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Full Length Research Paper

The role of satellite remote sensing data and GIS in population census and management in Nigeria: A case study of an enumeration areas in Enugu, Nigeria

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The paper examines the nature of census operations in Nigeria and identifies the contribution of satellite remote sensing (SRS) data and geographic information system (GIS) to the contingency planning, mapping and management of census (attributes) datasets in Nigeria. Enumeration Areas (EAs) of a site in Enugu, Nigeria was mapped. The census datasets were modeled and presented as an ideal process. This was implemented using (IKONOS-1 m) image data in carving out the area, to demonstrate that SRS and GIS are very useful tools in handling census datasets. Ground reference data for carved-out area was collected using GPS hand sets. A census database was created with various attributes, exploring certain aspects of data planning and processes. This was in terms of image (data) compatibility, modeling, and capacity for interactiveness of database management system (DBMS) network for spatial (query) analysis (based on user specified needs) was performed to determine the age, type or purpose of buildings and other facilities within the mapped EAs. The scale of the challenges faced by census managers; the no spatial credibility, crude data processing technique, socio-political tendencies, un-proportional houses, correlation, and attribute verification often results to contention, rejection and delay of census results in some cases. The paper concludes by suggesting new ways and means through which the Nigerian state through its agencies in census operations should explore to tackle this menace and save the nation from the embarrassments of poor handling of census datasets.

Key words: SRS, GIS, enumeration areas, census datasets, mapping, management.

INTRODUCTION

Nigeria is a unique country in terms of abundance human and material resources. The role of census in positioning man's well-being in terms of modern society is well known. Census in Nigeria has produced some results of doubtful values both locally and internationally on account of massive inaccuracies and lack of spatial credibility. A vital component of census work is the mapping of statistical areas sometimes referred to as enumeration areas (EAs) for the field enumeration, which is the spatial foundation for census datasets mapping. Accurate knowledge of population and its spatial distribution provides enabling platform on which man's natural and acquired needs could be optimally met and also provide appropriate data in quality and quantity on which an account on how and extent of man's utilization of resources within his living domain could be made (Eze, 2007). This primary data source in developing countries is largely faced with problems of accuracy and completeness. The heterogeneity and complexity of census datasets requires appropriate tools such as Satellite Remote Sensing (SRS) and Geographic Information System (GIS) to handle it. This is in view of challenges posed by global population explosion and its attendant stress on scarce available resources.

Major census processes involves demarcation and mapping of EAs and Supervisory Areas (SAs) for appropriate management of census datasets. EAs and SAs demarcation in the field involved; azimuths (bearings) and distance measurements, using conventional surveying principles. Satellite Global Positioning System (GPS)

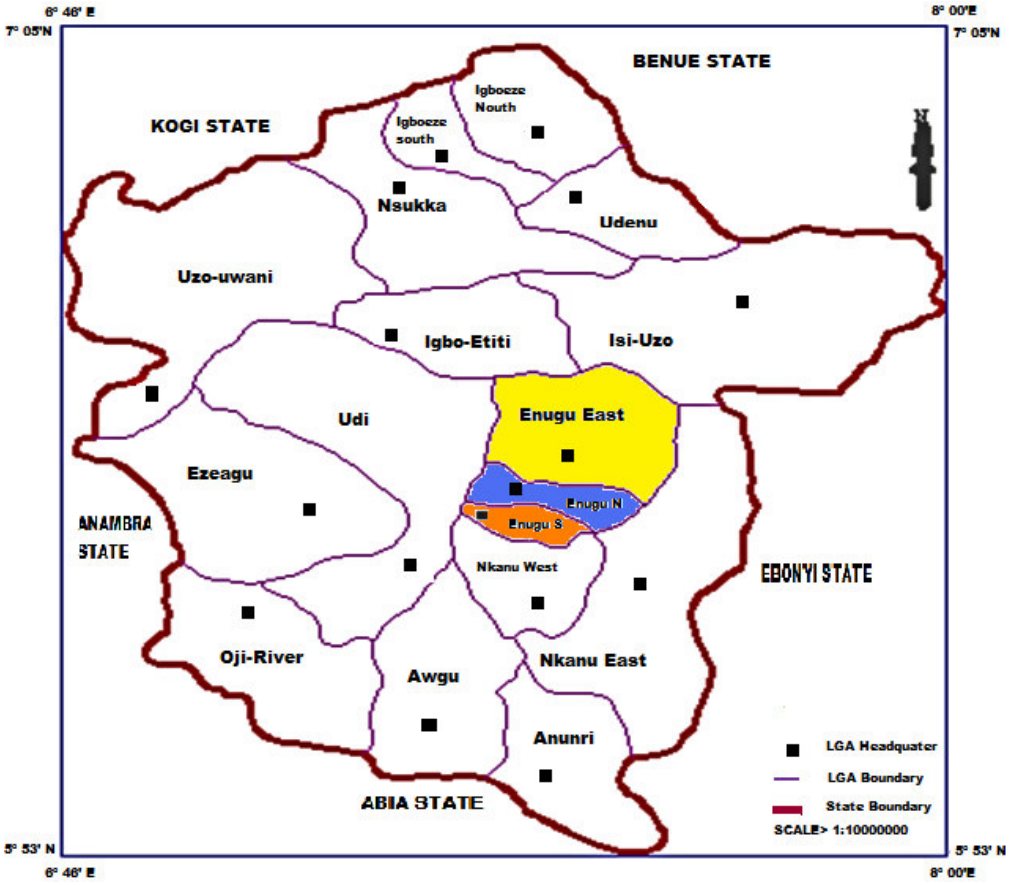

Figure 1. Map of Enugu State, Nigeria showing Enugu - the study area.

technique was used for point positioning, which enabled appropriate geo-relation and geo-framing of EAs and SAs, and building of locality maps of the EA. In the process of the mapping, an ideal process was fully implemented using a preprocessed high-resolution (2005 IKONOS-1 m) image data in planning, understudy and carving-out the project area in Enugu, Nigeria. Moreso, certain salient aspects of the data planning and processing methods were explored in terms of image (data) compatibility and modeling on a digital environment through appropriate hardware and software. This brought out the capacity of the database management system (DBMS) in terms of interactiveness, network and spatial analysis (spatial queries based on user specified needs). This is to determine from the datasets; the age, type or purpose of buildings and other facilities within the EAs. Spatial analyses of the mapped area were easily manipulated on the road network to determine spatial characteristics of the buildings along the roads. Population census is about the people and their welfare, any development that seeks to improve the living conditions of the people must therefore take into consideration the rare insights provided by population census. This paper demonstrates the mapping of EAs using the SRS data and GIS tools for handling census datasets in Nigeria.

The study area

Enugu is the administrative capital of Enugu State, one of the constituent thirty-six states of the Federal Republic of Nigeria. It is located within latitudes 6° 17' to 6° 36'N of the equator and longitude 7° 17' to 7° 37'E of the Greenwich meridian. Enugu metropolis is bordered in the north, east, south and west by Igbo-Etiti and Isi-Uzo, Nkanu East, Nkanu West and Udi Local Government Areas (LGAs) respectively (Figure 1). Enugu comprised of three LGAs (Enugu North, South and East) out of the 17 LGAs of Enugu State, Nigeria. The ethnicity is Igbo and the history of the people is in tandem to the discovery of coal in 1909. Enugu Urban has a population of about 2.3 million (FRONG, 2007). The city is topographically characterized with natural scenery, sun-dappled landscape and contrast of hills, escarpments, valleys and waterfalls. It has a tropical climate, with the mean annual temperature oscillates around 27 - 31°C. There are two distinct climate dynamics in a year, with rainy season starting from April to October. The annual rainfall in Enugu is between 1.5 and 2 m (Widijaja, 2001). In dry season, from November to March the lowest rainfall of about 16 mm is normal in February. These climatic dynamic results to the tropical rainforest type of vegetation, which has

been heavily destabilized by rapid urbanization and increased population.

Problems of census enumeration in Nigeria

The embarrassing effects of poor handling of census datasets in Nigeria have continue to ringer especially as there are many unresolved issues on the mapping and management of EAs. The issues have either resulted in contention, delay and or outright rejection of the census results. Such issues can be briefly described as follows:

No spatial credibility: Sometimes NPC are not able to relate the census figures with what is on the ground (no spatial credibility) and as a result, could not substantiate their results (Figures) in a competent law court in Nigeria.

Crude data processing technique: Non-inclusion of the state-of–the-art technology in mapping and demographic analysis, due to lack of man-power and or corruption. This tends to aid the cooking-up of census figures in some cases.

Socio-political tendencies: The ethnic, political, religious ranglings and acrimonious tendencies aimed at scuffling figures which may have revenue sharing undertone.

Un-proportional houses: The existing threshold across the EA in a locality is a function of area concerned (Enumerators Manual, 2006). Therefore, a population census could be rejected or questioned based on un-proportional houses to population declared.

Correlation: Building information as declared in any EA must be correlated with the “unbiased satellite information”.

Attribute verification: Other attribute information could still be verified with the Federal Office of Statistics – an office charged with collection of social statistics for the nation.

Managing EAs with SRS and GIS

The ability to combine SRS and GIS data has enabled the generation of new data based upon characteristics unique to each data source and thus adequate for effective management of census datasets. It thus has the capacity for:

i) Census datasets (attributes) modeling, post census survey and evaluation. Prompt location of EA of interest to an enumerator.
ii) Orbital SRS are especially important for household estimation, damage assessment, population estimate, and modelling.
iii) Radar would be required at the period of cloud cover.
iv) Spatial analysis of the EAs in terms of potential environmental impacts, and terrain characteristics.
v) Reduces under coverage and over counts in census operation by precise determination of the area an enumerator is to cover since EA boundaries are indicated in a special symbol.

MATERIAL AND METHODS

In the planning and execution of the work a well analyzed input and output formats, and appropriate data structured models were carried out, using relevant data, software and hardware. Since, maps are produced by the combined efforts of many professions using a variety of technologies (Lo and Yeung, 2002). Typically the mapping process involves the following phases of work: planning, data acquisition, production and product delivery. Therefore, the input and output specifics used in the work are as explained below.

Image data and maps: High-resolution satellite image data (2005 IKONOS-1 meter in multi-spectral band) covering the demonstration area, analogue topo maps of 1:50,000 - 1:25,000, cadastral maps of scales 1:2000 - 1:3000 and EAD forms and questionnaires were used to generate the desired products (Tables and Maps) in an interactive GIS environment.

Hardware and software: The hardware includes; Hp branded Pentium based dual core 1.8 MHz processor computer, A0 Flatbed-Mustek systems Scanner, A420 Cannon power shot, and Handheld Germin GPS map 76c with its downloading cable. AutoCAD, ArcView 3.2a, ArcGIS 9 were the main packages, complimented by ILwis 3.2, Adobe Photo Shop 5.0, GeoCalc and MS office.

Primary data capture

Field (site) capturing of data were based on basic survey principles and techniques. A handheld Germin GPSMAP 76c receiver was employed in the traverse for point positioning. Also, A420 Cannon power shot Digital Camera was used to picture the area, so as to aid better visual appreciation and spatial analysis of the area.

Secondary data capture

Input formats such as a satellite image (Ikonos) of the carved-out area, lines (graphic) maps of areas of the demonstration site were converted to required digital format by scanning. A newly digitized map typically requires editing and geometric transformation. Editing removes digitizing errors, which may relate to the location of spatial data such as missing polygons and distorted lines, or the topology such as dangling areas and unclosed polygons (Chang, 2007). However, the GeoCalc ‘94 package was utilized during the conversion process for automatic conversion of geographic coordinate to rectangular coordinate. The preprocessed raster (Ikonos) image on WGS 84 projection datum was converted to local (Mina) datum. The study area was framed and extracted using the input criteria of centre coordinates (latitude and longitude). The resolution of the Ikonos is 1 m in multi-spectral band. To achieve desirable (higher) image data quality to be used for geo-registration and feature digitizing, a framed IKONOS image of the study area was inserted into ArcGIS 9.0 environment (Figure 2). The image reprocessing module of this enabling software was used to reprocess the image for higher visual quality.

The EAD forms and questionnaires were merged with some modifications as desired to create the attribute database (Tables) of the carved-out area. House listing and enumerations were carried

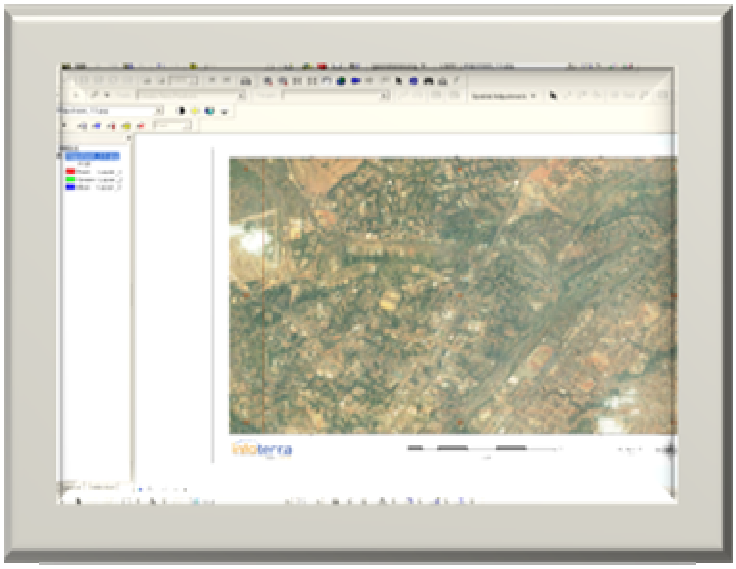

Figure 2. Ikonos 1-meter raster image of part of the carved-out area in ArcMap-ArcView.

Table 1. Entities and their attributes.

Entity (Feature)	Attribute
Buildings	Shape, ID, Household, Ea_Name, Bld_Type, Purpose, Ea_Code, Local_Govt, Comp_Name, House_No, Age,
Enumeration Area (Eas)	Shape, ID, EA_Code, LGA_Name, Demarcator, Dem_Status, Sex, Age, Dem_Qualif, Dem_Code, St_of_Origin,
Supervisory Area (Sas)	Shape, ID, No_EA's, Pop_Est, Locality_Name, Lg_Name, State, Geo_Pol_Name, Sa_Code, Area_Meter
Minor Roads (Min_rd)	Shape, Entity, ID, R_Name, R_Type, Status, Locality, Length_Meters
Major Roads (Maj_rd)	Shape, R_ID, R_Name, R_Type, Locality, Length_Meters

Source: GIS lab work.

out using appropriate EAD forms and questionnaires, which were filled in-suite at the site. The data (raster, vector and attribute) were processed and analyzed by creating objects and linking the resulting shape-sheet file (DXF) to DBMS. These were implemented through ODBC or Active-X technology (Loney, 2004).

Database modeling

The EA attribute database was modeled and developed for the purpose of interactiveness based on relational data model. A relational database is efficient and flexible for data search, data retrieval and creation of tabular reports (Chang, 2007). Each table in the database was prepared, maintained and edited separately from other tables. The tables remained separated until linked up by query or analysis. The respective forms (EAD 1A through to locality identification and classification questionnaire) were used for the basis of table creation and database modeling. In addition some forms were created digitally using spreadsheets, the Database Management System capability in which platform the databases were modeled internally and linked using the in-built table capabilities in the ArcGIS environment. Though, external database tables created with dbase with dbase, MS Access, SQL, Sybase, Oracle, etc, could be joined with the spatial table of the GIS software (Dbase and SQL server) which are the default DBMS for ArcView and ArcGIS for data manipulation and analysis. In the process, five (5) internal tables (Table 1 - the entities and attributes) were created and linked to ArcView GIS shape file using geo-relational technology. The modeled tables were created in consideration to linking mechanisms since the tables were properly normalized (Ndukwe, 2001). The building database was modeled as the primary table (Table 2); while others were modelled as secondary tables (Tables 3 - 6). Unique fields that serve as keys were inserted accordingly. Although there are few entries in which tables that make up the database ordinarily does not necessitate indexing. The entries in the table were indexed. This was because the system if fully deployed supposed to handle census data, which has a complex and large information.

Digital map products

Mapping tools in AutoCAD environment was used for drafting the polygons and the map product was inserted into the ArcView environment for cartographic annotations. Both manual and auto-

Table 2. Buildings - primary table.

Attributes of Buildings_shp								
Shape	**ID**	**House_hold**	**Ea_Name**	**Bld_Type**	**Purpose**	**Ea_Code**	**Local_Govt**	**Comp_Name**
Polygon	1	0	Lg_Hqtrs	Bungalow	Institutional	140161001	Enugu South	Adm_Block
Polygon	2	0	Lg_Hqtrs	Bungalow	Institutional	140161001	Enugu South	Store House
Polygon	3	0	Lg_Hqtrs	Bungalow	Institutional	140161001	Enugu South	Civic Reg Office
Polygon	4	0	Lg_Hqtrs	Bungalow	Institutional	140161001	Enugu South	Chairman's Office
Polygon	5	0	Lg_Hqtrs	Bungalow	Institutional	140161002	Enugu South	Security Post
Polygon	6	0	Eze Park	Bungalow	Recreational	140161002	Enugu South	Kiosk
Polygon	7	0	Eze Park	Bungalow	Recreational	140161002	Enugu South	Adm_Block
Polygon	8	0	Eze Park	Bungalow	Recreational	140161003	Enugu South	Security Post
Polygon	9	20	AP Filiing Stn	Two Story	Mixed	140161003	Enugu South	4 Nnobi Str
Polygon	10	0	AP Filiing Stn	Bungalow	Commercial	140161003	Enugu South	57 Zik's Avenue
Polygon	11	15	AP Filiing Stn	One Story	Mixed	140161003	Enugu South	6 Nnobi Str
Polygon	12	18	AP Filiing Stn	Bungalow	Mixed	140161003	Enugu South	8 Nnobi Str
Polygon	13	25	AP Filiing Stn	One Story	Mixed	140161003	Enugu South	10 Nnobi Str
Polygon	14	22	AP Filiing Stn	Bungalow	Mixed	140161003	Enugu South	12 Nnobi Str
Polygon	15	28	AP Filiing Stn	Bungalow	Mixed	140161003	Enugu South	14 Nnobi Str
Polygon	16	22	AP Filiing Stn	Bungalow	Mixed	140161003	Enugu South	16 Nnobi Str
Polygon	17	24	Lg_Hqtrs	Bungalow	Residential	140161001	Enugu South	18 Nnobi Str
Polygon	18	35	Lg_Hqtrs	Two Story	Mixed	140161001	Enugu South	20 Nnobi Str
Polygon	19	15	Lg_Hqtrs	Bungalow	Mixed	140161001	Enugu South	22 Nnobi Str
Polygon	20	25	Lg_Hqtrs	Bungalow	Mixed	140161001	Enugu South	24 Nnobi Str
Polygon	21	28	Lg_Hqtrs	Bungalow	Mixed	140161001	Enugu South	26 Nnobi Str
Polygon	22	32	Lg_Hqtrs	Two Story	Mixed	140161001	Enugu South	28 Nnobi Str
Polygon	23	15	Lg_Hqtrs	Bungalow	Mixed	140161001	Enugu South	30 Nnobi Str
Polygon	24	33	Lg_Hqtrs	Bungalow	Mixed	140161001	Enugu South	32 Nnobi Str
Polygon	25	28	AP Filiing Stn	Two Story	Mixed	140161003	Enugu South	59 Zik's Avenue
Polygon	26	15	AP Filiing Stn	Two Story	Mixed	140161003	Enugu South	61 Zik's Avenue
Polygon	27	24	AP Filiing Stn	Bungalow	Mixed	140161003	Enugu South	63 Zik's Avenue
Polygon	28	28	IK Aluminium Co	Two Story	Mixed	140161004	Enugu South	65 Zik's Avenue
Polygon	29	18	IK Aluminium Co	One Story	Mixed	140161004	Enugu South	67 Zik's Avenue
Polygon	30	29	IK Aluminium Co	Two Story	Mixed	140161004	Enugu South	69 Zik's Avenue
Polygon	31	14	IK Aluminium Co	Bungalow	Mixed	140161004	Enugu South	71 Zik's Avenue
Polygon	32	27	IK Aluminium Co	Two Story	Mixed	140161004	Enugu South	73 Zik's Avenue
Polygon	33	17	IK Aluminium Co	One Story	Mixed	140161004	Enugu South	75 Zik's Avenue
Polygon	34	23	IK Aluminium Co	One Story	Mixed	140161004	Enugu South	77 Zik's Avenue
Polygon	35	15	IK Aluminium Co	Bungalow	Mixed	140161004	Enugu South	79 Zik's Avenue

Source: GIS lab analysis.

matic text annotation methods were used to process the graphic components. This generated series of thematic maps to fully support population census management, e.g. Figure 3. The product of the carved-out area was overlaid on the raster data (Ikonos) using the georelational mapping tools in ArcGIS 9 (Figure 4). This ensures accurate geo-location and positioning of points for more accurate estimation of population and housing census with spatial credibility. The composite map of the EA (demo site) with the street network, buildings, attribute table, EAs and SAs were in single software (ArcGIS 9).

RESULTS AND ANALYSIS

Analyses on the data set to determine the age, type or purpose of buildings and other facilities within the EAs were performed. Spatial queries were equally implemen-

Table 3. Enumeration area

Attributes of Eas_Shp									
Shape	**ID**	**Ea_Code**	**LGA_Name**	**Demacator**	**Dem_Status**	**Sex**	**Age**	**Dem_Qualif**	**Dem_Code**	**St_of_Orign**
Polygon	1	140161004	Enugu South	Nart Anthony	Ad_hoc	Male	26	HND	EAD70514009	Cross-River
Polygon	2	140161001	Enugu South	Eze Ebere	Ad_hoc	Female	22	Bsc	EAD70514016	Enugu
Polygon	3	140161003	Enugu South	Micheal Peters	Ad_hoc	Male	24	SSCE	EAD70514028	Rivers
Polygon	4	140161006	Enugu South	Sunday Jaja	Ad_hoc	Male	30	ND	EAD70514031	Rivers
Polygon	5	140161007	Enugu South	Oko Anselem	Ad_hoc	Male	32	NCE	EAD70514032	Ebonyi
Polygon	6	140161005	Enugu South	Ososo Sunday	Ad_hoc	Male	24	HND	EAD70514037	Anambra
Polygon	7	140161002	Enugu South	Okike Eunice	Ad_hoc	Female	20	SSCE	EAD70514040	Enugu
Polygon	8	140161008	Enugu South	Momoh Kingsley	Ad_hoc	Male	23	SSCE	EAD70514042	Enugu
Polygon	9	140161009	Enugu South	Mercy Jude	Ad_hoc	Female	19	SSCE	EAD70514043	Enugu
Polygon	0	140161010	Enugu South	Utondu Uzo	Ad_hoc	Female	24	SSCE	EAD70514049	Anambra

Source: Author's GIS analysis

Table 4. Supervisory area

Attributes of Sas.shp									
Shape	**ID**	**No_ Eas**	**POP_ Est**	**Locality_Name**	**Lg_Name**	**State**	**Geo_Pol _Name**	**Sa_Code**	**Area_Meters**
Polygon	1	3	1002	Uwani	Enugu South	Enugu	South East	EAD/Sa/1001	43539.576
Polygon	2	4	0	Uwani	Enugu South	Enugu	South East	EAD/Sa/1002	20909.777
Polygon	0	3	1250	Uwani	Enugu South	Enugu	South East	EAD/Sa/1003	22442.73

Source: Author's GIS analysis

ted based on user specified needs. The basic queries were either single or multi criterion query using the query- builder command in the ArcGIS environment. The Results were presented in form of maps, structured (attribute) database or tables and figures. Analysis on database (Tables 2 - 6) via queries such as: buildings constructed before 1940 in an EA named AP filing Station, and the number of bungalows in place before 1950 within the EAs were performed. Table 2 comprised of 42 buildings made up of 22 bungalows, 8 two-story, 5 one-story, 5 insti-tutional structures, 1 fully commercial and 1 purely residential. This indicates that in the EAs, 83.3% of the buildings are serving mixed pur-poses, 2.38% each were either fully commercial or purely residential, and 11.91% were serving institutional purposes. This can be further ana-lyzed to identify different trends in EAs pattern. Originally the area was built for residential purposes. But with the location of LGAs headquarter within the EA, it can be seen that more offices and services are beginning to take up former residential structures. This trend could mean that the value of land has risen and therefore owners prefer to sell or sublet their property for commercial concern.

Table 3 shows that 10 EAs were involved in the study and these 10 EAs made up the 3 SAs with population estimate of 2252 people (Table 4). Spatial analysis of the area was done on the road network to determine spatial characteristics of the buildings along the roads in the EAs. This indicates that 2 major roads and 14 minor roads were in place. From the 14 minor roads, 4

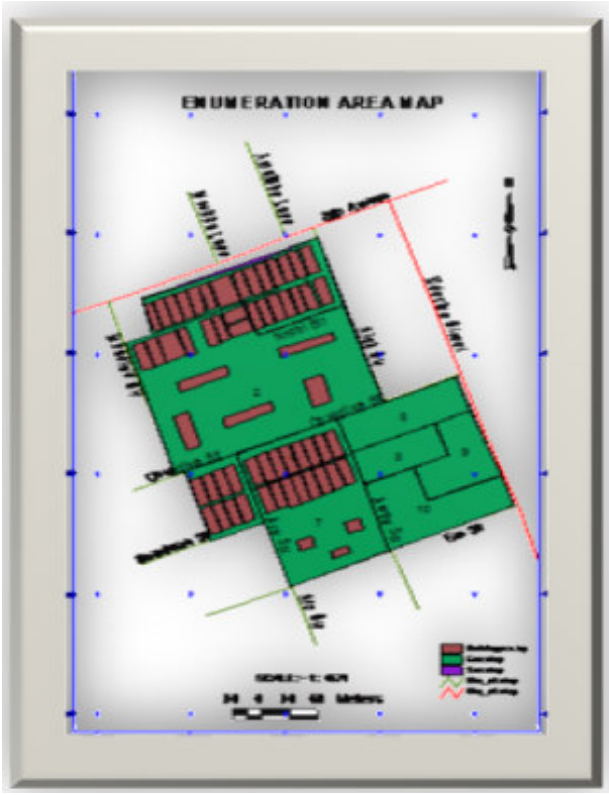

Figure 3. EA Map of the carved-out area.

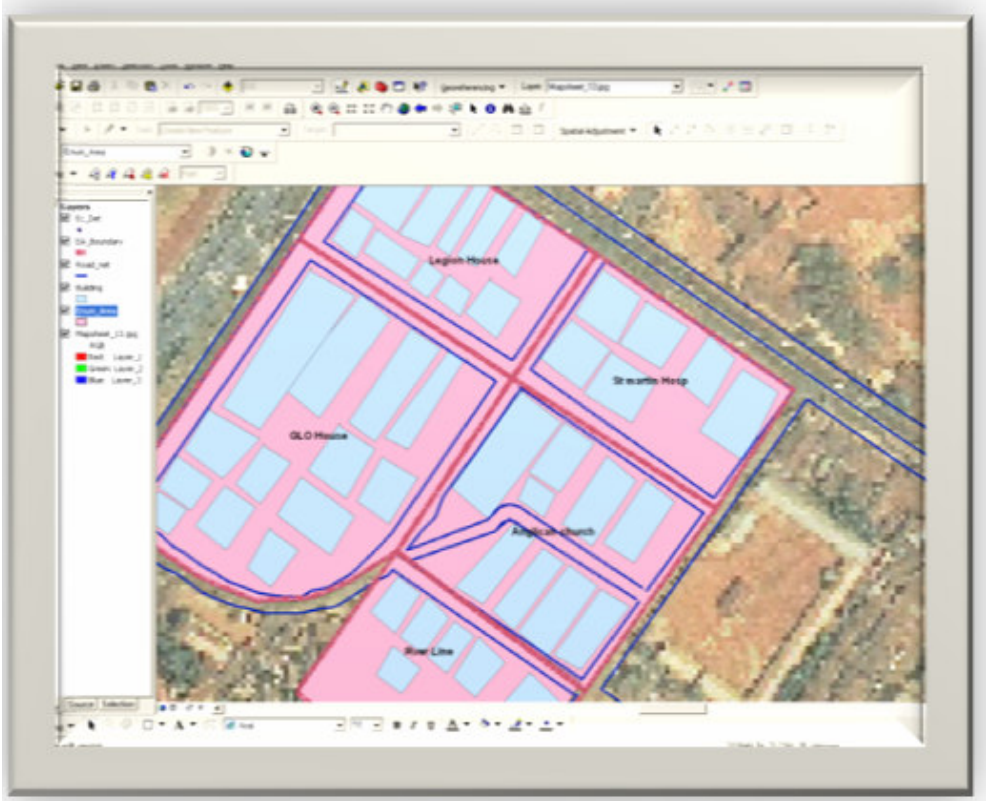

Figure 4. Overlaid map product on the raster data (Ikonos).

Table 5. Supervisory area

Attributes of Min rd_shp							
Shape	**Entity**	**ID**	**R_Name**	**R_Type**	**Status**	**Locality**	**Length _Meters**
PolyLine	Polyline	1	Nsukka Lane	Tarred Road	Serviceable	Zik's Ave-Amaigbo Lane	84.779
PolyLine	Polyline	2	Amaigbo lane	Tarred Road	Serviceable	Zik's Ave - CIC	113.755
PolyLine	Polyline	3	Eze Str	Tarred Road	Unserviceable	Ohofia Str Edozien Str	347.011
PolyLine	Polyline	4	Aro Str	Tarred Road	Fairly Serviceable	Onwudiwe Str -Robinson S	69.605
PolyLine	Polyline	5	Awgu Str	Tarred Road	Fairly Serviceable	Onwudiwe Str -Robinson S	71.475
PolyLine	Polyline	6	Aro Str	Tarred Road	Fairly Serviceable	Onwudiwe Str -Robinson S	156.096
PolyLine	Polyline	7	Onwudiwe Str	Tarred Road	Unserviceable	Ohofia Str Edozien Str	116.426
PolyLine	Polyline	8	Onwudiwe Str	Tarred Road	Unserviceable	Ohofia Str Edozien Str	250.292
PolyLine	Polyline	9	Mbadiwe Str	Tarred Road	Serviceable	Zik's Ave-Onwudiwe Str	204.893
PolyLine	Polyline	10	Nnobi Str	Tarred Road	Under Reconstruc	Ajali Str-Mbadiwe Str	229.534
PolyLine	Polyline	11	Ajali Str	Tarred Road	Under Reconstruc	Zik's Ave-Onwudiwe Str	114.893
PolyLine	Polyline	12	Ajali Str	Tarred Road	Under Reconstruc	Zik's Ave-Onwudiwe Str	91.107
PolyLine	Polyline	13	Awgu Str	Tarred Road	Faily Serviceable	Onwudiwe Str-Robinson S	156.098
PolyLine	Polyline	14	Boardman Str	Tarred Road	Unserviceable	Ohofia Str Edozien Str	187.776

Source: Author's GIS analysis

Table 6. Major roads

Attributes of Maj_rd. shp						
Shape	**R_ID**	**R_Name**	**R_Type**	**Status**	**Locality**	**Length_Meters**
PolyLine	1	Zik's Avenue	Federal	Tarred	Ogui-Agbani Rd	419.638
PolyLine	2	Edozien Street	State	Reconstruction	Zik's Ave-Keyetta	431.294

Source: Author's GIS analysis

roads were unserviceable, 3 serviceable, 4 fairly-serviceable, and the other 3 were under reconstruction (Tables 5 and 6).This could mean that the infrastructure in the area is aging and urban renewal is required to give the area a facelift. These results (maps/tables) is useful to businesses looking for prospective markets; developers in search of home or office, to planners concerned with population trends; and anyone else with interest in the numbers, distribution, income, life styles, etc of the carved-out area. Some samples of the results are as shown in Figures 5-6.

Figure 3 was generated after the drafted carved-out area in the AutoCAD mapping tool was imported to the ArcView 9 environment for appropriate cartographic editing. This indicates the EAs, SAs and the spatial layout of features in the area.

Figure 4 was achieved using the geo-relational mapping tools in ArcGIS 9 environment. The essence is to ensure accurate geo-location and positioning of points for more accurate estimation of population and housing census with spatial credibility.

Some of the results show a single criterion query on the estimated population in an EA with population more than 3003 (Figure 5). This is indicative of the result of digital map interrogation or browsing through the dbase with the help of the prompts (query builders).

Figure 6 was the query result used to determine the number of buildings serving mixed purposes with over 20 household in each of the buildings were 39 buildings. This shows that most buildings within the EAs have changed from their original purpose of pure residential to commercial or both.

Conclusion and Recommendation

The role of satellite remote sensing (SRS) and GIS in population census and management were found effective in this study. Especially, in terms of detection, monitoring, storing, retrieving, querying and analyzing population census and its spatial characteristics. This work uses a query language which combines the power of both SQL and graphic data in object relational model to provide information based on human and physical elements of the area. It provides a visual environment which allows users to display, query and browse their data. It provides a high level data abstraction and combines rules and procedures into data model that makes census data more manageable. The use of SRS and GIS allows regular update of spatial data and thus will resolve the controversies of census estimates. With regular Monitoring population census can be estimated through desktop analysis,

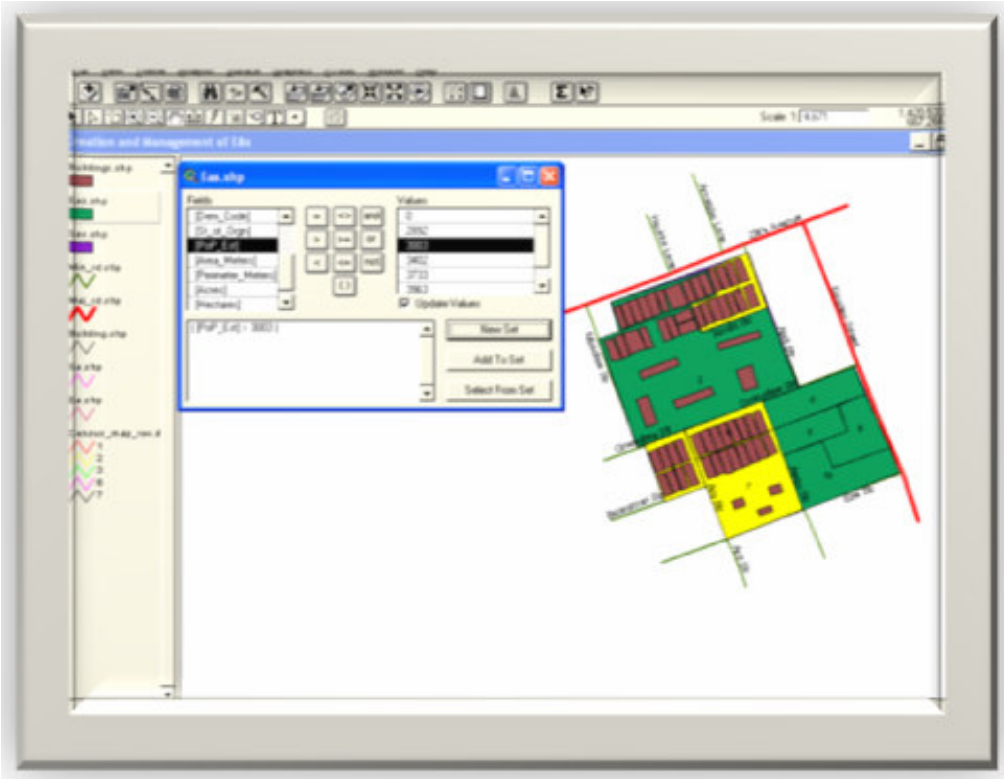

Figure 5. Enumeration area with population estimates of over 3003.

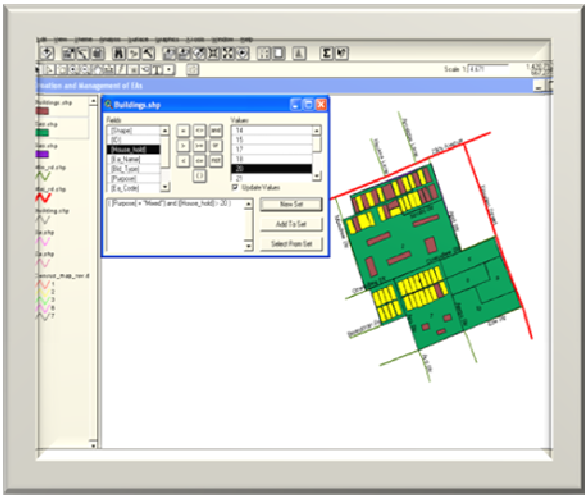

Figure 6. Mixed purpose buildings with household estimate more than 20.

thus saving enormous resources for the nation.

However, checks for data integrity and maintenance are basic for any automated dataset. Thus, to ensure integrity and security of the database, certain measures taken includes creation of backup copies for the work ranging from the digitized map, attributes of the EAs and the results of the analysis for easy retrieval of the database in case of any eventuality. To prevent cases of violation of integrity of the database, both referential and entity rules were applied for achieving these goals. The geographic objects in the study area were properly identified with unique attribute for each. The tools are thus recommended to serve as information medium and standard for implementation of future population censuses by relevant stakeholders. This is to save the nation from the embarrassments of poor handling of census results generated from EAs. The product will be useful to policy makers, investors, developers, and anyone else with interest in the numbers, distribution, income, life styles, etc of the EAs, and also add value to the economic landscape of the nation.

REFERENCES

Chang K (2007). Introduction to Geographic Information Systems, Fouth Edition. McGraw-Hill Publications, a business unit of the McGraw-Hill Co. New York, USA, ISBN 0-07252811-7 pp. 1-18.

Enumerator's Manual (2006). Federal Republic of Nigeria, Enumeration Manual for 2006 Population and Housing Census. National Population Commission, Abuja, Nigeria pp.122

Eze CG (2007). Application of Remote Sensing and Geographic Information System for Creation and Management of Enumeration Areas in Enugu State, Nigeria. Ph.D Dessartation Submitted to the Department of Surveying and Geinformatics, Nnamdi Azikiwe University, Awka, Nigeria.

FRONG (2007). Federal Republic of Nigeria Official Gazette. Printed and Published - the Federal Government Printer, Lagos, Nigeria.

91(Suppl): 24
Lo CP, Yeung AKW (2002). Concepts and Techniques of Geographic Information Systems, Original US ed, Published by Pretice-Hall, Inc., NewJersey, USA, ISBN-81-203-2230-4 pp. 19-62.
Loney K (2004). Oracle Database 10g: The Complete Reference. Tata McGraw-Hill Publishing Company Ltd, New Delhi. ISBN 0-07059425-2.
Ndukwe KN (2001). Digital Technology in Surveying and Mapping: Principles, Applications and Legislative Issues. Rhyce Kerx, Publications, Enugu, Nigeria. ISBN 978-35346-9-0 p.250.
Widijaja M (2001). Nnoo - Welcome to Enugu. An Insight Guide to Igbo land's Culture and Language. Published and printed in Nigeria, by KONGRATS Press, 19 Peter Okoye Street, Uwani, Enugu. ISBN .978-35949-0-7 pp. 1-15.