American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-6, Issue-10, pp-113-122
www.ajer.org
Research Paper Open Access

Topographic Mapping and Normalized Database Creation of Shehu Sule College of Nursing and Midwifery Damaturu

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Abstract: *This study demonstrates the use of Differential Global Positioning System (DGPS) data acquisition as input in to the database creation of Shehu Sule college of Nursing and Midwifery Damaturu using ArcGIS. The project entails the acquisition of 60cm spatial resolution satellite image from GeoEye–1, the image was added to ArcMap environment and georeferenced from where some details were digitized. DGPS observation was conducted where by precise spatial location of significant points not accessed or unavailable in the image during digitization were determined and contours were as well generated. Spatial database comprising various layers were created so also it attributes database comprising various records was created and normalized to minimize data redundancy. Different query analyses were performed on the created database, research findings were presented and the outcomes are effective and efficient.*

Keywords*: Database, DGPS, GeoEye–1, GIS, Query, Topography*

Date of Submission: 21-09-2017 Date of acceptance: 12-10-2017

I. INTRODUCTION

For a long time, topographic map have been used for military purposes but are now used as well by the public and as a background for spatial planning and other official uses. Topographic maps are produced at many scales and in many different designs. The topographic maps produced by the National Mapping Organizations (NMO) are normally called official maps. Nowadays, map production is combined with building geographical databases, which are regularly updated [1] and [2]. The most common topographic map for rural areas is a map at the scale of 1:25,000 or 1:50,000; in urban areas a map at a scale of 1:10,000 is normally called a city map or city plan. All those maps are very good for finding your way. That might be for hiking, berry picking or searching for mushrooms, or finding the route to a museum. In many countries, the rural maps are produced and sold by the NMO and the city maps by each municipality.

One of the most widely used of all maps is the topographic map. The feature that distinguishes topographic maps from other types of maps is the use of contour lines to portray the shape and elevation of the land both natural and manmade features which includes valleys, mountains, plains, lakes, boundaries, transmission lines and major buildings. The wide range of information provides by topographic maps make them extremely useful to professional and recreational map users alike. Topographic maps are used for engineering, energy exploration, natural resources conservation, environmental management, public works design, commercial and residential planning and outdoor activities like hiking, campaign and fishing [3].

A database is a collection of information organized in such a way that a computer program can quickly select a desired piece of data. You can think of database as an electronic filing system. Traditional database are organized by fields, records and files. A field is a single piece of information; a record is one complete set of fields; and a file is a collection of records [4]. For example telephone book is analogous to a file. It contains a list of records each of which consist of three fields; name, address and telephone number. In created database, specific information could be located or queried with the aid of using Database Management System as GIS tool. The Database Management System (DBMS) is a collection of software for organizing the information in a database, typically contains routines of data input, verification, storage and retrieval. Conventionally, Database Management System software (e.g. Dbase iv, v, Oracle etc.) deals with alphanumeric data and has no capability of graphic functions such as displaying maps.

Geographic Information System (GIS) is a system of hardware and software used for storage, retrieval, mapping and operating personnel and the data that goes into the system. Another property of GIS database is it has a “topology “which defines spatial relationships between features. the fundamental components of spatial data in GIS is are points, lines, arcs, and polygon, when topological relationship exist, you can perform analysis such as modeling the flow through connecting lines in a network, combining adjacent polygons that has similar characteristics and overlapping geographic features. Cadastral information system can be seen as the aggregation of discreet and independent record consisting of data for land. It is also a system, which is, concerned with attributes such as land ownership, land used and property values. Cadastral information system can also be regarded as a part of larger system of land related information system known as LIS [5].

Also of concern is the provision of spatially referenced information used in the management of these very complex networks that extend over the area. The effective management of these utilities is highly desirable for economic and social well-being of the individuals residing in the areas.

The management of properties has been of paramount importance to the Works and Maintenance department of Shehu Sule College of Nursing and Midwifery, Damaturu. An up-to-date map and records will make it easier to achieve the goal of efficient management of structures. So far, based on the records available, there is no recent topographic map of the college and even the ones available are only analogue and cannot fit into the present status of the college due to so many developmental changes that have taken place. More importantly, there is no database for some important features in the area that will be linked to the topographic map which will be very useful in decision making an this and lot more reasons called for this research.

II. STUDY AREA

Shehu Sule College of Nursing and Midwifery Damaturu, it is located along Damaturu to Biu road Damaturu. It is bounded between11° 44' 07"N and 11° 50' 00"N latitude with 11° 54' 08"E and and 12° 02' 27"E longitude, it has an average altitude of 298m above Mean Sea Level.

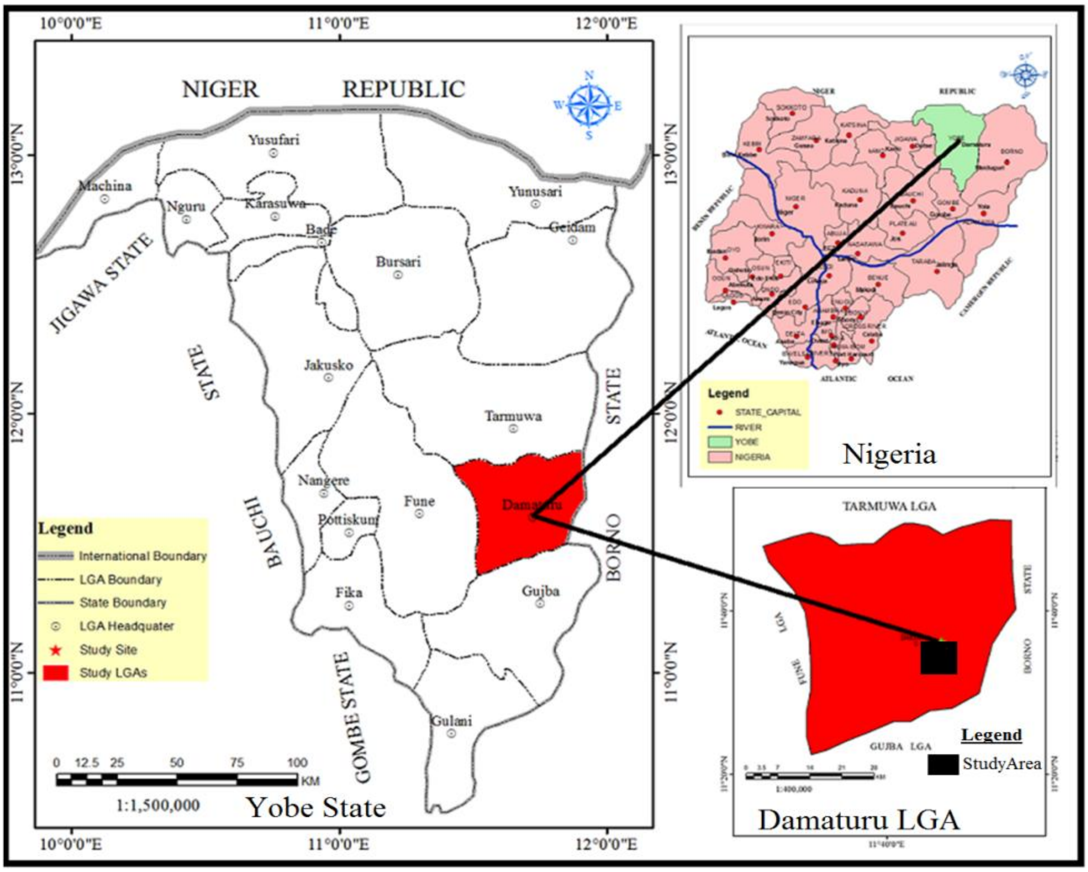


Figure 1: Location of the Study Area.

III. MATERIALS AND METHODS

Methodology adopted (See Figure 2) in this study include reconnaissance (both office and field) were by stations were established and marked at suitable points, taking into consideration the indivisibility, suitability, durability and free from traffic disturbance.

3.1 Data acquisition

DGPS observation was conducted on a post processed static mode to determine the precise spatial location of existing structures and details within the study area and a 60cm resolution GeoEye–1 satellite image was also acquired from which the road networks and relevant features were digitized from.
Secondary data were also acquired from various departments and sections of the college (study area) to serve as attribute information in the database design. Such information include: date of buildings construction, last date of buildings renovation, buildings capacity among others.

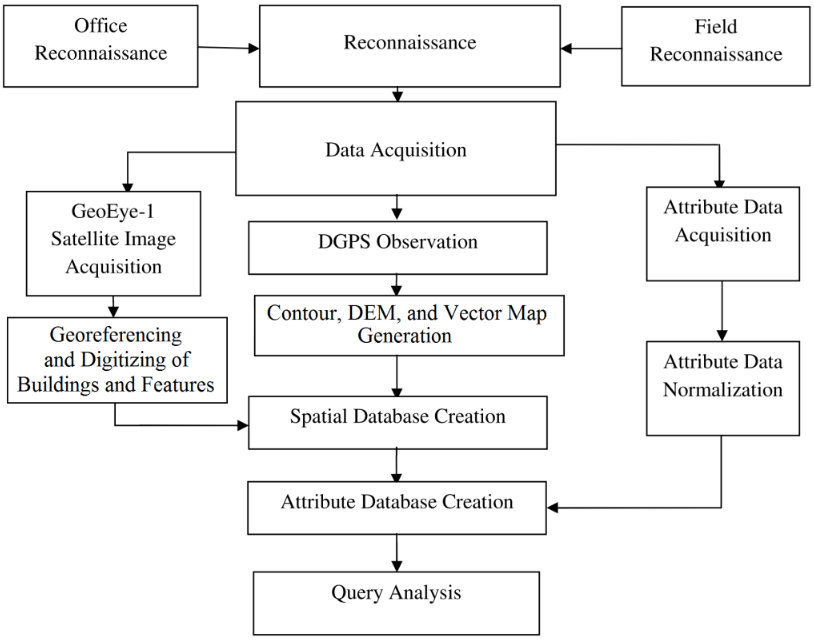


Figure 2: Flowchart Showing the Methodology of the Research

3.2 Spatial database creation

The raw DGPS data collected using Promark 3 was downloaded and post-processed in GNSS solution software to obtain the Eastings (E), Northings (N) and Height (H) coordinates values in World Geodetic System of 1984 (WGS84) of individual features within the study area. Output coordinates in Microsoft Excel file format were then imported into ArcMap environment using adding point data tool.
Satellite image was also added and georeferenced using tie points method by registering the coordinates of five (5) prominent points to their ground points coordinate in the ArcMap environment.

Table 1: Ground points used for Georeferencing the Satellite Image

Points	Easting (m)	Northing (m)
P1	822927.437	1298212.178
P2	822855.657	1297881.864
P3	822474.113	1297943.436
P4	822373.232	1297978.958
P5	822501.178	1298358.526

Digitizing which is the process of tracing all the details (not captured using DGPS) which include buildings, electric poles etc. was performed where by various shapefiles were created in Arc Catalogue window space for point, line and polygon and then added to the ArcMap work space where features were digitized.

Digital Elevation Model (DEM) is a topographic model of the bare earth terrain relief that can be manipulated by computer programs [6]. The data files contain the spatial elevation of the terrain in a digital format which usually presented as a rectangular grid was produced by producing contour lines covering the study area. This was achieved by using the data obtained during DGPS surveying. Also produced is the vector map of the study area that uses arrows in showing the magnitude and direction at any given grid node, the direction of the arrow points in the direction of the steepest descent. The magnitude of the arrow changes depending on the steepness of the descent.

3.3 Table normalization and attribute database creation

Normalization is a method for organizing data elements in a database into tables so as to reduced data redundancy and inconsistency in a database. The building information record was normalized to reduce data redundancy and inconsistency in the database.

Notice that we have many buildings with the same repeated use, date of construction (DOC) and date of last renovation (DOR) in multiple places in table shown in Figure 3. To be in 2nd normal form this table was split into four tables, the Building table, the Use table, the DOC table and the DOR table (see Table 2, 3 and 4 respectively). The repeating fields (Use, DOC and DOR) were removed from the original building table, leaving only the following FID, Shape, ID, Area, OID, Feild1, C and R. The Feild1 in the un-normalized table is refers to as the primary key which serves as the link to the Feild1 (the foreign key) in the use table, to the C field (foreign key) in the DOC table and R field (foreign key) in the DOR table as shown in Figure 4: Normalized Attribute Database.

Table

Building

FID	Shape *	Id	Area	Field1	C	R	OID	Field1	Use	OID	Field1	DOC	ID *	OID	Field1	DOR	ID2 *
0	Polygon	0	342.584	1	111	214	0	1	Class	1	111	1/3/1992	111	3	214	2/3/2016	214
1	Polygon	0	339.095	1	111	214	0	1	Class	1	111	1/3/1992	111	3	214	2/3/2016	214
2	Polygon	0	377.747	1	111	214	0	1	Class	1	111	1/3/1992	111	3	214	2/3/2016	214
3	Polygon	0	256.608	1	116	211	0	1	Class	5	116	3/5/2013	116	0	211	12/11/2013	211
4	Polygon	0	511.647	1	115	211	0	1	Class	4	115	1/4/2012	115	0	211	12/11/2013	211
5	Polygon	0	251.25	1	116	211	0	1	Class	5	116	3/5/2013	116	0	211	12/11/2013	211
6	Polygon	0	213.725	2	116	211	1	2	Staff Room	5	116	3/5/2013	116	0	211	12/11/2013	211
7	Polygon	0	226.151	2	111	211	1	2	Staff Room	1	111	1/3/1992	111	0	211	12/11/2013	211
8	Polygon	0	333.102	1	116	214	0	1	Class	5	116	3/5/2013	116	3	214	2/3/2016	214
9	Polygon	0	250.678	2	112	211	1	2	Staff Room	0	112	7/14/1993	112	0	211	12/11/2013	211
10	Polygon	0	338.257	1	116	211	0	1	Class	5	116	3/5/2013	116	0	211	12/11/2013	211
11	Polygon	0	283.212	3	116	211	2	3	Hostel	5	116	3/5/2013	116	0	211	12/11/2013	211
12	Polygon	0	439.22	3	111	211	2	3	Hostel	1	111	1/3/1992	111	0	211	12/11/2013	211
13	Polygon	0	539.237	3	111	211	2	3	Hostel	1	111	1/3/1992	111	0	211	12/11/2013	211
14	Polygon	0	962.88	3	111	213	2	3	Hostel	1	111	1/3/1992	111	2	213	4/12/2015	213
15	Polygon	0	717.24	3	111	213	2	3	Hostel	1	111	1/3/1992	111	2	213	4/12/2015	213
16	Polygon	0	906.386	3	113	211	2	3	Hostel	<Null>	<Null>	<Null>	<Null>	0	211	12/11/2013	211
17	Polygon	0	1252.908	3	113	211	2	3	Hostel	2	113	7/12/1995	113	0	211	12/11/2013	211
18	Polygon	0	496.46	3	113	211	2	3	Hostel	2	113	7/12/1995	113	0	211	12/11/2013	211
19	Polygon	0	2347.846	4	111	213	3	4	Religeous	1	111	1/3/1992	111	2	213	4/12/2015	213
20	Polygon	0	1343.42	5	115	211	4	5	ICT	4	115	1/4/2012	115	0	211	12/11/2013	211
21	Polygon	0	274.339	10	112	213	9	10	Library	0	112	7/14/1993	112	2	213	4/12/2015	213
22	Polygon	0	1266.195	6	111	214	5	6	Admin Block	1	111	1/3/1992	111	3	214	2/3/2016	214
23	Polygon	0	430.18	7	112	213	6	7	Staff Quaters	0	112	7/14/1993	112	2	213	4/12/2015	213
24	Polygon	0	418.222	7	112	213	6	7	Staff Quaters	0	112	7/14/1993	112	2	213	4/12/2015	213
25	Polygon	0	160.862	7	111	213	6	7	Staff Quaters	1	111	1/3/1992	111	2	213	4/12/2015	213
26	Polygon	0	202.054	7	111	213	6	7	Staff Quaters	1	111	1/3/1992	111	2	213	4/12/2015	213
27	Polygon	0	123.978	7	111	213	6	7	Staff Quaters	1	111	1/3/1992	111	2	213	4/12/2015	213
28	Polygon	0	116.208	7	112	213	6	7	Staff Quaters	0	112	7/14/1993	112	2	213	4/12/2015	213
29	Polygon	0	61.746	8	115	211	7	8	Commercial	4	115	1/4/2012	115	0	211	12/11/2013	211
30	Polygon	0	188.384	8	115	211	7	8	Commercial	4	115	1/4/2012	115	0	211	12/11/2013	211
31	Polygon	0	1823.818	9	113	211	8	9	Sport	2	113	7/12/1995	113	0	211	12/11/2013	211
32	Polygon	0	1694.112	9	113	211	8	9	Sport	2	113	7/12/1995	113	0	211	12/11/2013	211

Figure 3: First Normal Form of Attribute Database (Lot of Redundancy)

Table 2: Use Table

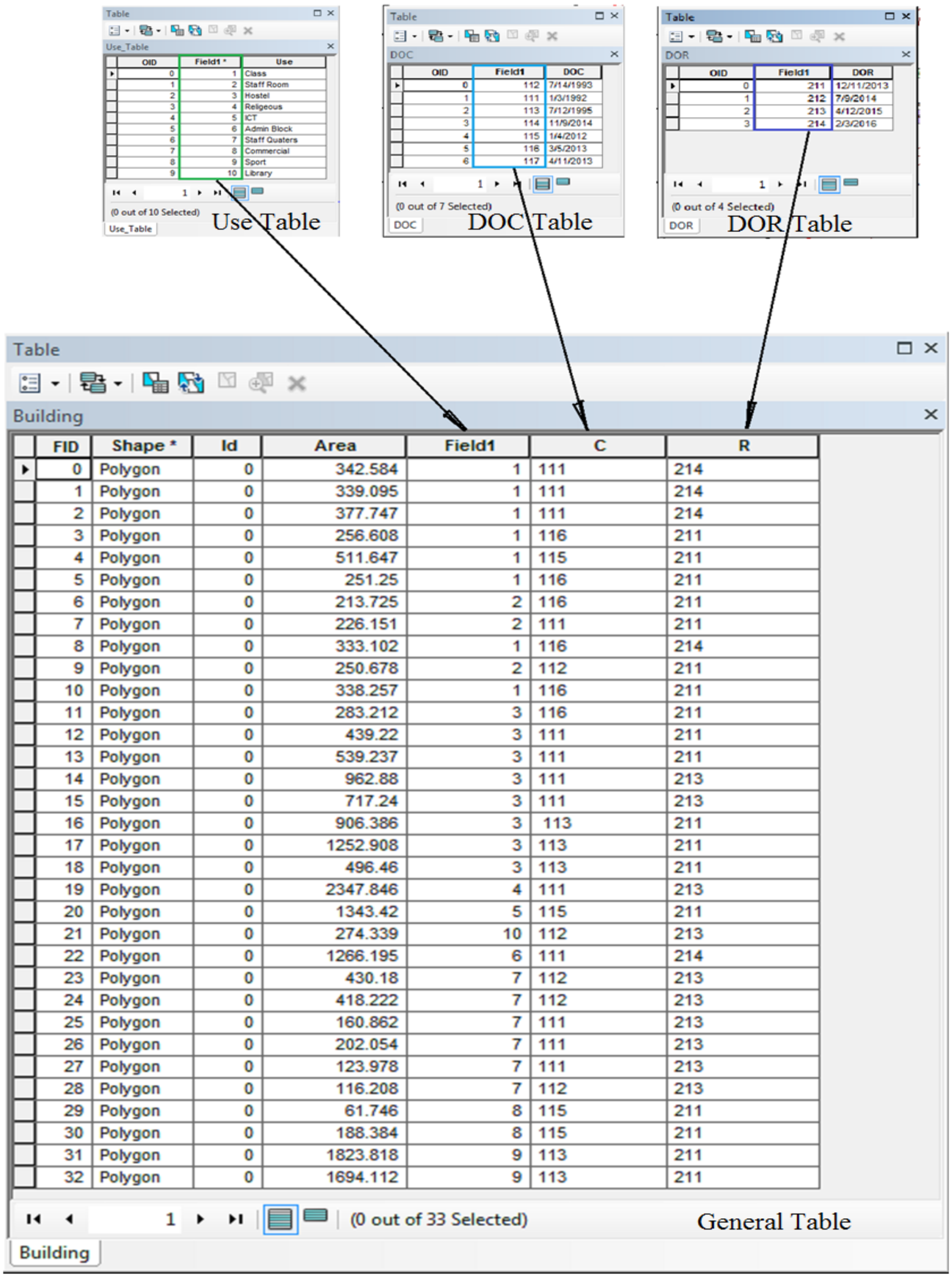
OID	Field1	Use
0	1	Class
1	2	StaffRoom
2	3	Hostel
3	4	Religious
4	5	ICT
5	6	Admin Block
6	7	Staff Quarters
7	8	Commercial
8	9	Sport
9	10	Library

Table 3: Date of Construction (DOC) Table

OID	DOC	ID
0	7/14/1993	112
1	1/3/1992	111
2	7/12/1995	113
3	11/9/2014	114
4	1/4/2012	115
5	3/5/2013	116
6	4/11/2013	117

Table 4: Date of Renovation (DOR) Table

OID	DOR	ID2
0	12/11/2013	211
1	7/9/2014	212
2	4/12/2015	213
3	2/3/2016	214



FID	Shape *	Id	Area	Field1	C	R
0	Polygon	0	342.584	1	111	214
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3	Polygon	0	256.608	1	116	211
4	Polygon	0	511.647	1	115	211
5	Polygon	0	251.25	1	116	211
6	Polygon	0	213.725	2	116	211
7	Polygon	0	226.151	2	111	211
8	Polygon	0	333.102	1	116	214
9	Polygon	0	250.678	2	112	211
10	Polygon	0	338.257	1	116	211
11	Polygon	0	283.212	3	116	211
12	Polygon	0	439.22	3	111	211
13	Polygon	0	539.237	3	111	211
14	Polygon	0	962.88	3	111	213
15	Polygon	0	717.24	3	111	213
16	Polygon	0	906.386	3	113	211
17	Polygon	0	1252.908	3	113	211
18	Polygon	0	496.46	3	113	211
19	Polygon	0	2347.846	4	111	213
20	Polygon	0	1343.42	5	115	211
21	Polygon	0	274.339	10	112	213
22	Polygon	0	1266.195	6	111	214
23	Polygon	0	430.18	7	112	213
24	Polygon	0	418.222	7	112	213
25	Polygon	0	160.862	7	111	213
26	Polygon	0	202.054	7	111	213
27	Polygon	0	123.978	7	111	213
28	Polygon	0	116.208	7	112	213
29	Polygon	0	61.746	8	115	211
30	Polygon	0	188.384	8	115	211
31	Polygon	0	1823.818	9	113	211
32	Polygon	0	1694.112	9	113	211

Figure 4: Normalized Attribute Database (Free of Redundant Data)

IV. PRESENTATIONS OF RESULTS

Figure 5 is the contour overlay and DEM of the study area which shows the elevation of the coverage of the study area above mean sea level. Figure 6 is the vector map of the study area that shows the direction and magnitude of water flaw within the study area. Figure 7 is the Topographic map of the study area which shows the contour lines with details. Figure 8 and 9 are the bar chart that shows the count of buildings and pie chart that shows the percentage of buildings count.

Figure 10 is a result of query for buildings that can accommodate more than 50 occupants. Figure 11 is a result of query for buildings that are hostels. Figure 12 is a result of query for buildings that are classes. Figure 13 is a result of query for spot heights that are greater than 377.488m. Figure 14 is a result of query for buildings that are Constructed on or Before 1995. While Figure 15 is a query result for buildings that are renovated from 2015 to date.

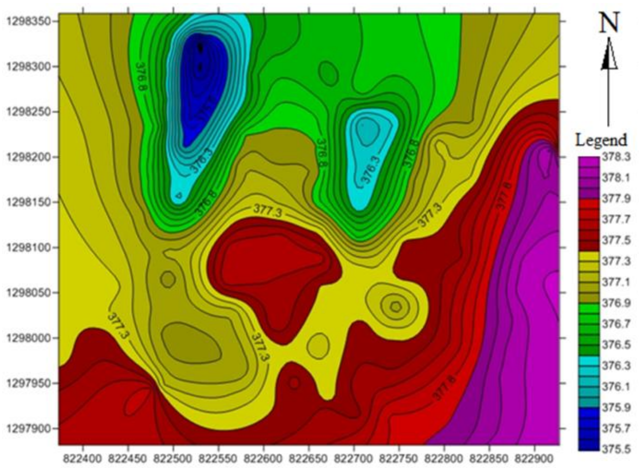

Figure 5: Overlay of Contour and DEM of the Study Area

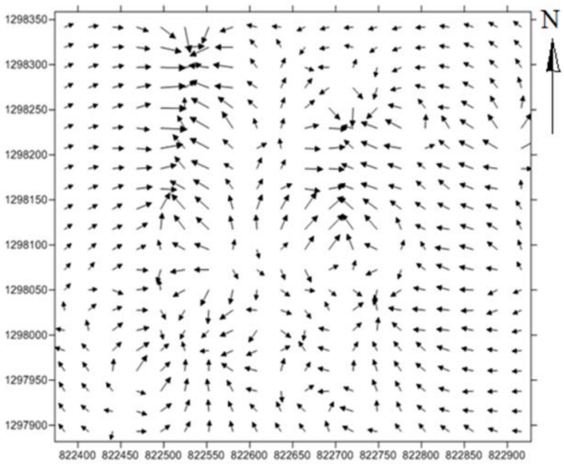

Figure 6: Vector Map of the Study Area

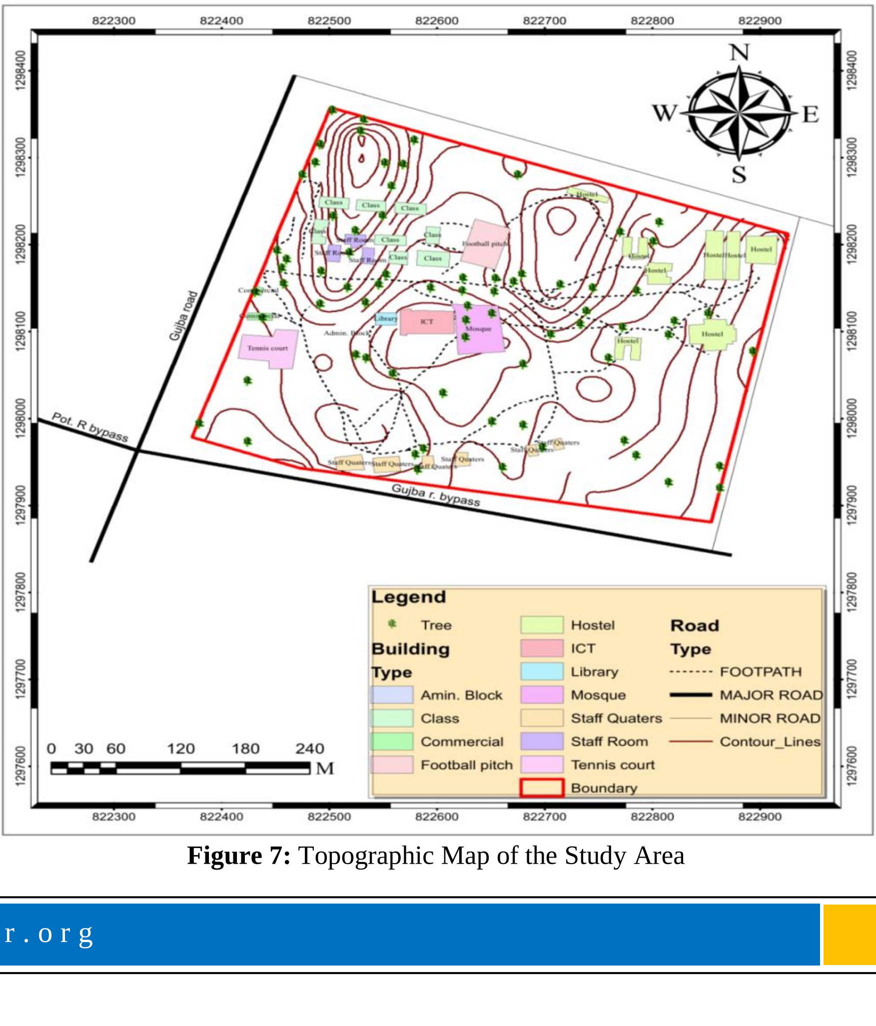

Figure 7: Topographic Map of the Study Area

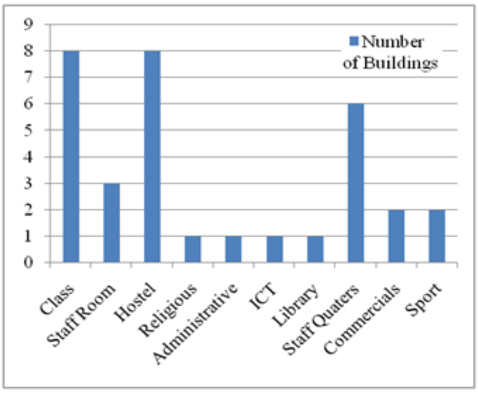

Figure 8: Barchart Showing Buildings Count

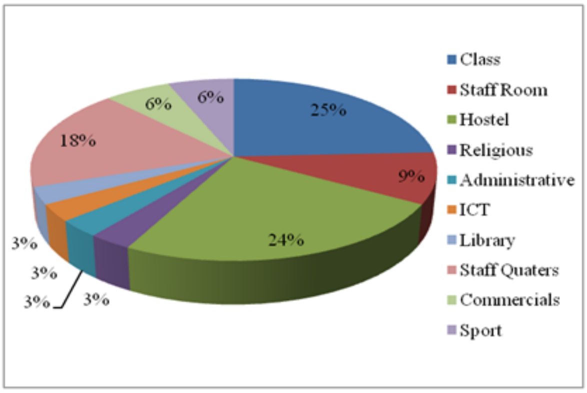

Figure 9: Piechart Showing Buildings Count in Percentage

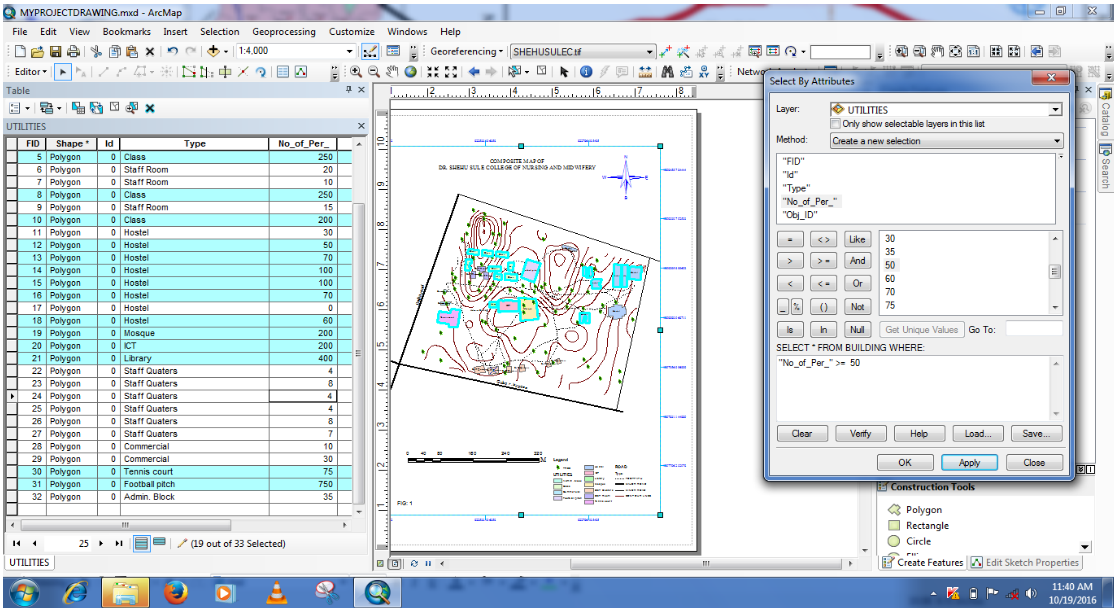

Figure 10: Query Result for Buildings that can Accommodate More Than 50 Occupants

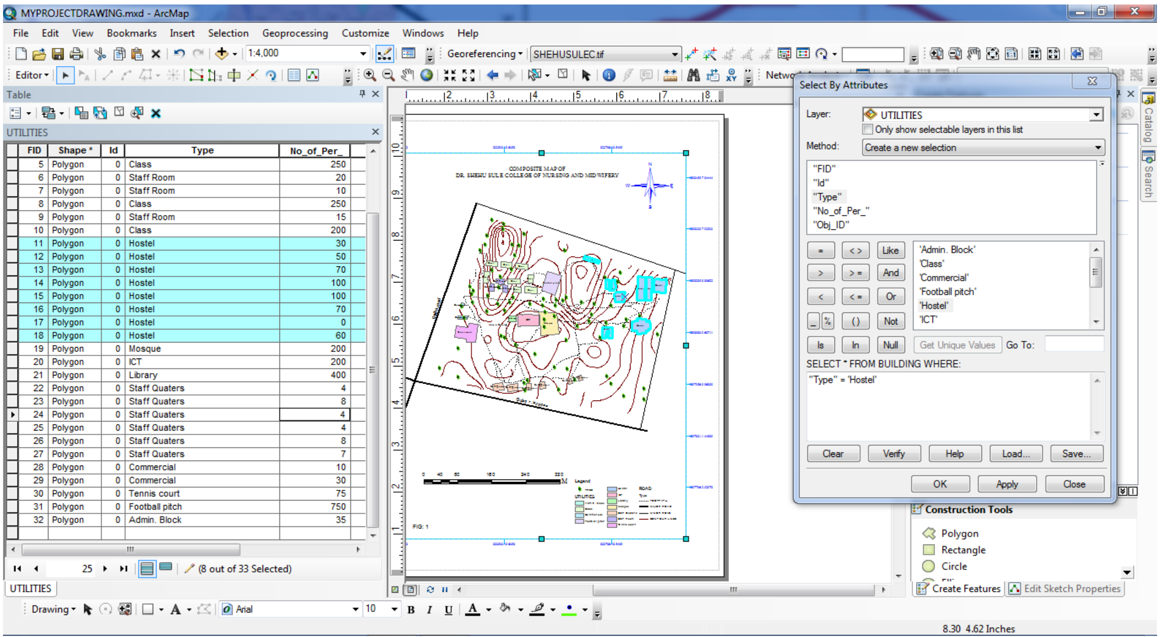

Figure 11: Query Result for Buildings that are Hostels

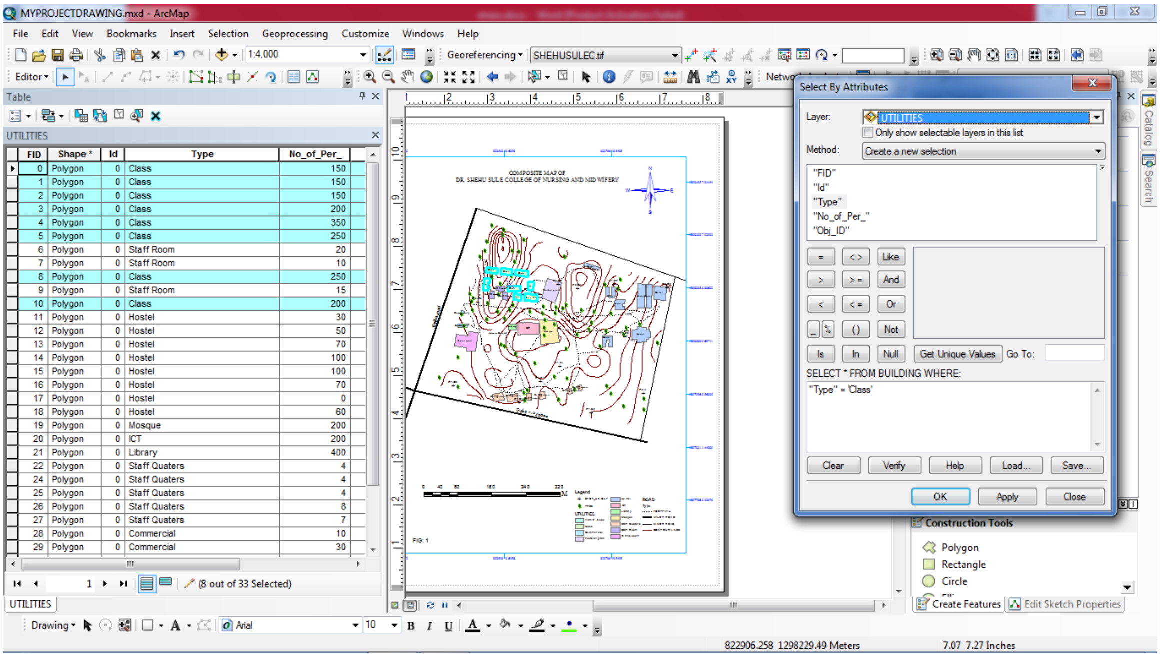

Figure 12: Query Result for Buildings that are Classes

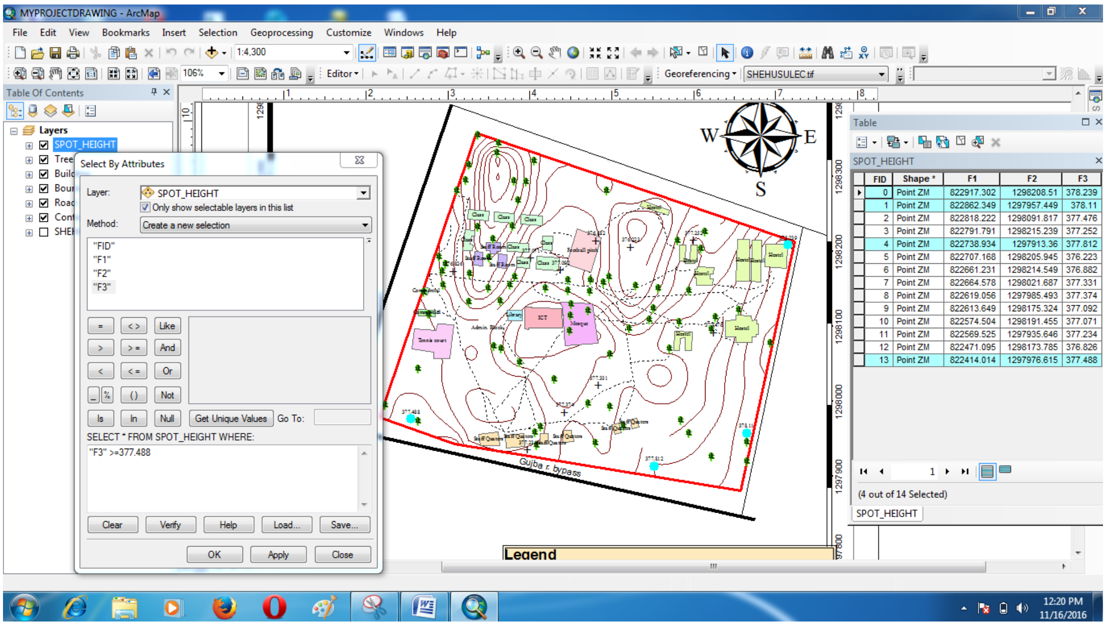

Figure 13: Query Result for Spot Heights that are Greater Than 377.488m

V. DISCUSSIONS AND ANALYSIS OF RESULTS

From Figure 5, the contour lines were overlaid on to the DEM layer which describes the undulating or topographical nature of the terrain within the study area. The dark blue color shows the lowest point which represents a water logging area with a height of 375.5m located around Northwest within the study area while the purple color on the map indicate the highest elevations at 378.3m located to the Southeast within the study area. The maximum height difference within the study area is around 2.8m which make the height difference fairly undulating compared to the area coverage.

Figure 6 shows a vector map which shows the direction of water flows within the study area. The arrows that converge at a point justify the dark blue color in Figure 5 which represents a water logging area on the contour map.

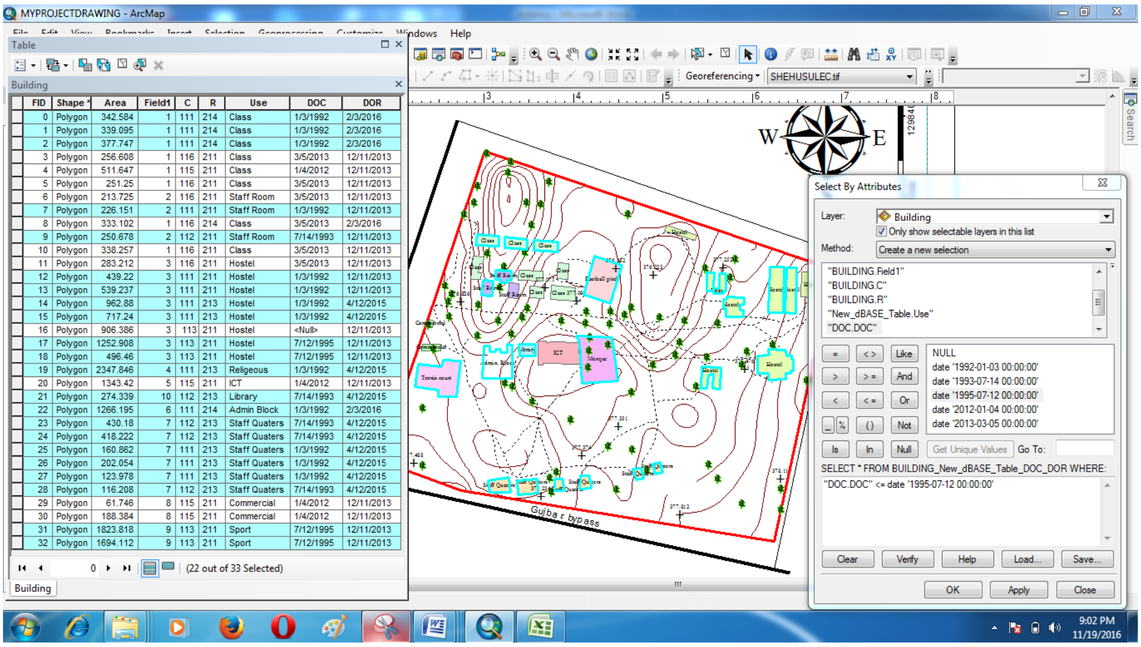

Figure 14: Query Result for Buildings that are Constructed on or Before 1995

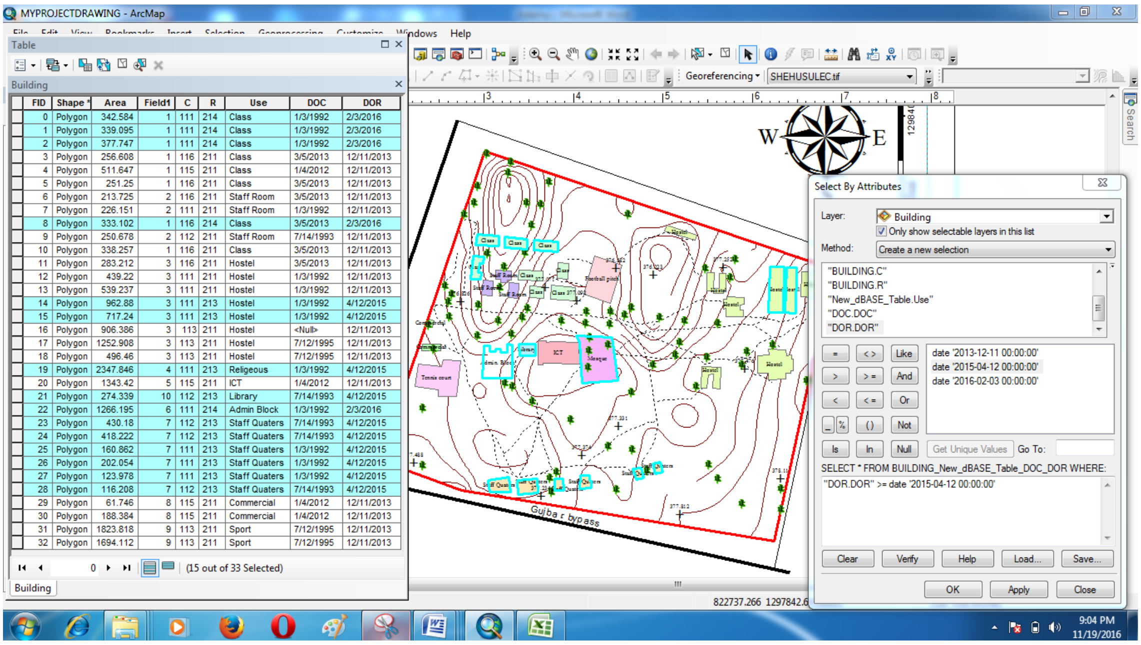

Figure 15: Query Result for Buildings that are Renovated from 2015 to Date

Figure 7 shows the topographic map that displays hostel blocks which are represented as polygons in green displayed on the eastern part of the detail map, the footpath are represented as line in black short dashes, trees are represented as point layer (trees icon) displayed across in green on the utility map, staff quarters are also represented as polygon in brown color displayed in the southern part of the detail map, and classes is a polygon in green displayed in the detail map on the northern parts. Commercial area, ICT center are polygons in red displayed on the detail map. Library is represented in light blue displayed in the detail map. Mosque under religious site is represented as polygon in light pink displayed in the detail map. Staff rooms are represented as polygon in blue displayed in the northern part of the detail map. Tennis court is represented in pink displayed in the detail map, major and minor roads are represented as line in black with long dashes displayed in the detail map while the boundary is represented as line in red which shows the extend of the project site. Figure 8 and 9 shows the number in count and percentage respectively of buildings in each category of use with classrooms has the highest number having 25% followed by hostels which has 24%.

Database developed acts as server that enable different types of questions to be asked about the details and their attributes in the displayed map, this process is called query analysis. Various queries were achieved to test the efficiency of the developed database using the query builder such as Figure 10: shows query result for buildings within the study area that can accommodate more than 50 occupants, Figure 11: shows query result for buildings that are hostels, Figure 12: shows query result for buildings that are classes, Figure 13: shows query result for spot heights that are greater than 377.488m, Figure 14: shows query result for buildings that are constructed on or before 1995 and Figure 15: shows query result for buildings that are renovated from 2015 to date.

In all the queries outcomes, the records that satisfied the criteria specified in the query builder were highlighted in light blue color both in the attribute table and in the map while those that does not satisfied the condition were seeing unselected. Advance queries can as well be performed with complex conditions or criteria which were not presented here to answer certain questions. Examples of such queries can be:

1. Buildings that are classes and are located in water logging area or areas below 376.00m above mean sea level.
2. Buildings that are hostel and have not being renovated for the past 10 years.

VI. CONCLUSIONS

The potentials of GIS technology in database design and creation has also been demonstrated and found to be more efficient than the manual approach. The database created showed at a glance how the attribute and spatial data of details within a given study area can be digitally captured and stored in a computer model. Queries carried out showed the capabilities of the GIS in manipulating data to solve environmental problems.

In this study, findings reveals that there are 32 buildings within the study area of which 8 are classrooms, 8 are hostels, 5 are staff quarters, 3 are staffrooms while the remaining are commercial, religious, library building etc. research also find out that the terrain within the study area is not highly undulated with minimum ellipsoidal height ranging from 275.5m around the Northwest to maximum of 378.3m around the Southeast of the study area.

Based on this study, the following recommendations were made:

1. Topographical Information System (TIS) could be integrated in to already created database to conduct further studies that may likely solve hydrological related problems such as floods and erosions.
2. The application of GIS to utility services management will bring about an increased ease in data communication and processing within a wide organizational structure.
3. The Building database created could be updated from time to time to make it current at any time.
4. Further researches to be conducted with multiple impute in to the database to make it very rich and advance queries to be performed to answer complex questions of interest.

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