American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-7, Issue-1, pp-320-328
www.ajer.org
Research Paper Open Access

Development of Cadastral Information System of Part of Government Residential Layout in Jimeta-Yola, Adamawa State, Nigeria

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ABSTRACT*; Analogue Cadastre consists of paper maps and land register which have difficulties during development and updating. The study was aimed at creating a digital Cadastral Information System (CIS) for part of Government Residential layout in Yola North L.G.A, Adamawa State. The spatial and non spatial data used are local coordinates of the land parcels and entity information obtained from Office of the Surveyor General, Yola. The local coordinates were transformed to Universal Traverse Mercator (UTM) coordinate system using EXCEL spreadsheet and were used in plotting the digital Map in ArcGIS 10.1. The database design was done in phases which include the conceptual design, the logical design, the physical design, and the implementation of the database system. The attribute data were linked with the spatial data to build the digital CIS and some queries were performed to test the efficacy of the database. The study has established the capability of CIS in handling of spatial and non spatial data. It is recommended that the digital CIS be adopted for proper record keeping and updating.*

KEYWORDS*: CIS, GIS, Database, Cadastre, Database*

Date of Submission: 15-01-2018 **Date of acceptance: 9-02-2018**

I. INTRODUCTION

Land is the vital resources of the biosphere which refers to a specific area of the earth surface with physical entity in terms of its topography and spatial nature, and one of the uniqueness of space that is widely recognized as important for planning and management purposes [1]. The increase in urban rural migration has increase pressure on urban lands which has led not only to ambiguity as regards ownership and spatial boundaries of land parcels, but also to the undue disintegration of land. This in turn leads to diminishing land productivity, uncontrollable development and environmental degradation [2]. Therefore, a systematic record and rational use of the land should be of prime importance to planners as well as policy makers [3]. Consequently, accurate and efficient land data records are necessary tool for appropriate resources management and tackling environmental problems. Since most of human activities are based on Land, there is a need for proper records of land parcels and their ownership [4]. Efficient Land administration and Management therefore begins with the creation and maintenance of an up-to-date record of all occupiers of Land and there interest in Land which form a basis for a Cadastre.

The three main aspects of cadastre as described by [5], as first, the Fiscal aspect, mainly for generating revenue for constitutional authority, the second is the legal aspect, which binds the interests of the land attached to a particular person or group of people and lastly, the technical aspect which outlines the method of demarcation survey and preparation of plans for the plots and it is been powered by a cadastral system. In a nutshell, a cadastral system consists of collection, recording and storage of all information related to individual land parcels. The CIS therefore stands as the starting point in the building of any relevant statewide cadastre. This contains the geometric description of the properties which forms the building block of the CIS as well as additional information like: the people, occupants and the value of the property [6]. The establishment of fully functional digital cadastral databases will help provide a proper information system that will facilitate

development in an ever changing world of technology [7]. [8] defined Cadastral Surveying as a branch of surveying which establish and records the location, boundaries of features thereon and ownership of land and property and is one of the data sources in Geographic Information System (GIS).
[9] utilizes the existing analogue map which was converted to digital format using a digitizing tablet in ILWIS environment and the spatial database was created in an ArcView environment which was subjected to query and analysis. [10] developed a digital CIS of part of Oluyole Local Government area in Oyo State, Nigeria to solve a problem of inadequate digital information about the area when the need arise. This realization led to the involvement of GIS, to assist in the creation, documentation, and management of land titles. [7] presents the possibilities for efficient implementation of a CIS for M. I. Wushishi Estate in a GIS environment. Logical and Physical models for the CIS were built and utilized in the creation of the CIS using an Entity relationship model. The reviewed literatures shows that scanned maps were use to create a digital map, which may not likely give the correct spatial reference and leads to discrepancy of what is obtainable on ground and the issue of redundancy has not been taken care of. In this study, digital map was produced by plotting from coordinates using suitable software and also the database designed was normalized to eliminate data redundancy and inconsistent dependency for efficient database management.

Development of CIS is to promote the accessibility and integration of spatial data in relation to land information. Based on these, the development of CIS for part of Residential layout of Adamawa State Yola Plan 35 (ADSYP 35) is of paramount importance for any meaningful development. The information being in digital format will assist in keeping the record safer and ease access to data any moment, this would be employed to control development.

I. STUDY AREA

The study area covers part of Adamawa State Yola Plan 35 (ADSYP 35) Residential layout at Gibson Jalo way (Army barracks road) close to Nyibango ward, in Yola North Local Government Area of Adamawa State in the north eastern part of Nigeria bounded between latitude 9°13'20"N to 9°13'35"N and longitude 12°25'18″E to 12°25'27″E, and is about 126134.185 Square Meters (12.613 Hectares) of areas as shown in Figure 1 below.

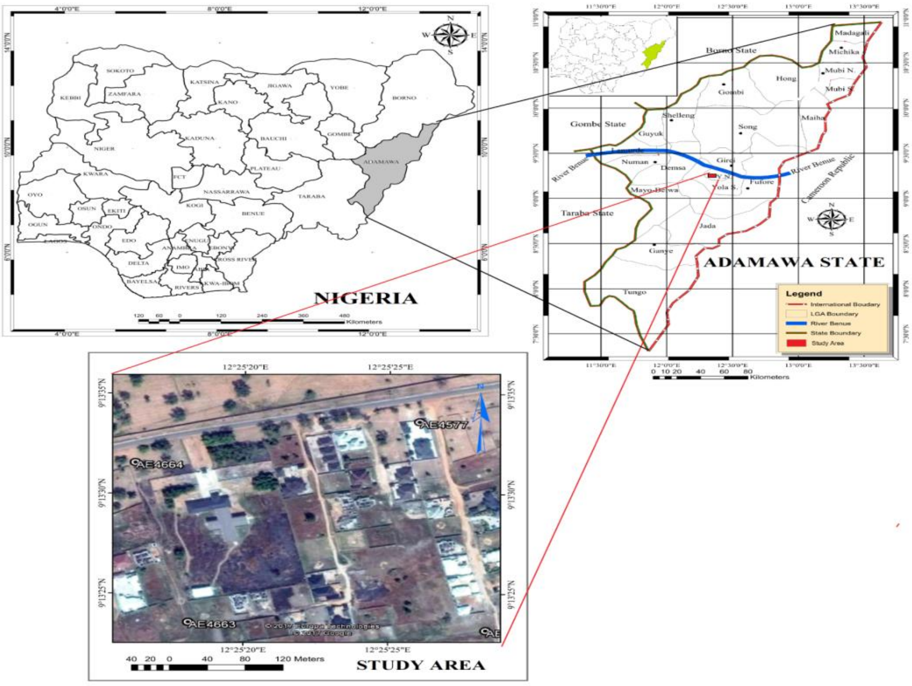

Figure 1: Map of Nigeria showing Adamawa state and Adamawa state showing the Study Area

II. MATERIALS AND METHODS

3.1 Data

The data that were used for this study include the Local coordinates obtained from the coordinate register, the analogue layout plan of the area and the attribute data which include the entity information such as ownership details, the Landuse and the parcel information acquired from the Office of the Surveyor General, Yola, Adamawa state.

3.2 Hardware/Software

The hardware includes: Hi-target Differential Global Positioning System (DGPS) was used to capture the coordinates of the base line and DELL Laptop with 4.00GB RAM & 500GB Hard Disk for processing data and the software used were used for creating the database, and EXCEL which was used for coordinate transformation.

3.3 Data Processing

The coordinates of property beacons of the baseline PBAE 4663 and PBAE 4664 were observed using the Hi-target in Post Processing (PP) static mode of DGPS observation and processed using the Hi-target Geomatics Office (HGO) processing software. The Local coordinates and the processed coordinates in UTM coordinate system of the baseline were inputted into an Excel coordinate transformation spreadsheet to transform the Local coordinates of the study area to UTM coordinate system. Table 1 shows the coordinates of the baseline both Local and UTM coordinates system and Table 2 shows the baseline transformation parameters.
The transformed UTM coordinates of the study area were added into and converted to shapefile. From the plotted points of the Beacons, the parcels were polygonized and streets as lines, which was used to create a database for further analysis.

Table 1: The Coordinates of the Baseline

Beacon No	Local Coordinates		UTM Coordinates	
	X(m)	Y(m)	X(m)	Y(m)
PBAE 4663	10252.66	10396.32	216700.4036	1020552.9271
PBAE 4664	10225.06	10645.28	216644.2365	1020797.3712

Table 2: The Baseline Transformation Parameters

Bearing:	-6.32579	deg	Bearing:	-12.94051	deg
Baselength:	250.4835	M	Baselength:	250.8140	m
Scale Factor:	1.001320		Base Error:	-330.5	mm
Scale Error:	1319.5	mm/Km	Rotation:	-6.61472	deg
Delta Height 1:	0.0000	M	Mean Ht Diff:	0.0000	m
Delta Height 2:	0.0000	M	Height Error:	+/- 0.0000	m
Easting Origin:	207701.7113	M	Alpha:	0.99465394	
Northing Origin:	1009029.5962	M	Beta:	0.11534435	

3.4 Database Creation

The database containing all the descriptive information about the parcel was created in environment after plotting the plan. It was achieved by right clicking on the plot shape file and adding fields through the attribute table such as plot size (area), plot owner, purpose, status, etc.

3.4.1 Database Design

The creation of a structured, digital database is the key and complex task upon which the efficacy of the Cadastral Information System depends. Database design is the process of producing a detailed data model of a database. The design phase consists of three levels [11]:

- Conceptual Design
- Logical Design
- Physical design

3.4.1.1 Conceptual design

This is the first stage of database design where the contents were identified and there spatial relationship that exist between them and is the representation of a human conceptualization of reality. The presentation of the view of reality in a simplified manner was decided and objects oriented conceptual data model was employed.
Every entity was treated as an object, the geometric and attribute data of the terrain features was treated as properties of the object, the objective of this phase is to determine the basic entities and their attributes and the relationship among entities were analyzed. The entities are road, buildings, parcel and owner as shown in Table 3.

Table 3 Entity and their Attributes

Entities	Attributes
Street	ID, Street name, Length, Condition
Parcel	ID, owner, purpose, location, nature of development, area
Owner	ID, name, sex, state, occupation

Each of the entities has a specific number of attribute; some functional relationships were identified among the entities. Figure 2 shows the Entity Relational Diagram.

3.4.1.2 Logical design

This is the representation of the data model, which is mostly design to reflect the recording of data in the computer system. It is the process by the conceptual schema is consolidated, refined, and then converted to system – specific logical schema. The objective of which is to identify potential problems that may exist in the conceptual data model. It was structured and stored as a simple record known as file, containing a set of attribute values that are grouped together in two dimensional tables known as 'relation'.

3.4.1.3 Physical Design

This is the representation of the data structures in the format of the implementation software. The objects and their attribute tables were translated into ArcGIS 10.1 structure. The way the data was stored involved the encoding of the data transformed in the logical design with the implementation software. The data type can be text, integer, float or long depending on the data source. This was done such that the stored information can be accessed and retrieved; update can be done from time to time and analytical functions can be performed to answer some generic question for the study

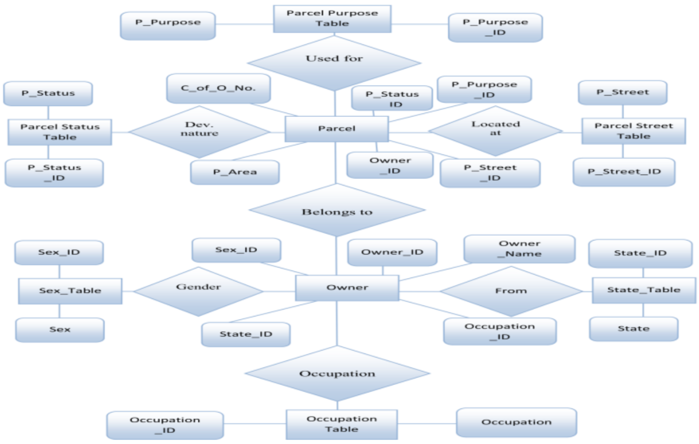

Figure 2: The Entity Relationship (E R) Diagram

3.4.2 Normalization of Attribute Database

Normalization is a process of decomposition, taking a table with all the attribute data and breaking it into small tables while maintaining the necessary linkages between them [12]. Normalization of the feature database created for this project was done to avoid the redundant data in the table that waste space in the database; to ensure that the feature attribute data in separate tables are maintained and updated separately and which was linked whenever necessary; and to facilitate a distributed database. This was done using the following steps;

3.4.2.1 First Normal Form

Repeating groups in individual tables were eliminated and separate tables were created for each set of related data, each set of related data were link with a primary key.

3.4.2.2 Second Normal Form

Separate tables were created for sets of values that apply to multiple records, and then the tables were joined with a foreign key.

3.4.2.3 Third Normal Form

Fields that do not depend on the key were eliminated. Once these tables are separated as relational tables, then relate operations, bring together the two tables based on a common key which was used to link those tables during query and analysis.

III. RESULTS AND DISCUSSION

4.1 Presentation of Results

The results of this study are presented inform of digital maps, tables and reports. Figure 3 shows the digital map that was produced from the UTM coordinates on which the database was build. Tables 4, 5 and 6 shows the related database tables which have been normalized, Tables 4 and 5 were joined to Table 6 which is the main table on which queries were performed. Also, Figure 4 shows the result of a query by attribute of plots that were undeveloped within the area which are highlighted in light blue i.e. 25 plots were undeveloped out of 62 plots within the study area. Figure 5 shows query by Attribute of Plots that are greater or equal to 900sqm in area within the study area, the result of the query shows that 17 plots out of 62 plots are greater or equal to 900sqm. Figure 6 shows query by attribute of plot owners that their occupation is business; the results shows that out of 62 plots, 11 plots are owned by businessmen. Figure 7 shows query by attribute of plots along “AAB” road and it was revealed that there are 6 plots along that road. Figure 8 shows query by attribute of Plot ID which highlighted all the beacon numbers that demarcates the limit of that plot.

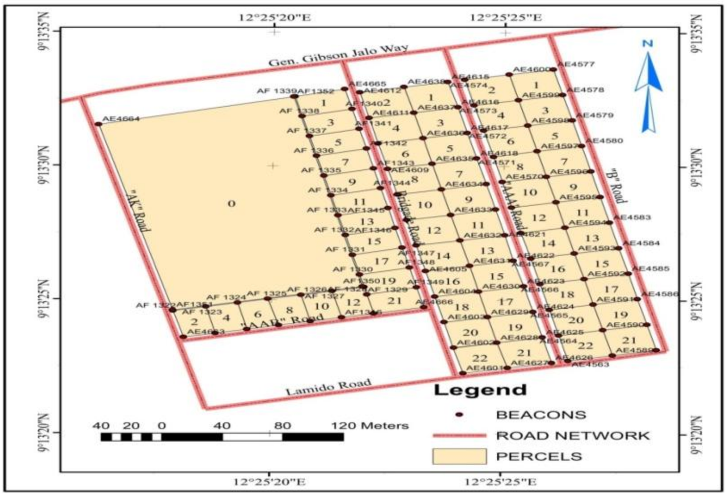

Figure 3: Digital Map of Part of Residential Layout ADSYP 35

Table 4: Percel-Beacon Table Linked with Beacon Table

Table — P_Beac_Tab

OID	Id *	Percel_Bea	Beacon_Num	BeaconID	X	Y
0	100	1109	AF1350	2110	216818.6768	1020611.0256
1	100	1110	AF1351	2111	216693.2820	1020584.1559
2	100	1111	AE4664	2113	216644.2365	1020797.3712
3	100	1112	AF1352	2112	216773.3556	1020829.0488
4	101	1078	AF1320	2078	216721.4368	1020557.4283
5	101	1079	AE4663	2079	216700.4036	1020552.9271
6	101	1080	AF1322	2080	216693.4902	1020583.1809
7	101	1081	AF1323	2081	216715.1195	1020587.8158
8	102	1077	AF1319	2077	216742.4042	1020561.9159
9	102	1078	AF1320	2078	216721.4368	1020557.4283
10	102	1081	AF1323	2081	216715.1195	1020587.8158
11	102	1082	AF1324	2082	216736.0864	1020592.3083
12	103	1076	AF1318	2076	216763.3717	1020566.4035
13	103	1077	AF1319	2077	216742.4042	1020561.9159
14	103	1082	AF1324	2082	216736.0864	1020592.3083
15	103	1083	AF1325	2083	216756.0625	1020596.6873
16	104	1075	AF1317	2075	216784.3392	1020570.8912

Table — BEACONS

FID	Shape *	Pilar_No_	X	Y	BeaconID *
0	Point	AE4563	216954.670547	1020525.261852	2001
1	Point	AE4564	216948.554005	1020554.424604	2002
2	Point	AE4565	216942.359503	1020583.829374	2003
3	Point	AE4566	216936.196353	1020613.398356	2004
4	Point	AE4567	216930.056261	1020642.678868	2005
5	Point	AE4568	216923.65028	1020672.08949	2006
6	Point	AE4569	216917.409648	1020701.458852	2007
7	Point	AE4570	216911.196467	1020730.85144	2008
8	Point	AE4571	216905.533783	1020759.586652	2009
9	Point	AE4572	216898.947804	1020789.837697	2010
10	Point	AE4573	216892.650966	1020818.909493	2011
11	Point	AE4574	216886.494959	1020848.328718	2012
12	Point	AE4577	216945.221727	1020859.995492	2013
13	Point	AE4578	216951.358001	1020830.704504	2014
14	Point	AE4579	216957.573947	1020801.46281	2015
15	Point	AE4580	216963.774624	1020772.179211	2016
16	Point	AE4581	216969.988942	1020742.776715	2017

Table 5: Owner Table Linked with Occupation, Sex, and State Tables

Occupation Table

OID	Occup_ID *	Occupation *
0	301	Business
1	302	Civil Servant
2	303	Contractor
3	304	Legal Practitioner
4	305	Military Personnel

Sex Table

OID	Sex_ID *	Sex *
0	701	Male
1	702	Female

State Table

OID	State_ID *	State_of_O
0	801	Adamawa
1	802	Anambra
2	803	Bauchi
3	804	Gombe
4	805	Taraba

Owner_Tab

OID	Owner_ID	Occupation	Sex_ID	State_ID	Owne_Name
0	201	301	701	801	MAULUD AHMED
1	202	302	701	801	ISMAIL BUBA
2	203	302	702	801	SAKINA MUSA
3	204	302	702	801	SA'ADATU DAHIRU W.
4	205	302	701	804	TUKUR HAMMAN ADAMU
5	206	301	701	804	MUSTAPHA UMARU JIBRILLA
6	207	301	701	801	UMARU SAHABO MURTALA
7	208	302	701	801	ALVARI W. GUNDIRI
8	209	302	702	801	HAJ. LAURATU MOHAMMED
9	210	302	702	801	NAOMI HALIDU
10	211	302	701	805	ADIEL MAKAUMENSO DOLARE
11	212	302	701	801	WAKILI DAN AZUMI GARBA
12	213	302	702	801	JAMILA USMAN BUBA
13	214	302	701	801	ABDULLAHI ZAKARI
14	215	302	702	801	RABI MUSA GEMU

Table 6: Percel Table Linked with Street, Percel Status and Percel Purpose Tables

ROAD NETWORK

FID	Shape *	Id	Street_ID *	Street_Nam
0	Polyline	0	406	Gen. Gibson Jalo Way
1	Polyline	0	401	"AAA" Road
2	Polyline	0	405	"B" Road
3	Polyline	0	402	Bridgade Road
4	Polyline	0	404	"AAB" Road
5	Polyline	0	403	Lamido Road
6	Polyline	0	407	"AK" Road

P_Status_Tab

OID	StatusID *	Status *
0	601	Developed
1	602	Under Construction
2	603	Undeveloped

Purpose Table

OID	PurposID *	Purpose
0	501	Residential
1	502	Recreational

PERCELS

FID	Shape *	Id	Percel_No	P_Area	C_of_O_No	P_StreetID	OwnerID	StatusID	PurposID
0	Polygon	101	2	678.1160	ADS/49852	404	243	603	501
1	Polygon	103	6	651.2820	ADS/49766	404	244	602	501
2	Polygon	104	8	682.2175	ADS/54216	404	245	602	501
3	Polygon	105	10	653.5141	ADS/50111	404	246	601	501
4	Polygon	106	12	676.1227	ADS/52835	404	247	603	501
5	Polygon	107	21	775.8949	ADS/50764	402	247	601	501
6	Polygon	108	19	788.4803	ADS/50987	402	248	601	501
7	Polygon	109	17	788.4209	ADS/48888	402	249	602	501
8	Polygon	110	15	788.3502	ADS/53246	402	250	602	501
9	Polygon	111	13	791.1854	ADS/49833	402	251	603	501
10	Polygon	112	11	788.2301		402	252	603	501
11	Polygon	113	9	788.1406		402	253	603	501
12	Polygon	114	7	789.9782	ADS/55791	402	254	601	501
13	Polygon	115	5	788.0505	ADS/51073	402	255	601	501
14	Polygon	116	3	787.9571	ADS/49123	402	256	603	501
15	Polygon	117	1	787.9086	ADS/50777	402	256	603	501
16	Polygon	100	0	28820.38		406	242	601	502
17	Polygon	118	2	906.1023	ADS/46181	402	201	601	501

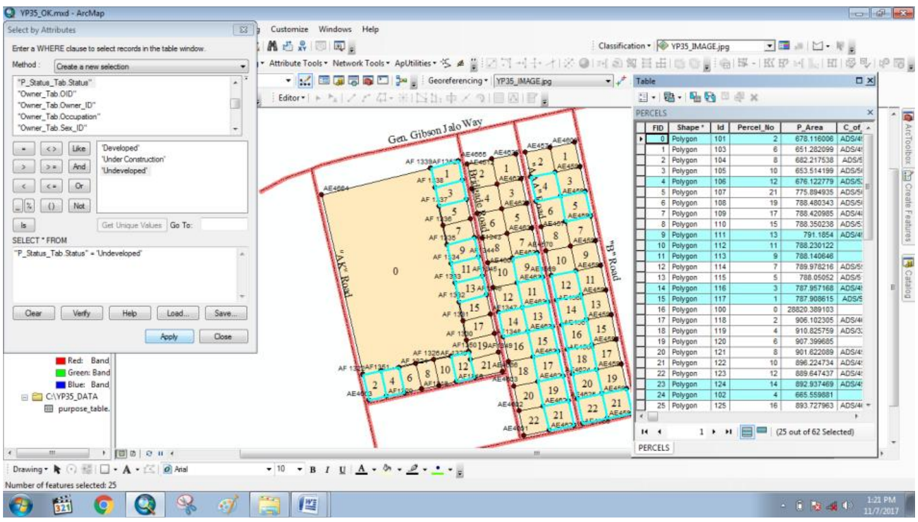

Figure 4: Query by attribute of Plots that were undeveloped within the Study Area

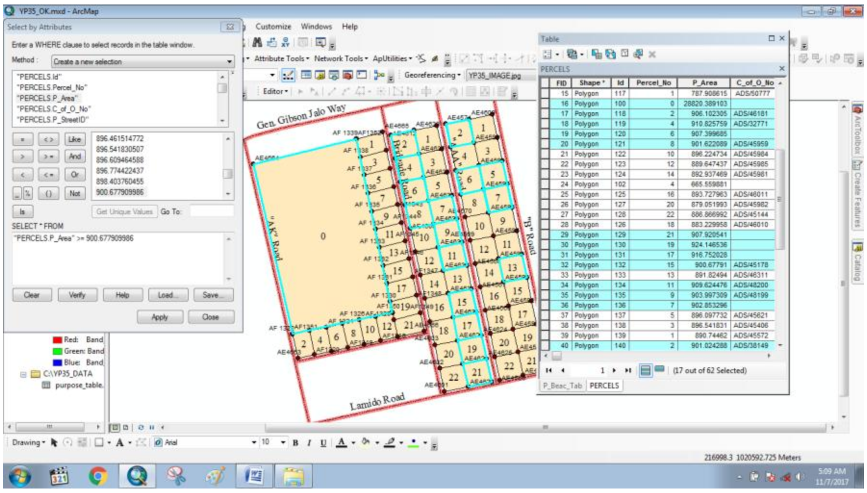

Figure 5: Query by Attribute of Plot greater or equal to 900sqm

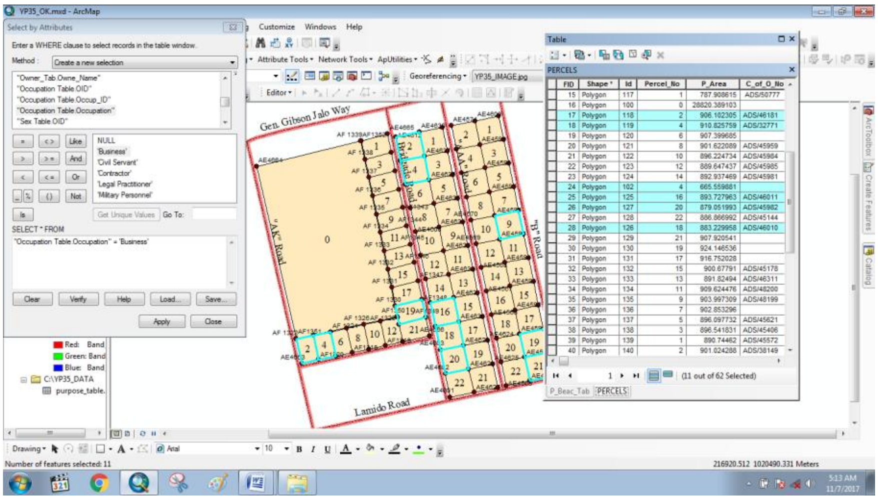

Figure 7: Query by attribute of plots along "AAB" road

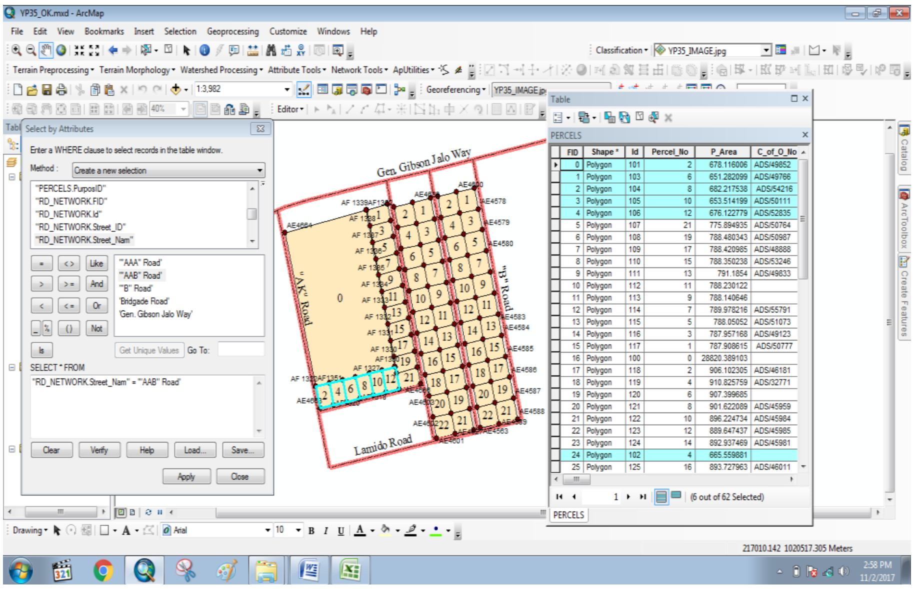

Figure 6: Query by attribute of plot owners that are businessmen

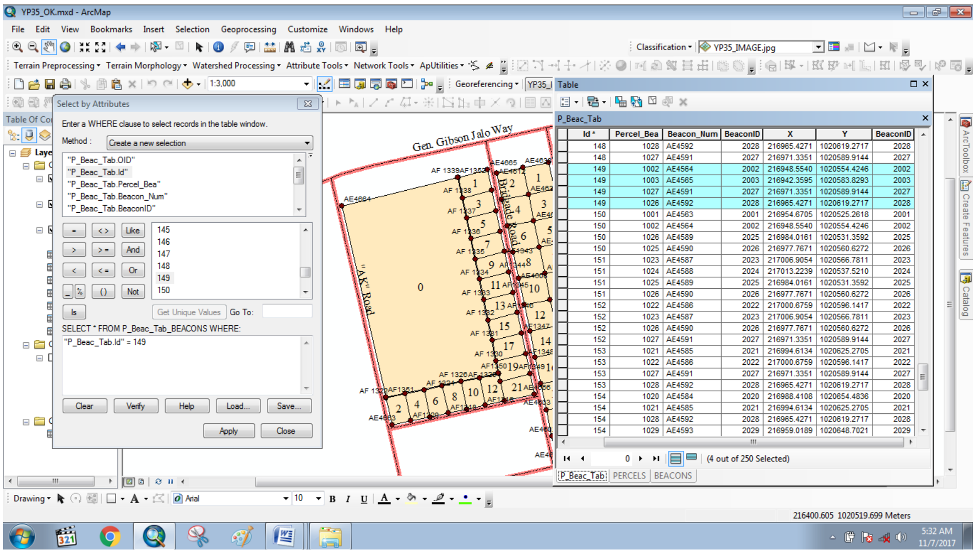

Figure 8: Query by attribute of Plot ID

4.2 Discussion of Results

In this study, a Cadastral Information System was developed as presented in the results shown above. The result of the normalization of the database was shown in Tables 4, 5, and 6 in which redundancy and inconsistency dependency was eliminated to make the database more flexible; hence, the data occupy less space in the memory of the system and very simple to access. The result shown in Figure 4 will assist the decision and policy makers to determine the level of development within the study area. Also, the query operations results in Figure 5, 6 and 7 demonstrates the efficacy of GIS in handling cadastral information. Furthermore, the query result in Figure 8 will help the Surveyor and Land administrators to be able to extract coordinates of any plot within the study area in case there is any missing beacon that called for re-establishment.

The queries generated from the database shows clearly the evidence of digital cadastral information system over analogue in which queries cannot be performed on any plot or feature. The study has established that GIS is competent of producing an accurate computer cadastral map and can handle large volume of spatial and attribute data. Rapid and accurate decision taking on land matters which are some of the fundamental ingredients necessary for any economic development of any organization was fully improved.

Implementation of a digital CIS will go a long way in helping the relevant authorities charged with the responsibility of managing land records more efficiently. This CIS will also give the authority an opportunity to make some typical analysis in the assessment of Landuse, as well as building code violations; the sales transaction of a particular parcel and the assessment of property for issues of planning permission. Finally, it can also serve as an interactive means of land information for immediate and ready extraction of plot-wise details through the query facility that was provided in the database which allow any individual user to gather information regarding land holding.

IV. CONCLUSION AND RECOMMENDATIONS

Application of a digital cadastral information system using GIS technique in cadastral record keeping is a welcome development as it reduced the cost of storage, efficiency and improved processing time, retrieving, updating, managing and assessing cadastral data. The study also show how computer technology is being used and it plays a vital role in keeping cadastral record in different digital format, allowing it to be assembled in any desired manner by individuals and performing different queries analysis as required.

The following recommendations are advanced for cadastral records keeping: The digital Cadastral Information System created in this study should serve as a model to be adopted and replicated in creating database for all landed properties which need to be updated from time to time. A further research is also been recommended to utilize a Parcel Editor provided in ArcGIS environment in creating a more effective database.

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Fimba Domworu Emmanuel " Development Of Cadastral Information System Of Part Of Government Residential Layout In Jimeta-Yola, Adamawa State, Nigeria" American Journal of Engineering Research (AJER), vol. 7, no. 1, 2018, pp. 320-328.