

# A Perspective View on the Development and Applications of Geographical Information System (GIS) in Nigeria.

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## ABSTRACT

This paper provides a perspective view on the present status of Geographic Information Systems (GIS) in terms of its development and applications in Nigeria. Despite its popular use in many developed countries, GIS is still in its infancy in most developing countries, including Nigeria. A few educational institutions are offering GIS as a course of study in the country. This paper discussed the concept of GIS and the challenges the technology faces in Nigeria. The main body of this paper is devoted to the problems of development and applications of GIS in the country with their solutions proffered.

(Keywords: GIS, development, application, information technology, developing countries)

## INTRODUCTION

A Geographic Information System (GIS) is a computer system that records, stores, and analyzes information about the features that make up the Earth's surface. A GIS can generate 2- or 3-dimensional images of an area, showing such natural features as hills and rivers along with artificial features such as roads and power lines. Scientists use GIS images as models, making precise measurements, gathering data, and testing ideas with the help of the computer. A GIS is designed to accept geographic data from a variety of sources, including maps, satellite imageries, photographs, and printed text and statistics.

The applications of a GIS are vast and continue to grow. By using GIS, scientists can research changes in the environment; engineers can design road systems; electrical companies can manage their complex networks of power lines;

governments can track the uses of land; and fire and police departments can plan emergency routes. Many private businesses have begun to use a GIS to plan and improve their services.

Fabiya (2004) defined GIS as a unique integration of computer hardware, software, peripherals, procedural techniques, organizational structure, people and institution for capturing, manipulating, storing, analyzing, modulating, modeling and displaying geographically referenced data for solving complex human related problems. This definition suggests that GIS is neither the software nor hardware, it neither is the procedure to solve problem, but a good integration of all these components of GIS. It plays five important capabilities (Table1).

Table 1: GIS Capabilities

Query	Task	Description
What is it?	Location	To find out what exist at a particular location; kind of development.
Where is it?	Condition	To identify what exist at a given location and what could exist.
What has changed since?	Trends	To find the differences within an area over time.
What spatial pattern exists?	Patterns	To know the concentration of certain activities and where they are located.
What if?	Modeling	To determine what happens, if a certain action is taken.

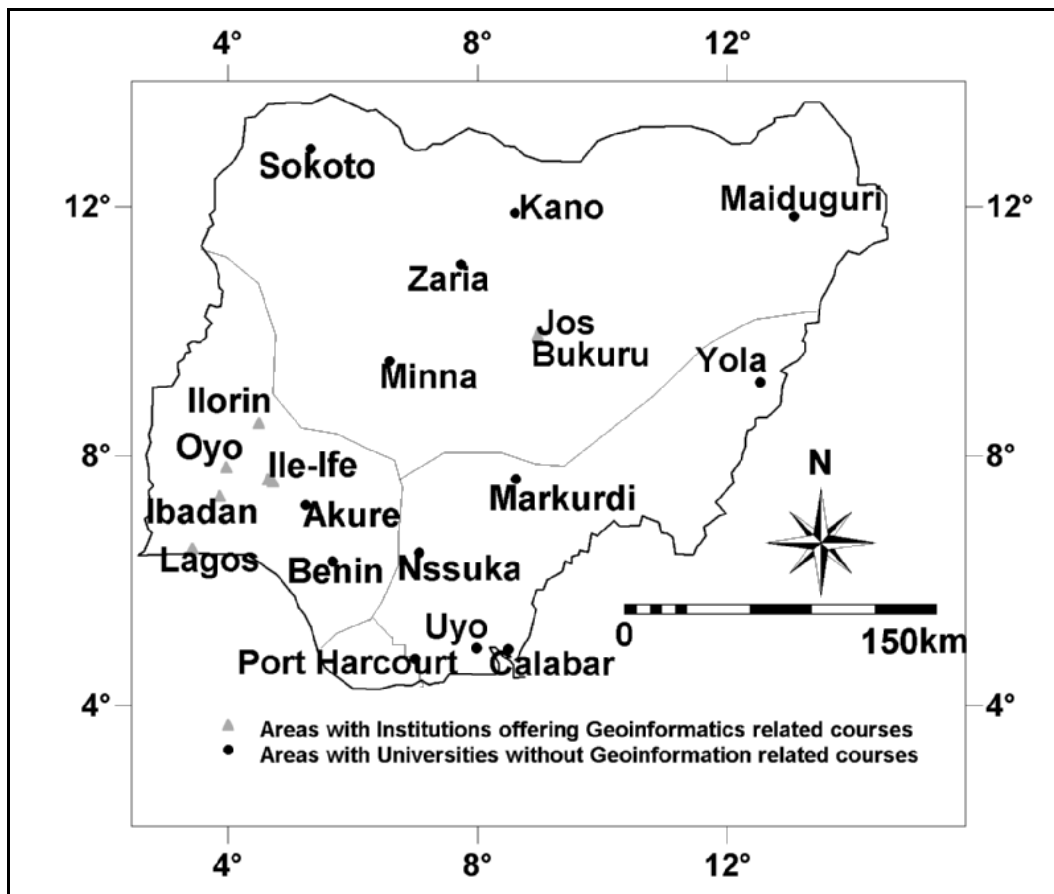
## DEVELOPMENT OF GIS IN HIGHER INSTITUTIONS IN NIGERIA

According to Yusuf (1997), GIS education in higher institutions in Nigeria started in the 1996/97 academic session with the pioneering efforts at the Department of Geography, University of Ibadan, Ibadan. With a pioneering students' enrolment of 30 graduate students, the program has grown in leaps and bounds in tune with current trends and demands for GIS education in Nigeria. The program now boasts of students' enrolment of about of 100 participants per stream. Similarly, in the 2002/2003 academic session, the Department of Geography of Obafemi Awolowo University, Ile-Ife started M.Sc.

research and M.Sc. professional programs in GIS. Also, the University of Lagos, Akoka Lagos runs a program. Other institutions that run the GIS program at the Post Graduate Diploma level are the Federal School of Surveying, Oyo, Oyo State and the Regional Centre for Training in Aerospace Surveys (RECTAS) OAU Campus, Ile-Ife.

There are a number of reasons that hampered the implementation of GIS in developing countries, including Nigeria. Nigeria presently has few training institutions in Geographical Information Systems. Figure 1 shows at a glance, the distribution of GIS training centers in Nigeria.

**Figure 1:** Distribution of GIS Training Centers in Nigeria.  
Source: Eludoyin *et al.* (2007).



## **CHALLENGES OF DEVELOPMENT AND APPLICATION OF GIS IN HIGHER INSTITUTIONS IN NIGERIA**

As with most areas of modern technology, Nigerian higher institutions are lagging behind in the development and utilization of GIS technology. Poor telecommunication facilities, erratic electricity supply, and the generally poor maintenance and management of public facilities have slowed down the entry of Nigeria into the international information highway. These factors are in addition to the almost herculean task of obtaining the necessary hardware and software.

With particular reference to GIS, a major problem facing its development and use in the Nigerian higher institutions is the lack of foreign exchange to purchase the necessary hardware and software. Another problem is that of equipment maintenance and the purchase of necessary spare parts and consumables once the systems are set up. A further hurdle is the training of the trainers at the local level to keep them abreast of developments in the field, especially, in a situation of rapid development of new software packages and of the continuous upgrading of existing ones (Abumere, *et al*, 1997).

A major problem with most organizations is getting the top management staff to accept the huge initial costs of setting up a geographical information system. The scarce foreign exchange in the country is partly responsible for this as it constitutes a serious bottleneck to the acquisition of the necessary computer hardware and software.

Erratic electricity supply still constitutes a major problem to the smooth running of computer outfits. The installation of un-interrupted power supply (UPS) and power surge protectors is standard for any serious computer unit. But these do not take care of the frequent and sometimes prolonged power cuts experienced in many areas. The solution is to install generators with a capacity high enough to carry all the systems in a computer laboratory. Such additional equipment makes setting up and operating a geographical information system that much more expensive than would otherwise have been the case.

An institutional environment such as is provided by a university or multinational organization with its own standby electricity generating set, is still the most ideal for operating a GIS establishment

in a developing country such as Nigeria (Abumere, *et al.*, 1997).

## **PROBLEMS OF APPLICATION OF GIS TECHNOLOGY IN NIGERIA**

Despite the numerous advantages that accrue from the use of GIS technology, the adoption and implementation of the technology in developing countries such as Nigeria still face a lot of impediments. The problems are enumerated as follows:

### **a. Application Environment**

The rapid development and expansion achieved by specialized vendors in developing GIS software did not only attract users with the simplicity of their products which are easy to apply and operate, but also placed the user on the first step of GIS system applications.

GIS software was developed for scientific and practical applications and passed through a number of states of design, development, testing, and evaluation before it reached the end-user. Those stages of the process were mainly to comply with the scientific, cultural, and social environments of those societies, thus insuring a maximum level of success. As such, systems were developed at first in industrialized countries they will be most suitable their environment. Developing countries such as Nigeria, often tend to use the industrialized countries production of the GIS systems, and apply them the way they were designed, thus, they do not achieve the positive results anticipated. This happens especially because developing countries often buy systems from different sources, which results in incompatible systems. Finally, the use of different products in the same country leads to building an isolated system-based in many organization on the same country that are difficult to integrate due to heterogeneity of systems used in GIS applications. Therefore, the successful implementing of GIS programs in many developing countries depends upon a reasonable degree of similarity of infrastructure environment of both producer and the user (Al-Romaithi, 1997).

### **b. Organizational Issues**

Organizational matters are vital in all initial implementations of GIS facilities. The

organizational problems are often more complex and more crucial to success than the technical problems involved. As a rule of thumb, technical problems can be solved in a direct manner, by acquiring and installing new equipment or new software modules. However, the human factor causes different consequences. Introducing new technologies means repositioning and replacing staff members which is not a straightforward process, and may trigger unexpected problems, because it may entail shifts in the perceived power structure. Consequently, organizational issues require more continuous management attention than do technical problems. Changing the organization alters staff authorities and relationships, and staff changes always bring in human factors that are difficult to predict or control.

The efficient exploitation of a new technology in an organization often mandates alterations in daily work schedules and the chain of command which, in turn, affects the whole organization. In practice, altering an organization may prove difficult, both because the new organizational structure is intangible and hence difficult to define, and because there are both formal and informal positions in all chains of command.

On the other hand, other subjective factors can further complicate the initiation of a GIS infrastructure. Human habit apparently dictates that about a quarter of the personnel in any organization always prefer the existing situation and will resist any change whatsoever. Expect that in high-tech firms, executives are often indifferent to newer information technologies, partly out of ignorance and partly from being overly concerned with cutting costs rather than increasing benefits.

Finally, with respect to initiating and managing GIS programs, many non-technical issues must be considered in order to absorb organizational obstructions, these are resistance to changes from groups of personnel in an organization can be expected and need to be identified. Incremental organizational changes may be made after the first operational phase of a new GIS facility and organizing or reorganizing should prevent the monopolization of information.

### **c. Data Exchange Standards**

Information technology development leads to the adoption of some standards which change the

way the broad community of providers and users of information operate. They are key factors to the process of data integration and bringing together disparate data sets.

Some of these key factors are achieved by clear definition and general understanding and are acknowledged by a large part of the community. These become recognized standards. Alternatively, standards may be developed at national or international levels and may be adopted by agreement to regulate a wider community. Eventually such standards should be part of a country's legalization process similar to metric standards.

Numerous standards exist within the Information Technology industry, covering computer hardware components, communication, and software, such as databases and programming language. These have developed over many years and many continue to be revised and further developed. At the same time, new standards are constantly being formulated as the industry and the user communities' change.

Inevitably the development of standards lags some way behind the growth in a particular sector, and in the case of GIS with its rapid expansion in the last decade; standards are only now being developed [Seppe, 1993].

The main role of standards in GIS is to facilitate the integration of data set from various distributed sources. The format and structure for holding geographic information is likely to differ between computer systems, so the exchange of information requires the use of standardized formats which are understood by both the provider and the receiver of the data.

From the above one can see the urgent need for applying national standards for data exchange, not only to facilitate the data flow between the information providers within the country, but also to communicate with other countries. Those standards are not necessarily being established from zero, but an existing one can be adopted with some required enhancement to match the local nature of an application. By adopting specific standards, a number of benefits can be obtained such as allowing the transfer of digital information between incompatible systems while preserving the meaning of the data being transferred; allowing users to evaluate the data, by supplying them with information of data quality;

reducing the projects costs by sharing data, resulting in lower costs for obtaining; and maintaining data and supporting efforts to update a database using multiple sources, by smoothing the flow of information (Al-Romaithi, 1997).

**d. Legal Issues**

The laws and regulations governing the data acquisition and management were written before the introduction of GIS technology in Nigeria (i.e. before the electronic age). The application of old rules to new technology results in an open field for creative interpretations, but the law lacks guidance for uniform public policy regarding the ownership and treatment of invisible information assets (Ndukwe, 2001).

The problem for most GIS users is how one knows who owns the data and what rights they have to use the data. There are also issues of integrating datasets for the purposes of analysis and what rights exist for passing such derived data on to third parties. The problem of ownership and copyright also lead in the vexed question of ownership of an 'added value' dataset and to legal issues of responsibility for data accuracy, currency and use. There are also legal questions related to the liability of GIS systems and who is responsible for quality of the result produced. The legal framework within which information is controlled has to consider the increasing desire to capture and distribute information both as a part of the function of government and for commercial gain. The increasing capabilities of computer-based information handling systems result in the translocation of data and information more easily, faster and in ever increasing volumes. Technological change is also increasing the ability to obtain data and to establish legal systems that make data more widely available without penalizing the data providers (Al-Romaithi, 2006).

Eventually, legal statutes take time to prepare and to put into place, not only in the developing countries but also in the developed ones. The result in many countries is that the legal framework in which information transactions are conducted was not designed to meet the current needs. Existing legislation may or may not cope with every aspect of the information revolution in an appropriate manner and it may be that the inadequacies of the system take time to be recognized, particularly where legal precedents need to be established. The result is a legal

framework that is somewhat out-of-date with a rapidly developing technology and increasingly information-based society (Seppe, 1993).

**e. Human Resources**

The problem of training is also very severe because of the lack of expertise in country. Universities and other higher institutions general lag behind in GIS development. Very often, it is the government agencies which buy and use GIS, before courses are offered by the systems suppliers. The training of GIS personnel is often carried out by software companies by either sending their staff (vendors) to give short courses on site or sending the operators and users to be trained in the company's headquarters. The role of vendors in this issue is not positively as anticipated, most vendors concerned with increasing benefits by spreading their product rather than education matters. When GIS programs are established a high cost of training is involved, practical experience has shown that about 40% of the total cost of the programs is dedicated to training.

**f. Lack of Awareness of the Technology**

Many see GIS as a "beyond-the-reach" technology, while some mystify it; this has kept many people from grasping the immense opportunity and power it gives especially in decision making. The above views capture the mood of the nation as far as the implementation and application of GIS is concerned in Nigeria. Thus, it slows pace of its implementation and application in Nigeria.

**g. Cost of acquiring the components of GIS**

Another problem in the implementation and application of GIS is the cost of acquiring the components of Geographic Information System such as the hardware, software, and methodologies. These include servers, workstation, global positioning system (GPS), software like ILIWS, Mapinfo, ArcView GIS, ArcGIS, etc., and conversion equipment such as digitizer, scanners, and plotters. Further still, the Nigerian Sat-1 launched in September 2003 cost an astounding \$13M. This no doubt is an expensive venture for a country whose annual budget is just over \$3B. This is perhaps why despite the political will, not much has been done after the launch.

## **h. Conservatism**

Conservatism is another factor slowing down in the implementation of GIS in Nigeria. A lot of professionals are not willing or are reluctant to change from the old method of collecting and analyzing data. Many are yet to change their focus from the traditional drawing board, pens, and T-square. Many people still acquire, store, process, sort, retrieve, and display data manually. It must be said however that any professional in geo-science circles that wants to continue to be relevant in the new dispensation would have to acquaint himself with the power of automation.

## **FUTURE PROSPECTS OF GIS IN NIGERIA**

From the earlier presentation it is clearly understood that GIS application in Nigeria is it relatively in an initial stage. Based on the recent technology in this field, organizations working on technologies application should change their working strategy and develop the system to accommodate the latest technology as far as possible. Some of the future prospects of GIS technology applications are as follows:

- Poverty reduction programs: GIS technology could help in better planning of various natural resources and land use thereby helping in balanced development in poverty reduction programs.
- Disaster management: The technology could help in various measures for prediction, mitigation and management of disaster such as erosion, solid waste, floods, etc.
- Education: By educating school children, tertiary institutions students, and the general public on the issues of environmental awareness through better illustrations by GIS technology.
- Agriculture: This technology could provide suitable tools to various agriculture crops, yield forecasting and monitoring agriculture areas.
- Forestry: Application of these technologies in forestry sector could help better inventory forest resources, sustainable use of forest resources, reforestation activities, and the management of community forests.

- Biodiversity: Also helps in better management of biodiversity through better mapping of resources, and strategies for biodiversity conservation.
- Tourism: Tourism is one of the important sectors of the national economy. The use of this technology could assist the industry with better planning of tourism infrastructure, generation and dissemination of such by virtual reality, better quality maps, etc.
- Health and Medicine: This technology could help in monitoring and management of areas under herbs, designing herbs plantation areas, monitoring disease and epidemics, etc.

## **CONCLUSIONS**

Throughout this paper we have raised a number of issues that we believe must be faced in any country to develop and implement its information systems, namely GIS programs. The implementation of GIS technology should carefully consider the nature of the developing countries with respect to its socio-economic priorities and cultural character, thus preventing any conflicts with the inherited values. On the other hand, GIS vendors are requested not only to introduce GIS technology but also to share the responsibilities of educating society and to play a major role in making GIS a useful for tool social development.

Business environments no longer operate on a comparative advantage basis but also on competitive advantage. Therefore, the professionals in the construction industry and their decision makers should be prepared and equipped to be able to compete in the new economic environment. Thus, these professionals must brace up to the fact that the era of planning or decision making by intuition has passed and that the 21<sup>st</sup> Century the professionals in the construction industry require automated and scientifically based plans. One of the ways of achieving this is to be GIS compliant. However, it must be known that there is no single key to being GIS compliant. Many factors come into play and must all be addressed.

It is believe that the development and application of GIS technologies in Nigeria does not succeed the way it should be because of the absence of a firm political stand on the side of government.

Hence there is no guarantee that the GIS technology is going to benefit society unless there is a political will at the highest echelon of the Government fully committed to (Woldai, 2004):

- Take the initiative as its own and involve its citizens in the technology;
- Invest money fully in supplying the necessary logistics with or without outside support for a long time to come; and
- Invest in its people's education, training and awareness campaign.

Without these issues in place, the GIS technology is doomed to fail.

Despite numerous constraints, the importance of GIS technology applications is realized to serve as decision support system for the overall development of the country. Future visions and working areas seems to be interesting and feasible to implement the plans. Due to the problems discussed the country has not been able to realize their full growth and application potential of GIS technology.

One problem which needs to be addressed urgently is the need for policy makers in Nigeria to be aware and recognize the relevance and impressiveness of GIS technology. Such "awareness" led to a deliberate policy of professional consultation on syllabus content and relevance of the technology for sustainable development in Nigeria.

## RECOMMENDATIONS

Gatekeepers cannot afford not to move with the technology of the age, hence the following recommendations are put forward in order to achieve sustainability that preempts poverty:

As a matter of urgency, databases that are in hard copies in files gathering dusts should be converted to digital format in order to have intact historical knowledge of previous decisions that may impact on future benefits;

- Training and retaining opportunities should be embedded in the scheme of service of those involved in the built environment especially in the area of decision making;

- Development agencies should encourage networking of their facilities to enable decisions that bear in mind area-side and inter-generational consequences;
- Computer building companies should be encouraged (their production line subsidized) so that acquisition would be easier to sustain interest in its use for a better society.
- Though implementing Geographic Information Systems may be expensive as noted earlier, governments and the professionals should look beyond the cost and focus on the benefits by doing more through a follow up to the launch of Nigeria-Sat-1. Governments at all levels should set machineries in motion for the implementation of Geographic Information Systems.
- Professional bodies (such as Nigerian Institution of Surveyors and Nigerian Institution of Town Planners) have a role of play here. They need to create awareness and put pressure on various Governments to implement Geographic Information System.
- The hindrance of funds can also be removed if states come together and pool resources together for the purpose of implementing Geographic Information Systems. We can have a regional implementation, if the states get their priorities right and all the funds wasted on money laundering and extravagance ventures are channeled towards implementing Geographic Information System.
- Organizational and managerial issues are as important as technical ones. Thus, there is need for more Geographic Information System research-based guidance on GIS management issues. This research will lead to the development of a GIS implementation plan and process.

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