THE CHALLENGE OF SPATIAL DATA INFRASTRUCTURE FOR EFFECTIVE PLANNING IN DEVELOPING COUNTRIES – THE NIGERIA EXAMPLE

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ABSTRACT

The need for spatial data infrastructure in Nigeria has never been pertinent than now. The last one and half years marked tremendous growth in the telecommunication industry in Nigeria. With the debut of the global system of mobile (GSM) technology came an increase in demand for geospatial data for network propagation planning. It came as a shock to some that spatial data that are often available as commercial off the shelf (COTS) commodity in other parts of the world are very difficult to come by in Nigeria.

This paper therefore examines the status of spatial data in Nigeria, the challenges facing spatial data infrastructure (SDI), current SDI efforts and initiatives, as well as the prospects for the future.

1. INTRODUCTION

Development planning process consists of two complementary chords – spatial and economic planning. The seemingly lack of success in development planning endeavors in most developing countries could substantially be traced to the relegation of the space concept to the backwaters with all attentions focused on economic planning. Only a few countries realized that economic planning theories are not implemented in abstract space. Regional development plan is a futuristic endeavor that entails planning for supra-urban space with the view to, and purpose of, enhancing the social and economic well being (quality of life) of the people within the space (region, area or territory). It therefore deals with allocation and reallocation of resources over sub-national, supra-urban space.

In the process of formulating a regional development plan, lots of resource issues within the space have to be considered. Such resource issues include human resource and capital, existing infrastructures, renewable and non renewable natural resources, land use patterns, agriculture, mining, energy and power, water resources, commerce, industries and services, education and health, etc all of which constitute the basic life support systems and social conditions and are embedded in the term 'environment' (1) of the given region.

Experience have shown that in order to effectively harmonise all these resources to development planning process for result oriented national growth and development, there is the need to evolve a system that can conveniently integrate data and information on both renewable and non-renewable resources in space in a way that will not only allow for proper functioning and coordination of each, but will also ensure that the general biophysical life support systems of the environment and by implication the long term sustainability of life, is not negatively impacted. Access to timely, accurate information is fundamental to sound decision- making (2). This is exactly what a Geographic Information System (GIS) stands to offer. Data and information resident within a GIS too should not only be available locally, but should be transformed and stored in such a way that it is available, accessible and usable (with minimal processing) to decision makers and professionals from varied fields and backgrounds. This is where Spatial Data Infrastructure (SDI) becomes important.

2. SPATIAL DATA INFRASTRUCTURE AND GEOSPATIAL DATA COLLECTION

A basic requirement for sustainable development planning is the presence of policies, resources and structures to make spatial information available to decision makers and communities when, where and how they need it. Spatial data provides the basic bedrock or platform on which development activities in space rest. Project development and planning at micro, meso and macro scales requires adequate knowledge about the nature and characteristics of the environment, and the early this is recognized the better. According to the United States Geological Surveys (USGS)," the (US) Executive order 12906 calls for the establishment of the National Spatial Data Infrastructure, defined as the technologies, policies, and people necessary to promote sharing of geospatial data throughout all levels of government, the private and non-profit sectors, and the academic community. The goal of this infrastructure is to reduce duplication

of effort among agencies, improve quality and reduce costs related to geographic information, to make geographic data more accessible to the public, to increase the benefits of using available data and to establish key partnerships with states, counties, cities, tribal nations, academia and the private sector to increase data availability" (3). In essence, a spatial data infrastructure (SDI) can be described as a repository of data that is complete, correct, current and accessible to community of end users and decision makers.

SDI consists of the framework datasets which are the core spatial and attribute datasets; the metadata which provides key for inventory, catalog and documentation of the core datasets; the clearinghouse services which provides facilities for uniform search and distribution of the core datasets, and of course the data access and standardization protocols (4).

Spatial data collection technologies have advanced greatly in the recent past. It is now easy to collect large volume of data at short period though the cost of acquisition is still relatively expensive and potentials for inconsistencies are still present.

Geo-spatial information refers to geographically referenced information that are obtained from remote sensing (RS) and global positioning systems (GPS) platforms and managed within a GIS framework. The need for geospatial information for sustainable resource planning cannot be overemphasized. For example, while we may know much about soil, we know less about particular interaction of soil types, weather elements and human interference with the environment that produces best agricultural output or land degradation. If resource and development planners are to make proactive decisions about available renewable and non-renewable resources, future land uses, future food and water security, future energy security, about where to site new developments in rapidly expanding urban areas, and about potential productivity of agricultural lands and the damage to the environment that are may likely result from existing and future facilities, and also ways and means of preventing future environmental pollution and degradations, then data are required on all the components of the environment. Detailed, quantitative and qualitative information about the extent of available renewable and non-renewable natural resources, current land use, land degradation and future risks are required. These and other spatially referenced information are described as geo-spatial information**.**

Remote sensing has assumed the most comprehensive and economically cost effective tool for obtaining synoptic information about spatial features and natural resources over a large area. Remote sensing also offers a platform for obtaining spatial information at consistent temporal intervals, thereby making it the only platform through which spatial-temporal monitoring of natural resources is possible. The ability of remote sensing systems to record images in multispectral (in different energy bandwidths) fashion has greatly enhanced its use in resource inventory and mapping. Different terrain features behave differently at different wavelengths of electro-magnetic spectrum (EMS). Hence, multispectral sensing has therefore proved invaluable in differentiating terrain conditions.

Geographic Information System (GIS) is a rapidly advancing computer based technology where information is organized, analyzed and presented with reference to location. It is a system of computer hardware, software, and procedure designed to support the capture, management, manipulation, analysis, and display of spatially referenced data for solving complex planning and management problems (5).

GIS is a powerful decision support tool that can assist in solving many environmental and resource management and monitoring problems. The power of a GIS lies in its ability to overlay data from various sources, together with their attributes, obtained at various times, at various scales and manipulate/analyze them within a common/unified framework. This indicates that environmental and resource data on vegetation, soil, geology, wildlife, water resources, oil and gas, mining, agricultural lands, and land use and cover can be overlaid with data on human and cultural features such as: roads, dredged canals, farming practices, cultural and architectural artifacts and operational facilities. This makes it easy to predict or model what happens to a given land resource feature if there is a malfunction or incidental occurrence in some or any other layers of the database.

3. THE STATUS OF SPATIAL DATA IN NIGERIA

The Federal Surveys Department (FSD) of the Ministry of Works and Housing is the statutory authority with the mandate and responsibility for mapping and maintaining spatial data in Nigeria. Sadly enough, the best this organization has been able to do is to print and sell outdated maps and aerial photographs. Although resource mapping and inventories in Nigeria dated back to the colonial era, spatial data for planning is still a hard commodity to come by. The history of resource mapping in the country started with several narrow-scope resource inventories for specific tasks and purposes including irrigation planning, dam construction, surface and ground water resources inventory, solid mineral exploitation, oil and gas prospecting and forest resources inventories, carried out at different times in different parts of the country.

The first comprehensive large scale resource surveys and mapping in the country after independence was probably the 1960-63 aerial photography of Nigerian territories carried out by the Canadian Aero Services Limited on behalf of the

Canadian Government for the Government of Nigeria under the Commonwealth Africa Aid Programme. From this, the 1:50,000 and 1:100,000 series topographic maps of Nigeria were plotted and produced by the District Oversea Surveys (DOS) Department of the British Government and later taken over by the Nigerian Federal Surveys Department. This has formed the most complete survey for spatial-natural resources inventory in Nigeria though few of the map sheets are yet to be published up till today.

In 1976, as a national requirement for a reliable assessment of forest cover and timber resources in Nigeria, the Federal Government through the Ministry of Agriculture and Natural Resources invited Motorola Aerial Remote Sensing Inc (MARS) and Hunting Technical Services Limited to produce vegetation maps covering the whole of Nigeria territory from Side Looking Airborne Radar (SLAR) imagery (6). The mapping was completed in 1978 and the vegetation maps were produced at a scale of 1:250,000. Furthermore, between 1994 and 1996, the Forestry Resources Management and Coordinating Unit of the Federal Ministry of Agriculture through the assistance of the World Bank embarked upon another vegetation and land use mapping of Nigeria at a scale of 1:250,000. Geomatics, Beak Associates, and UNILAG Consult carried out the mapping exercise. Vegetation was classified up to formations level together with the names of dominant plant (trees and grasses) species.

In the sudano-sahelian zone of Nigeria, the Canadian International Development Research Council (IDRC) has assisted in resource mapping of Fadama agriculture in the Sokoto-Rima basin of Northwestern Nigeria in the early 1990s.

In areas such as the about 60,000km^2 Niger Delta with rapid environmental change due to concentration of oil and gas exploration activities, extensive but private resource surveys and inventories have been carried out. For example, Shell Petroleum Development Company (SPDC) has spatial resource data including soil and geological maps covering the entire Niger Delta. Other major oil companies have tended to be concerned with their areas of operation. The latest attempt at providing a comprehensive baseline environment and natural resource data for the Niger Delta area was funded by Oil Producers' Trade Section (OPTS) of the Lagos Chamber of Commerce and Industries, supervised by Niger Delta Environmental Surveys (NDES) and carried out by UNILAG Consult between 1998 and 2001 and. The mapping employed existing 1:50,000 topographical maps as base while interpreting and carrying out change detection mapping for the Niger Delta area from Landsat Thematic Mapper and SPOT Multispectral satellite imageries for the decades 1980s and 1990s respectively.

Accessible spatial data on urban area in Nigeria has also been limited to city maps produced in the late 1970s by the Federal Surveys Department. Though several private organizations have spatial data on some urban areas, these are not publicly available. Lagos with estimated population of about 10 million people is Nigeria's most populous and fastest growing city. In order to make spatial data available for planners and end-users, the Government of Lagos State around 1991 commissioned Reid-Crowther, a Canadian mapping company to produce digital orthophotos of the city. As part of the package, the company was to set up a functional GIS support unit for the government of Lagos State. This gave birth to the Land Information Systems Support Unit (LISSU) at the Survey Directorate of Lagos State. Unfortunately, almost a decade after its establishment, LISSU has not been able to give the much-expected spatial data support to planners and end-users due to reasons that are difficult to understand.

In the area of soil and hydrogeological mapping, not much national coverage has been achieved. Out of about 52 sheets of 1:250,000 hydrogeological map sheets that are supposed to cover the Nigerian territory only 11 sheets have been produced as at year 2000. The Federal Surveys in collaboration with the Department of Geography of the University of Lagos in the 1980s manually produced the best of the soil maps available at a scale of 1:1,000,000.

While the non-availability of current and up-to-date spatial resource data is a problem, the lack of integration of existing data, which therefore results in their non-availability when most needed, is even a greater problem. From the brief review done above, the following problems are very obvious:

- There is incompleteness of spatial environmental and natural resources inventory during mapping exercises
- The available spatial and natural resource data are outdated, disparate and analogue. This renders them not useful for any meaningful resource planning and resource management tasks.
- There is lack of access to existing spatial data. This often led to duplication of costs and efforts and uncoordinated mapping and inventory. While private companies will not make available their spatial data because of so called data security, which is based on economic interests, the government agencies including the Federal surveys Department cannot even keep track of what data they have in their archive. Data storage and maintenance systems are poor and analog which makes data retrieval difficult.
- There is lack of awareness by majority of stakeholders of the power of remote sensing (RS) and geographic information systems (GIS) technologies as quick means for integrating, updating, storing, and retrieving wealth of earth resource spatial data.

4. CHALLENGE OF SDI IN NIGERIA

The key to scientific relevance in a changing, world is integration (7). The need for spatial data infrastructure in Nigeria has never been pertinent than now. The last one and half years marked tremendous growth in the telecommunication industry in Nigeria with the debut of the global system of mobile (GSM) technology. It came as a shock to some of these companies that spatial data which are often taken for granted in some developed parts of the world are very difficult to come by in Nigeria. While large-scale urban maps for network propagation planning are hardly available, the few available ones are more than 20 years old. In rapidly expanding metropolitan cities such as Lagos, Ibadan, Kano and Kaduna, the implication of this for network planning could be imagined.

The importance of affordable and readily available spatial data for planning in the other sectors of the economy vis-à-vis the implications of lack of this cannot be overemphasized. Apart from the telecommunication companies, other utilities companies in Nigeria such as government controlled water and electricity corporations also suffer from acute lack of spatial data for planning. Some of these corporations hardly know the locations of their assets in space. The implication of this is that the cost of doing business especially in the utilities sector becomes enormous. This is because basic digital spatial data for planning are just not available on the shelf. Hence, an investor interested in the utilities sector in Nigeria will therefore has to start right from spatial data generation from conversion of archived analogue data and maps. Since most of these analogue data are rather outdated, the next step is to embark on updating those using remotely sensed images. The implication of this is a substantial increase in the original estimated cost of investment.

Environment and environmental planning in Nigeria too has greatly suffered from this lack and inaccessibility of existing spatial data. Mostly the private operators dominate the environment sector in Nigeria unlike the utilities sector. The quality of environmental assessment reports, environmental action plans, environmental evaluation reports, and other studies suffer in depth due to lack of spatial data to work with. There is the problem of non-synchronization of results due to lack of data standardization; and duplication of costs and efforts resulting from lack of data sharing.

An obvious fact is that it becomes difficult for even the government regulatory agencies to monitor what the private operators are doing in the environment sector because they lack the necessary tools and data for enforcement. Hence, the government regulatory agencies are no more than active on-lookers in a case where they are supposed to be the determining actors.

Large scale urban maps and cadastres for town, city and urban planning are also not available for most towns in Nigeria. Where they are available, they are dated and in analogue format. Elevation data are only available at best as contours and spot heights on some of these maps. A number of vegetation and land use maps are available in the archive of some governmental agencies, but they have not been able to convert and package them in format that can make them readily available for end-users. It is also of note that there is lack of basic necessary spatial data to carry out effective agriculture and rural development planning and water resources planning, not to talk of emergency response to natural disasters.
In this era of commercial off the shelf (COTS) spatial data, the challenge for spatial data infrastructure in Nigeria is therefore a very great one that required concerted efforts from the government and assistance from international organizations.

5. SDI INITIATIVES IN NIGERIA

In all, there is a wealth of spatial environmental and natural resource data in Nigeria, which if properly converted, harmonized, stored, and made accessible and affordable for planners and end-users would generate enormous data for effective pro-active development planning in the country. There is also considerable attribute data on social-economic variables available in analog format with the relevant agencies within the country.

What is required is data conversion into digital format and integration for building a spatial database infrastructure.

Until very recently, efforts at establishing a spatial data infrastructure framework for the country have been the thrust of some few committed individuals and organizations in the geo-spatial technology business. The Nigerian Society for Remote Sensing was established around 1991 with the purpose of promoting remote sensing activities in Nigeria, while educating the government and private sectors on the enormous potentials offered by remote sensing for national development. A committee of experts and stakeholders on GIS was inaugurated in 1998 with the aim of identifying, classifying and coordinating geo-information resources all over the country. The exercise was to facilitate making geospatial resources available to all users at minimal cost. The committee was to identify fundamental data that are of critical national importance and to recommend effective procedures for monitoring and coordinating the activities of geo-information parastatals, multinational companies and any other relevant geo-information producer in Nigeria (4). Patterned after what obtains in United States and United Kingdom, where the USGS and Ordinance Survey respectively has the responsibility of making geospatial data available to end users, the committee was resident with the Federal

Surveys Department which is the statutory organization for spatial data in Nigeria. Although the progress has been slow, the committee succeeded in establishing the National Geographic Information Database (NAGID), although only in name. As a follow up to this, the Federal Surveys Department started the conversion of all existing 1:50,000 series of topographic map sheets to digital format. The Federal Ministry of Water Resources has also awarded contact for the production of hydro-geological maps for the entire country.

A workshop of National Geo-spatial Data Infrastructure (NGDI) stakeholders and users that is expected to be a major leap at getting the nation towards the geospatial epoch was convened in Abuja in February 2003. The workshop was convened by the newly established National Space Research and Development Agency (NASRDA) a parastatal of the Ministry of Science and Technology. This is a likely indication that NASRDA is taking over from the Federal Surveys Department as the coordinating agency for SDI in Nigeria. The first Nigerian earth resources monitoring satellite "NigeriaSat1" with a spatial resolution of 30m is also due for launch in the middle of year 2003. This is expected to provide the much desired land resources inventory data across the country, though the 30m resolution seriously limits its application to urban infrastructure planning and management. All these are positive notes that geospatial data in Nigeria will soon become a COTS commodity.

However, certain problems and loopholes still exist. Much of the base data are still in analogue format and are yet to be converted into digital. A spatial data clearing house and modalities for data standardization are yet to be fully established. There is still lack of awareness of the benefits of spatial data infrastructure as the key to workable development planning and national development on part of political leaders and decision makers

6. RECOMMENDATIONS AND CONCLUSION

Human and natural resource development are closely knitted. To achieve sound and sustainable development in Nigeria, the natural and environmental resources must be fully harnessed. And if this is to be done in a sustainable way, then data and information are required on these resource components and variables of the environment. These data and information must not only be current and up-to-date, they must be repository in a medium that is easily accessible, and at a cost that is affordable, to planners, policy and decision makers and end users.

An integrated GIS database has wide applications for national planning for such diverse interests as infrastructure planning, water resources planning and management, erosion, flooding and forest resource management applications, floodplain and agricultural land use planning, environmental waste, pollution and land degradation management and control, urban planning, urban waste disposal and management problems, etc. which are all components of holistic development plans.

However, the appreciation of spatial data infrastructure and geoinformation technology by political leaders, ministers, local government leaders and even most bureaucrats and administrators in government offices are still very inadequate. There is therefore the need to enhance the knowledge and understanding of political leadership and decision-makers at national, regional and local levels on the roles of SDI and space science and technology in the development process. Government and decision makers need be educated on numerous untapped application potentials of geospatial technology in development of rural areas, infrastructure and health planning and management in the urban areas, disaster monitoring, intervention, mitigation and relief, sustainable environmental and natural resources management, military operations, etc. There is also the need for planners and decision makers to recognize that maps and geospatial data are part of the nation's infrastructures as much as network of transportation, health, telecommunications, and water supply systems (8). International organizations such as the World Bank and IFC, UNICEF, UNECA, UNEP, WHO and others who are long-run stakeholders in this business should assist Nigeria by providing the resources and training in order to accelerate the processes of building a robust SDI.

The challenge is enormous, but Nigeria is already on the road to achieve this great task. It is our hope that in the near future, spatial data on Nigeria will be available commercial off the shelf commodity and on the Internet.

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