Role of Geospatial Technology in Environmental Sustainability in Nigeria-An Overview

Njike CHIGBU and Daniel ONUKAOGU, Nigeria

KEYWORDS: Geospatial Technology, EnvironmentalSustainability, Poverty Eradication and climate change

SUMMARY

The world as a whole is becoming highly geospatially-enabled and there is the need to study trends and patterns and also communicate these phenomena with the evolving spatial technologies such that end users would benefit from this advancement in technological development. Since climatic changes and human activities could amount to the degradation of our natural environment, there is the need for us to acquaint ourselves more and embrace the vast emerging geospatial technologies in solving a number of environmental challenges to humanity today.Nigeria and other developing countries have a long way to go in this pursuit due to dearth of expertise to drive home the technological development of the country. Climatic change and anthropogenic factors can lead to environmental resource depletion with a drastic impact on the human population and other endangered species. In 2000, over 189 developing countries adopted the Millennium Declaration that re-affirmed their commitment to strengthening global efforts for peace, human rights, Democracy, good governance, environmental sustainability and poverty eradication. Today, we live in a fast changing world where every event or occurrence needs to be properly studied, integrated and analyzed for the benefit of all. The capabilities of geospatial technology are such that decision makers will be exposed to different options to handle different environmental challenges. By addressing the environmental issues through efficient use of geospatial technologies it is possible for developing countries like Nigeria to ensure a sustainable path to poverty reduction and human development. This paper focuses on discussing (an overview) the importance of geospatial technology, GIS and its tools for good decision making in sustaining the environment.

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1. INTRODUCTION

Geospatial technology offers a wide range of innovative and cost effective solutions for environmental sustainability; hence, many countries now appreciate the relevance of geospatial technology in the sustenance of our environment. The relevance of environmental information is based on the degree of its availability to the end users and to what extent such information can be shared effectively with external organizations largely over the internet and other available global information infrastructure (SDI) platform. In this regard, the emphasis should be on accessibility and distribution of available information over wide range of networks and environmental information market-place (Matambanadzo,1999).

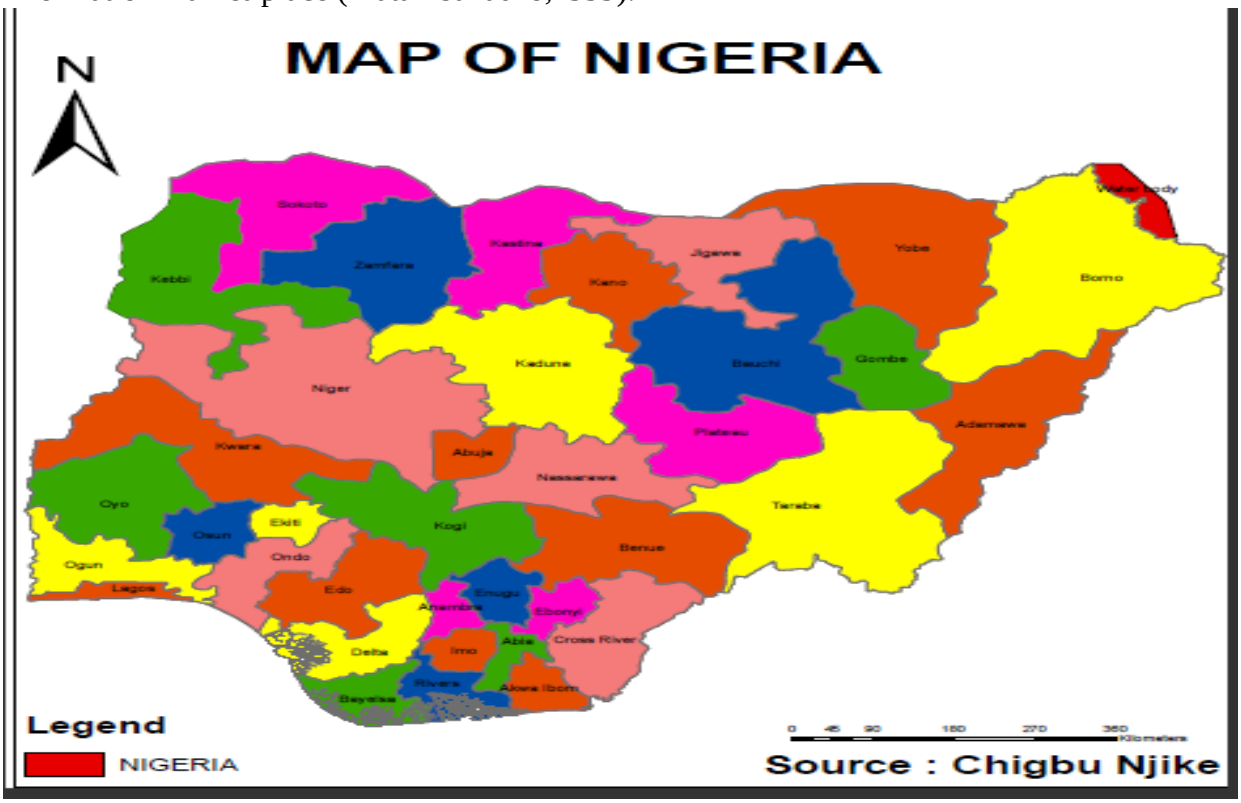

Fig 1.0 showing the administrative map of Nigeria (source: Chigbu, 2013)

The use of Geospatial technology in mitigating environmental problems and challenges is thus on the increase the use information driven tools such as GIS, Earth imaging systems/Satellites,

Global Positioning System (GPS) and Remote sensing techniques to mitigate environmental problems has find global application and acceptance.

2. RELEVANCE OF GEOSPATIAL TECHNOLOGY TO ENVIRONMENTAL SUSTAINABILITY

Geospatial Technology is the specialized set of information technologies that include Aerial Photography, Remote Sensing, Surveying, and Global Positioning Systems that support a wide variety of uses. This stretches from data acquisition to data storage, manipulation, image analysis, geo-visualization /display and data output (Tsou and Yanow, 2010). These disciplines if properly harnessed and given its rightful place by the appropriate authorities in Nigeria and globally would play enviable roles in the sustainability of our environment and good governance. Some of the identified applications of geospatial technology in Nigeria and globally includes the following:

- Flooding, environmental degradation and climate studies.
- Agriculture and Precision Farming.
- In the Health Sector and Paramedics.
- In the Mining and Extractive Industry
- City planning, Transportation, Communication Network designs and in Aviation Industry.
- Traffic and Accident control and prevention.
- Planning and Re-Planning program (Slum Re-settlement).
- Crime Mapping and hot-spots delineations.
- Land use and Land cover Studies for sustainability.
- General Developmental control and resource inventory and allocations.
- Emergency planning and alternative route development.
- Development of agronomical data and early warning data for food security issues.
- Deforestation and A forestation studies and preservation of wild life and biodiversity.

This applications and different areas of usage of geospatial technology is vividly captured in the figure 2.0 below.

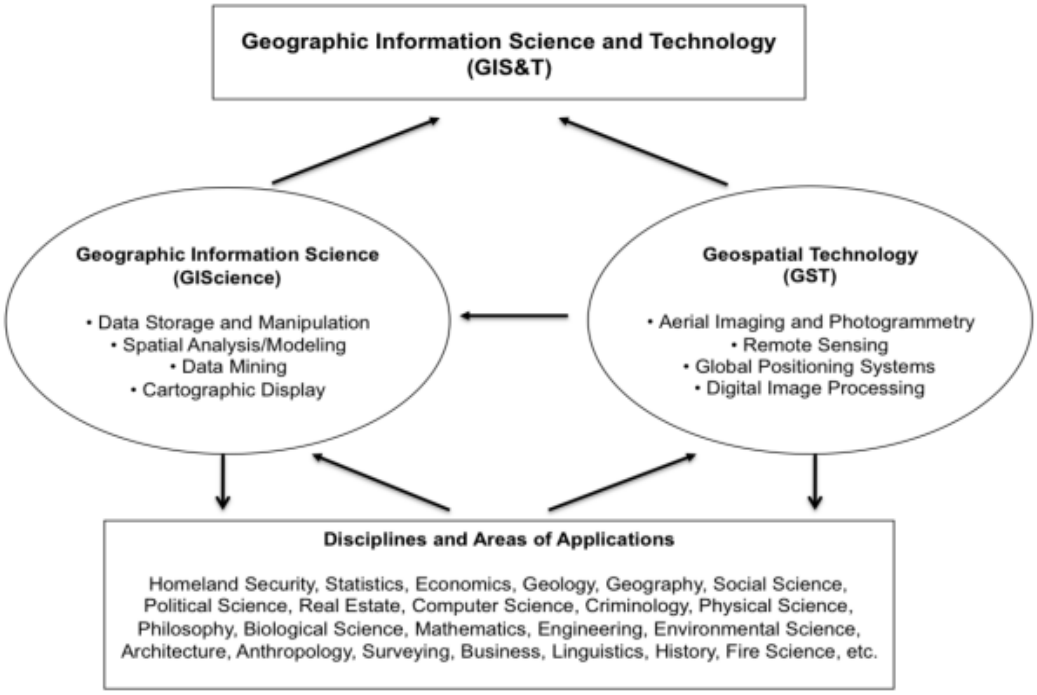

Figure 2: GIS Science and technology adopted from ((Tsou and Yanow, 2010))

Therefore, geospatial technology has enabled the use of and application of satellite/space techniques to solve a number of environmental related problems. This includes Urban sprawl/ slum studies, flooding, and erosion menace, environmental degradation due to oil spillage; crop health and early warning signals. Urban changes have been monitored by means of readily available remotely sensed imageries and aerial photographs of different spatio-temporal resolutions which can be analyzed using the necessary software, algorithm and expertise (human capacity).However, the continuous data acquisition by different satellite sensors has made change studies for sustainability easier and cheaper to extract, identify, describe and even readily understood.

3. SPECIFIC APPLICATION AREAS OF GEOSPATIAL TECHNOLOGY

3.1 Land-use/Land cover

While there is no set definition for urban growth, the intent which is the concept of providing sustainable development as a target for creating a better future for the world; economically, socially and environmentally has been under-appreciated. The contradiction in the reason for a sustainable future has caused critics to review and analyze the term ‘urban growth’, and it has been concluded that this pattern of development is of more disadvantage than the intended advantage. However, the result of urban growth shows that land use and land cover types are constantly changing (Zhang 2009, Weng 2001). The dynamics of change in land cover types of

urban regions can be attributed to the expansion of residential and commercial/industrial facilities, which has resulted to structural challenges such as inadequate facilities, inefficient street layouts & transportation networks, less space for conservation and parks, low agricultural farm lands and resultant high use of energy (environmental pollution), land degradation and even water pollution. Hence, monitoring the spatial- temporal changes is significant for advanced urban planning and development (Deng et al., 2008, Lu et al., 2004).

Spatial Changes and monitoring can be accomplished using satellite imagery or Aerial photography, advance image processing techniques and GIS analysis to highlight land cover changes (Zhang 2009, Weng 2001). Remotely sensed images have changed the way scientists study the atmosphere, oceans, vegetation, and the environments of the earth. Different studies from various related literature reveals that the use of Remote Sensing Techniques are significant for studying land use and land cover changes and other environmental issues as a result of natural and anthropogenic factors. With the rapid advancement in RS techniques, new and improved change detection techniques are being developed and categorized by many researchers, thus making remote sensing a vibrant study (Igbokwe, 2010).
The Land use and land cover study of Aba (Abia Sate) using RS and GIS tools, was undertaken with the objectives of finding out the percentage /rate of vegetal consumption and its overall effect on food security and environmental sustainability. The overall objective of the study includes but not limited to:

- Selection and extraction of a sub-scene covering of Aba Main Township from the Full scene of Landsat ETM+ (2000) and Nigeria Sat-1 (2005) images of the area.
- Overlaying the classified datasets and obtain changes in Land uses and Land covers of the study area.

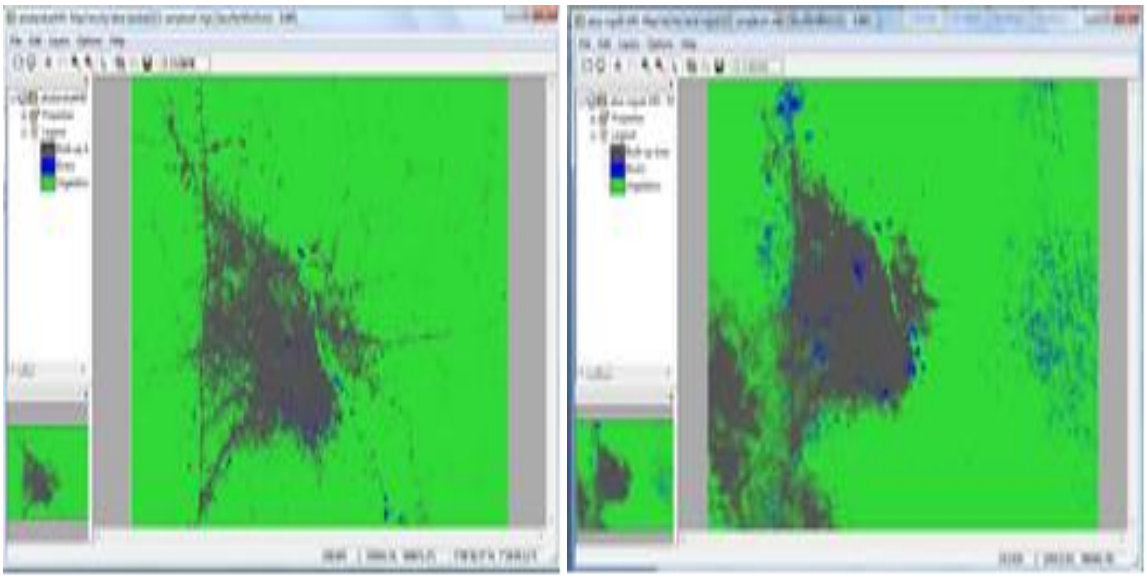

Fig. 3(a) Classified 2000 Landsat ETM+ (b) Classified 2005 NigeriaSat-1(chigbu, 2010)

Table 1.0 Analysis of the land use and land cover of Aba main Town for sustainability

Land use	River			Built-up Area			Vegetation		
	1991	2000	2005	1991	2000	2005	1991	2000	2005
Area (Ha) Covered (%)	62	91	92	89	110	150	260	210	169
	15.1	22.1	22.4	21.7	26.8	36.5	63.2	51.1	41.1
% diff.	0	+7.0	+0.3	0	+5.1	+9.7	0	-12.1	-10.0

(Source: Chigbu, 2010).

Based on the results and the analysis done in the study shown on table 1.0 above, it was concluded that Remote Sensing and Geographic Information System can be used as effective tool to analyze land use and detecting changes over the years of study. Land use pattern and dynamics in Aba (Abia State) showed phenomenal increase in the Built-up areas and the River body while the vegetation decreased tremendously. If this scenario is left unabated, this will impact negatively on the environment and have adverse effect on sustainable environmental development (Chigbu, 2010).A number of studies relating to this have also been carried out over the Eastern region of Nigeria and some other parts of NIGERIA which have also contributed to meaningful development and sustainability.

4. GROUND WATER POTENTIAL AND CONTAMINATION

We all know that **w**ater is fundamental requirement by all living things for cell metabolism. Continuous existence of man on this planet will definitely depend on the availability of good quality water. Several activities deter good water quality in Nigeria today. The problem of nitrate pollution in groundwater is a common global phenomenon and has been reported by various authors in many parts of Nigeria (Egboka & Ezeonu, 1990; Adelana & Olasehinde, 2003; Amadi, 2010). Our landscapes are so susceptible to all forms of contamination from both human-induced pollution such as animal- waste, agricultural chemicals, leakage from several underground storage tanks e.g. septic tanks and also transportation fuel and mineral exploitation and exploration (Activities of the Multi-national oil companies in the Niger Delta region of Nigeria). Application of GIS framework allows for a better visualization of ground water system and the best approach to also protect its quality.

With the help of geospatial technology one is able to understand the ground/surface water interactions pattern and able to deduce appropriate sites or locations for any sort of construction. Using the powerful spatial analyst embedded in Arc-toolbox within Arc GIS desktop application one is able to carry out such investigation. A number research work has been done in this regard for the good of the teeming Nigeria population.

Fig, 4.0 Nigeria's Groundwater nitrate pollution status(Source: Adelana, 2006)

5. ADOPTION OF GIS METHODS IN ENVIRONEMTAL SUSTAINABILITY

5.1 Spatial Planning and Route Optimization

GIS as a tool and technology has helped a lot in advancing the pursuit of environmental sustainability on a global scale and narrowly in Nigerian context. Its usefulness is not only limited to natural resource assessment, environmental impact assessment, operational efficiency in power utilities but also it plays enviable roles in sustainable development of our environment. GIS has been used in several studies around the globe for land use planning which cuts across all aspects of urban planning and Industrial Township planning etc. GIS aids in the mapping and visualizations of route optimization which play a significant role in identifying potential deprived areas that don't have equal accessibility to these route network system. One of the strength of GIS is that it allows for real time visualization and interactions which brings the realization of your geospatial data to a more unique expression. Over the past few years, we've seen water and waste-water utilities increasingly recognized that GIS techniques can be used to (plan for optimal route in transportation business) or reduce fuel consumption in their fleet vehicles and more

efficiently carry out their work through route optimization.

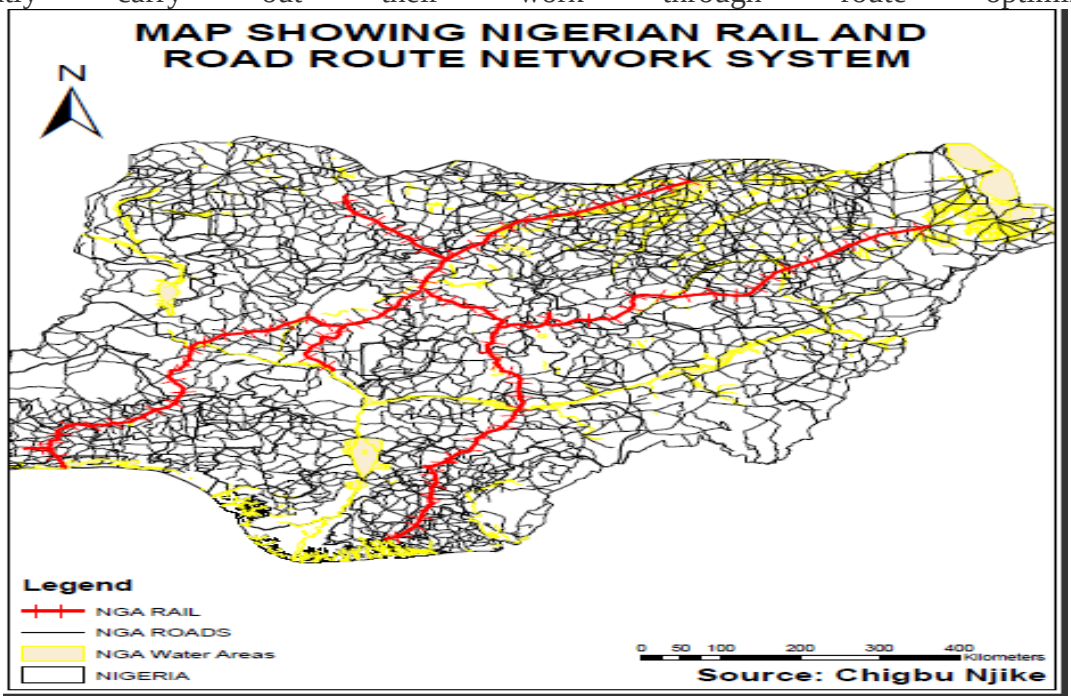

Fig. 5.0 Nigeria Railway Route
(Source: Chigbu, 2013)

6. CHALLENGES FACING GEOSPATIAL TECHNOLOGYADVANCEMENT IN NIGERIA

6.1 Availability and Access to Geospatial data (The NGDI Question):

Many at times independent researchers in Nigeria want to carry out scientific investigations/observations but as a result of data unavailability it becomes almost impossible to achieve this feat. This brings to question and serious concern on the achievements of Nigeria National Geo-spatial Data Infrastructure and the Geo-spatial data policy of the country. IT also gives serious room for concern over the core activities of National Space Research and Development Agency(NASRDA) who are appointed as the data clearing house of the country and also the conflicting roles of the National Mapping Organization of Nigeria(OSGOF) in roles and responsibilities definition and specifications.
Previous researchers that have employed geospatial technology techniques fail to either properly document their data and methodologies based on a number of reasons e.g. acquisition of their respective geospatial data (geo-data) which can be very uneconomical and this could have led to them not wanting to make it readily available for other end-users who are also interested in carrying out similar investigations(lack of interoperability resulting from lack of standards and uniformity or scale problem).

Embedding geospatial capabilities on the Web and making these resources readily available and as useful as possible for as many purposes inclusive of environmental sustainability is what defines a good SDI (Jackson et al 1999). A National Spatial Date Infrastructure is now a fixture in the vocabulary of geospatial technology users and policy-makers around the world. Shedding more light on the usage of Web-based GIS which is also under the umbrella of geospatial technology helps to provide a better dissemination of geodata for optimum utilization in investigating environmental trends and seeking solutions to these problems in order to achieve sustainable environmental developments.

Considering our Web-based GIS infrastructure in Nigeria, it can be more or less said to be lagging behind. The architecture is such that it needs a lot of reformation, the ability to discover spatial relations using the web is either slow or not functional. Both retrospective and prospective researchers need to surf the web for data in order to discover relevant information patterns about the environment and also be curious on how to proffer better remedies to this problems. Robust data descriptions and quick access to the data will enable more rapid exploration of hypothetical relationships which will help in better environmental sustainability.

Other critical factors to poor geospatial development in Nigeria include the following:

- Poor capacity built and lack of necessary expertise.
- Poor Funding by Government on research work.
- Administrative Bottlenecks, corruption and lack of transparency in the discharge of set goals.
- Lack zeal on the part of Nigerian researchers and trainers.
- Brain drain due to the above.
- Poor educational system and inability to pursue technological development of the country holistically and gender disparity and poverty.
- Problem of unstable power supply and communication pit-falls.
- Problems inherent in development economies like that of Nigeria and other third worl countries.

7. ROLES OF GEOSPATIAL TECHNOLOGY IN ENVIRONMENTAL SUSTAINABILITY

- Geospatial technology serves as a good decision support system in environmental issues and sustainability. It has been proved as an appropriate tool for managing decisions relating to environmental concerns and challenges. With the help of these modern geospatial technologies/innovations one gets prepared for an increasingly global challenges as a result of increasing population with its attendant environment problems.
- The use of geospatial technology enhances a better means or techniques of data capture and the distribution. This could be done in 'real time' and thus will reduce the time and energy needed in data acquisition for solving environmental problems.
- Geospatial technology also promotes participatory visualizations using the powerful tools embedded in its user interface.This tools help in the overall assessment of

environmental impacts and will also play important roles in physical planning of the environment in Nigeria.However, with the emerging trend in 3D and 4D geospatial information, this will enhance proper visualization techniques. These visualizations would help create avenues where humans can handle complicated issues and also give them the ability to garner better understanding and knowledge more efficiently and provide insights on the environment that may not be easily notable in traditional formats. Lol et al (1999) points out that communication via visualizations is very important in natural resource management.

8. CONCLUSION AND RECOMMENDATION

8.1 CONCLUSION

In order for Nigerians to have the capability to predict the effects, positive or otherwise, of economic developments on our environment, there is the need for us to embrace and emphasize the compulsory adoption of geospatial technology and also not to limit it to private practice or government. There should be an awareness creation on public participatory GIS as well in the decision making process which involves the citizens and their environment. Adoption of geospatial technology in all national endeavor such environmental monitoring, Agriculture, Climate change studies, land use and land cover studies will help foster environmental sustainability. Efforts of the National Space Research and Development Agency (NASRDA) Abuja, the National agency responsible for all space applications in Nigeria is highly commendable in terms of the recent strides in making available the Nigerian Sat-x image data sets for good environmental inventory, monitoring and mitigation and early detection of environmental challenges and treats. If the government of the day employs and uses the avalanche of opportunities readily provided by geospatial science, most environmental challenges will be overcome OR BE MITIGATED ON THE AVERAGE. This will lead to a sustained growth and development in Nigeria.

8.2 RECOMMENDATION

For Nigeria to harness the gains of geospatial science in solving most environmental problems, the following recommendations are necessary:

- There must be a well-developed surveying and mapping policy for the country
- There is urgent need to increase the capacity of expertise (CAPACITY DEVELOPMENT) especially in Surveying and Geoinformatics and other Built professional disciplines.
- There need for all stakeholders to support the Federal Government strive to ensure that the Geoinformation policy on the establishment of National Geospatial Data infrastructure stands.
- The space agency of Nigeria NARSDA must live up to her bidding as the national clearing house or hub of geospatial data in the country.

- The Federal Government agency responsible for Surveying,Mapping and co-ordination of all Surveying activities-The office of the surveyor General(OSGOF) must live up to the challenges of the age.
- Equally, the Surveyors' Council of Nigeria (SURCON) must continue to play her oversight functions in training and in practice throughout the control.
- More tertiary institution, Universities and Polytechnic running Geoinformatics and surveying must be encouraged to continue to exist by providing them with necessary funding and interventions.
- The Nigerian Institution of Surveying (NIS) must remain proactive politically and should be ready to initiate and influence bills at the National Assembly. That will enhance the practice of the profession nationally.
- Efforts of FIG and her commissions are commendable in advocating global best practices in the profession.

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Chigbu, Njike (M.Sc. Mnis)
Dept. of Surveying and Geoinformatics
Abia State Polytechnic, Aba.
P.M.B 7166, Aba, AbiaState, Nigeria.
Email:njikec@gmail.com

Onukaogu, Daniel, Chukwuemeka
Dept. of Surveying and Geoinformatics
Abia State Polytechnic, Aba.
P.M.B 7166, Aba, Abia State, Nigeria.
Email:danonukaogu@yahoo.com