
CONTEMPORARY PRACTICE IN MODELING DEMOGRAPHIC DETAILS IN AN INTERACTIVE SYSTEM

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ABSTRACT

This paper made attempts to unravel the unique processes in using an interactive system known as Geographic Information System (GIS) to model demographic details of an area in Nigeria. In order to achieve the main objective of the paper, an interactive computer-based system that can support effective management of demographic data management was developed. In the process, attribute data modeling and linkage of the attribute data with the spatial information was performed. The main package for the study was the ArcGIS 9, which was complimented with AutoCAD among other softwares. They were useful for the dataset querying and analysis. Demographic datasets thus provided an important input to GIS. The study was restricted to GIS and its implication in database building and management for spatial and non-spatial dataset required for overlay and query analysis. Therefore, complex statistical details and other demographic variables that accompany census related activities were not on focus. Recommendations were suggested after the exercise.

Keywords: *Interactive, Demographic dataset, Contemporary practice, modeling.*

INTRODUCTION

The conventional method of handling map and map-data (pure analogue data) which has been the case in the past has not yielded the desired output, because it is in most cases not easy to integrate in terms of linking mechanisms. Analogue maps which should be the bases of demographic activities are not easily updated (revised). Geographic information system (GIS) is ideally suited for management of various demographic details such as, base mapping, delineation of enumeration areas (EA), post-census verification and analysis. Demographic studies have taken advantage of the latest GIS tools in planning, execution, processing and analysis of datasets needed for physical planning and resource sharing. GIS allows user to be more productive and devote more time to understanding problems and less time to the mechanical task of preparing input data and interpreting the output. Though, this technological capacity has not been fully maximized in various Nigeria's national census exercises (Eze, 2009). Currently, GIS is being implemented for census planning and management in Nigeria. This is probably due to the perceived benefits offered by GIS and other geospatial tools in census operations and management. The United Nations Statistics Division emphasis on recent geospatial technological advances and contemporary practices in census-mapping and the use of GIS (United Nation, 2009) were among the main forces heightening the use of this technology. However, a standard concept of population census management remains elusive due to its multidimensional nature as well as its dynamic properties (attributes). The census mission is the collection and provision of timely, relevant

and quality socio-demographic data. The knowledge of the population, and its attributes distribution and spatial contents means well for the standard of development planning in any particular city. But how interactive are the population figures-based? For the past 50years or more, national census operation has come under severe criticisms for failure of the exercise to produce an interactive (linked and queried) census (database) results. What is at stake is for Nigeria to produce a locally and internationally linkable result through the use of geospatial modeling tools and inputs. Details on problems faced by census in Nigeria were given in Eze and Igbokwe (2010).

OBJECTIVE AND SCOPE

The main objective of the study is to evolve ways with which the nation can embark on automated (interactive) census activities. In order to achieve the above objective the following functions will be performed:

- a. Development of computer-based system that can support the effective management of census operation.
- b. Attribute data modeling and linkage of the attribute data with the spatial information.

This is useful in census data querying and analysis. The population spatial distribution and the (population) predicted level are essential information to planners and developers when deciding what types of facilities need to be constructed now in order to best suit the needs of the future population. Census data thus providing an important input to GIS. The study is restricted to GIS and its implication in database building and management for spatial and non-spatial data required for overlay and query analysis. Therefore, complex statistical details and other demographic variables that accompany census activities will not be in focus.

CONTEMPORARY PROCESSES

In contemporary practice, the unique (industrial) process in GIS technique could be phased into seven (7) as shown in Table 1 below. However, these unique phases involve other details as contained hereunder (a-g). The main essence is to guide the product (dataset) modeler on the standard procedure for data acquisition, processing, quality checking, analysis, and or product delivery stage. It is also meant to add value to product delivery time by speeding up the process since the stages/phases involved are clearly known.

Table 1: Unique Process

Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7
Collection of input map from client	Scanning of maps	Digitization of scanned maps	Edge matching of sheets in vector format	Geo-referencing/ Geo-rectification	Quality checking/A ssurance	Product delivery

(a) Phase 1: Collection of Input Map from Client

- Collection of maps
- Procurement of satellite image
- Plot wise distribution of parcels through survey
- Plot wise survey and corresponding details with respect to each plot
- Geo Referenced Administrative Boundary Map

(b) Phase 2: Scanning of Maps

- Scanning of all map sheets
- Rectification of the scanned maps with precise grid network (Rectification of scanning distortion)
- Noise removal and Quality checking of scanned maps

(c) Phase 3: Digitization of Scanned Maps

- Template creation
- Blocks/symbol creation
- Digitization and Labelling with unique keys
- Map cleanup and topology building
- Date base Generation

(d) Phase 4: Edge Matching and Mosaicking of Sheets In Vector Format

- Edge matching mosaicking
- Clean up and topology building
- Checking for edge match distortion
- Feature table identification
- Building of the metadata submitting the data

(e) Phase 5: Geo-referencing/Geo-rectification

- Identifying of common features on vectorized map and imagery and building models
- Checking of GCPs, models and RMS
- Overlaying of maps and image to check for fitting
- Transforming of village maps and adding of projection parameters

(f) Phase 6: Quality Checking/Quality Assurance

- Generating check plots (100%) in color and quality checking of digitized maps

(g) Phase 7: Product Delivery

- The product delivery is done as follows:
 - CD
 - Internal ptp
 - E-mail transfer
 - A Microsoft Excel file is created containing the names of sheets, title etc. is created for reference.

Research Methodology

Data Collection

An integrated digital technique (GIS) with its powers to accept inputs from various sources on an interactive system through its queries were used for data collection for the study and thus, the methodological frameworks shown in figure 1.

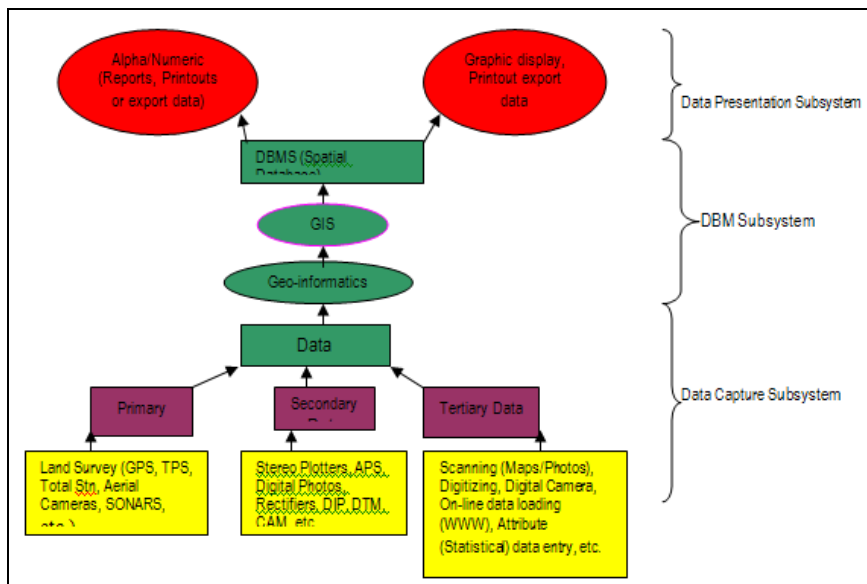


Fig 1: Methodological Framework Used in GIS technique

The relevant datasets used for the study, includes:

- Data collected from the field - based on combination of on-the-ground (GPS) observations.
- modified forms and questionnaire - sourced from NPC's offices, Abuja.
- IKONOS-1m resolution satellite image data - was made available on request at NASRDA, Abuja.
- analogue (and digital) maps at various scales, e.g. topographical maps (scales 1:50,000 to 1: 25,000) admin map (scale 1:1, 000000) and cadastral maps (scales: 1:2000-1:3000) – collected from Land and Survey Division, Abuja.
- Other information (text and numeric) were sourced appropriately from the world wide websites (WWW), Journals, Publications, etc.

PROCEDURE

The dataset processing entails all processes concerned with the transformation of data acquired in terms of its validity, required format, classification, modeling, storage and sometimes updating (maintenance). The major roles of topographic base maps, includes planning purposes, especially in logistics planning and in rural areas where they served as aid to location of travel routes to various localities. They were scanned at 150-~~X~~-150dpi (resolution) and in full RGB colours using Mustek A3 scanner, and later overlapped. Raster-

to-vector conversion was carried out in both automatic bitmap and manual tracing. The two processes used both application and complimentary packages. Such as: *CorelDraw Graphic 12 Software Suite* that handles automatic bitmap tracing. The scanned raster-map was inserted into AutoCAD Map 2000i for map construction, due to its rich contents in tools that are suited for interactive map construction. The admin-maps were used in conjunction with the gazetted names of autonomous communities which are the basic unit upon which the EAs were based. Cadastral maps were particularly useful in the urban centers where there are large concentration of details and people. Since Nigerian urban areas contains over 60% of the population. However, the Corel-Photo and Adobe Photoshop packages complimented the scanning process. Satellite (IKONOS 1-meter in multi-spectral band and SPOT 5) images were very helpful due to the 'currency' (most recent) of the imagery among the various graphic (maps) inputs available. Also, large-scale aerial photos and ortho-photo maps make excellent base-maps for census surveys especially in very rural areas which do not have existing maps. This could have been used in this work, but was not used due to incomplete coverage of the study area and 'out-datedness' of the photos (1963 and 1966 coverage's). Substantial preprocessing was required on the relevant imagery before it could be utilized for EAD. The study area was framed and extracted using the input criteria of centre coordinates (latitude and longitude). However, the framed Ikonos image was subjected to image reprocessing for the purpose of achieving desirable (higher) image data quality to be used for geo-registration and feature digitizing, in ArcGIS 9.1 environment. The image reprocessing module of this enabling software was used for a three band (RGB) recombination in conjunction with other image reprocessing techniques such as contrast stretching, histogram equalization, edge enhancement, etc.

The field observation involved the identification, reconnaissance, and GPS point fixing using Garmin GPSMAP 76C handheld receiver. The GPS point fixing based on Zone 32 were used for direct input of coordinate value in AutoCAD Window. This usually requires three points with other point(s) acting as a check for the georeferencing. In the process, pictures to aid visual appreciation of the spatial and network analysis of the site were acquired using Cannon Power Shot-Digital Camera. Oral interviews (narrative aspect of data gathering), were used to fill-in the various questionnaires in-suite. The house listing and enumeration were carried out using the EAD forms that were actually modified to the researcher's specific needs to create database tables.

Database Creation and Modeling

Unique fields that serves as keys (primary and foreign) were inserted in the tables, though there are few entries in which tables that make up the database and which ordinarily does not necessitate indexing. The entries in the table were indexed because the system if fully deployed supposed to handle census data, which has a complex and large information. Before the databases were created - the geographic features and their classes (shapes) and attributes were declared (table 2). The field data type listing were equally declared, and besides stating text [string], number or memo, the width to be covered by the text or number in the database table must also be declared and any excess was naturally truncated. Report and geometry were attached respectively as graphics and texts to records, and they

formed part of primary tables' values in the database tables. The fields and attributes of the abstracted database (tables) are shown as table 3 below. The data modeling process is one of the most important tasks and aspects of our GIS database development process. The data are structured, arranged and sorted in such a manner the GIS can easily understand each table and how the fields are defined. This made the querying of the table possible. It is important at this juncture to remember that an important property of a good GIS is its capability to display the spatial distribution of the objects concerned. To achieve this, linking and joining of the data attribute in the Arcmap-ArcInfo environment with the graphic map were carried out.

Table 2: Entities with their Geographic Features/shape and Attributes

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

Table 3: Field Data Type Listing–Relations, Attributes and their Data Declaration

Table Name	Attribute	Description	Data Type	Data Width
Buildings	Shape	Polygon	Polygon	-
	ID	Building Identifier	Number	10
	House_hold	Number of	Number	5
	Ea_Name	Persons	String	20
	Bld_Type	Enumeration Area	(Text)	16
	Purpose	Name	String	15
	Ea_Code	Type of Building	(Text)	12
	Local_Govt	Purpose/ Use of	String	14
	Comp_Nam	building	(Text)	20
	e	Code Number of	Numeric	5
House_No	the EA	String	6	

	Bld_Age	Name of LGA	(Text)	
		House or Street Name	String (Text)	
		Street Number of the house	Number Number	
		Year of construction of Bld		
Enumeration Area (Eas)	Shape	Polygon	Polygon	-
	ID	EA Identifier	Number	5
	EA_Code	Code Number of the EA	Number	16
	LGA_Name	Name of LGA	String (Text)	15
	Demarcator	Name of LGA	(Text)	15
	Dem_Status	Name of	String	10
	Sex	Demarcator	(Text)	8
	Age	Employment	String	5
	Dem_Qualif	Status of Dem	(Text)	6
	Dem_Code	Sexuality of the Dem	String (Text)	13
	St_of_Origin	Age as the time of EAD	Number String	12
		Academic Qualification	(Text) String	
		Service Number of Dem	(Text) String	
		State of Origin in Nigeria	(Text)	
Supervisory Area (Sas)	Shape	Polygon	Polygon	-
	ID	SA Identifier	Number	5
	No_EA's	Number of EAs	Number	5
	Pop_Est	Population	Number	10
	Locality_Name	Estimate of	String (Text)	10
	Lg_Name	Locality\Community	String (Text)	15
	State	Name of LGA	(Text) String	10
	Geo_Pol_Name	Name of State	(Text)	15
	Sa_Code	Name of	String	16
	Area_Meter	Geopolitical Zone	(Text)	Auto allocation
		Code Number of SA	String (Text)	
		Size of Land Space (Units)	Number	
Minor	Shape	Polyline	Polyline	-

Roads (Min_rd)	Entity	Polyline	Polyline	-
	ID	Road Identifier	Number	10
	R_Name	Name of Road or	String	20
	R_Type	Street	(Text)	16
	Status	Type of Road or	String	20
	Locality	Street	(Text)	25
	Length_Meters	Present Condition of Rd	String (Text)	Auto allocation
		Name	String	
		Locality\Community	(Text) Number	
		Distance Covered in Meters		
Major Roads (Maj_rd)	Shape	Polyline	Polyline	-
	R_ID	Road Identifier	Number	10
	R_Name	Name of the RD	String	20
	R_Type	or Street	(Text)	10
	Status	Type of RD or	String	20
	Locality	Street	(Text)	20
	Length_Meters	Present Condition of Rd	String (Text)	Auto Allocation
		Name	String	
		Locality\Community	(Text) Number	
		Distance Covered in Meters		

Note: All the IDs (Code) - Integer; Names- String; Centroid- Point (X, Y); Sizes - Real number or float; Dates – Date; Reports - Text or String; etc.

DATA PRESENTATION AND ANALYSIS

Map Layers

Some of the map layers (products) achieved during the map construction was as shown in figure 2 (a-f):

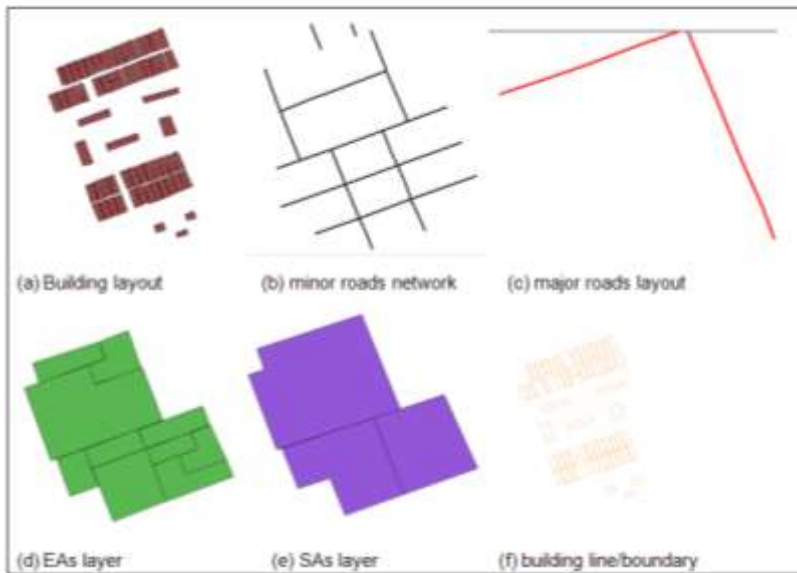


Fig.2: Map layers generated

Layers help a GIS user to sort out the relationship between different maps (layers) in map comparison. If the maps to be compared consist of only point or line features, they can be coded in different colours and superimposed on one another in a single view. But this process becomes difficult if they include polygon features or raster data (Chang, 2004). One option is to use transparency as a visual variable. A semitransparent map allows another map to show through. Therefore, if the maps to be compared are both in raster format, one grid can be displayed in a colour scheme and the other in semitransparent shades of gray. The grays simply darken the colours symbols and do not produce confusing colour mixtures. Application of transparency is, however limited to two raster or polygon layers. Place all polygon and raster layers, along with other point and line layers, onto the screen but turn on and off polygon and raster layers so that only one of them is viewed at a time (figure 2). The other two options for comparing polygon or raster layers includes; the use of a set of adjacent views, and use of map symbols that can show data from two polygon maps.

Merged Layers

The final product of the cartographic work in any GIS is usually a component of all the layers merged to form a map (figure 3). On completion of the digitization process in the AutoCAD, the map was exported into the ArcGIS, with a view to carry out necessary management, spatial analysis and querying using in-built SQL (Standard Query Language). The ArcGIS default layout makes it easy to produce quality maps with ArcView-ArcMap. The layout has the ability to assemble and arrange all the components as desired to appear on a map and in desired format (design). This automatically assigns grid, legend, scales, etc. It is known that manual process (editing) are used to complement the automatic process. The purpose is for map beautification (aesthetics value), improvement of visualization and communication aspects.



Fig 3: The all-layer-merged portrait layout map of after on-screen cartographic process.

In some cases further editing (map cleaning) and digitization of features like roads to polyline, buildings to polygons, etc, were also carried out in ArcGIS environment for complete compatibility of data. Once the well structured attribute data tables have been linked with the graphic database (map product) an interactive system (GIS) emerges. The querying tool in ArcGIS is then used to build fast and easy queries. The extent of possible queries in any GIS database depends on the amount, variety and structure of the attribute data. The possible queries are user defined (thus depend on users needs).

Spatial Query

Analysis by spatial query using the interactive map products provided answer for single and multi criterion queries. Single query brings one field result, while multi-criterion brings more than one field to generate result. In this study, both single and multi criteria queries were performed using the query builder for basic commands. A further analysis on the road networks using buffering operation was achieved. The aim of buffering on the road networks of the area was to enable analysis in relation to the buildings too close to the road at 10m distance (figure 4). On the bases of minimum allowable distances from the roads, the buffering result indicates that most buildings along the streets were found to be a big constrain for future road expansion.

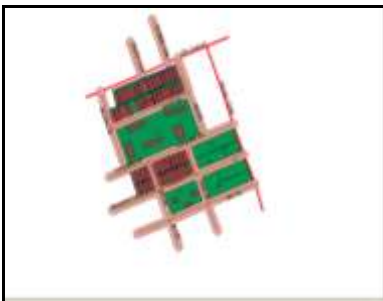


Fig 4: Result of buffer on Road Network at 10m

Result Assessments

Figure 1: Shows the methodological framework used in GIS technique for the purpose of achieving the objective of the study. Figure 2 presents the various component layers generated. The various layers are used for map (layer) comparisons, and when the

generated layers were merged, a single portrait (map product) was generated as shown in figure 3. The buffering operation for spatial analysis resulted in figure 4. This shows the buffered road network at the area and it was deduced that most of the buildings are less than 10m away from the streets. This could make feature road expansion nearly impossible or still at a very high cost implication. Since efforts to expand such roads may involve demolition of some buildings. This will lead to displacement and relocation of inhabitants of the area, and could result to decrease in population of the area.

On the tables, Table 1: shows the main unique process or phases of conducting the dataset modeling in contemporary GIS technique. Table 2: shows the geographic entities with their Geographic features/shape and Attributes. Table 3: shows the field data type listing–relations, attributes and their data declaration. It also infers that the construction of database using the GIS technique is dependent on the extent of data declaration. When the databases are properly structured, it provides the user with available information on the database and serves as a spatial decision support system for solving spatial problems. These further shows the effectiveness of spatial and attribute linking in modeling of census database, which was evident on the ability of the computer-based system to interactively provide answers to the spatial queries.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The remarkable contributions made in this work were found on the fact that, the project further demonstrates the efficacies and 'power' of GIS in terms of integrating the spatial and attribute content in a single domain, and its applications in analyzing the vector content from map data and attributes (descriptions) in one software. This has facilitated database queries based on spatial and attributes tables as demonstrated in the project. This was made possible through the use of AutoCAD facilities for updating and planning using raster data; conversion of base map to digital format, and features were then digitized into different themes. Also, designing and creation of database through extension (in-built) facilities of the ArcGIS for the purpose of information representation and spatial analysis. Moreso, geospatial tools are for feature research on human well-being, with respect to sustainable development. Performing spatial analysis is what sets GIS apart from other information systems. The ArcMap-ArcInfo GIS was used to carry out the analysis. These analysis involved query, layering and network buffering operation. At the end of the analysis, the results confirmed the efficiency of GIS approach in detection, monitoring, storing, retrieving, querying and analyzing census spatial patterns and human activities on earth's surface.

RECOMMENDATIONS

In view of the effect of the input and output specifics on this study, the following recommendations were carefully made:

(1) The current (contemporary) drive is information technology (IT); as such census data can be made readily available to other relevant ministerial and extra-ministerial departments that were saddled with overall national (political, economic, ecological and social) planning through the internetworks.

- (2) For proper coordination and dissemination of census outputs which is in form of graphics (maps) and data (database) a national data sharing standard is very crucial.
- (3) That database creation is central to GIS and should remain mandatory to GIS practitioners. This will go a long way in supporting local (regional) spatial and non-spatial information base.
- (4) Database processing including GIS expertise are scarce, especially in the areas of software engineering. This is why 100% of commercial and research packages used in the country are imported mainly from India and other western nations. Therefore, there is a great need for locally made packages (software).

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