Delineation Of Enumeration Areas Using Geographic Information System Part Of Atiba Local Government Area, Oyo State, Nigeria

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Abstract—The importance attached to demarcation mapping as a part of integral statutory functions for census in Nigeria cannot be overemphasized. Each Enumeration and Supervisory Area had been designed as national frame for census mapping. The study primarily focuses on the premise that no units of enumerations are not allowed to overlap, it builds the physical and cultural features as options to function as the boundaries for every Enumeration area, and it estimates population of 250-500 people and it builds the Special and regular enumeration area. It treated Ajayi Crowther University, Alaafin Palace and Ajegunle market as special Enumeration area and Adeshina, Baago, Isaleoyo, Ashipa, Saamu, Yidi, Odejin, Okeeebo, Okeeebo II, Adiokuta, Agbaaluasa, Agboye and Agunpopo as regular Enumeration area. Five Supervisory Areas out of eighteen enumeration area were created. Each enumeration areas range from three to five which depends on population in the geographical region. In Ajayi Crowther University (ACU), male population dominated over the female counterparts with 55%, Agboye 53%, Baago 54.6%, Isale Oyo 55% and OkeEebo I 55% while in the returns female population dominated in Adeshina with 55%, Agbaluasa 53.3%, Ajegunle Market 60%, Alaafin Palace 60%, Ashipa 53%, Lagbondoko 51.1%, Odejin 66.7%, EkoEebo II 60.2%, Police Barracks 70%, Saamu 59.4% and Yiidi-Agunpopo 56.25%. Agunpopo maintained optimum population of 50% for the each male and female counterpart. The functional geodatabase was created for digital demarcation mapping for easier update whenever it is necessary.

Keywords—Census;Population; GIS; Enumeration, ArcGIS.

1. Introduction

Past census exercises in Nigeria had been marred with irregularities due to lack of scientific Enumeration space framework with other factors that compromised the accuracy, responsibility and acceptance of census figures. From 1952 to 1953 before independence, census was conducted in Nigeria, however the commission did not utilize maps to ascertain the completeness of the exercise and it absolutely was not typically accepted by the entire country. In 1963, the first post-independence census in Nigeria was conducted. It remained solely acceptable census for planning functions as a result of its absolute focus on human population and socio-economic standing of well-being of Nigerians. It becomes precise for effective socio-planning and use. In 1973, an attempt to delineate the country into Enumeration Area (EAs) began. A total of 112,000 Enumeration areas (EAs) were carried out successfully. The exercise lacked objectives of logical spatial frame work akin to inadequate time for planning and execution, taking census as an ad-hoc exercise which lacks National frame work for proper demarcation and identification of enumeration areas, lack of knowledgeable about skilled in census operation and non-availability of essential materials such as map of demarcation of enumeration area, non-availability of spatial imagery, over-politicization and lack of needed base maps. The results were declared unacceptable and unreliable based on the account of massive inaccuracies in data. This era had been a turning point where funding was given to cater for demarcation in the country as it ought to be in the past. In 1991 precisely, the National Population Commission (NPC) succeeded in subdivision of the country into 212,000 EAs. Thus the results were more accurate, reliable and acceptable because the enumeration was centered upon the spatial features for the demarcations. Though, the results were contested by sectional professional bodies because EA sketches were neither drawn to scale nor georeferenced. This occurred because NPC did not have GIS experts or required more time to achieve such goals. In 2006, 662,529 EAs were produced of which 40,000 digitalized from high spatial resolution images (National Population Commission, 2018), while 622,529 EAs were untouched either drawn to scale, georeferenced or vectorized and that still remain a bone of contention. However, the digitalized 40,000 EAs on high spatial resolution images were better off by traversing, identifying and carving out of EAs boundaries which required zero tolerance for boundary disputes. Its importance in census mapping can no longer be over-emphasized by ruling out direct measurement on the field rather

ground truthing is done to verify and annotate the maps, knocking out the need for reconnaissance survey as it provides an overview of the entire area, ruling out cases of no man`s land and rather aid the total coverage, providing visibility on the imagery both EAs proposed boundaries and existing localities; it provides easy way to delineate EAs or local boundaries using identifiable physical features on the imagery and it finally makes annotation and ground truthing easier [5]. These efforts had been geared towards automation using Geographic Information System (GIS) techniques where features allow drawing to scale, georeferencing and querying to their spatial references inquest to further the next line of actions. From 2006 till date, Delineation of Enumeration Areas had been done using satellite imagery. The results have been very effective by identifying the household and carving out Enumeration Areas' boundaries and Supervisory Area boundaries. Population is defined as the total process of collecting information on the size and characteristics of the population as well as the number and characteristics of dwelling units, various business enterprises and agencies and dissemination of such demographic, economic and social data collected at a particular time or period is known as Population Census [6].The census described as demarcation of territory into smaller census units known as Enumeration Areas [3]. It is one of the most tedious operations to handle but the outcome results are very significant since it displayed precise boundary of Enumeration Areas, Supervisory Areas, Localities, Local Government Area, State and Country [3]. It is evident therefore, that the basic unit of operation is the enumeration area. It requires accuracy and completeness to avoid overlaps at any point in time. Proper delineation of Enumeration Area provides the conceptual linkage between features, census taking, political wards and Localities. Lack of scientific EAs framework, overlapping boundaries, inflating population figures for political reasons, or delineating of no-man's land and among others had contributed to the inaccuracy, unreliability and unacceptability of census values. This study attempts to use GIS approach to create a model and produce maps for census EAs delineation. It is also focused at creation of structured demographic data captured during survey field with EAs and SAs. The EA maps need support of digital mapping to facilitate the management and maintenance of census records which defines one the concept system of GIS.

2. Geographic Location and Description

The study area is Part of Atiba Local Government Area (Fig. 1). It is one of the local governments created from Old Oyo Local Government in 1998. Politically, it is in Oyo State in Southwestern part of Nigeria. It shares border with Oyo East and Ori-Ire local governments in the South-West, and Orelope and Olorunsogo in the North-West, in the North-East, it shares borders with Atisbo and Saki East while in the South-East, it shares border with Oyo West and Itesiwaju local government areas. It occupies total of

166,413.569 hectares with a population figure of 168,246 (NPC, 2006) but 266.149 hectares of the built-up area was selected for the study while the larger portions were covered by the forest. It lies within latitudes$3^{°}$ 49`31``and $3^{°}$ 59`34``N of the equator and longitudes$8^{°}$ 34`44``and $8^{°}$ 35`38``E of the Greenwich Meridian. Its headquarters is Offa Meta. 90% of the people occupied are the Yoruba tribe and they are the tribe of Alafia of Oyo. The remaining 10% contains other tribes.
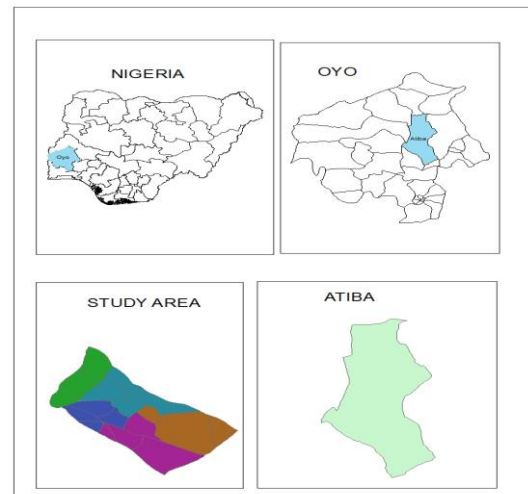

Figure 1: Map showing the study area and Supervisory area

3. Data and Methodology

Creating EAs involves Pre-field, Field work and Post field [5]. The Pre-field exercise involves the gridding of the selected study area in ArcGIS environment by using appropriate coordinate system and it is usually done in the office. The established grid cells are superimposed on the 1m Ikonos imagery which is known as secondary data. These formed the base map for the study. The boundary, roads, footpath, rivers, canals and buildings were extracted from the imagery forming the basis of EAs and SAs. These were verified on the ground as against what was on the map during the field work and Global Positioning system (GPS) was used for update and the Demacator estimate the population. Finally, after the completion of the delineation of EA and SA boundaries which displayed more of Post field. This commences with database design, conceptual and logical schema. [2] describes conceptual design as a process by which real world entities and their relationships are modeled to achieve maximum output while utilizing minimum amount of data. They are stated as follow:

i.   An EA must have a starting point and an end point;

ii.   An EA must have a range of estimated population between 450-500 people in urban areas and 250-400 in a rural area;

iii.   Demarcations should be made with identifiable physical features that stand the test of time;

iv.   An EA must contain record of buildings, roads, footpath, fences etc. and

v.   An SA must be made up of 5 EAs in a rural area and 3-5 EAs in an urban area.

4. Results

Finding a way out of the EAs anomalies in Nigeria becomes critical. Producing EA maps in digital format enhances census preparedness; facilitate the management and maintenance of census records. GIS possesses capability of handling the spatial and non-spatial problems and these make it absolutely different from other computer based information system. In Figure 2, 250 to 500 estimated populations were considered to delineate the EA into the eighteen EAs with aid of polygon and auto complete polygon tools. The numbers of the buildings that fall into the various EAs vary from one locality to another. It is presented in Table 1. This describes the estimated population figures of area that comprises of Ajayi Crowther University, Ajegunle Market, Police barrack, Alafin Palace, Adeshina, Baago, Isaleoyo, Ashipa, Saamu, Yidi, Odejin, OkeEebo I, OkeEebo II, Adikuta, Agbaaluasa, Agboye and Agunpopo. While considering of carving a new Enumeration Area (EA)

or updating the existing ones, the manual guide for the [5] was considered and it stated as follows:

1. That EA must be compact with clear boundaries,
2. EAs must not be overlapping but compact in nature (boundary),
3. All physical and cultural features such as roads, streets, footpaths, fence, walls, gutters, building, survey pillars, and power-line e.t.c. must be properly identified and that may serve as the boundaries of EAs.

4. The estimated population of an EA is between 250-500 people.
5. The EA boundaries must not overlap administrative boundaries that is Atiba L.G.A boundaries should not overlap with Oyo East or remaining LGA boundaries.
6. Special institutions such as boarding house, remand homes, prisons, hospitals e.t.c. should be treated as special EAs where they are big enough to form an EA.
7. An SA must be made up of 5EAs in a rural area and 3-5 EAs in an urban area.

Table 1: Population Distribution of eighteen Enumeration Areas

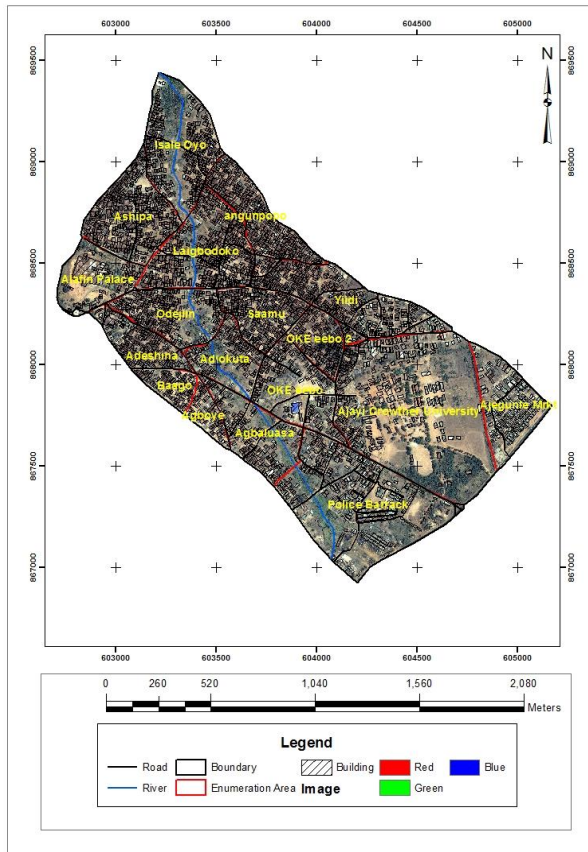| S/N	EA Name	Male Population	% of Total Population	Female Population	% of Total Population	Total Population	% of total Population
1	ACU	275	55	225	45	500	100
2	Adeshina	225	45	275	55	500	100
3	Adiokuta	228	45.6	272	54.4	500	100
4	Agbaluasa	140	46.7	160	53.3	300	100
5	Agboye	240	53.3	210	46.7	450	100
6	Agunpopo	150	50	150	50	300	100
7	Ajegunle Market	200	40	300	60	500	100
8	Alaafin Palace	200	40	300	60	500	100
9	Ashipa	235	47	265	53	500	100
10	Baago	273	54.6	227	45.4	500	100
11	Isale Oyo	220	55	180	45	400	100
12	Lagbondoko	220	48.9	230	51.1	450	100
13	Odejin	150	33.3	300	66.7	450	100
14	OkeEebo I	220	55	180	45	400	100
15	OkeEebo II	199	39.8	301	60.2	500	100
16	Police Barracks	150	30	250	70	500	100
17	Saamu	203	40.6	297	59.4	500	100
18	Yiidi	175	43.75	225	56.25	400	100

Source:NPC,2006

Figure 2: Overview of 1 m Ikonos image for Enumeration Area

(Source: Office of the Surveyor-General of the state, Oyo)

census where every locality were counted per head population [4] in Table 1. The data was linked to the geometric data from the imagery and forming a geospatial database which is usually the heartbeat of any GIS. This has shown its capability by displaying each individual population in gender type by using multiple bar chart as displayed in Table 1 and Figure 3 and also find their population density using appropriate formula from the geodatabase created respectively and the result shown in Table 2 where Ajayi Crowther University (ACU) possessed the least of 995 people per Km^2 while Agboye EA recorded the largest figure of 12872 per Km^2 in terms of landmasses and the bar chart is shown in Figure 3. The highest and lowest population ranges between 500 and 300 per EA in the study.
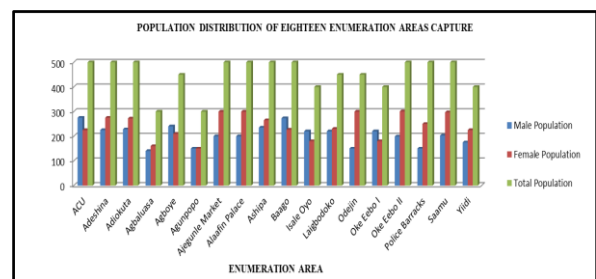

Figure 3: Population distribution of Enumeration Area in multiple bar charts

Population Distribution

The population figures of the Eighteen (18) Enumeration areas were stated categorically in 1991

Figure 3: Population distribution of Enumeration Area in multiple bar charts

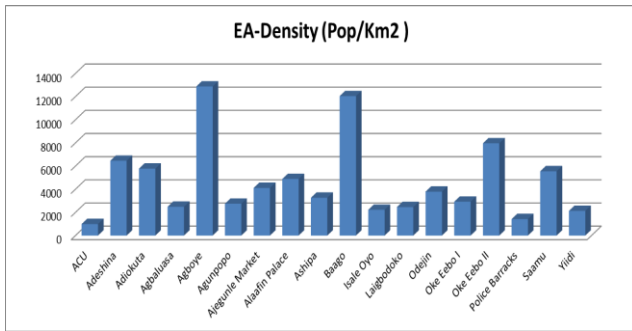| S/N	EA Name	Total Population	Area (km^2)	EA-Density (Population/Km^2)
1	ACU	500	0.502636	995
2	Adeshina	500	0.077442	6456
3	Adikuta	500	0.086537	5778
4	Agbaluasa	300	0.12069	2486
5	Agboye	450	0.034959	12872
6	Agunpopo	300	0.109225	2747
7	Ajegunle Market	500	0.121677	4109
8	Alaafin Palace	500	0.10238	4884
9	Ashipa	500	0.153201	3264
10	Baago	500	0.04153	12039
11	Isale Oyo	400	0.179829	2224
12	Lagbondoko	450	0.183138	2457
13	Odejin	450	0.118662	3792
14	OkeEebo I	400	0.136857	2923
15	OkeEebo II	500	0.062785	7964
16	Police Barracks	500	0.352029	1420
17	Saamu	500	0.090058	5552
18	Yiidi	400	0.187855	2129

Figure 4:The Enumeration Area population density in bar chart

I. TESTING OF DATABASE

The phenomena test were EA regular and EA special in the study. Single criterion query approach was utilized to recover spatial data from the database where the Special Enumeration areas were chosen without other features in the investigation region.

The Syntax = Select * From E_A Where: Enumeration Area = "Special" and the result was displayed in Figure 5; where Ajayi Crowther University, Ajegunle Market, Police barrack and Alaafin Palace were chosen from the database. They are exceptional Special Enumeration areas since people are not permanently residing in these areas. Figure 5 shows the query of Special Enumeration Area from the database, Figure 6 displays the results of the Special Enumeration Areas and Figure 7 shows the generated map of Special Enumeration Area found within the study area and other physical features.
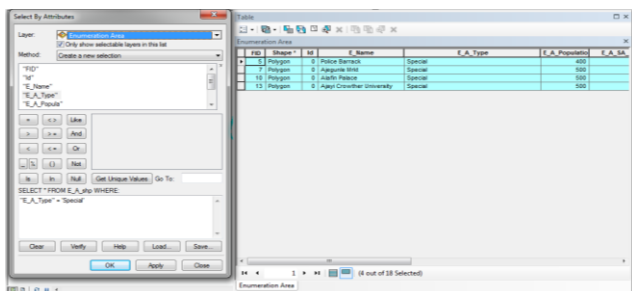

Figure5: Query of Special Enumeration Area

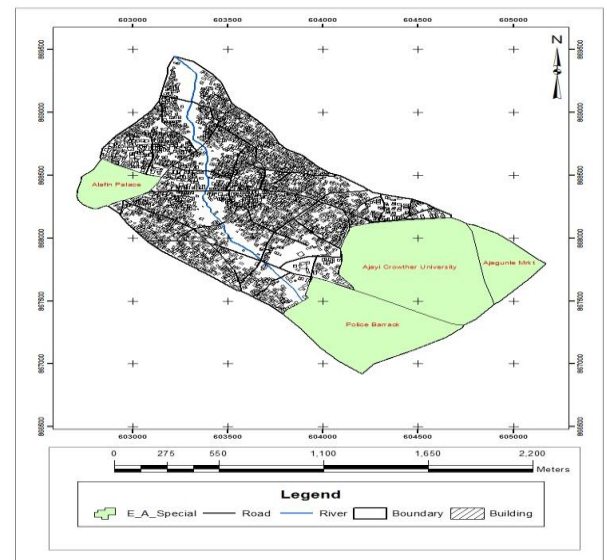Figure 6: Result of Special Enumeration Area

Figure 7: Map of Special Enumeration Area

Figure 8 describes the multiple criteria situations where two or more conditions are used to query from the functional geodatabase created because regular EAs and special EAs make up the Supervisory Area. This multiple criteria condition was employed to retrieve the required information from the database by querying with the Syntax Select* from where: E_A_Type" = 'Regular' OR "E_A_Type" = 'Special'. All the EAs were selected from the geodatabase. Figure 9 presents the map of both the EA (Regular and Special) in colour blue and brown respectively. The Special EA contains Ajayi Crowther University, Ajegunle Market, Police barrack, Alafin Palace while Regular EA contains Adeshina, Baago, Isaleoyo, Ashipa, Saamu, Yidi, Odejin, Okeeebo, Okeeebo II, Adiokuta, Agbaaluasa, Agboye and Agunpopo.
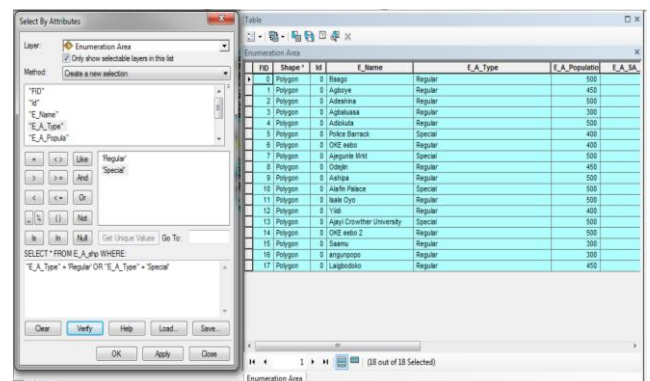

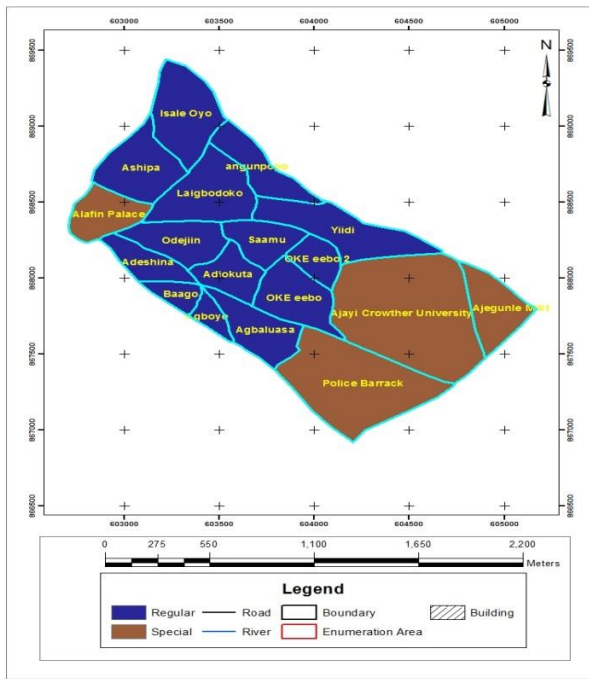Figure 8:Query of Special and Regular Enumeration Area

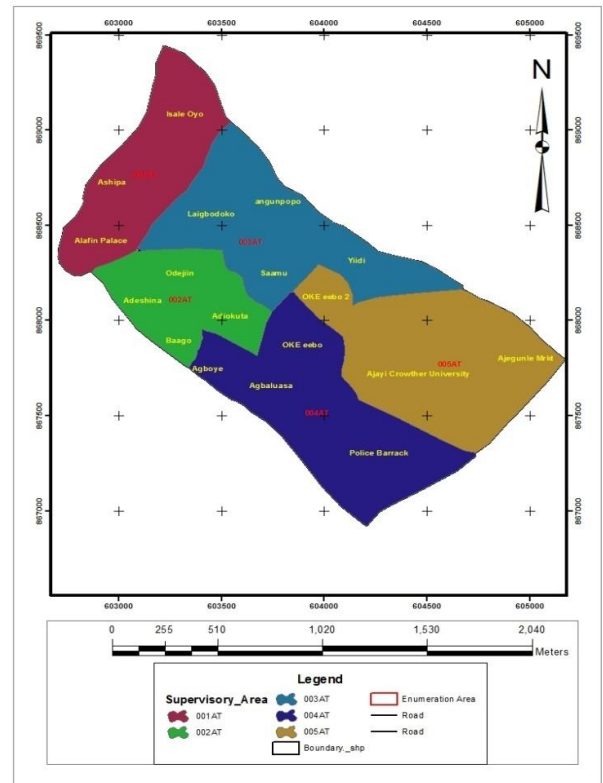Figure 9: Map of Special and Regular Enumeration Area

Figure 10 shows the Map of Supervisory Area and this was to generate the final map aided by the instruction that SA must be made up of 5 EA's in a rural area and 3-5 EAs in an urban area.OyoTownship had been one of the ancient towns in the history of Nigeria and it had been credited as urban. The notableSupervisory area was formed from eighteen Enumeration Areas which contained four special and fourteen regular EAs by considering the estimatedpopulation and numbers of buildings found within the EAs. Five Supervisory areas (SAs) were created from eighteen EAs. The Supervisory Areas were coded based on the Local Governments they are found, AT denotes (ATIBA) i.e. SA 001AT, SA002AT, SA003AT, SA004AT and SA005AT. The SA 001AT contains Alafia Palace, Ashipa and Isale Oyo, SA002AT contains Odejiin, Adiokuta, Baago and Adeshina, SA003AT contains Yiidi, Saamu, Lagbondoko and Angunpopo, SA004AT contains Agboye,EkoEebo,Agbaluasa and Police barrack and SA005AT contains OkeEebo II,Ajayi Crowther University and Ajegunle Market.

Figure 10: Map of Supervisory Area

Discussion

Having undergone the various steps of data acquisition, data analysis and generation of assorted results and maps, it is imperative to discuss the various results that were generated. The populations of the eighteen Enumeration areas were gotten from physical contacts with the residents throughout the census of 2006 as given in Table 1. Figure 3showed the population distribution of every Enumeration space in multiple bar charts. Out of the eighteen EAs created within the study area, Ajayi Crowther University, Ajegunle Market, Police barrack, Alaafin Palace, Adeshina, Baago, Adiokuta, Ashipa, OkeEeboII, and Saamu had population of 500 each, Agboye, Lagbondoko and Odejin had total population figures of 450 each, IsaleOyo, OkeEeboI, and Yidi had a total of 400 each and lastly Agbaaluasa and Agunpopo had three hundred each. In Ajayi Crowther University (ACU), male population dominated over the female counterparts with 55%, Agboye 53%, Baago 54.6%, Isale Oyo 55% and OkeEebo I 55% while the female population was greater in Adeshina with 55%, Agbaluasa 53.3%, Ajegunle Market 60%, Alaafin Palace 60%, Ashipa 53%, Lagbondoko 51.1%, Odejin 66.7%, EkoEebo II 60.2%, Police Barracks 70%, Saamu 59.4% and Yiidi-Agunpopo 56.25%. The Agunpopo Enumeration space maintained optimum population of 50% for the each male and female counterpart. Within the population density, Agboye, Baago and OkeEebo II maintained the most important dry land, no thanks to the actual fact there exists an old garage within the

Enumeration area that had extended towards southern and western parts to Baago and OkeEebo II as 12872, 12039 and 7964(Km^2) whereas ACU, Police barracks and Yiidi had the smallest unit in terms of landmass among the other Enumeration areas as 995, 1420 and 2129 (km^2). Single criterion query approach was utilized to recover spatial data from the database where the Special Enumeration areas were chosen without other features in the area. The Special Enumeration areas contain Ajayi Crowther University, Ajegunle Market, Police barrack and Alaafin Palace as a result of the activities taking place in the area on occasional basis whereas remaining Enumeration Areas that contained Adeshina, Baago, Isaleoyo, Ashipa, Saamu, Yidi, Odejin, Okeeebo, Okeeebo II, Adiokuta, Agbaaluasa, Agboye, Lagbondoko, Agboye and Agunpopo were found to be Regular Enumeration Areas.

Multiple Criteria query operation was deployed to extract from the database the regular EAs and special ones that make up the Supervisory Area. The special Enumeration areas had four and regular Enumeration Area got fourteen which make up the Supervisory area in the study area. Special EA covered 107.8722km^2 whereas regular EA covered an area of 158.27km^2.The Supervisory area was created from eighteen Enumeration Areas by considering, the population and number of buildings. Five Supervisory areas were created from eighteen enumeration areas by taking the population and numbers of buildings into consideration.

The Supervisory Areas were coded based on the Local Government they fell within. They were presented in these manners; AT denotes (ATIBA) i.e. SA 001AT, SA002AT, SA003AT, SA004AT and SA005AT.The total numbers of 3521 buildings were extracted. ACU contained 74, Adeshina contained 158, Adiokuta contained 134, Agbaluasa contained 157, and Agboye contained 64. Agunpopo contained 326, Ajegunle Market contained 128, Alafin Palace contained 48, Ashipa contained 322, Baago contained 93, Isale Oyo contained 275, Lagbondoko 396, Odejin 205, Oke-ebo 154, Oke-ebo-II 153, Police Barrack 195, Saamu 252 and Yiidi contained 390.

Conclusion

In delineating the enumeration area, database was created, tested and analyses were performed based on the criteria set for the study. The result had shown that GIS techniques were capable of handling the pre and post enumeration area demarcation. It possessed a strong link between the spatial and non-spatial data within the EAs in the study. It builds from the kernel of Enumeration area to the most important unit that referred to as super ordinate space which model had been excellent. Finally, the study has been able to establish that, enumeration space delineations can be effectively designed for census.

Recommendations

The following are recommended at the end of the study.

1. Census counting should commence from enumeration areas to supervisory areas then to localities, LGAs, state and country at large.
2. National Population Commission should embrace a well-structured database for all the 582,529 EAs of which 40,000 EAs have been kicked off in 2006.
3. Census exercise should be conducted at ten (10) years interval.
4. The commission should develop well-structured database of all maps, which can be updated from time to time and
5. Gap between censuses should be used in staff training and development.

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