

Management of National Resources through an Electronic Atlas Database: The Case Study of Nigeria

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Key words :

ABSTRACT

With an increased awareness of the finite nature of the earth's resources, coupled with population pressure, shortage of natural resources and degradation of the environment, it is a critical challenge to national governments to manage their resources. Environmental information including natural, human and technological resources can be located within a spatial framework so that their spatial inventory can be used in making crucial decisions for solving national problems. Of great importance to a national resource management is an electronic national atlas, which contains an inventory of national resources.

A vital component of the electronic atlas is the GIS database which establishes an organisational framework bringing together information in a variety of themes (often from unrelated sources) which cut across disciplines such as geography, geology, biology, forestry, statistics, education, religion, medicine and agriculture. The wealth of information contained in an electronic atlas describing the country's assets and economic potentials can be used by policy makers in policy formulation and implementation which will enable national government provide services effectively and efficiently.

This paper examines the management of national resources through an electronic atlas database using a prototype Electronic National Atlas of Nigeria (PEAN) as an example. Prior to the design of the database of the PEAN, a user requirement survey was conducted to identify the users needs. Based on the survey results, the database was designed and implemented. The atlas database being in digital form makes quantitative and qualitative comparison in the changes in resource development in the country possible using spatial analysis techniques. Recommendations are made as to how developing countries can use their electronic atlas database for efficient development and management of their national resources.

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1. INTRODUCTION

The management of a nation's resources is vital to its national development as decisions concerning national developments are made based on available environmental information which include natural, human, and technological resources. These resources can be located within a spatial framework and managed so that they are used to aid decision-making. The 2001 Nobel Price winner in Economics and former first Vice President of the World Bank, Professor Joseph Stiglitz while speaking at a guest lecturer in Enugu, Nigeria, described Nigeria as a country endowed with human and natural resources. He also pointed out that the problem confronting Nigeria is that of mismanagement of the country's resources (Vanguard, 2002).

1.1 Nature of Nigeria's Resources

Nigeria with a landmass of about one million sq. km is naturally and potentially rich in natural resources. There is abundant solar thermal, and hydroelectric power vast areas of virgin forest and rich grass lands full of animals, fruits, crops, copious arable land and plenty of valuable mineral deposits including petroleum, asphalt, tin, gold and uranium, and other mineral resources. There is also abundant human resources in the country. With a population of about 120 millions, Nigeria accounted for 25% of Africa's population. In spite of all these natural and human endowment, Nigeria is still classified as a poor country, her copious natural and human resources potential not withstanding.

1.2 The Role of National Atlas

Salishtcheu has defined national atlas as "atlas of individual countries that contain a comprehensive characterisation of the natural environment, population, economy and culture of the country and are produced by government and public agencies as works of national significance and prestige". (Salishtcheu, Leont'yen, 1974). Leszczychi also defined national atlas as an atlas which "encompasses a single state and supplies a comprehensive objective characterisation of the country and of its current social and economic relationships by the techniques of scientific cartography" (Leszczychi, Leont'yen, 1974). From the foregoing, a national atlas is expected to bring together an up-to-date and comprehensive information about the physical environment, the natural wealth, the population, the economy and cultural development of a country, as well as information on its political and administration structure.

In different spheres of activities a national atlas performs the following roles:

- stands as an educational tool and also serve as cultural ambassador.
- represents scientific repository published by the scientific societies and constitute a basis for scientific research.

- provides a good foundation for public policy in all levels of government in the fields of economic planning, environmental protection, and distribution of social and cultural amenities.
- broadens ones horizon about the nation and contribute to national self awareness.
- aids in an intelligent use of the country's wealth, as individuals can also use them to make private decision regarding business, tours, recreation, and vacation.

2. SPATIAL INFORMATION TECHNOLOGY AND ATLAS CARTOGRAPHY

Spatial information is vital to the socio-economic and political development of any nation. A national atlas contains a wealth of information assembled in textual as well as in graphical form about a country's natural and human resources and activities, cutting across such disciplines as geography, geology, biology, forestry, statistics, education, religion, medicine and agriculture. Developments in information technology and atlas cartography have brought about the establishment of a database for a computerised atlas. Immediately after the publishing of its 4th edition of its national atlas, Canada drew up a program towards the development of a National Atlas Service (NAIS) of Canada that supports the Electronic National Atlas of Canada. In order to provide a global access to the information provided by the NAIS, it was linked with the Internet-based global information system that permits the exchange of images and textual information (Federal Geomatics Bulletin, 1995). Sweden also produced a PC-version of its National Atlas which to Helmfrid (1993), is to serve as "a low cost GIS for the Sweden people". Other countries in the world are also moving towards this trend of obtaining an electronic national atlas.

An electronic atlas is one in which the acquired raw data, the database organisation, data manipulation, and data output and display are electronically dependent. Most national mapping agencies are changing from the routine manual approach to atlas cartography to a computerised approach. There are various levels of electronic atlases (Ayeni, 1998). Perhaps, the lowest level is one in which the maps concerned are digitised and converted into digital data for easy storage in the computer to enable them to be printed by means of some on – line graphic devices in black and white or in colour. This is a computer Assisted Atlas. There is the middle level in which GIS principles are utilised for acquisition, data modelling, database organisation and structuring and data manipulation and display. This may be called the true Atlas GIS. An example of this is reported in Adebisi (1998). The highest level of electronic atlas is the Multimedia Atlas which is a GIS Atlas in which text, data, graphics, still and motion pictures and sound are combined in the production of the atlas. An example of this is the Multimedia National Atlas of Canada.

The establishment of a National Atlas Information Service (NAIS) can be of immense benefit for the maintenance of the database of the electronic atlas. NAIS can be regarded as a GIS based administrative service that contains a wide scope generalisation of the country. Apart from the advantage of bridging the gap between the data acquisition agencies and geographic information users, NAIS can be concerned with an appraisal of the quality of information output rather than merely supplying necessary information to the users.

2.1 Electronic Atlas and National Resources Database

In Nigeria the idea of producing a National Atlas first came from a group of geographers at Ibadan in 1962. This idea was supported by the Federal Surveys who constituted a National Atlas committee of experts from various fields relevant to the contents and objectives of the National Atlas. The first edition of the National Atlas of the Federal Republic of Nigeria was published in 1978 and was commissioned in 1981 (Ayeni 1983). Some of the maps found in this edition of the atlas was found to be obsolete and it was difficult to get reliable and up to date information concerning the country using the atlas. The atlas was later revised in 1992. The atlas was redesigned to meet the present need of information at the time. The revised edition contains an updated information on some of the themes contained in the previous version. The former themes were modified for example, the human Geography and Rural Economy theme and some new themes were introduced for example Commerce theme. The maps were also updated. For instance all the maps showing some important towns in the country were updated to contain the current developments in the towns. Ten years after the revised edition of the National Atlas of Nigeria there is a need for another revision of the atlas. The use of GIS in the production of the National Atlas is an urgent need in the country since it has the capacity to support institutions and individuals' demand for spatial information concerning the physical environmental conditions, natural resources, population and other social and economic characteristics of the country. The change from the hard copy atlas to an electronic atlas is particularly important because of its merits.

2.1.1 Merits of an Electronic Atlas

Some of the merits of an electronic atlas are as follows (Ayeni, 1998):

- Easy and quicker access to map data in both hard and soft copy form
- Quicker production of up – to – date atlas
- Ability to perform analyses and make decision on map data in electronic form
- Ease with which to update and correct, reduce and enlarge map and map information
- Enhanced opportunity to sensitise potential users who can have access to map data in digital form for display on their own personal computers
- Has potential to support the establishment of national Atlas Information Service

Computer technology is developing visualisation techniques of animation, audio-visual capabilities, and three dimensional modelling and cartographers are not only able to analyse time dependent geographic data to discover development trends and predict future distributions of phenomena but also thinking about producing Multimedia National Atlas. Electronic atlas has the potential to support the database of Multimedia Atlas.

When the GIS concept is applied in atlas cartography, it allows the separation of data storage and display so that the same database can be applied to different uses, allowing database sharing and therefore reducing duplication of data collection and storage which in the past was difficult to do.

3. A PROTOTYPE ELECTRONIC NATIONAL ATLAS OF NIGERIA (PEAN)

The most important component of the electronic atlas is the national database that contains a wide scope generalisation information of the country. It involves the establishment of an organisational framework that brings together information on a variety of themes (often from unrelated sources) such as land use, demographics, geology, ecological issues, e.t.c. It is therefore crucial for a database designer for the Electronic atlas to have a full and complete understanding of the existing information sources in the country and the requirements of the user community who are to benefit from the new system, before committing to a design.

The creation of the Prototype Electronic National Atlas of Nigeria (PEAN) started with a Users Requirements Survey that was conducted. This survey was analysed in order to note what is relevant to the design and implementation of the electronic database. The database was designed and implemented taking into considerations some of the suggestions in the users requirements survey.

3.1 Users Requirements Survey

There is a need to determine the information needs of the end user and design the electronic atlas database to satisfy these needs. User requirement survey is therefore necessary in order to find out reasons why a system is to be created, the functions it must accomplish and to identify the conditions on how the required system will be implemented. A Users Requirements survey was carried out before embarking on the design of database of the PEAN.

3.1.1 Sampling Technique Used in the Selection of the Sample

A non-probability (purposive) sampling technique was used in the users requirement survey because of the high level of illiteracy in the country and because most of the educated ones cannot even be described as “computer literate”. Focussing on the objective of the study, lecturers, researchers, civil servants and private sectors which all constitutes the users community as well as many of the data generating institutions that could be contacted were chosen on the basis that they could understand and meaningfully answer the research questions.

Questionnaire, documentary evidence and discussions are some of the methods that were used in the users requirements survey. Two questionnaires were used in the survey, one for the users of spatial data and the other for the data generating institutions. Discussions and documentary evidence were also used to supplement the questionnaire, especially with respondents who were too busy to complete the questionnaires. Details of this can be found in Adebisi (1998).

3.1.2 Analysis of the Data

Thirty-six (36) questionnaires were given out to both the data generating institutions and the data users through out the states of the federation. Few responses were received from Lagos,

Oyo, Ebonyi, Abuja, Rivers, Kogi, Enugu, Delta, Kaduna, Bayelsa and Sokoto States. From the survey, it was discovered that some data generating institutions are also users of spatial data.

A total of 20 respondents completed the Data Users Questionnaire. These include 3 lecturer and researcher, and 9 from the general public, which constitutes of the civil servants from the states and federal government departments as well as private sectors such as oil company, private survey company and environmental assessment company. Some of these users also generate data of their own.

Table 2.1 Response rates among users

Response and Non-Response Rates	Data Users		Data Generating Institutions	
	Absolute	%	Absolute	%
Response	9	64	3	50
Non-response	5	36	3	50
Total	14		6	

Some of the data generating institutions contacted are survey companies (both public and private), meteorological departments, National Electric Power Authority (NEPA), National Museum and Monuments, etc. The types of data being generated includes mapping, population, land use, solid minerals, petroleum, agriculture, tourism, meteorology, geology, forestry, industries, water resources and communication. The techniques for generating data in the institutions include any or combinations of any of the followings: field works, manual, or computerised measurements/observations. These data were stored in office files, sheets, diskette or microfilm. The data acquired were updated when it is necessary to do so and it ranges from daily, by the government departments, to yearly, by the mapping organisations. The products generated from the data include published brochures, manuals, reports and maps. The maps were usually at a scale that ranges from 1:100 to 1:15000000.

About 25% of the data users' respondents and 45% of the data generating organisations have their data collection, processing, display and output units automated (see Table 2.3 in Appendix). Some of them that were not automated, however, have plans to automate their activities. About 27% of these organisations have heard about GIS while 9% have heard about National Atlas Information Service (NAIS) (See Table 2.2 in Appendix). The opinion of these people about the use of GIS especially in electronic atlas production was positive. The respondents required Atlas of different themes. These include School Atlas, Political Atlas, Economic Development Atlas, Pollution Atlas, Agricultural Atlas and National Atlas. They would also prefer Digital or Electronic Atlas to conventional Atlas.

These respondents also give some suggestions about the type of datamodel and database structure to be used for the electronic atlas. From the survey, 57% suggested the use of vector datamodel while 33% suggested the raster model (see Table 2.4 in Appendix). The data structures suggested are Network (33%), Relational (40%) and Hierarchical (27%) (see Table 2.5 in Appendix).

Through the survey, it was observed that Nigerians always like to keep pace with developments and, thus, prefer Digital or Electronic Atlas to the hard copy atlas. The automation of some of their operations like the data collection, processing, display and output attest to this fact.

Apart from bringing an awareness of the electronic atlas to the respondents, the survey allows the respondents to have input in terms of idea to some aspects of the electronic atlas database design. The vector data format and relational database structure are two aspects of the database design suggested by the respondents.

3.2 The Database Design and Implementation

In the user requirements survey a few themes were identified for the database of PEAN. These are mapping, agriculture, tourism, population, meteorology, geology, forestry, solid minerals, industries, petroleum, water resources and communication. The base map data and these thematic data constitute the PEAN database. This section involves the description and synthesis of the model into an integrated database design for the Electronic Atlas of Nigeria. The vector data model and relational database structure were used in the design.

A map of Nigeria drawn at a scale of 1:1000000 was used as the base map. The map was digitised. Thematic data which are independent mapping themes consisting of features (e.g location of tin ore, area where mechanised farming is practised, etc.) that are related to the base map were linked so that the relationship that exist between two or more themes can be demonstrated. These themes are identified into classes of lines, areas or points. They are then provided with feature identifiers, which links the attribute data and the geometric data (base map). The themes represented in the database are Population, Tourism, Agriculture, Solid Mineral, Industry and Political.

4. MANAGEMENT OF NATIONAL RESOURCES USING THE ELECTRONIC ATLAS DATABASE

In the section above an attempt was made to produce a prototype Electronic Atlas of Nigeria; thus, transiting from the hard copy National Atlas to Electronic Atlas. A cartographic presentation of any theme in the database can be produced. Of great importance is the fact that the database can be queried to obtained information that can also be presented either in a cartographic format or in tables of attributes.

The GIS software used for the implementation is Arcview 3.1. The choice of this software was based on its availability.

4.1 Electronic Atlas Database Query

The spatial relationships that exist between different phenomena represented in the database can be analysed to study their influence on each other. Each of the themes represented in the database can be queried to obtain useful information based on some selection criteria and can be used as input in solving national problems. The agricultural, political and population themes represented in the database were queried to obtain information. Fig 1 depicts query result showing the distribution of Cocoa or Cassava in Nigeria. This information may be required for efficient planning to boost food production in some area for both domestic consumption and export. Particularly now that Nigeria is experiencing shortage of cassava due to high demand for export in Britain. Fig 2 is the query result showing states that were created on or before 27th August 1991 which have female population of less than 1.95 million. This information can be useful for national programmes such as women empowerment programme. It can also help in formulation of policies which concern women education, especially when the contents of the database is broadened to include information on the age group and level of illiteracy in the country. Similarly, databases on Solid Mineral, Tourism and Industry can be queried to obtain information to support decision-making and policy implementation.

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

National resources can be managed effectively by the use of an electronic atlas database. A prototype Electronic Atlas of Nigeria was developed. Prior to its design, a users requirements survey was conducted and the results of the survey was analysed in order to ascertain the information needs of the users. The software used for the implementation is Arcview 3.1. Queries of some themes of the atlas database were presented.

5.2 Recommendations

The following recommendations are made:

- i) African countries should create an electronic atlas database for the management of their national resources. The potentials of the database should be explored for creating other products such as Multimedia Atlas and Agricultural Atlas.
- ii) A users requirements survey should be conducted before embarking on the design of the database so as to ascertain users needs and design the system with the users in mind.
- iii) The establishment of a National Atlas Information Service (NAIS) can be of immense benefit for the maintenance of the database of the electronic atlas, it can also be involved in an appraisal of the quality of the information output rather than merely supply necessary information to users.

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APPENDICES

Table 2.2 Rates of Respondents who have heard about NAIS and GIS before.

	About NAIS		About GIS	
	Absolute	%	Absolute	%
Users	2	17	2	17
Data generating organisations	1	9	3	27

Table 2.3 Rates of Respondents who have part of their operations automated and respondents who have GPS.

	Automation		GPS	
	Absolute	%	Absolute	%
Users	3	25	3	25
Data generating organisations	5	45	3	27

Table 2.4 **Response rate for the choice of vector or raster data model.**

Data model		
	Absolute	%
Vector datamodel	8	17
Raster datamodel	4	9
Total	12	

Table 2.5 **Response rates for the choice of data structures**

Data structures	Absolute	%
Network	5	33
Relational	6	40
Hierarchical	4	27
Total	15	

Fig 1. Query Result Showing the Distribution of Cocoa or Cassava in Nigeria

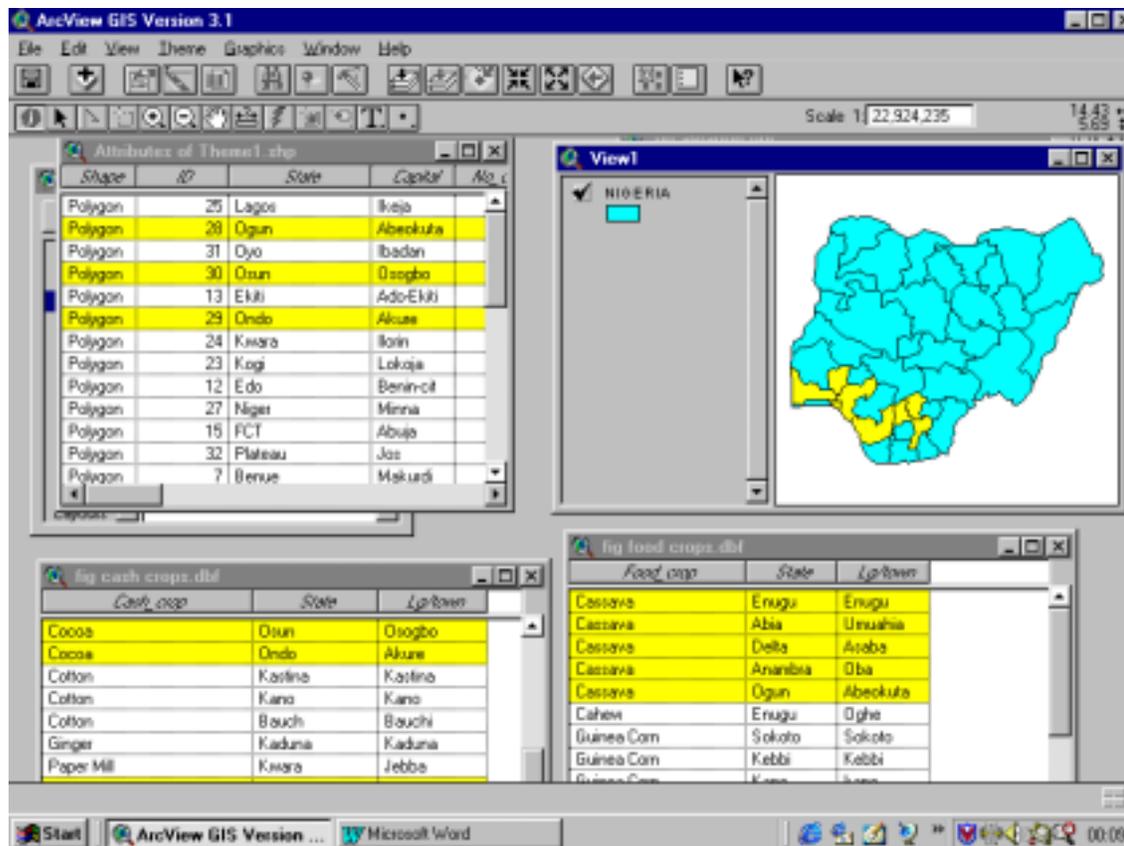
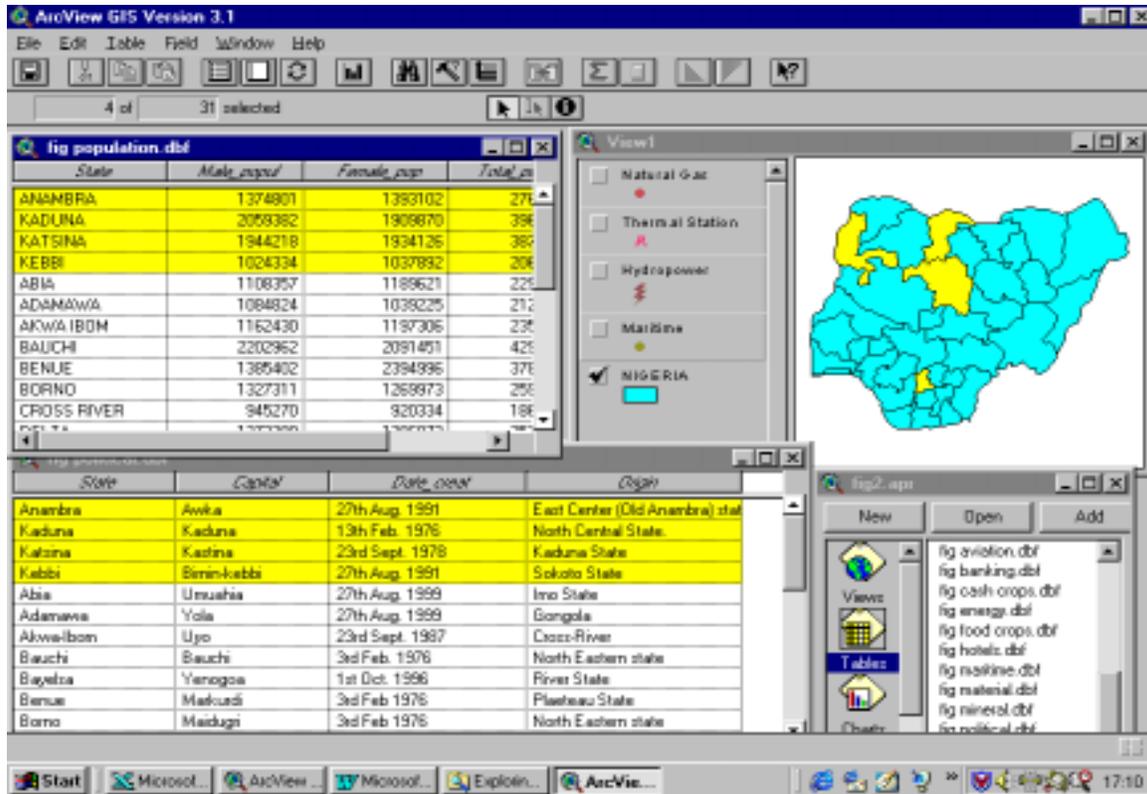


Fig 2. Query Result Showing States created on or before 27th August 1991 which has Female Population of less than 1.95 million based on 1991 Census



BIOGRAPHY

Prof. Olubodun O. 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.

Amos O. Adebisi started as a National Diploma holder in Land Surveying from Yaba College of Technology, Yaba, Lagos. He has B.Sc. and M.Sc. degrees in Surveying from University of Lagos, Akoka, Lagos. He has worked extensively as a surveyor as well as a GIS analyst. He is presently an Assistant Lecturer in the Department of Surveying and Geoinformatics, University of Lagos, Akoka, Lagos, Nigeria.