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CREATION OF TOPOGRAPHICAL INFORMATION SYSTEM: A CASE STUDY OF AKUFO HIGH SCHOOL, IBADAN.

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ABTRACT

Infrastructural development is one of the most important development any school should have, Akufo High school is no different, this has increased the need for topographic data to enhance a proper decision-making process. Creating a topographic information system will further serve as a tool for impactful planning and management of land matters. This paper is focuses on the creation of Topographical Information System (TIS) for Akufo High School, Ibadan, Oyo state.The methodology adopted to gather the topographic data was the Ground Survey technique used to create a topographic database, a kolida total station was used for the spatial data acquisition, while attribute data where acquired by questioning on site, AutoCAD 2018 software, surfer 10 and ArcGIS 10.3 were used for data processing, a database was also created in order to carrying out several analysis and queries on the data captured whenever the need arises. Map showing the 3d wireframe, 3d surface & slope was produced, this alongside queries produced will support decision making policy needed by the school authority, Land surveyors, Architects, Engineers, Urban and Regional planners to plan, design and carryout important infrastructural projects in the study area.

KEYWORDS: ***TIS, Infrastructural, database, spatial data and attribute data.***

1.0 INTRODUCTION

Infrastructural changes are in the basic essential services or amenities put in place for development to occur. The need for building more structure in a developing country keep increasing, this automatically has caused increasing demand for geo-information about the topographical features on the landscape which is multiplying continuously, as the precise and on time informative details about land dynamic changes is important to the update and management of topographic features on map (Zhang and Li, 2018). Vital areas of application include spacious planning of power supply, road construction, planning of flood control and more. All these areas of use will always need an up-to-date digital topographic database.

Topography of an area describes the terrain characteristics of relief features of such area as depicted by hills, valleys and plains. It can be used to study and represent as a surface, any characteristic that has a continuously changing value other than elevation, for instance, population, geo-magnetic data and geo-chemical data (Odo et al., 2016). Topographical surveying involves the capturing of spatial and non-spatial data of the terrain features on the topographic surface, both man-made and natural in three-dimensional form (x y z).

Ndukwe (2001), said topographic information system (TIS) is the combination of topographic survey and geographic information system (GIS). It can be defined as a GIS database of topographic features and other related data.

According to Uluocha (2007), the implementation of GIS into the planning aspect to enhance decision making has continued at an impressive rate. This is because GIS manage large spatial and attribute data with a distinct valuable application for policy makers in area of planning. A geographical information system (GIS) integrates hardware, software, and data (spatial and attribute) for capturing, managing, analyzing manipulating and displaying all forms of geographically referenced information. GIS allows one to view, understand, question, interpret and visualize data in many ways that reveals relationship, patterns and trends of form of maps, globes, reports and charts. Emakoji,and Otah (2018), also explains GIS as a tool to solve enquires and produce solution to arising problems which are related to earth by viewing the database in quick understandable manner and related.

Several methods are applied in topographic surveying. Some include, ground surveying, photogrammetry, aerial imagery and satellite imagery, remote sensing. Olaniyi, (2013), said the most appropriate method to be used on a project at hand depends on the location of interest (size), scale, purpose etc. Furthermore, it's based on availability, accuracy and precision i.e. quality of the existing map of the study area.

Need for erecting more buildings has continually increased in the akufo high school, having the knowledge that no meaningful development can occur without the topography data of the area. Therefore, this study shows the topographic information system created for the study area by acquiring the spatial value of the controls nearby, which serve as the base in which the spatial data acquired rely, the attribute data was acquired, the processing of this data was done using the necessary software such as AutoCAD 2018 software, surfer 10 and ArcGIS 10.*3*, a database was also created which relate both spatial data and attribute data and maps such as digital terrain model (DTM), water flow map where produced to serve as reliable data which should guide decision making for the development of the school.

2.0 STUDY AREA

The study area is Akufo High school located along Awotan / Opawole road, Ibadan, Ido Local Government of Oyo State. It is a government owned school which is situated between latitude 7 30' 37.30" to 7 30' 19.8"and longitude 3 47' 45.18" to 3 47' 44.73". The total area of the study area is 125169.122 square meters and 12.517 hectare. The study area is an area with features such as residential, administrative and academic buildings, street light, roads, electric poles and power line etc.

Fig 1.0: AKUFO HIGH SCHOOL (STUDY AREA)
Source: GOOGLE EARTH (Imagery date- 21-01-2018)

3.0 METHODOLOGY

The method used for this study is depict in fig 2.0 below;

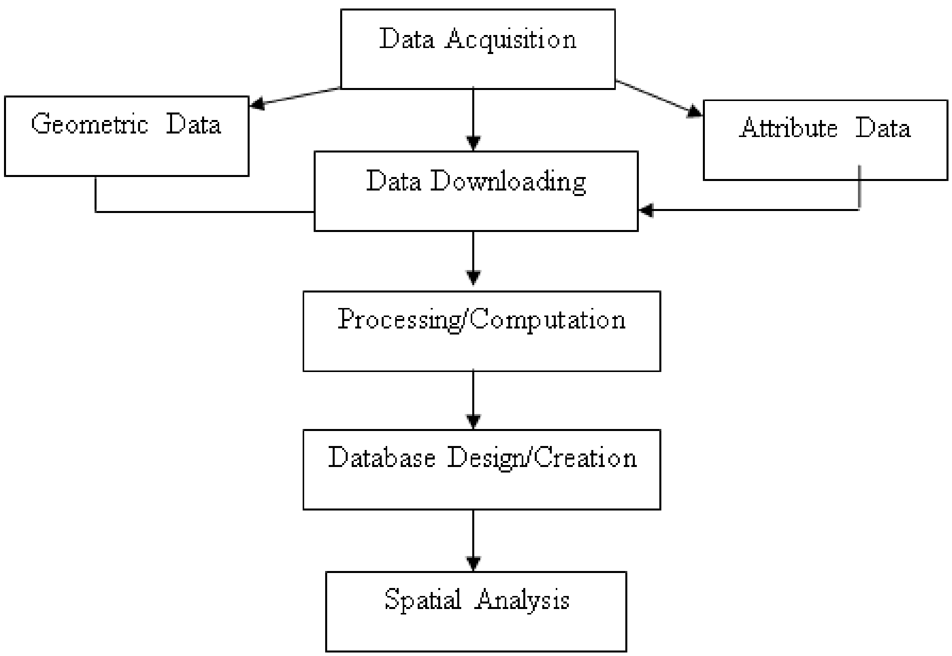

Fig.2.0: Methodology adopted Flowchart

3.1 DATA ACQUISITION

This involves collection of data that can be processed for the required information needed for decision making. The spatial database creation most important aspect is the acquisition of geometric data. In this research, spatial data were acquired using digital equipment like total station. This geometric data acquisition was in three phases namely; perimeter traversing which involve measurement on the points that forms the study area boundary, detailing includes the measurement details within the boundary such as footpaths, walkway, buildings, electric poles, borehole, car park and sport facilities, which were identified with unique code during observation to have a distinguished entity and the spot heightening was done at an interval of 10m based on the topography of the study area.

The attribute data include the characteristics of features especially man-made features, this were obtained through a physical contact survey (social survey) which made it possible to get information such as; object name, object use and related data about features from the students and staffs in the school. All these data formed the non-spatial aspect of the feature are specifically for the database creation. Example of these is: building's name, building's purpose, building colour etc.

3.2 Data Downloading and Processing

The spatial data obtained during the field work was saved in the total station SD, and the data were downloaded into computer system for manipulation purpose. These data were processed using AutoCAD 2018 where the acquired coordinate where plotted, details fixed to depict the study area, after which were exported to ArcGIS 10.3 where digitizing was done, and the attribute data was used to create a database table in relationship to the details. Surfer 10 was used to produce the 3D surface map and the 3D wireframe map using the X, Y, Z value obtained on site. These data table was queried to provide useful cadastral information.

3.3 Database Design

This is the arrangement of data in-line with the database model. The designer determines what data must be stored and how the data elements interrelate, with this information, we can begin to fit the data to the database model. A database is designed to meet the rising needs of users everywhere. The first step in database design is to carry out user's requirement studies, consider the available database and relevant hardware and software, before going ahead to database creation. The design phase of any database design involves three stages namely (Kufoniyi, 1998):

a) Conceptual design
b) Logical design
c) Physical design

3.3.1 Conceptual Design

It is the first stage in database design that involves an arrangement and the presentation of the view of reality by presenting the view in a simply form which can still give the information needed for the topography (Ojiako & Jimoh, 2017). The realities in this paper refer to the boundary, building, road, spot height, as found in the study area. The reality was conceptualized as points, lines and polygons as X, Y and Z with positional coordinates. The entities of preference for Topographic Information System were identified and analyzed to produce a conceptual data model. The relationship among entities and the attributes of each entity were also identified.

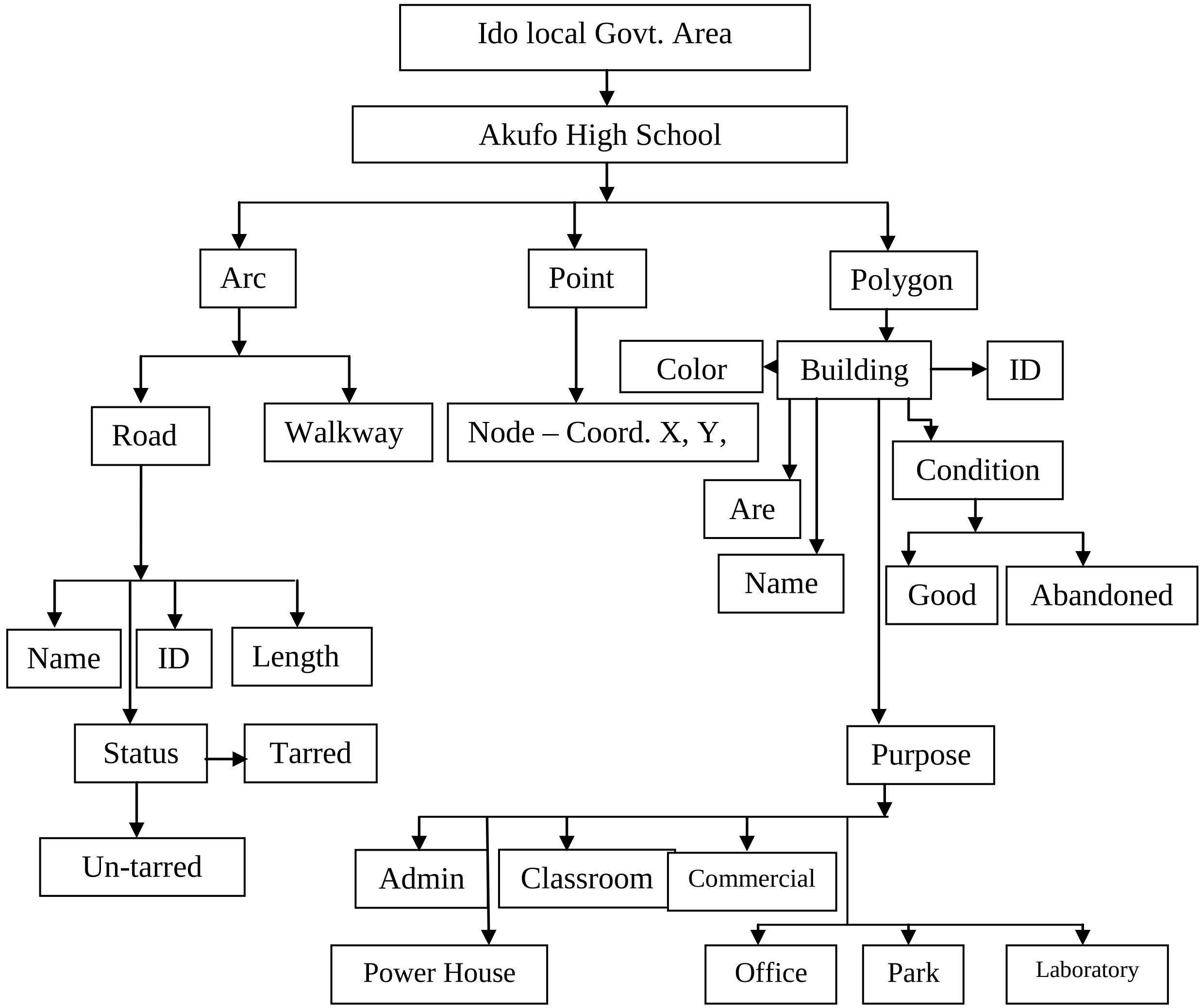

Fig 3.1: ENTITY RELATIONSHIP

3.3.2 LOGICAL DESIGN

This is the phase that translated the conceptual design into data structure. It is the representation of data model designed to display the recording of the data into a personal computer. The data structure organizes data in a single uniform manner in tables (relations). Each table was recognized by a distinct table name and was arranged in turples (rows) and attribute (columns). The table was populated with fields. Each column has a unique name identifier. In this project, conceptual data was developed and later translated into a data structure in a single uniform manner in form of relation (tables). The conceptual model was translated into schemas as stated below:

Electric pole Table (EP_ID, EP_E, EP_N, EP_NAME, EP_H).
Road Table (R_ID, R_N, R_NAME, R_L).
Buildings Table (B_ID, B_USE, B_TYPE, B_CONDITION, B_NAME, B COLOUR)

3.3.3 PHYSICAL DESIGN

At this stage of the design, the data type and the attributes domain constraint (width) were well defined to be recognized by the implementation software. This marked the first stage of database creation. In this case, the capacity of available hardware and software was considered. In this project, Microsoft excel was used for editing and saved as script file. AutoCAD 2018 was used for plotting & final embellishment, Surfer 10 version was used for contour, spot height and DTM generation and finally ArcGIS 10.3 version was used for database design and analysis. The physical design was done to cover all investigated entities. In other, word, relationship that exist between each point features (i.e. electric pole, bole -hole and spot height), each line features (i.e. road and walk ways) and each area features (i.e. Building, Sport facilities, Car park, and boundary) was established. The table 1.1 below shows the building entities;

TABLE 1.1: DATA DECLARATION FOR BUILDING ENTITIES

FIELD NAME	FIELD ALIAS	DATA TYPE	ALLOW NULL VALUE	FIELD WIDTH
Bd_Id	Building Identity	Short Integer	Yes	5
Bd_Name	Building Name	Text	Yes	30
Bd_Use	Building Use	Text	Yes	30
Bd_Type	Building Type	Text	Yes	25
Bd_Conditn	Building Condition	Text	Yes	25
Bd_Colour	Building Colour	Text	Yes	25

3.4 DATABASE CREATION

The AutoCAD plotted file were exported to Arc MAP environs of ArcGIS 10.3 to allow table creation for analysis purpose. In Arc MAP environs the graphic form was converted to shape files and then added as a theme. The creation of table for each feature was done and this assisted in carrying out spatial analysis such as querying and buffering from the database. Following the successful design of the database for each feature class (layer) in Arc Map, the tables created were filled using the obtained non-spatial data. Each column in the table contained attribute values for each field, while each row contained records of a particular feature. The table 1.2 below shows samples of table created and their records during this operation.

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TABLE 1.2: ATTRIBUTE DATA TABLE OF THE CLASS ROOMS

Table

LECTURE_ROOMS

FID	Shape *	Layer	CLASS_NAME	STRUCTURE	TOILET_USE	AREA	PERIMETER	GOOD_SEATS	BAD_SEATS	N_FAN	TOTAL_SEAT
0	Polygon	BUILDINGS	JUNIOR CLASS 1	BUNGALOW	JUNIOR TOILET BLOCK	375	93	26	4	2	30
1	Polygon	BUILDINGS	JUNIOR CLASS 2	BUNGALOW	JUNIOR TOILET BLOCK	374	93	28	2	2	30
2	Polygon	BUILDINGS	JUNIOR CLASS 3	BUNGALOW	JUNIOR TOILET BLOCK	375	92	27	3	2	30
3	Polygon	BUILDINGS	JUNIOR CLASS 4	BUNGALOW	JUNIOR TOILET BLOCK	370	89	30	0	2	30
4	Polygon	BUILDINGS	JUNIOR CLASS 5	BUNGALOW	JUNIOR TOILET BLOCK	374	93	29	1	2	30
5	Polygon	BUILDINGS	JUNIOR CLASS 6	BUNGALOW	JUNIOR TOILET BLOCK	374	93	24	6	2	30
6	Polygon	BUILDINGS	JUNIOR CLASS 7	BUNGALOW	JUNIOR TOILET BLOCK	371	90	25	5	2	30
7	Polygon	BUILDINGS	JUNIOR CLASS 8	BUNGALOW	JUNIOR TOILET BLOCK	371	90	23	7	2	30
8	Polygon	BUILDINGS	SENIOR CLASS 1	BUNGALOW	SENIOR TOILET BLOCK	372	91	23	7	2	30
9	Polygon	BUILDINGS	SENIOR CLASS 2	BUNGALOW	SENIOR TOILET BLOCK	372	91	23	7	2	30
10	Polygon	BUILDINGS	SENIOR CLASS 3	BUNGALOW	SENIOR TOILET BLOCK	374	93	25	5	2	30
11	Polygon	BUILDINGS	SENIOR CLASS 4	BUNGALOW	SENIOR TOILET BLOCK	371	90	27	3	2	30
12	Polygon	BUILDINGS	SENIOR CLASS 5	BUNGALOW	SENIOR TOILET BLOCK	371	90	26	4	2	30
13	Polygon	BUILDINGS	SENIOR CLASS 6	BUNGALOW	SENIOR TOILET BLOCK	370	89	28	2	2	30
14	Polygon	BUILDINGS	SENIOR CLASS 7	BUNGALOW	SENIOR TOILET BLOCK	371	90	29	1	2	30
15	Polygon	BUILDINGS	SENIOR CLASS 8	BUNGALOW	SENIOR TOILET BLOCK	378	97	30	0	2	30
16	Polygon	BUILDINGS	SENIOR LABORATORY 2	BUNGALOW	GENERAL TOILET	154	50	0	0	0	0
17	Polygon	BUILDINGS	JUNIOR LABORATORY 1	BUNGALOW	GENERAL TOILET	157	53	0	0	0	0
18	Polygon	BUILDINGS	SENIOR LABORATORY 1	BUNGALOW	GENERAL TOILET	152	48	0	0	0	0
19	Polygon	BUILDINGS	JUNIOR LABORATORY 1	BUNGALOW	GENERAL TOILET	153	49	0	0	0	0
20	Polygon	BUILDINGS	COMPUTER ROOM	BUNGALOW	GENERAL TOILET	157	53	0	0	0	0
21	Polygon	BUILDINGS	UNCOMPLETED BUILDING 1	2 STOREY BUILDING	UNKNOWN	1009	140	0	0	0	0

4.0 RESULTS AND DISCUSSIONS

The maps produced, spatial and non-spatial results of the area of study are shown in figures below. These spatial queries were classified as single and multiple criteria queries.

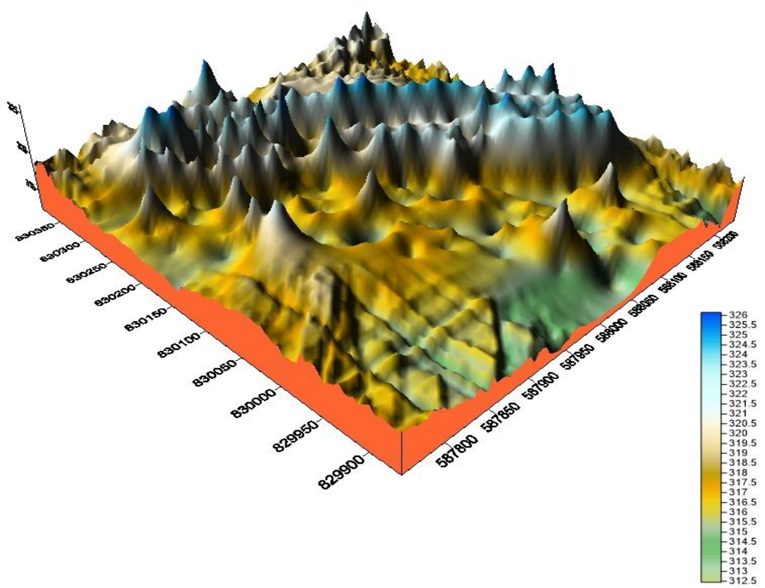

Fig. 4.1: 3D Surface Map/ DTM of the Study Area

Ndukwe, (2001) defined digital terrain model (DTM) as a topographic model of the terrain relief that can be manipulated by computer programs. This map shows the nature and configuration of the terrain in a pictorial form, make obvious the water possible flow pattern and to calculates accumulated weight of all cells flowing into each down slope cell in the output raster. If no weight raster is provided, a weight of one is applied to each cell, and the value of cells in the output raster will be the number of cells that flow into each cell.

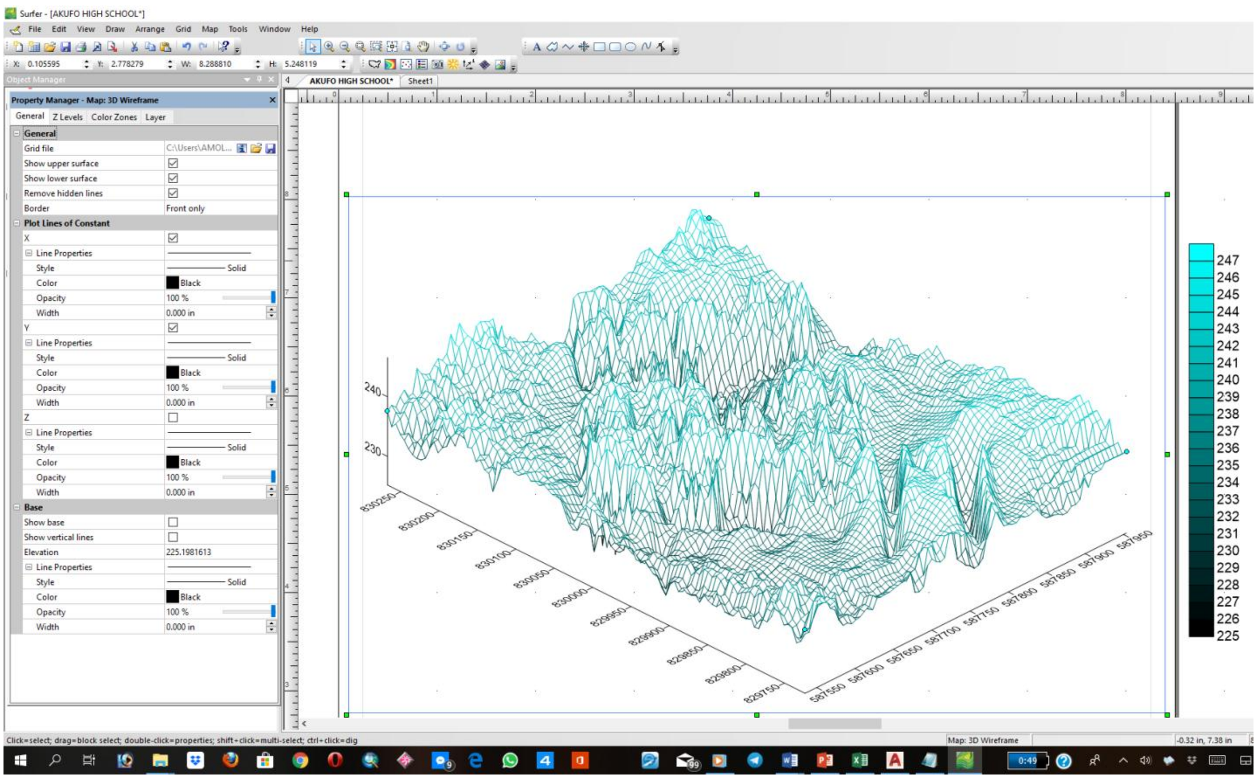

Fig. 4.2: 3D Wireframe map of the Study Area

The three-dimensional wireframe map gives an impressive 3D display of the study area. The wireframes are created by connecting Z values of defined X and Y. This map can be used in designing drainage network, terrain analysis, line of sight analysis, and also for creating relief maps of the study area.

Multiple Ring Buffer (Analysis)

The study area is without a library structure that can serve the student, this analysis can be performed on the base map of structures in the school to specify a good place for sitting of the proposed library to avoid distraction for the users of the library. i.e., having the school library located in an area void of noise pollution and distraction from other structures.

Therefore, this analysis was done to avoid the propagation of noise pollution, this means the library should be sited not less than 100 meters to other structures (classrooms, offices, commercial buildings etc.). Hence multiple point with 100 meters buffering radius were place at the edges of all the buildings where the structure should not be sited, hence a common point to them all will be selected.

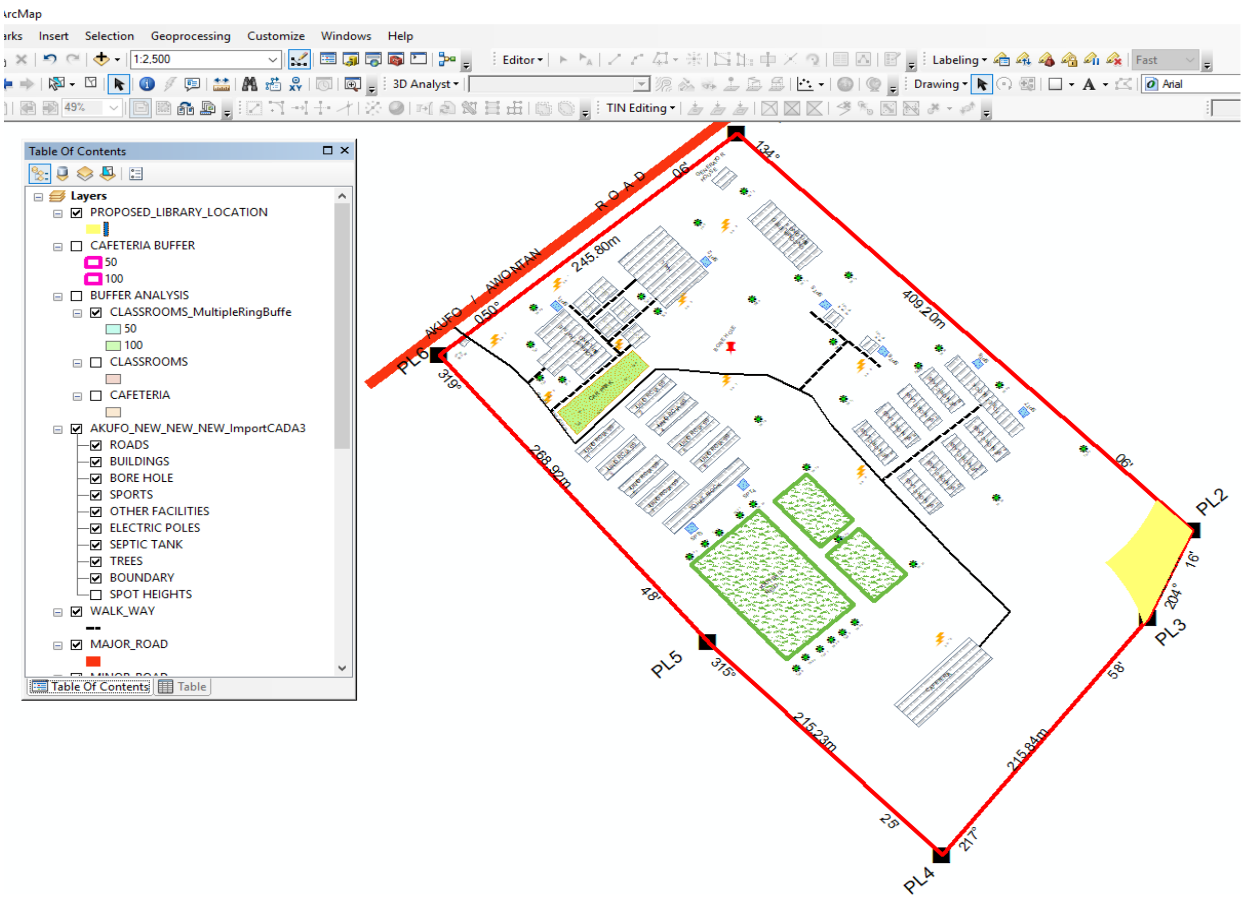

Fig. 4.3: Multiple Ring Buffer Analysis Result for the Suitable Library Location (100 Meters Away from Other Structures)

The yellow portions indicate where the library can be sited to avoid the propagation of noise pollution from other structure.

QUERY ONE: determine the height points where water reservoir to be used for water distribution can be located. i.e., determine heights that are lesser than or equal to 232.58 meters within the project area which is the height at the borehole point.

Syntax: "HEIGHT" <= 232.58

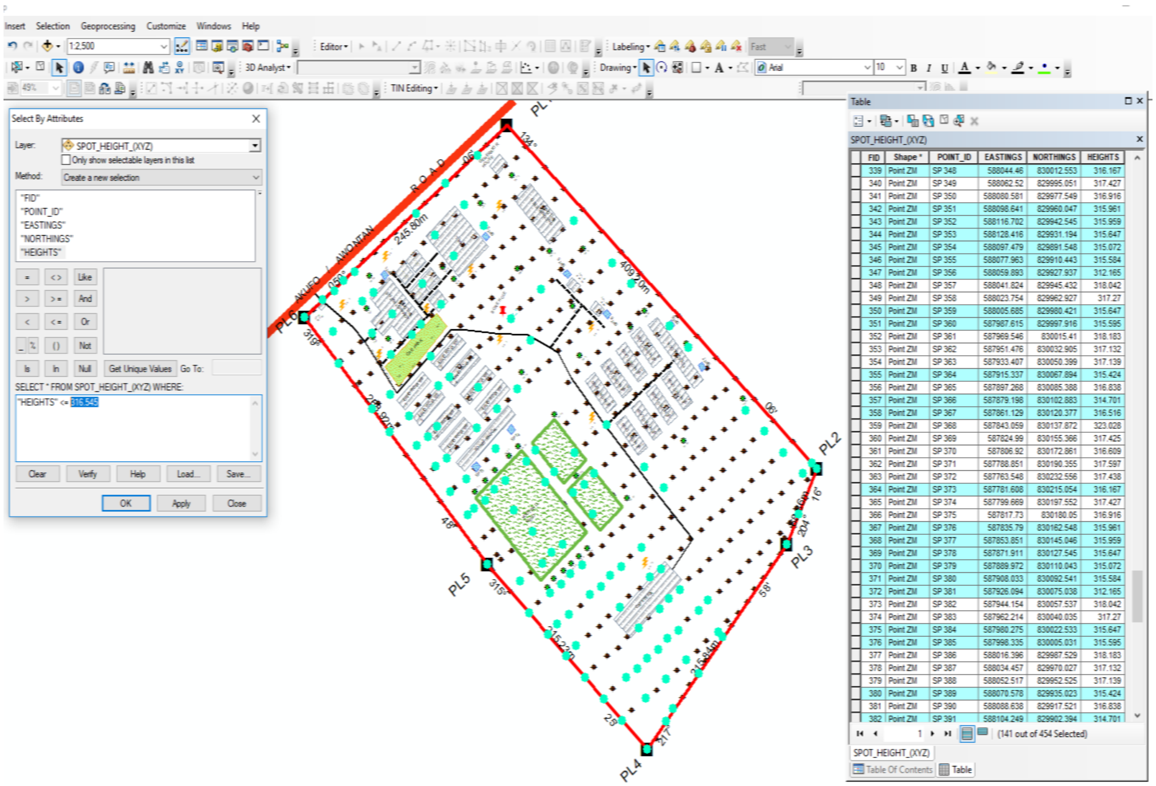

FIG 4.4: Result Showing Spot Heights Query Which Are Lesser Than or Equal To 232.58m within the Project Area

The blue like colour point in figure 4.3 above indicates spot height that has height that is equal to or greater than 232.58m which can be applied in application area below.

This shows the school management the low points prominent for flood within their environment so as to establish water reservoir for water distribution purposes and give the right channel to the drainages.

The query result will further allow the school authority to make decision based on the terrain nature and the pattern infrastructure should take in every area of the study area, giving careful look at the topography of the study area. Other application of this query may include sitting of telecommunication mast, construction of towel for security purpose, etc.

QUERY TWO: Show buildings which their purpose is for academic work

Syntax: *"BLD_PURPOS" = 'ACADEMIC'*

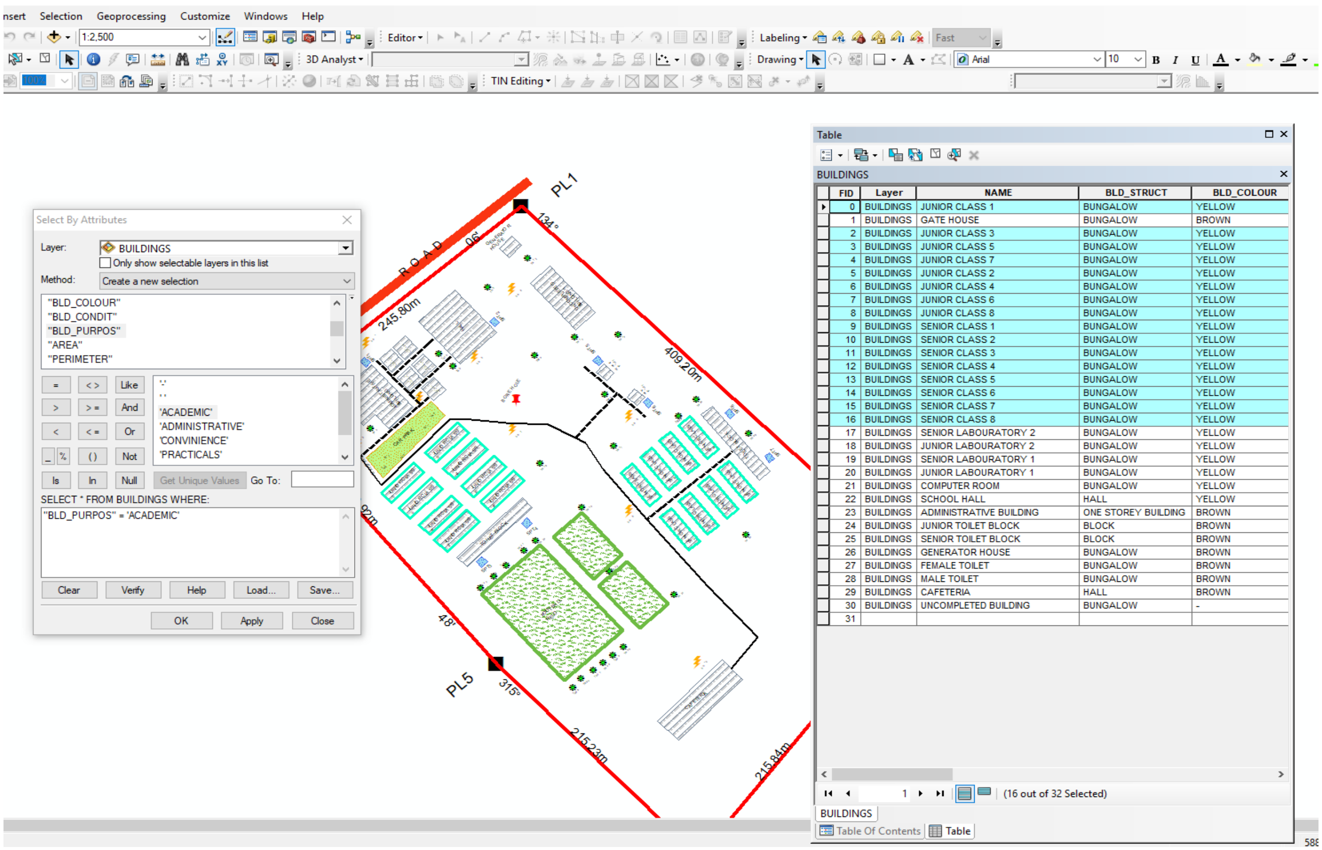

Fig. 4.5: Result of Query Showing Buildings Which Their Purpose Is for Academic Work

In Figure 4.5 above, the blue like colour portion indicates the buildings that are used for academic purposes within the school area with indicate a total number of sixteen (16) buildings in the database table.

This will aid the school authority in considering if more academic buildings need to be built, it can also be used as guide when distributing academic materials in the school environment or any other related purpose.

QUERY THREE: Show Buildings with bungalow structure with yellow paint colour which are used for practical purposes.

Syntax: "BLD_TYPE" = 'BUNGALOW' AND "BLD_COLOUR" = 'YELLOW' AND "BLD_PURPOS" = 'PRACTICALS'

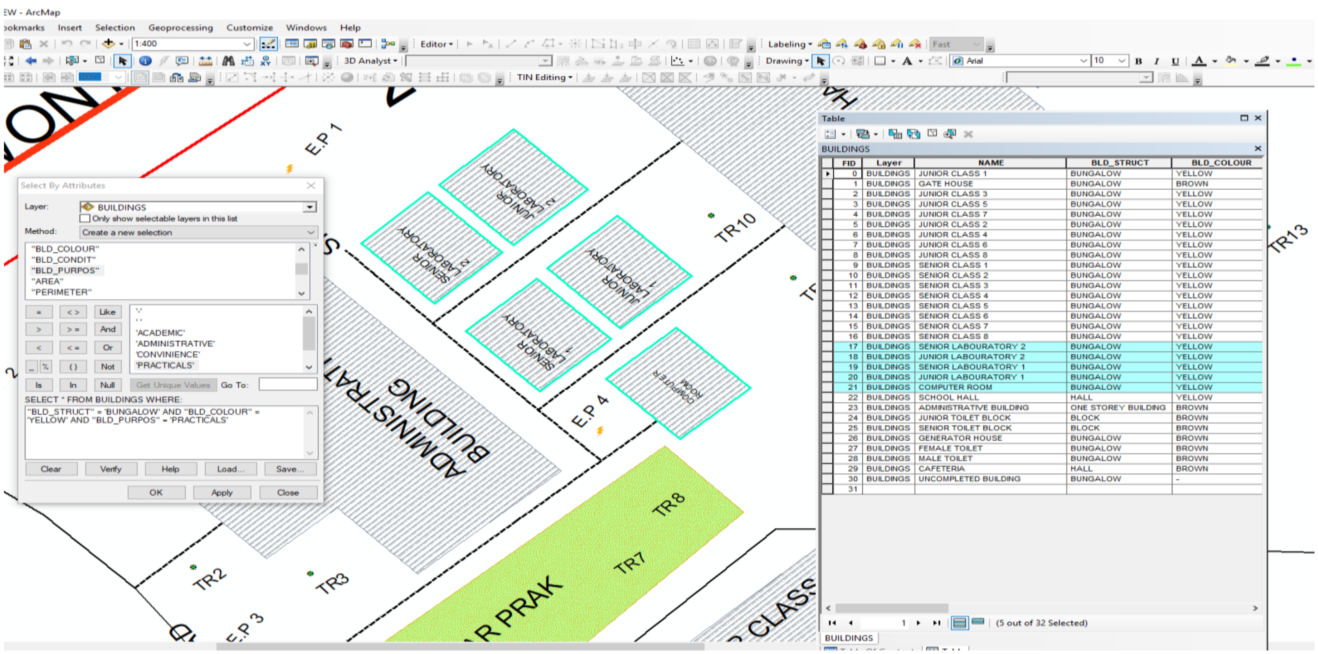

Fig. 4.6: Result Showing Buildings Query with Bungalow Building Structure Having Yellow Paint Colour Which Their Purpose Is for Practical

In Figure 4.6 above, the blue like colour portion indicates the buildings that are used for practical purposes having bungalow building structure and painted in yellow colour within the school area with indicate a total number of five (5) buildings in the database table.

This can be used to locate the position of bungalow buildings used for practical purposes so that it can be used as guide when distributing practical materials in the school environment.

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Alausa, O. A., & Adaradohun, O. S.

QUERY FOUR: To show building that has the highest height within the project area

Syntax: "Elevation" = 14.856

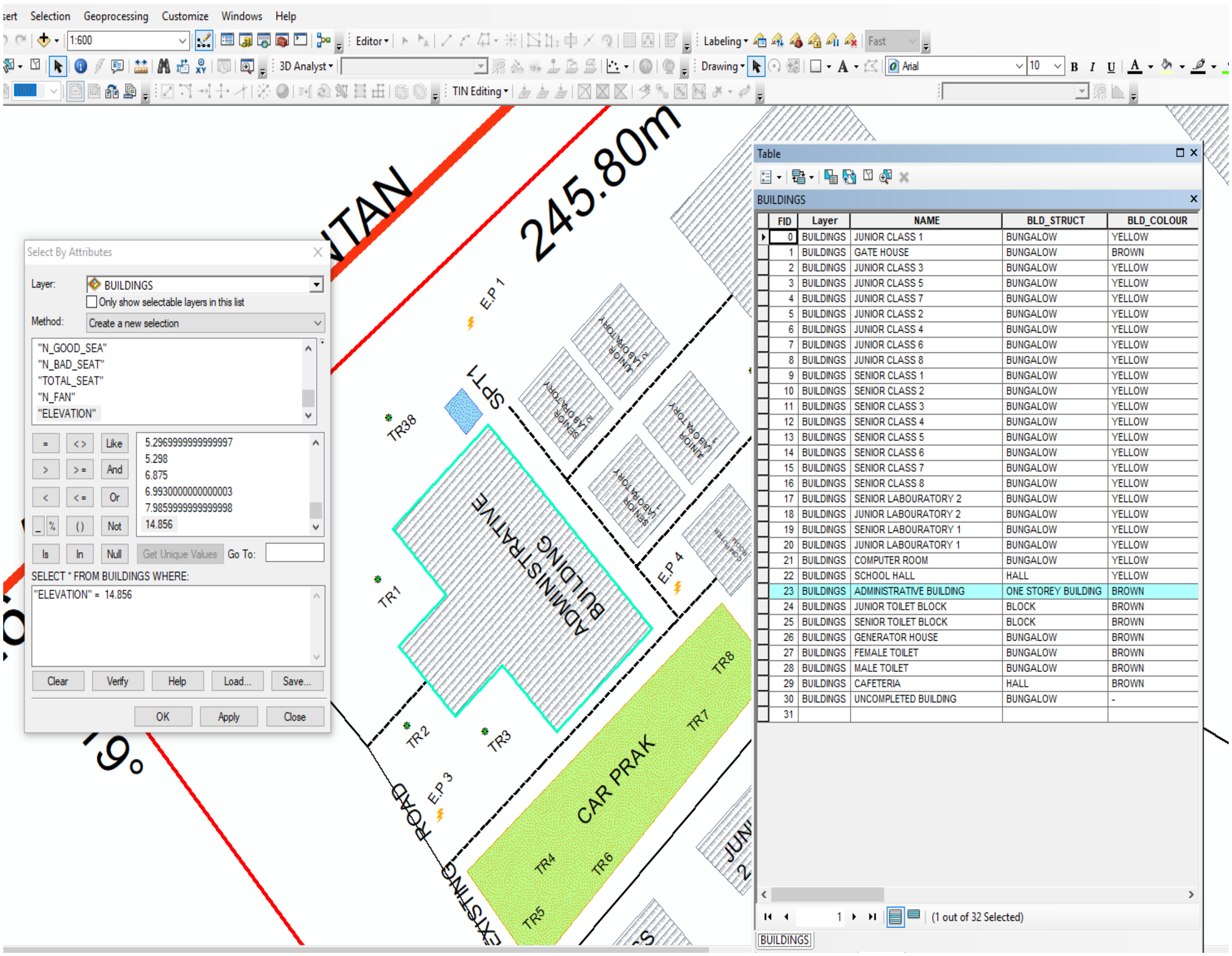

Fig. 4.7: Result of Query Showing Building with the Highest Height in the Study Area

Figure 4.7 above, the blue like colour portion indicates the building with highest height within the school area with indicates in the database table as 'Administrative Building'. Visibility shading is one of the major problems affecting the distribution of internet satellite dish signal to various receivers and to avoid this visibility shading, the dish must be sited on the highest structure within the environment so that the signal can be available to various receivers. Hence this query provides solution to this problem as it indicates the highest structure in the school environment.

5.0 CONCLUSION

In a developing country like Nigeria, the progress has been very slow in adopting Topographic Information System as a basis for the planning and decision making. This is hardly surprising given the prevailing environment of low technology capability whereas, Topographic Information System (TIS) is essential to economic planning and development such as the transportation network, agriculture, the health care system, telecommunications just to mention a few should be accorded the same level of support and priority.

Topographic Information System developed in this paper would go a long way in enhancing physical planning, future development and decision making in the school as shown in FIG 4.3 – FIG 4.6. The spatial database designed and created in this paper, showed several query functions and buffering which were performed, a digital terrain model/ 3D surface map and 3D wireframe map were produced, which serve as guide to decision making where infrastructural development is concerned FIG 4.1 and FIG 4.2 shows this. Furthermore, the database created can serve as model for future work within the study area that will include the use of GIS basic analysis functions such as query or overlay and buffering. The database created to entertain developments within the area, it's capable of being updated. Updating of the information system and map will not be a problem in future because it is just a matter of taking some measurements of the few developments and updating the database to give a new map due to continuous topography change. Also, the reliability of the data was ascertained by achieving the required accuracy and precision, using a tested digital equipment, the principle of whole to part was employed by relying on a higher order control.

5.1 RECOMMENDATIONS

Having completely done this study successfully, I recommend the following:

1. The data obtained from this project can be used in enhancing physical planning, future development and decision making in the school.
2. From the spatial database designed and created in this paper, several questions about the school could be provided with prompt assist able answers when query functions and buffering are performed.
3. Digital terrain model/ 3D surface map and 3D wireframe map generated can serve as guide to decision making.
4. The database created can serve as model for future work within the area that will involve the use of GIS basic analytic functions such as buffering, query or overlay.
5. Due to the flexibility of the database created, accommodating new changes within the area will be easily carried out that is, updating the information system and map will not be a difficult task in the future, all it would take is just a matter of taking some measurements of the few developments and updating the database to give a new map due to continuous topography change.

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