A Geospatial Database for Development Control in Jimeta Metropolis, Nigeria

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Abstract— This study aimed at developing a geospatial database using geographic information system (GIS) for Adamawa State Urban Planning Development Authority (ASUPDA) with a view to provide a comprehensive, reliable and up-to-date database that will enhance effective, accurate and rapid development control process in Jimeta Metropolis. The GSYP 18 layout and Quickbird satellite imagery were acquired, georeferenced and projected to UTM zone 33N based on WGS 84 datum. The digitization of layers, namely; plots, development control zones, and road was carried out using the Onscreen digitization method. In addition, a geospatial database was created using attributes extracted from ASUPDA's approved development permit archives. Such attributes include, names, address, proof of land ownership, occupation of plot owners, date of application/registration, etc. Furthermore, an online platform was developed to enable developers submit their applications. Spatial analysis such as database query, overlay, data edit/update were executed. The results of this study revealed that there is low level of awareness on development control among developers, majority of the buildings were built without development permit, developers faces a lot of challenges applying for development permit, and that ASUPDA is not playing by the rules and lacks basic infrastructure. The study observed that a comprehensive geospatial database will help the ASUPDA greatly in effective data storage, data management (edit/update, data retrieval), spatial analysis for the purpose of assessing development permit applications, and report generation. To this end, the study recommend that ASUPDA should adopt geospatial technology with immediate effect.

Index Terms— Geospatial database, GIS, development control, Jimeta Metropolis, Nigeria

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1 INTRODUCTION

1.1 Background of the Study

Development control is the process by which planning authorities manage the extent and nature of physical development in urban areas. Landowners/developers wishing to develop their landed properties are required by law to apply to a planning authority for permission prior to commencing any development work. Such development control allows authorities to manage land across a large area, balance competing needs of land allocation for farming, protection of areas with particular values (Housing & Environment Ministry of Local Government, 2015), ensure that the building comply with building bye-laws and codes, and prevent developers from erecting illegal structures (Ayotamuno, 2015). Development control is also viewed as a collaborative decision-making process where a group of urban planners, architects, and engineers review or process the building application submitted by the developer according to predefined regulations and workflow (Chen et al. 2004).

In Adamawa State, the control of physical developments is handled by the Adamawa State Urban Planning Development Authority (ASUPDA) formerly known as Gongola State Urban Planning Development Authority which was established by Edict No.12 (1986).According to this Edict, the Authority has the following functions:

a) to administer, execute and enforce the provisions of the

Town and Country Planning Law within the areas for which the Authority has been appointed responsible;
b) to foster the development of the State through the exercise of its powers and functions under this Edict;
c) to carry out the functions and duties provided for in areas declared as Urban areas in the State;
d) to conduct functions advantageous for the purpose of carrying into effect its responsibilities as specified in the Edict.

To achieve the above functions, there is need for rational use of land, accurate, comprehensive and up-to-date geospatial database. However, despite the advancements in science and technology and falling costs of computer hardware and software, ASUPDA and many other planning agencies in Nigeria still lack such vital infrastructure. Presently, the organisation is operating on an out-dated analogue(manual) system of file indexing, storage and retrieval(Figure 1). Relevant layout plans that can be used when going out for site inspections are lacking. In addition, application for development permit, payment of fees, processing, analysis and decision-making, and communications with applicants are also done manually. Thus, the system usually lead to frequent loss of applicants files, delays, corruptions, time and labour intensive organization and retrieval. This manual approach is cumbersome, time demanding, costly and ineffective to the interest of all involved. It also led to general encroachments on road corridors, road reserves, sewer and water lines reserves, substandard structures, building collapse due to lack of timely action. Inconsistencies in decision-making and lack of public participation in planning process has also been observed. Furthermore, the Adamawa Sate Government looses huge revenue (internally generated revenue) that may be accrued from develop-

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ers.

The solution perceived, and the contribution of this paper is to mitigate the above problems by adopting modern technologies such as geographic information system (GIS), remote sensing, and the internet. The main advantages of GIS over manual approach are that it handles both spatial and non-spatial data effectively and will be used at all levels of development control process, for example, initial discussion, registration, invitation of objection, and consideration by both technical and planning committees. It is anticipated that the geospatial database could be used by many parties involved in the process as reference point in evaluating development permit applications. Having access to the database will provide the flexibility in assessing a development and deciding on the overall urban growth management programme in the most cost effective manner. The system will also provide transparency and consistency in the development control procedure (Yaakup et al. 1994). According to Olajuyigbe and Rotowa (2011) effective control of physical developments especially in those sections of our cities experiencing rapid urban sprawl is important in addressing growing land use problems including slum formation, rising costs of land, accessibility to urban land for housing, incompatible land use, flooding, overcrowding, etc. for the purpose of achieving sustainable city development and ensure the safety and well-being of its inhabitants. In this regard, this study aimed at developing a geospatial database using GIS for ASUPDA with a view to provide a comprehensive and up-to-date database that will enhance effective, accurate and rapid development control process in Jimeta.

Figure 1. Stacks of approved development permit files in ASUPDA (Source: Field Survey, 2015).

1.2 Literature Review

GIS, remote sensing and the internet can serve the needs of urban planning especially in building permitting, tax collection, transportation, infrastructure and mapping for governmental organizations (Alkan and Bulut, 2010). Çete et al. (2009) reported that the use of computerized systems is inevitable for city managers to realize the complex tasks they faces on daily basis due to rapid urban growth, and to manage the huge volume of data accumulated effectively.

Chen et al. (2004) developed a graphical user interface GIS-based Computer Supported Collaborative Work (CSCW) sys-

tem for controlling physical developments in an urban area. CSCW system integrated the representation of agents, events, states and their relations in modeling both the structural and behavioural aspects of the development control process. The system has the capability to integrate both spatial and non-spatial data. To handle routine works of development control, specific functions were developed namely, office automation, desktop spatial data handling and mapping tools, generic queries, and a web-based catalogue browser. In another study, Yaakup et al. (2002) designed a GIS for the purpose of development control for Kuala Lumpur, Malaysia. The system contained a comprehensive database and can be used at every stages of development control process, for example, in initial discussion, registration, invitation of objection, development control process, consideration by technical committee and consideration by planning committee. Holden and Turner (1997) reported that the Institute d'Amenagementet de l'Urbanisme de la Region de l'Ile de France has established a GIS database for the Paris region. The system utilized a software bridge technique between GIS and computer aided design (CAD) to facilitate visualization purposes. In addition, the GIS database was equipped with 190 components including transport, population, topography, environmental factors and land use. Thus, the database is comprehensive and updated frequently through land-use surveys (1982, 1987, 1990, 1994, 1997) and the information is made available to different organizations at minimum price levels.

2 MATERIALS AND METHOD

2.1 The Study Area

Jimeta is located between latitude 9° 10" N to 9° 15" N and longitude 12° 11" E to 12° 17" E (Figure 2), and has a surface area of 9,670.10 hectares. Jimeta is the other part of the twin city to Yola. It is also the administrative and commercial capital of Yola which is the capital of Adamawa State, and headquarters of Yola North local government area (LGA), (Husain and Ismaila, 2014). To the north and east Jimeta is bounded by Girei LGA while to the south and west with Yola South LGA. The city is growing at a faster rate. In 2006, Jimeta has a population of 198,247 (National Bureau of Statistics, 2009). Ten (10) years later (i.e., 2016), the population rose to 253,773 (projected based on 2.5 growth rate). There are five (5) development control zones (DCZ) and over 10 residential layout plans in Jimeta. However, this study used GSYP 18 layout located along Yola and Gibson Jalo Way. The GSYP 18 layout is a combination of high and medium density residential layouts and consists of over 1,000 plots and adequate circulation network. It is bounded to the north with Karewa and Masakare, south and west with ADYP35 layout and to the east with Yola Road (Figure 2).

2.2 Data and Sources

The study utilized the following data sets: (i) primary data, (ii) shapefiles of road, land marks and water bodies, (iii) residential layout plan (GSYP 18). This layout plan contained both developed and undeveloped plots, (vi) high resolution (0.6 meter) Quickbird satellite image extracted from Google Earth,

(v) file records of property owners which contains attributes data of approved development plan for plots of land in GSYP 18 residential layout. For the purpose of this study, 100 files were randomly selected and then used, (vi) description of development control zones from ASUPDA.
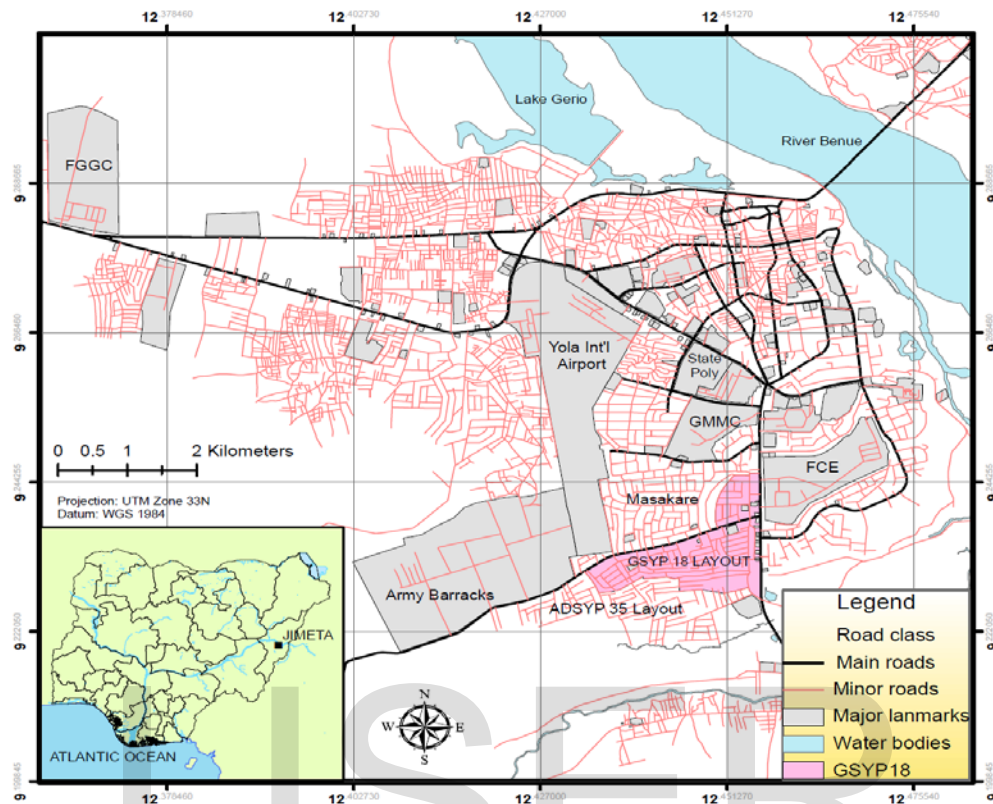

Figure 2. The study area (Husain and Ismaila, 2014).

2.3 Methods

The methodology used for this study is based on; (a) questionnaire administration; (b) updating of base map (c) development of geospatial database; (d) designing of website for ASUPDA; and (e) application of the geospatial database in development control process. The details are given below;

a) Questionnaire administration:-Two sets of structured questionnaires were designed and administered using purposive sampling. The first set totalling 120 was administered to landlords of both completed and uncompleted/ongoing buildings in all the five development control zones (DCZs). Table 1 shows the proportion of how the questionnaires were administered. Whereas, the second set of the questionnaires totalling (5) goes to the officials of ASUPDA. The goal here is to understand the problems facing the Organisation as well as their requirements when developing the geospatial database.

b) Updating of base map: This stage involve; (i) extraction and georeferencing of Quickbird satellite images; (ii) digitization of features into layers.
   ✓ Extraction and georeferencing of Quickbird images:-Google Earth Pro 7.0 software was used to extract Quickbird satellite image (0.6 m resolution) and coordinates of some selected locations. The images were extracted in bits and then imported into ArcGIS 10.0® where georeferencing was carried out using the coor-

dinates. Then the images were mosaiced and projected to Universal Traverse Mercator (UTM) zone 33N coordinate system and WGS 84 datum.
   ✓ Digitization of features into layers: the shapefile layers obtained from Husain and Ismaila (2014) were updated using on-screen digitization method after overlaying them with the georeferenced satellite images. In addition, new feature layers were created and then utilized in digitizing the GSYP 18 residential layout, roads and development control zones.

c) Development of geospatial database: to develop the geospatial database series of process were followed including; data analysis through which the types and quality of the data to be incorporated in the database are identified. In the database design, parcels, owners and documents data were maintained in different attribute tables. Figure 3 shows a portion of the database schema. Fields were created in the database on the basis of identified attributes. Then, the C-of-O number on GSYP 18 layout was used in conjunction with the files obtained from ASUPDA to identify the attributes of each plot for data entry. The application letters, proofs of land ownership, building plans, site inspection report, receipts, comments by respective officers, and building permit letter were all scanned as pdf format and then tied to the database using hyperlinktool.

Table1. Distribution of questionnaires.

S/N	Development Control Zones	Population 2006*	Population 2016**	(%)	Questionnaires Administered
1.	Zone A - Gwadabawa, Alkalawa, Ajiya, Yelwa, Rumde, and Limawa Wards	95,217	121,886	44.7	54
2.	Zone B - Parts of Karewa and Bole/Nyolde Pate Wards	15,000	19,201	7.0	8
3.	Zone C - Karewa Ward	22,227	28,452	10.4	13
4.	Zone D - Luggere, Nassarawo, and Doubeli Wards	62,822	80,417	29.5	35
5.	Zone E - Jambutu Ward	17,981	23,017	8.4	10
	Total		272,974	100	120

* National Bureau of Statistics (2009).
**Projected based on 2006 National Population Census data by merging wards population.

Parcel

Obj_ID	C-of-O No	Dev't control zone	Town	LGA	Plot No	Street name	Landuse Type	Layout No

Owners

Obj_ID	Application ID	C-of-O No	Name	Last name	Address	Sex	Occupation	Photograph

Documents

Obj_ID	Application ID	C-of-O No	Application Date	Land Title Doc	Bldg Plan	Directives	Field Report	EIA Report	Approved Permit

Figure 3. Portion of the database schema.

d) Designing of website for ASUPDA: a website was developed for ASUPDA and contains the followings; Home, Administration, Downloads, Login, Contact, and Notice board.
   ✓ Home page gives information about ASUPDA.
   ✓ Administration:- General Manager, Board Secretary
   ✓ Departments:-Administrative, Town Planning, Health, Engineering, Housing.
   ✓ Download:- consist of application process and requirements, Edict No. 12 of 1986,publications, etc.
   ✓ Login:- comprised of both staff and developers access.
   ✓ Contact contains address and map location of ASUPDA, inquiry form.
   ✓ Notice board provide information on ASUPDA's activities.

For the purpose of this study, we utilized WordPress 4.6.1 to develop the website. The main goal of developing the website is to avail all the necessary information about ASUPDA and their activities to developers, as well as developers having easy medium to apply for development permit.

e) Application of the geospatial database in development control process: to access the database, it is expected that all the departments are networked using local area network (LAN) and internet. In addition, user name and password are issued to staff so as to enable them access the database. This reduces data duplication by departments. Administrators are permitted to edit/update the database but data query, generation of maps and reports, visualization, and spatial analysis can be done by any of the technical staff. Below is the explanation of how these functionalities were achieved;

✓ Edit/update:-editing is the process of making changes to a geospatial database by adding new features or changing existing ones as part of database update and maintenance operations. A database update is any change to the geometry and/or attributes of one or more objects or any change to the database schema (Longley et al. 2005).In this study, majorly Edit Tool was used to edit and update the database.

✓ Query:- Structured Query Language (SQL) is used to match an attribute value to the attribute value in a feature class. The SQL is a powerful language you use to define one or more criteria that can consist of attributes, operators, and calculations (ŚLIŻ, 2009; Reddy et al. 2013). Thus, using the database created, select by attribute queries were carried out. In addition, identify tool is used to learn information about any feature on any layer.

✓ Generation of thematic maps and reports:- maps and reports can be generated showing the spatial distribution of approved developments and vacant land still available.

✓ Spatial analysis:-there are several analysis tools abound in GIS. However, the analyses used in this study include; overlay, symbology, and buffer analyses.

✓ In addition, descriptive statistics (tables, charts, percentages) were used to analyse the data obtained

through questionnaire administration.

3 RESULTS AND DISCUSSIONS

3.1 The Level of Awareness on Development Control Among the Residents

The study revealed that majority of developers in Jimeta metropolis are unaware of the existence of planning authorities and their duties, planning laws, and importance of development control (Table 2). However, it is important to note that Zones A and D covering about 74% of the questionnaires administered comprises of old/traditional neighbourhoods that have very old buildings.

Table 2. Residents Awareness on Existence of Town Planning Authorities and their functions.

Awareness	Aware (%)	Unaware (%)
Existence of Planning Authorities	45.0	55.0
Duties of Town Planning Authorities	40.8	59.2
Existing Planning Laws	38.3	61.7
The Importance of Development Control	39.2	60.8

Source: Field Survey (2016).

3.2 Possession of Development Permit Approval

Development permit is a legal document issued by planning authority to developers granting them permission/approval to erect temporary or permanent structure on their landed property (Ayotamuno, 2015). The result of this study revealed that 60% of developers in Jimeta Metropolis did not acquire development permit while embarking on their building projects, whereas 40% obtained it (Figure 4). Thus, majority of the erected structures in Jimeta illegal. This indicates that the current methods used by ASUPDA in implementing development control measures in Jimeta are not yielding the desired outcome to be a modern city.
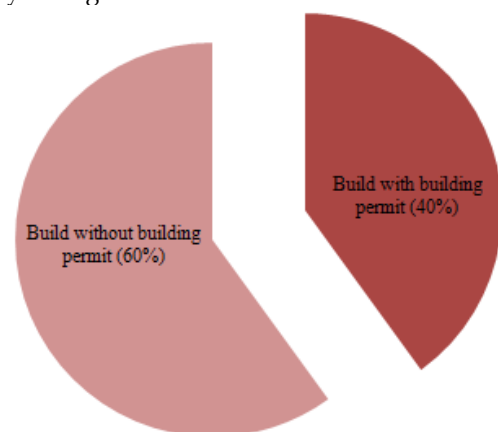

Figure 4. Possession of development permit approval in Jimeta Metropolis (Source: Field Survey, 2016).

3.3 Problem with Present Method of Development Permit Application

The results of this study revealed that Developers in Jimeta Metropolis faces various challenges while processing devel-

opment permit. These challenges include; delays (27%), corruption by officers (24%), stringent bureaucracy (21%), high fee charges (22%) and others account for 6% (Figure 5). These challenges makes it difficult especially for low income earners who are vast the majority of the population to seek development permit.
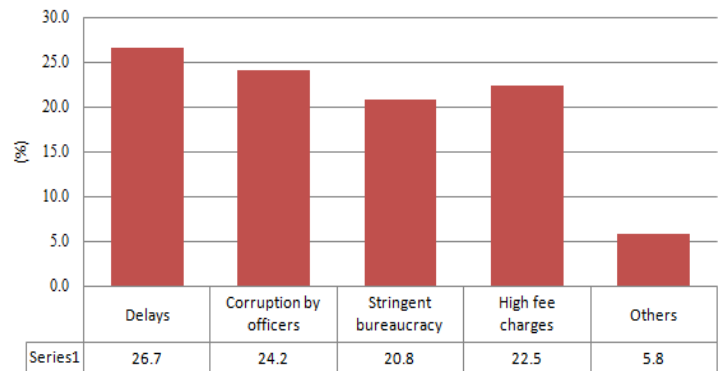

	Delays	Corruption by officers	Stringent bureaucracy	High fee charges	Others
Series1	26.7	24.2	20.8	22.5	5.8

Figure 5. Problems face while processing development permit (Source: Field Survey, 2016).

3.4 Registered Building Plans

In ASUPDA, the administrative department is responsible for registering all applications for development permits except fencing permit, whereas the development control department keep records of all approved development permits. The study revealed that records of the administrative department is incomplete and not well kept. Furthermore, there are wide variations as to the number of registered applications and approved development permits (Table 3). This suggest that there may be some sharp/corrupt practices going on in some departments or lack of proper record keeping.

Table 3. Registered and approved building plans in Jimeta (2006 to 2015).

Year	No. of registered applications	No. of Approved plans
2006	-	255
2007	-	259
2008	-	213
2009	-	243
2010	-	201
2011	250	235
2012	250	286
2013	200	316
2014	200	553
2015	150	781

Source: ASUPDA (2016).

3.5 Digital Map

Figure 6 comprises of four (4) layers namely, digitized GYSP 18 layout, road, satellite image, and DCZs. The converted analogue GYSP 18 residential layout into digital data format comprises of 1,144 plots and different land uses including residential, commercial, educational, circulation, civic/public uses. With digital maps, all other layout plans in Jimeta can be converted from analogue to digital format and then incorporate them into one seamless layer. This will avoid misplacement of plans and contradictions with respecting to decision-

making. In addition, the spatial visualization of DCZs will help the inspectors monitor developments within their areas of jurisdiction effectively and avoid living any area un monitored due to assumptions that those areas did not fall within their areas of jurisdictions. It is expected that all the necessary spatial data that is required when making decision with respect to development permit applications must be converted to digital format in form of layers. Such data include; electricity transmission lines, location of transformers, telecommunication lines, location of GSM mast, water distribution pipeline, sewerage line, waste disposal, lakes, rivers, reservoir and drainage, contour, slope, etc. Therefore, having these data in place can be very useful to ASUPDA in controlling physical developments in Jimeta as well as for other purposes.
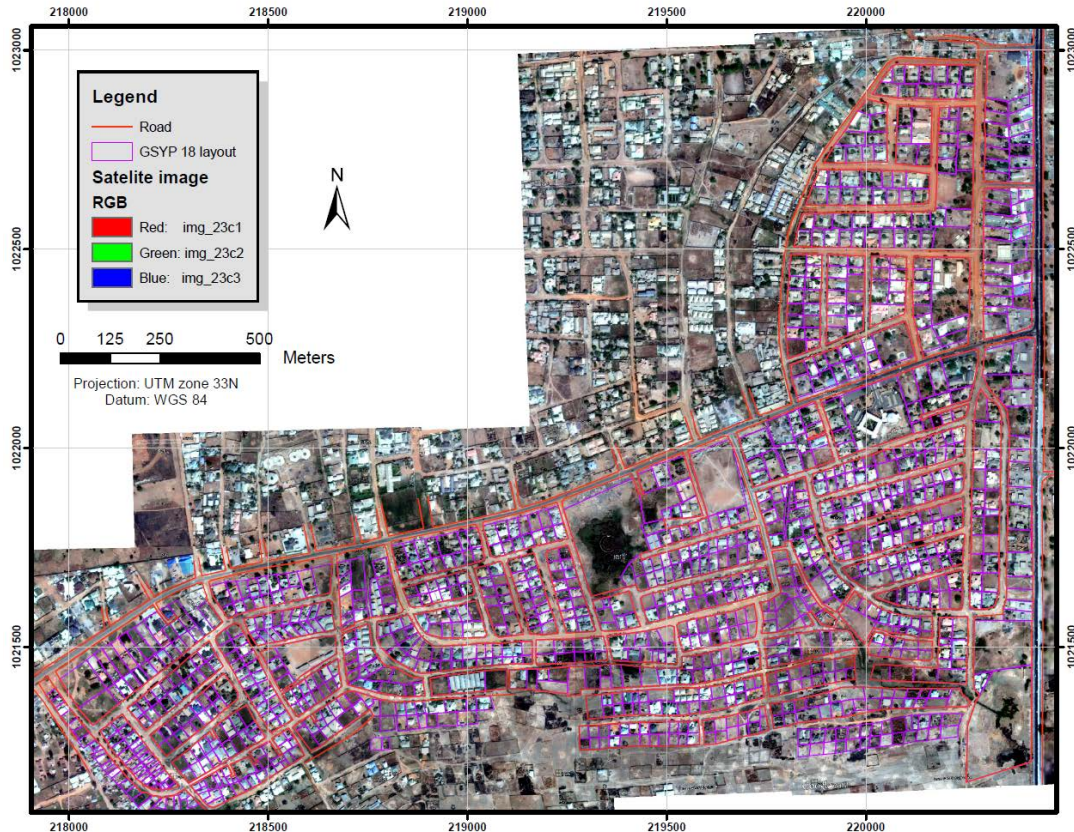

Figure 6. Digital layout plan of GYSP18overlayed on satellite image.

3.6 Geospatial Database for GSYP 18 Layout

Figure 7 shows the geospatial database developed for GSYP 18 layout plan which comprises of developers name, contact address, plot address, names of property owners, address, proof of land ownership, for instance, C-of-O, date of application and date of approval among others. The geospatial database consist of samples of 100 names of approved files for development permit from ASUPDA, ranching from the year 2001-2015. This kind of database will provide a comprehensive information on both spatial and non-spatial data, for instance, spatial location of plots, permits issued in the past, permit type, date permits were issued, and what type of development they were for.

3.7 Application of Geospatial Database for ASUPDA

For easy access to the database by each member staff responsible for decision, it is expected that offices in the Authority is networked using both local area network (LAN) and the internet. In addition, username and password is issued to each staff. Using the above geospatial database, the development control department can utilize the database in various ways. A few are explained below;

➢ Edit/update:-

✓ Any new layout plan can be easily integrated into the base map.
✓ Circulation of application for development permit: when such information is received, the staff responsible will identify the plot on the base map and keyed in all the information on the online application submitted. Thereafter, send an email to the next staff that is supposed to comment on the file. All staff responsible for any decision must do it on the database.
✓ This help to avoid the expensive and slow process of hand correction and redrafting.
➢ Spatial query:- Assuming one is interested in knowing the followings:
✓ Information on whether a specific plot is granted a development permit or not.
✓ Number of residential land use approved between x, y periods.
✓ Number of plots granted development permit with an area greater than 900 square meters or less than/equal to 900 square meters.
✓ Verifying information about selected plot using Identify tool (Figure 8). By clicking the hyperlink sign, the

attached documents, for instance, proof of land ti-
tle/ownership, building plan, approval for planning
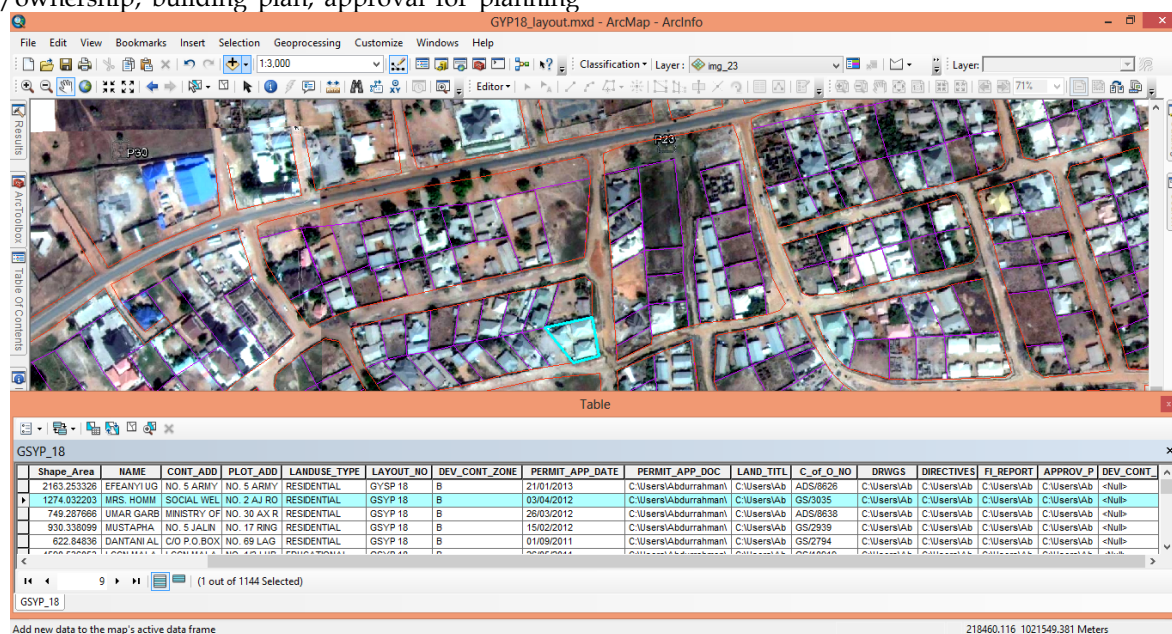
permission, etc., can be displayed on the screen.

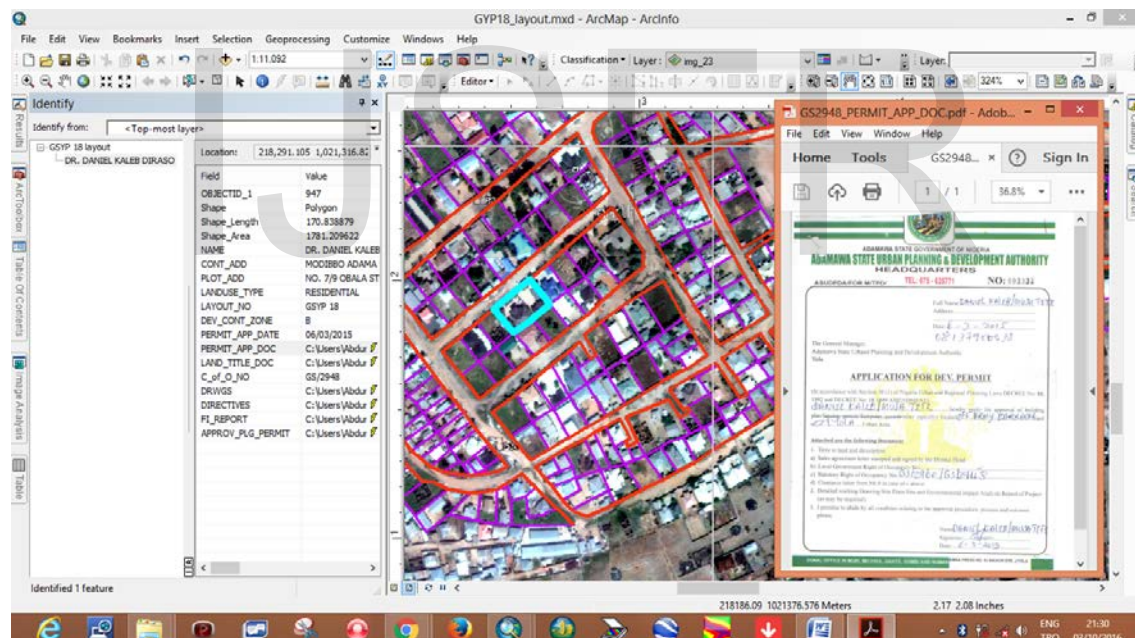Figure 7. Geospatial database for GSYP 18 layout.

Figure 8. Verifying information about a plot using an Identify Tool.

➢ Generation of thematic maps:- thematic maps are statis-
tical maps that display a particular "theme" of data
which may be qualitative or quantitative (United Na-
tions, 2000), and are one of important geographic
products within geospatial support system (Kovarik
and Talhofer, 2013). Results of statistical analysis, for
example, number, percentage or rate, and type of de-
velopment permit issued per DCZs, site inspection
map, etc. Figure 9 shows the type and percentage of
land use type that were issued with development per-
mit in GSYP 18 layout and in particular DCZ C.

➢ Spatial analysis:

✓ overlay: is one of the most common and powerful GIS
functions. Series of layers of different types of infor-
mation are added together meaningfully through
overlay analysis to arrive at conclusions.

All these analyses and many more will support quick and
effective decision-making process.

3.8 Designed Website for ASUPDA

The website for ASUPDA (Figure 10) was designed using a
simple and free (open source) but sophisticated program that
does not require the knowledge of computer programming
language. However, having the knowledge of programming
language is an additional advantage. With little training any

person can operate it. Thus, there is no need for contracting a consultant to maintain the website. The website is comprehensively designed with all the necessary information a prospective property developer may require in respect of development permit application as well as information about the Au-

thority. In addition, developers do not need to visit the Authority because of their applications. Everything can be done online ranging from application to approval of development permits. The developers can also track their applications.
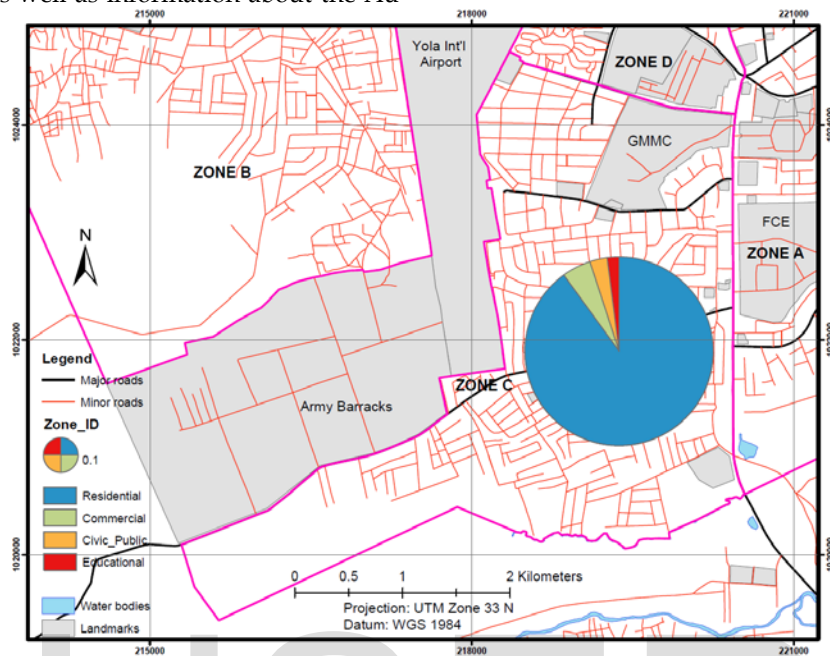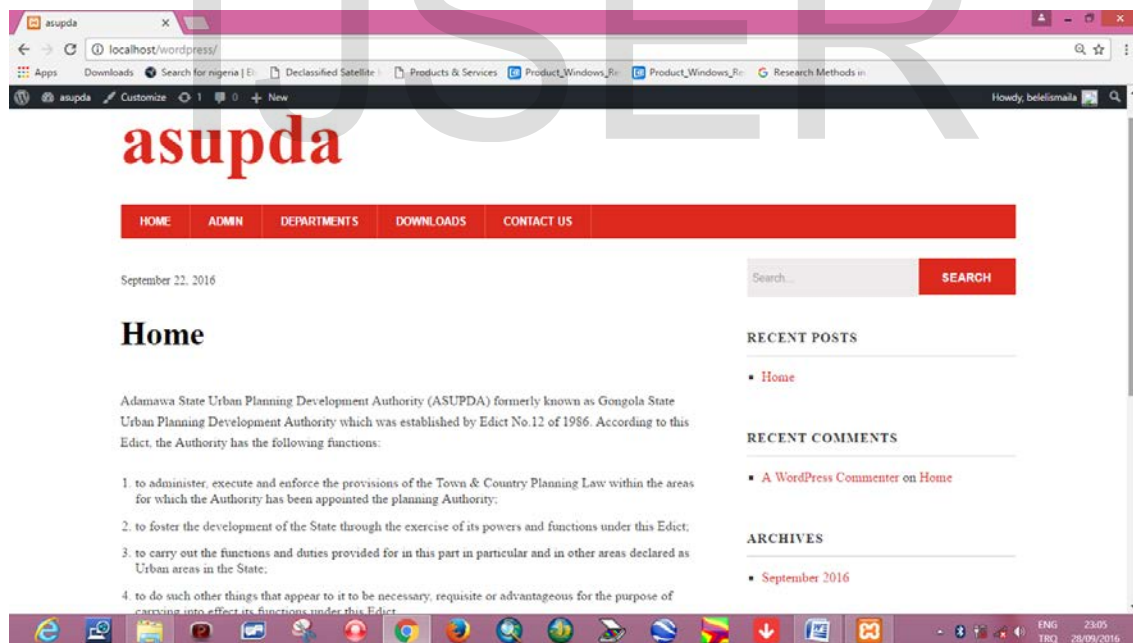

Figure 9. Type of development permit issued.

Figure 10. Designed website for ASUPDA.

4 CONCLUSION

This paper presents a GIS application to promote easy and efficient development control process in Jimeta. By using GIS, all necessary data and information needed for development control were stored, organized, analyzed, and accessed by staff responsible for making decision in the development control process. It also provides the capability to respond ade-

quately, to rapid urban growth and societal changes in norms and values with increasing ease, foresight, and responsiveness.

In order to make the development permit application process easier and effective to both the developers and the Authority, this study proposed the following;
a) Developer

✓ The first thing a prospective developer will do is to visit ASUPDA's website and create user account using GSM phone number and N500:00 recharge card.

✓ Login and fill the online application form which comprises of name, contact address, sex, date of birth, state of origin, local government, nationality, email, plot address, type of development (residential, commercial, etc.), upload: passport photograph, proof of land ownership (C-of-O, Sales agreement), building plan, EIA report, etc. After submitting the application, an automatic reply will be send to the developers email address indicating that his application is received and necessary action will be taken.

✓ Payment of all other fees, for instance, site inspection fees, development fees, etc. will be done online with the help of RIMITA (an e-payments/collections solutions).

b) ASUPDA

✓ The first thing to do by the Agency's staff responsible for registration when a developer applied for a development permit is to identify the site in the geospatial database and fill in his/her information such as name, phone number, email, plot address, type of development, type of land ownership document (certificate of occupancy, customary, sales agreement), development control zone etc. The staff will also scan and attach all the supporting documents e.g. application letter, proof of land ownership, building plan, payment receipt among others. A reference number must also be issued to the applicant.

✓ Then, the General Manager or his/her representative will log-in and order for the assessment and comments of various departments in the Authority. Each head of department is to make comment on the column added for him, which will serve as a medium for granting development permit for the developer of which if properly utilized would fasten development control process in ASUPDA.

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