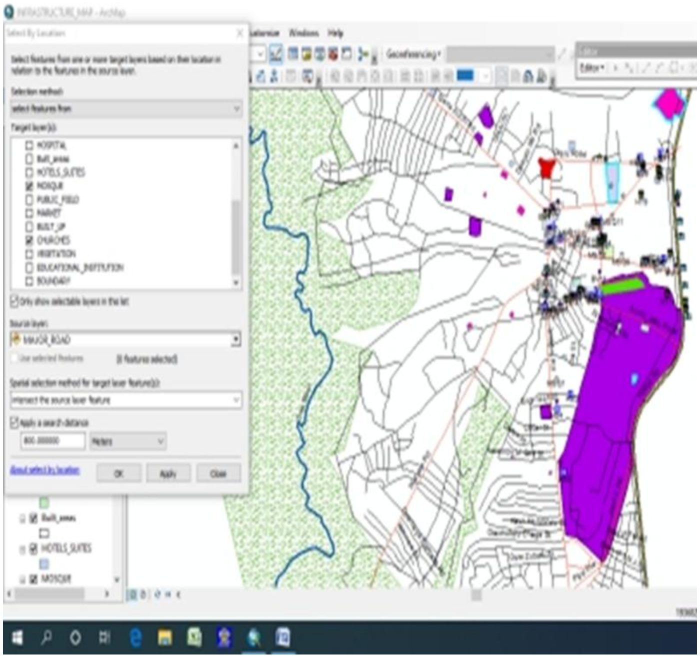

Figure 6: List of worship centers in Auchi

4. Conclusion

Infrastructure mapping in Auchi town was carried out by visiting the facilities in the study area and conducting an oral interview with the facilities owners in cases where there is no name (attribute) to describe the facility. The global positioning system (GPS) was used in getting the coordinates of all the infrastructures within Auchi settlement. The coordinates and the attribute data were entered in an Excel sheet that serves the database management system. An image of the study area was downloaded via Terra Incognita using the coordinates obtained from the department of Surveying and Geo-informatics, Auchi Polytechnic. The downloaded imagery was exported into ArcGIS via a plugin. The coordinate system was set to zone 32 using Minna datum as the coordinate reference system (CRS). A shapefile was created for the boundary; roads and other infrastructures were represented using points while boundaries and roads were digitised as lines. Attribute data was overlaid on the digitised imagery and was segmented by type and category and necessary information such as legend, title, orientation, scales, gridlines, boundary frame, and grid coordinates. The map was set on A0 paper size after it was imported in a new print layout with a scale of 1:10,000.

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