A GEO-REFERENCED INFORMATION SYSTEM FOR POPULATION MANAGEMENT

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ABSTRACT

A key requirement in the planning, development and management of human population, National economy, National manpower, National Security, and National Resources is the knowledge of the population of a nation. Population management, entails the processes and procedures involved in the acquisition, storage, retrieval, analysis and dissemination of appropriate information designed to manage the human resources of the people(s) living within a particular geographical entity.

The implementation of an effective population management system, will determine to a large extent, the degree of success or failure of any hybrid programme designed to provide and manage sub-settlement projects within and without (as occasioned by refugee problems) the geographical entity. Such population management system will require some critical but efficient information processing tools that may require the setting of certain standards, procedures and designs (of appropriate hardware and software packages). A strategic composite of such a system is the Geo-referenced Information System (GIS), a system designed for the capturing, storing, checking, retrieving, integrating, analyzing, and displaying spatial information.

The authors adopted parts of the 1991 census data of Nigeria for a sample implementation. The results indicate that, if optimally applied, the system stands to enhance planning, decision-making, policy formulation, resource allocation and developmental programs of government, non-governmental organizations, International bodies and other corporate entities with sufficient interest in managing human resources management.

1. INTRODUCTION

The human race is faced with an increasing number of resource management and environmental problems. Population growth, particularly in the developing world, has become a significant part of these environmental problems. Simply put, a major problem of lasting significance facing the world in this century may well be the sudden and unprecedented expansion of its population. Studies have shown that, the recent population growth in all regions of the world was the consequence not of increased birth rates *per se,* but of unprecedented worldwide decreases in the death rate especially in countries with developed economy.

Reasons adduced have been that, since the 20th century the human race had begun to declare victory over both famine-related and infant mortality problems and at the same time significant advances in public health and medicine were applied. These advances, although felt around the world, did not happen in the same way in today's richer and poorer nations. Death rates--already lower in Europe and North America--declined more gradually in these more developed areas, basically due to change in preference from large family size to the much smaller sizes prevalent today.

These advances also came at a different stage of development in the third world from what applied in earlier decades in Western Europe and North America. With the majority of population still agrarian in nature, children were still deemed an economic asset, and as a result, birth rates in these countries did not typically fall in concert with death rates. Population growth rates climbed to unheard-of heights: at three or four percent per year--a pace sufficient to double a country's population in about 20 years. As a result, 89 percent of global population growth is reported to have occurred in the developing countries since 1950.

It is therefore imperative that an effective approach for managing these figures be designed particularly for regions/countries most affected.

2. OBJECTIVES AND REQUIREMENTS

2.1 Objectives

There are several reasons that can be adduced for the need to put in place a Geo-referenced information System for productive population management, some of which are listed below:

1. Providing the platforms for studying the dynamics of population and social change.
2. Generating plans for the future on the basis of present understanding and current action.
3. Creating programme/projects that are maximally effective yet economical in tackling needs of the populace.
4. Establishing priorities and otherwise provide a rational basic for taking action to alleviate needs.
5. Identifying current and future needs of the various groups in the society.
6. Identifying current needs of various sectors of the country for services.
7. Measuring progress in goals attainment.

2.2 Requirements:

The key requirements for population management include the maps, census data, and the tools for its management – the GIS;

2.2.1 Census Mapping and Map Data Requirements

The mapping requirement will consist of two classes of maps:
- The paper/analogue maps
- The digital maps (either from the satellite/photographic imageries or digitized/scanned analogue maps).

The Maps
The categories of maps needed for an accurate census may be enumerated as follows:
- National Administrative maps (1:5000,000:1,500,000)
- States Administrative maps (1:50,000 – 1:500,000)
- Maps of local government areas (1:25,000 – 1:50,000)
- Urban maps (1:10,000 – 1:25,000)
- Maps of settlements (1:5,000 – 1:10,000)
- Maps of Administrative units within towns (district maps) – 1:5,000 – 1:10,000

These maps provide necessary information, particularly at the local government/cities/towns levels, for the purpose of delineating the population Enumeration Areas (EA). Thus apart from supporting census data gathering, they can form the respective base maps upon which the development of the database system for population management is based depending on the scope of coverage; for instance, at the national level, the national administrative map will form the base map and vice-versa.

The maps could cover different themes, such as utility land use, planimetric and/or topographic maps. In current digital environment, remote-sensing images can be used to generate the needed maps, even in large scales because demarcation of administrative boundaries is faster with remotely sensed imageries.

Remotely Sensed Data

Remotely sensed data could be from either aerial photography or from the earth observation satellite system (EOSS). These data cannot be used in their raw form in census gathering and population management. They have to be processed and information needed for a realistic census extracted. This processing in a digital environment is known as digital image processing (DIP).

In case of aerial photography, the analogue photographs will have to be converted to digital form by scanning. Digitized aerial photographs can be processed in digital photogrammetric workstations. There are now digital aerial camera systems, which acquire images directly in digital form. Digital processing of aerial photographs, usually for production of orthophoto map which can be used in a census exercise, follow these operations, (Igbokwe, 2001).
1. Radiometric Correction/image enhancements
2. Automatic point identification/orientation and Aerotriangulation.
3. Image matching and feature extraction.
4. Interface with GIS.

In case of Data from EOSS, the method of digital processing differs slightly and include:
- Initial statistical Extraction to assess the quality of image
- Radiometric/Geometric correction
- Image enhancement
- Thematic information extraction through supervised or unsupervised classification.

A more generalized variety of pre-processing procedures that, in addition, requires non-spatial data prior to encoding or interface to GIS will include, (Terence, et al 1987):
12. Format Conversion
    - Conversion between different data structures
    - Conversion between different data media
13. Reconstruction and Generalization of data.
14. Error detection and editing
15. Merging of points into lines and lines into polygons.
16. Edge matching
17. Rectification and registration.

The thematic information required for census exercise belongs to either of a Point, Line or Area feature classes. These are known as topological entities. Examples of the point feature objects are, buildings, bridges, road junctions, etc; Linear: roads, street rivers, etc; and Area: districts, towns, settlements, etc. These features are very vital in census mapping exercise because it is upon them that demarcation of Enumeration Areas is based. Required non-spatial features - the population data - can be extracted based on the above spatial features.

2.2.2 Population Data

Usually obtained from census exercise, its database would include information on the following: Name, sex, age, citizens, place of birth, residence, local government area of place of birth, marital status, educational qualification, occupation, ethnic group, religion, etc.

2.2.3 A Geo-referenced Information System (GIS)

In its simplest form, a GIS may be viewed as a database system in which most of the data are spatially indexed, and upon which a set of procedures operates in order to answer queries about spatial entities in the database.

In its professional context, a GIS may be viewed as being been made of the following five sub-systems, (Knapp, 1978).
(i) Data encoding and input processing
(ii) Data management
(iii) Data retrieval
(iv) Data manipulation and analysis
(v) Data display.

The order of listing is indicative of the procedural steps or operational modalities inherent in existing GIS software packages.

2.2.3.1 Hardware And Software Requirement

As a decision support system, the components of a GIS include Hardware and Software. The system can be designed to function as standalone or in a network environment. The latter is recommended for population management.

The hardware and software components of a GIS for population management can be clearly identified after a detailed user requirement study (feasibility study).

For optimal performance, each of the computer unit or workstation should, apart from having high processing speed and memories, should possess a full multi-media capability as minimum configuration. Several of the hardware platforms that meet these requirements include such brand names as: SUN, HP, IBM, Dell, and Compaq.

Recommended peripherals that could be networked with these workstations are: A0 colour plotter, A0 Digitizer, A0 scanner with 800-1800 dpi resolution and Laser/Deskjet Printer.

The Software is of two types;
- Operating System software
- Application software

Existing **Operating System Software** include such names as: MS Dos, UNIX, Motif User Interface, Open Look Interface, Windows ‘95, ’97, ’98, Me, 2000 and NT Interfaces.

Application Software is used by analysts and programmers to handle specific tasks. Proprietary GIS packages belong to this category, such should have the following functions and capabilities (Shyllon, 1993; Dangermond, 1983; Parker et al, 1991).

1. An interface to a standard electronic data recorder
2. Data input and edit function
3. Data manipulation function, which include: The reduction of angles and distances, and Application of corrections
4. Display facility in the screen and hardcopy in 2-D or 3-D in multiple scales.
5. Data analysis as obtained in statistical application, which may include: smoothing, filtering, prediction, location and allocation, modeling, building topology, map generalization.
6. Data integration for data captured from different sources such as: COGO, GPS, Aerial Triangulation, Remote sensing, Data files such as DXF ASCII etc.
7. Command language for developing user customization and interface in:
   - 4^{th} generation language
   - C^{++}, Java scripts, Visual Basic, Visual C^{++}, etc.
   - Macros, etc.

8. Data management, which should include modules for managing spatial and attribute database.

Arc View 3.1 was the application software used for this project.

3. FORMATION OF DATABASES

The GIS database would consist of the spatial and non-spatial (attribute) database. Often the non-spatial data are embedded in the spatial database inform of descriptive information about the stored spatial objects or the relationship existing between them. The map is perhaps the most familiar form in which geographic data are represented.

The information required of a geographic feature consists of the following characteristics:
- Its location with reference to a standard coordinate system.
- Its spatial attributes
- Its relationship with other geographic features and
- The epoch of the feature.

3.1 Database Structure for Population Census

The first step in developing a database for a GIS is to acquire the data and place them into the system. The database system of a geographic information system provides the means to organize the spatial and non-spatial attributes for efficient storage, retrieval and analysis. Since population data are basically numerical values defining the spatial entities of interest, a tabular format for data recording will be the best choice of form of database to use, reason for adopting the relational database structure for this presentation.

The data collected from the field on spatial and census entities can be geo-referenced with respect to the graphic data – the administrative map of the area.

Classes of data can be structured into layers of diverse information called themes, using chosen criteria. For instance, following themes may be created, (NPC, 1992):

Tables	Themes
1	Population distribution by single (and/or classified) year of age and sex.
2	Population distribution by marital status, age and sex.
3	Population distribution by States of the Federation.
4	Growth rate.
5	Land area and population density of the unit areas or political sub-divisions of the country.
6	Manpower tables – labour force by occupation in unit areas, age group and Sex (and/or marital status).
7	Disease tables: Yellow fever,, Malaria fever, Cholera, leprosy, Tuberculosis, etc.
8	Facility tables for the country and its political subdivisions: Industries, Medical centres, Ports(air or sea), Schools, etc.

Fig. 1: Classes of Information abridged from the results of Nigerian Census Exercise of 1991.

Only Tables, 3 & 5 are represented in this paper. Other categories of information could not be displayed for reasons of space constraint. However, the System is flexible, and the number of queries that can be built will depend on the levels or amount of databases available.

4. DATA ANALYSIS AND DISPLAY

Analysis of data from multiple spatial data planes as earlier enumerated requires the use of processing techniques capable of the manipulation and analysis of both grid and x, y – coordinate structured data and for conversion from one structure to another. Similarly, capabilities also exist for the manipulation and analysis of attribute and tabular date files.

The census data and the spatial data must be integrated in order to give an accurate perspective on the number of people living in any geographical area so that government at various levels can successfully carry out adequate planning and management techniques that will enhance the quality of lives of the populace.

For instance, by issuing appropriate querying commands, following tasks can be performed on data obtained from fig.1:

1. Size of the population, its distribution by rural, urban, local government, state and country – Tables 1 & 3.
2. Patterns and trends of demographic events, such as births, deaths, migration, the associated growth rates for the country and its political sub-divisions – Tables 1–5.
3. Planning and Location of Infrastructures, Agricultural/Farm settlements, industries, Educational Institutes, etc – Tables 5,6,8, & Utility Maps.
4. Transportation planning and traffic routing – Tables 5,8, & Utility maps.
5. Map out and control spread of certain diseases and epidemics – Tables 3,5 & 7.
6. Manpower development planning – Tables 1,5,6 & 8.

Other supportive information or tasks that can be performed through the Query processes include:

- Making projections for School enrollments on yearly basis or at designed intervals in order to schedule funds for specific areas of needs, such as, staffing, structural developments, Educational materials' supplies, etc.
- Structuring a family planning programme to curtail abnormal growth in population
- Crime control
- Accident rate monitor
- Verifying the reliability of past census data
- Determining the spatial extent of a unit area and information on adjacent areas.

Two queries based on Table-3, illustrating problems this System can resolve are displayed in fig. 2 & 3, respectively.

1. What is the population distribution per States of the Federation, Fig.2
2. Show States with population size of more than 3million, Fig. 3

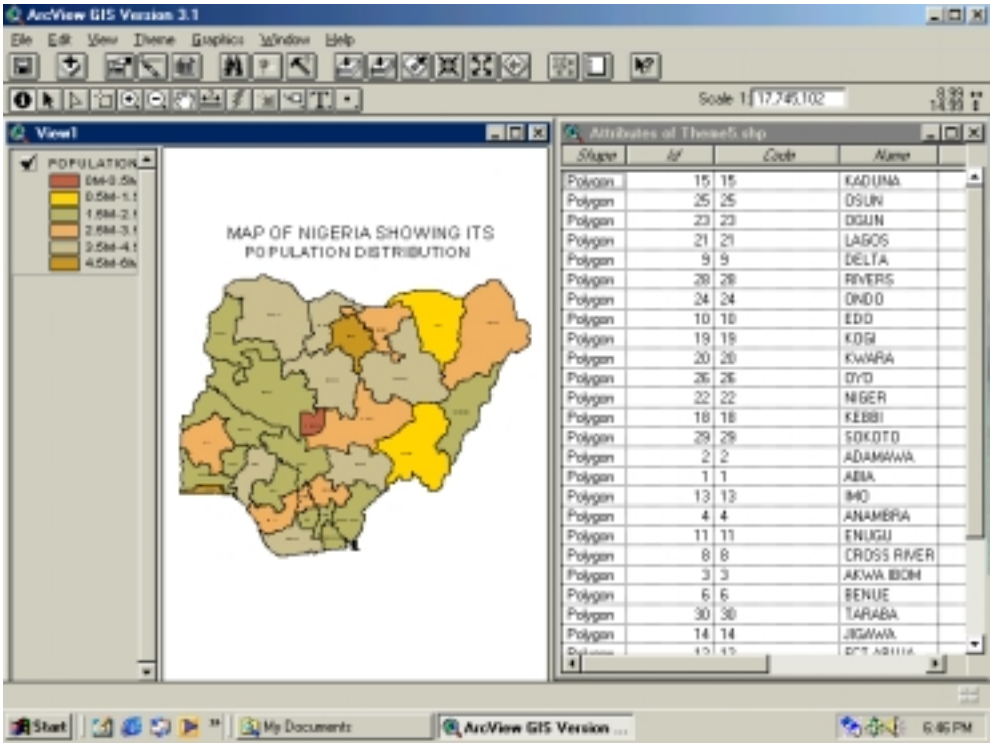

Fig. 2: View of the Country showing its population distribution.

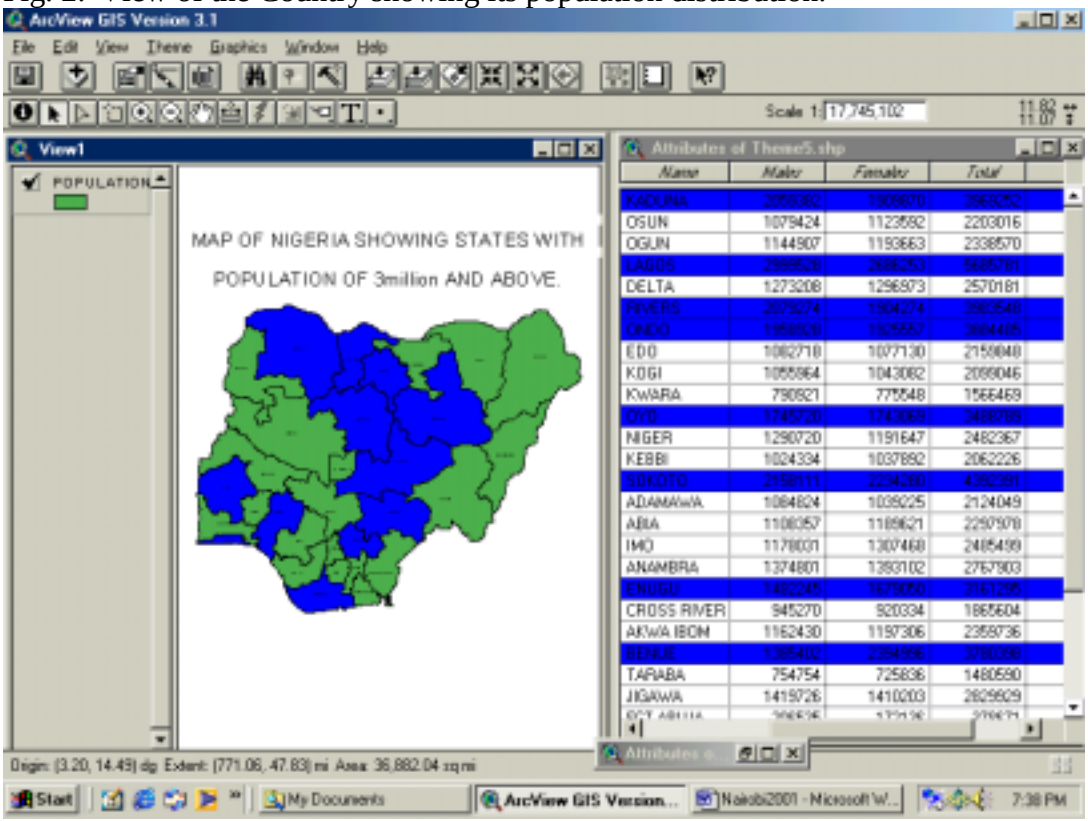

Fig. 3: View of States with Population size of more than 3million.

5. CAPACITY BUILDING

An integral part of requirements for the design and application of GIS to Population management is the need for training and re-training personnel involved in the use of the geoinformation systems. A modular, as well as, web based training programmes should be designed to keep key personnel abreast of information on recent advances in GIS functionalities and capabilities especially as it affects population management.

Institutions of higher learning could be co-opted into facilitating internal and outreach programmes to educate the populace and organizations on derivable information available within the System.

Also, research into other avenues of population management, like multi-media application, should be encouraged. This apart, constant review and update of the existing System should be a priority to the system's administrators. Information communication channel should be established to act as organ of information dissemination on population and settlement matters within the framework of established regulations and set criteria.

6. CONCLUSION

For a population management system to be effective and efficient in handling population data and related information, it is required that all available information be properly harnessed and managed to justify investments in resources through meeting the users' needs. This may not be possible if the right tools are not used to process, manage, analyze and disseminate the available information.

It was Naisbitt (1984), who warned that, "We are drowning in information but starved for knowledge". That is, it is all too well and easy to become confused with the avalanche or superfluity of information in the world today, especially if there are no available tool(s) to manage it. GIS provide, as yet, the most efficient geospatial population management tool available. This paper has been able to discuss the various requirements and applications areas of this 'tool' that could help to tackle the population problems of countries of the world, particularly those that are currently enmeshed in growth rate problems.

Such a tool would be seen to be of daily interest for the population management process because it requires the explicit use of the census figures for the location of interest. This apart, it also requires access to adequate information and development of adaptable simulation models whenever necessary. The Geo-referenced information System (GIS) is able, both to provide the environmental planner with the necessary appropriate spatial data and program development environment needed to adapt/develop tools/models that can make use of available database to produce results that will enhance the planning, decision making, and resource allocation and management processes of our governments and interest groups for a sustainable socio-economic development of her peoples.

ST. NAME	MALES	FEMALES	TOTAL
Abia	1108357	1189621	2297978
Adamawa	1084824	1039225	2124049
Akwa Ibom	1162430	1197306	2359736
Anambra	1374801	1393102	2767903
Bauchi	2202962	2091451	4294413
Bayelsa	685478	698741	1384219
Benue	1385402	2394996	3780398
Borno	1327311	1269973	2597284
Cross River	945270	920334	1865604
Delta	1273208	1296973	2570181
Ebonyi	1230114	1189756	2419870
Edo	1082718	1077130	2159848
Ekiti	801221	798659	1599880
Enugu	1482245	1679050	3161295
Gombe	745654	749698	1495352
Imo	1178031	1307468	2485499
Jigawa	1419726	1410203	2829929
Kaduna	2059382	1909870	3969252
Kano	2858724	2773316	5632040
Katsina	1944218	1934126	3878344
Kebbi	1024334	1037892	2062226
Kogi	1055964	1043082	2099046
Kwara	790921	775548	1566469
Lagos	2999528	2686253	5685781
Nassarawa	1062132	1081001	2143133
Niger	1290720	1191647	2482367
Ogun	1144907	1193663	2338570
Ondo	1958928	1925557	3884485
Osun	1079424	1123592	2203016
Oyo	1745720	1743069	3488789
Plateau	1645730	1637974	3283704
Rivers	2079274	1904274	3983548
Sokoto	2158111	2234280	4392391
Taraba	754754	725836	1480590
Yobe	719763	691718	1411481
Zamfara	689741	674987	1364728
FCT-Abuja	206535	172136	378671
COUNTRY TOTALS	**49758562**	**50163507**	**99922069**

Table. 3: Population distribution by States of the Federation

STATE	POPU	AREA (Sq.Km)	DEN. / Sq.Km
Anambra/Enugu	5,929,198	17,675	335
Bauchi	4294413	64605	66
Bendel (edo & Delta)	4730029	35500	133
Benue (and Kogi)	2780398	45174	62
Borno/Yobe	4008070	116400	34
Cross River/Akwa Ibom	4225340	27237	155
Imo/Abia	4783477	11850	404
Kaduna/Katsina	7847596	70245	112
Kano/Jigawa	8461969	43285	195
Kwara (and Kogi/Niger)	3665515	66869	55
Lagos	5685781	3345	1700
Niger	2482367	65037	38
Ogun	2338570	16762	140
Ondo	3884485	20959	185
Oyo/Osun	5691805	37705	151
Plateau	3283704	58030	57
Rivers	3983857	21850	182
Sokoto/Kebbi	6454617	102535	63
Abuja	378671	7315	52
	88514501	**923768**	

Table 5: Land Area and Population Density

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BIOGRAPHICAL NOTES

Prof. Olubodun Ayeni (1941)**:** A Professor of Surveying, He was engaged as a Senior Lecturer in 1979 at the University of Lagos, Nigeria. He became a Professor in 1983. Between 1985 and 1991, he was the Director of RECTAS (Ile-Ife, Nigeria), and has since been back to the University where he lectures at the Department of Surveying and Geoinformatics. He has many published works in Remote Sensing, Photogrammetry, Geographic Information Systems, and Adjustment Computation & Statistical Analysis of Survey Data. He has also been involved in numerous international projects.

Oluwaseun S. Adewale (1966): Received his first degree in 1988 and in 1998, a master's degree in surveying both from the University of Lagos. He has over ten years of professional experience in engineering surveying, seismic survey data acquisition, GPS applications, Geographic Information Systems and Remote Sensing Data applications. He is presently an Assistant Lecturer at the Department of Surveying and Geoinformatics, University of Lagos, Nigeria. His research interest is in Spatial Information Systems, Digital Mapping and Remote Sensing.

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