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Geospatial Technologies for Resource Development in Nigeria

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Guest Lecture delivered on the occasion of the conference on *Geospatial Technologies and Digital Cartography for national security, tourism, and disaster management*, organised by the Geoinformation Society of Nigeria (GEOSON) and the Nigerian Cartographic Association (NCA), in technical collaboration with the African Regional Centre for Training in Aerospace Surveys (RECTAS), which held in RECTAS in November, 2012.

Cours délivré a l'occasion de la conférence sur les Technologies Géospatiales et la Cartographie Numérique pour la sécurité nationale, le tourisme et la gestion des catastrophes, organisée par la Société Nigériane de Geoinformation (GEOSON) et l'Association Nigériane de Cartographie (NCA), en collaboration avec le Centre Régional de Formation aux Techniques de Levés Aérospatiaux (RECTAS), tenue au RECTAS en Novembre 2012.

1. Introduction

I would like to start by expressing my gratitude to the organizers of this conference for being so kind as to invite me to give this lecture. The gesture is highly appreciated and I value the opportunity that this has given me to begin my re-integration into the geospatial technology community in Nigeria after about a decade of absence. My period of absence has enabled me to catch a glimpse of how things are done in other parts of the world and this has informed some of the comments and

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viewpoints that I will express or expound during the course of this lecture.

I am also most delighted that this conference has been jointly organized by the Geoinformation Society of Nigeria and the Nigerian Cartographic Association, in technical collaboration with the Regional Centre for Training in Aerospace Surveys (RECTAS). This is a most welcome development and a change from what transpired in the past between the associations which have interest and competences in geospatial technologies. At the time of the introduction of Nigeria to new technologies in spatial information systems there was so much unhealthy rivalry and petty squabbling over jurisdiction among the different cognate government departments, professional associations, academics and practitioners that made mutually beneficial collaborative endeavours almost impossible. In the process we were all the losers for it because much of the initiatives and programs in the field of geospatial technology in this country in the last two decades or so including in particular Nigeria's fledgling space program has been handled by non-professionals or practitioners. Many experts and practitioners in geospatial technology or spatial information systems have occupied largely peripheral positions as consultants, rather than as major players and decision makers on critical issues associated with the development of new technologies for mapping, monitoring and modeling Nigeria's natural environment and its resources.

2. Geospatial Technology

Geospatial technology or Geomatics is a term coined fairly recently to encompass all the tools (instruments/equipment, devices) and techniques commonly applied in the mapping, monitoring and modeling of the earth, its features and wide ranging resource elements. These technologies are common to all the geospatial fields of geodesy, land surveying, geography, cartography, aerial surveys, photogrammetry, remote sensing, geographic information systems, and others. The heightened interest in and the great value attached to these earth and resource mapping technologies is due partly to the increased global interest in the environment and environmental issues including deforestation, biodiversity degradation, food security, drought, desertification, global warming and climate change. The advantages that they offer include

- provision of real time or near real time data on both natural and human-induced processes on the earth;
- the markedly increased speed and accuracy of measurements and mapping of earthly phenomena;

- greater spatial coverage and broader scope for judging spatial patterns an spatial processes;
- capacity to cope with huge volumes of data and to subject them to compex quantitative procedures and modeling; and
- the ability to develop dynamic spatial information systems for the collection, storage, update, manipulation, analysis and dissemination of data on a wide range of phenomena.

The developments in geospatial technology also cannot be divorced from the global interest and widespread applications of satellite based communications and information technology. Geospatial tools, techniques and products are progressively being incorporated and applied in the global communication and information networks and devices. Finally, it is worth noting that all these developments have been made possible by advances in computer science and technology, software engineering and information science.

However, I do not believe that the organizers of this conference have invited me to give a classroom lecture on the different types of geospatial tools and techniques and their applications. I do not intend to do that either although some of these tools and techniques will certainly crop up in later discussions in the lecture. But, I rather would like to focus on what I consider to be critical issues in Nigeria's move towards developing and harnessing the immense capabilities and promise of these geospatial technologies in resource development.

3. Pre-Requisites for Advancement of Geospatial Technology Applications in Nigeria

But, I would like, first of all, to draw attention to certain pertinent issues which I have termed pre-requisites for the advancement of geospatial technology applications in Nigeria. First, I would like to observe that since the advent of the first Landsat (ERTS-1) images in 1972 (Areola, 1975), there have been several studies and projects in Nigeria involving the applications of various geospatial technologies. But, these studies have not really made much impact on the resource mapping, analysis and modeling scene in the country. The reason for this is that there has been no organ or establishment to serve as a repository to collate the outcomes and provide a unifying principle and focus for these applications. One of the saddest things about the state of environment and resource mapping and monitoring in Nigeria is that most of the developments in the field have taken place outside the established institutions with the mandate to oversee different aspects of Nigeria's environment and natural resources,

particularly the Federal Surveys Department, which is in charge of aerial and geodetic surveys and mapping in the country.

If Nigeria is to establish a firm foundation for sustainable development and application of modern technologies in development planning, the established government departments must be rehabilitated and revitalized. In the USA, the USGS, the Census Bureau, the Forest Service and the USDA Soil Conservation Service played pivotal roles in the development and sustained growth of spatial information systems for the management of land and its resources in the country. They were vital in helping the country to absorb and incorporate the new technologies in resource and development planning right to the grassroots (county) level. Those institutions, in collaboration with professional bodies, such as, the Association of American Geographers, the Soil Science Society of America and the American Society for Photogrammetry and Remote Sensing, have succeeded in diffusing these new technologies to the schools (K-12) and colleges and even households. For example, the average educated housewife or school pupil in the USA knows about Google maps and how to access them on the internet. But, here in Nigeria, spatial information systems are still restricted very much to the specialist level both in terms of their development and applications.

Another example to follow is Britain where the Ordnance Survey Department has remained the bedrock of all mapping and resource surveys even in the modern era of geospatial technologies. This has imposed stability and sustainability on the mapping programme and spatial information systems in the country. Furthermore, the Directorate of Overseas Surveys (D.O.S.) which directed topographic mapping and land resource studies in the colonies is still going strong; it has not been sidelined because of the emergence of new geospatial technologies. As is the case in the USA, so it is in Britain where the Ordnance Survey has been promoting use of geospatial technology products at the grassroots level. For example, in 2002, the Ordnance Survey launched the Free OS Explorer Map which it distributes to school children to support learning about geography and the environment and encourage children and their families to get out and explore their neighbourhoods. By late 2009 the Ordnance Survey had distributed 5 million copies to school children.

As we think about incorporating geospatial technologies for resource development in Nigeria, we must seriously consider the institutional framework for achieving such by repositioning such official units as the Federal Survey Department, the Nigeria Geological Surveys, the Department of Forestry, the Census Board and the Meteorological Services, among others, to play their rightful roles. It is time to put a permanent closure to the era of *ad hoc*, piecemeal development programs

that largely sidestep and sideline the established agencies and which thereby make very little impact on how things are done within the country. Most of these units have lost valuable manpower and lack the requisite exposure and experience in the applications of the emerging geospatial technologies. Professional and academic associations in the field such as the Institution of Surveyors, the Association of Nigerian Geographers, the Nigerian Cartographic Association, and the GeoInformation Society of Nigeria have a responsibility to help the process of re-energizing the government departments responsible for mapping and monitoring the environment and its resources. Unlike the situation in the past, these government departments and their officials must be more open to the idea of working with each other and with relevant professional bodies and experts outside the civil service. They must be less obstructive to new initiatives by professionals and professional associations outside all in the name of protecting jurisdiction and mandates.

Secondly, I would like to suggest that before we can intervene meaningfully and promote the application of geospatial technologies in resource development in particular and development planning in general, we have to be honest with our needs' assessment. What exactly is the state of knowledge of the Nigerian environment and its resource elements? What is the state of mapping of both the physical and human landscapes in the country? I would like to hazard the opinion that with all the efforts of the past four decades or so, including a space program, mapping in Nigeria has not advanced beyond the small scale reconnaissance level. The country is not getting any more detailed information than what is presented on the old 1:50,000 series topographic maps and the aerial photographs on which they were based. These 1:50,000 topographic maps, in spite of being outdated, still serve as 'base maps' for most of present day mapping and development planning! Those "old reliables" the 1:50,000 topographic maps and the source aerial photographs are still extensively used to make sense out of the products of latter day technologies.

The essence of what I am saying is that our data, mapping and spatial information needs for resource development and planning have not changed; we are still in dire need of basic technical data and information on our natural and human environment and the constituent natural and human resources. Our old 1:50,000 maps have been and are being digitized but that has not added to the quantum and quality of data and information that they contain. The Nigeria Geological Survey Agency has started compiling geological and mineral prospecting digital maps and data in parts of Nigeria but there is still a great deal of ground to

cover. I am sure there are pockets of high quality, even digital, data in the country but what are they compared to the vast territories yet to be covered and the huge data needs in the country. Available geospatial technologies should enable us improve on the volume and quality of available data and enable us do more things, with greater accuracy and efficiency than before. Therefore, in order to derive maximum benefits from the new geospatial technologies, we need to go back to the era of systematic survey and mapping of resources which we inherited from the Colonial Administration. We have done enough of running round deceiving ourselves thinking we are achieving something with the new geospatial technologies through the numerous *ad hoc* projects. No, there is nothing on the ground comparable to the 1:50,000 series topographic maps.

Thirdly, ladies and gentlemen and colleagues, I am not so sure that Nigeria needs to look far in search of geospatial technologies to apply as it has not adequately utilized the capabilities of existing readily available geospatial technologies, including aerial photography, satellite imagery (e.g. LANDSAT, SPOT), Radar, and digital image processing and analysis capabilities. Like the waste dumps of discarded desktop computer terminals and monitors found in some cities, Nigeria is like a junkyard of inadequately mastered and utilized geospatial technologies. Individual professionals and practitioners have benefited but the country at large has not. Many practitioners, both qualified and not so qualified, are doing a lot of work for clients both in the public and private sectors but the outputs are of variable quality. Quality control is very poor. The lack of departments comparable to the USGS and the US Census Bureau or the Ordnance Surveys in Britain, to provide standard databases, base maps and other products is largely responsible for such poor quality control among practitioners in geospatial information systems.

Today, in the USA, it is common place to download USGS digital maps to use as base maps for most forms of mapping in the country. The same goes for the TIGER files of the US Census Bureau which are used for mapping purposes in the built environment. The USGS Land use/land cover classification scheme provides a unifying principle and standard for land use mapping and development planning in the USA. It is thus easier to correlate and coordinate development planning at national, state and county levels. Nigeria should aim at such an ordered system so that her efforts in developing space technology and geospatial technologies for mapping and monitoring its land and natural resources for development purposes would bear the desired fruits.

Fourthly, promotion of geospatial technologies for development would also call for increased training of manpower in our universities

and technical colleges. And for a start, the learning and teaching environment must be upgraded in all the training institutions. ICT development and utilization must be promoted in every institution. Web-based learning (e.g. through Blackboard or Moodle) and on line instruction as well as interaction between learners and teachers through local intranet network are the hallmarks of new age universities. Instructional classes are held in "smart classrooms" with adequate video and audio-visual facilities and internet and intranet access during class sessions. This is already happening in universities across Africa but particularly in southern Africa. The low rating of Nigerian universities among African and world universities is largely due to the poor ICT and instructional environment. The reality of our situation in Nigeria is that many of the trainees in geospatial technology come as almost total strangers to the computer; many would be development planners in government ministries are also still not very comfortable working with the computer. We can begin to break down this resistance to the computer at the training institutions by doing things on line and by giving instructions in smart classrooms. On line admission and registration in our institutions are steps in the right direction but as we all know many students and parents still employ the services of ICT professionals and some quacks to do these basic chores for them. They are big business in Nigeria!

Furthermore, in all the disciplines related to geospatial technology including geography, cartography, surveying, urban and regional planning, architecture etc, Nigerian universities and colleges need to incorporate more laboratory or practical sessions where students can learn through hands on experience. In university departments of geography or environmental sciences elsewhere, it has become the norm to attach practical laboratory sessions to almost every course. For this reason, continuous assessment has become established as a mode of course examination: laboratory grades constitute at least 40 per cent of final grades.

One last initial point before we move on: new technologies cannot help any country where access to the data and derived products is highly restricted either directly through denial of access or indirectly through the charging of exorbitant prices to gain access. The countries that have benefited immensely from geospatial technologies are those which have facilitated access to the products and which also actively promote their use by the general public, apart from educational, public and private sector institutions. Providers and government departments and universities are voluntarily putting geospatial data and information online to make them freely available to relevant users in the field. There are

pockets of high quality spatial data and information in Nigeria but many of them are under lock and key. Free flow of data and information is necessary for Nigeria to derive maximum benefits from new technologies applied in resource development and development planning. The Federal Government of Nigeria can take a cue from the government of Bahrain, to give just one example, which has established the Bahrain Spatial Data Infrastructure (Al-Haidan, 2009) to make information available to all concerned ministries, public and private organizations and thereby increase their efficiency. The idea is to provide the fundamental data required for achieving diversified national objectives. This has been achieved by creating "a spatial data clearing house with a centralized data repository, directing and supporting the development of integrated GIS systems"(Al-Haidan *op cit*). Nigeria does not necessarily have to create one giant spatial data infrastructure like Bahrain, a small country, but the concept is a good one to adopt.

4. Targets for Geospatial Technologies for Application in Resource Mapping and Management

I would like now to turn my attention to the specific issue of geospatial technologies for resource development. If we as professional associations and practitioners seek to promote applications of geospatial technologies in resource management and development, we should first help develop the infrastructure and the institutional and policy frameworks for such a process. We need to focus on the official government agencies that are put in charge of various resources and get them to adopt a policy of creating databases on the different resource elements including soil, land, water, wetlands, agriculture, forestry, fisheries, and so on.

A database is a system or framework for the collection, storage, analysis and dissemination of data and information on a given resource element. Such databases exist for individual countries and there are also global databases. For example, Botswana has produced a digital soil map of the country which is now linked to the soil database to create a soil information system for the country that can be accessed on line. The positive outcomes of the move towards the development of geospatial technology and spatial information systems in environment and natural resource development are:

- the closer attention being paid to the provision of more detailed systematic surveys with a higher degree of accuracy of data and information;
- the application of sophisticated quantitative and spatial analysis techniques to the manipulation of resource data;

- the ensuing comparability of data and information on a given resource throughout a country or globally;
- the availability of data for planning purposes on each natural resource; and
- easier access to environment and resource data and information by the general public and stakeholders in the different fields.

For instance, there are global soil databases (Batjes et al., 2013), the most well-known being the Global Soil Moisture Data Base(Robock, *et al*, 2000), which has several datasets that provide various soil constants for determining, for example, wilting level, field capacity, and porosity. These databases ensure that resource surveys and studies are not wasted exercises whose outcomes get lost in the files or store rooms of government ministries and departments. Initially, the development of a given resource database may merely involve the computerization and archiving of existing data on the resource e.g. soils. But, over time, these data will need to be updated, upgraded, or reformatted. Also, additional data from previously un-surveyed or from re-surveyed areas will need to be incorporated. Then, as time progresses, there would be some degree of standardization in the measurement and recording of parameters, and in the number and types of data required.

While waiting for our various official departments to adopt this culture, we can encourage all professionals and practitioners to strive to contribute to existing global databases. This would help all of us to develop a healthy respect for quality standards in our resource studies which would later be reflected in our own national databases. Global databases maintain strict quality standards for acceptance of contributions from different parts of the world. Database development also leads to (1) standardization of survey and mapping procedures, (2) development of classification schemes, (3) specifications on acceptable analytical procedures, scales and units of measurement of individual parameters, and so on. Therefore, the next step in repositioning Nigeria for the application of geospatial technologies for resource development is for the various professional associations and practitioners to work with the cognate government agencies to develop rational classification schemes for the survey and mapping of each major resource element in the country. Such classification schemes may simply be adaptations of existing schemes from other parts of the world. Such schemes of classification are pre-requisites for turning resource databases into veritable resource information systems. The NIRAD project, a praiseworthy initiative of the Forestry Department in the 1970s was confronted with this problem when it came to the interpretation and

mapping of vegetation on the radar images. In spite of the noteworthy efforts of the NIRAD project to impose some order on the classification and mapping of Nigeria's vegetation cover, it did not succeed in developing a comprehensive rational or consistent vegetation classification or vegetation mapping scheme. There can be no significant progress in the application of geospatial technologies to resource management in Nigeria where there are no agreed rational schemes for classifying and mapping the different elements of our resource base. This is a major challenge to all of us who are interested in promoting applications of geospatial technologies in environmental and resource management and development in Nigeria. We need research teams or task forces to work with the relevant agencies to develop these schemes.

However, it is important to note and warn that it takes time to work out a classification scheme; the USDA Soil Taxonomy came into being after the 7th Approximation. Comments and criticisms from professionals and researchers in the field helped the group to develop the final version of the soil classification scheme called the Soil Taxonomy. We need to summon up courage and begin our own process in Nigeria. For instance, in the 1980s, there was a noble attempt at Soil Correlation by the Soil Science Association of Nigeria which was to reconcile all existing soil classification and mapping schemes in Nigeria and come up with a unified comprehensive soil classification and mapping scheme for the country. But, I think the effort got sidetracked with the formation of some *ad hoc* land development agency that sidestepped and sidelined the Federal Ministry of Agriculture. Fortunately all hope is not lost; Nigeria can follow the example of other developing countries and put some effort into adapting for her own use the widely acclaimed World Reference Base for Soil Resources scheme that came out of the FAO/UNESCO soil classification scheme first published in1975.

By now we should have learnt our lessons and do things that will last being firmly grounded in the well-established government departments or institutions. As I noted earlier, Nigeria is yet to exhaust the capabilities of existing geospatial technologies and bring them to bear fully on the classification, mapping, modeling and monitoring of its environment and natural resource base. For instance, as commendable as the NIRAD project was even if the outcomes were modest, it is a sad commentary on the way we do things in Nigeria that there has been no follow up to improve on those outcomes. Indeed, the government agency that championed that initiative, the Federal Department of Forestry, has been seriously weakened over the years in its ability to do anything worthy of note to match its initial effort. I dare say this story can be

repeated for all other agencies including the Federal Surveys, the Geological Surveys and so on.

Nigeria does not need to search very far for relevant geospatial technologies to use; all we need do is invest in the acquisition and analysis of the existing plethora of technologies (e.g. Buenemann et al., 2011, Aplin, 2003; Batty, 2003): aerial photography, multispectral satellite imagery (LANDSAT TM, SPOT, ASTER, AVHRR, IKONOS, MODIS), meteorological satellites(e.g. GOES – geostationary operational environmental satellite), active remote sensors (e.g. RADARSAT, TerraSAR-X, LIDAR), and hyperspectral sensors (ARIES, AVIRIS, HYPERION, WORLDVIEW). However, in order to be more focused in the use of these geospatial technologies and derive lasting benefits from them, we need a programmed systematic approach to environment and natural resource mapping and management. I would like to suggest the setting up and recognition of at least four activity centres for resource mapping, monitoring and management in the country to achieve some of the things already highlighted in this lecture. The notion of an activity centre is to emphasize that any unit designated as such must see itself as a hub of collaborative activities to promote progress in its areas of responsibility. Each activity centre will have a variable number of collaborating and cooperating institutions and establishments. These suggested geospatial technology activity centres for resource development comprise:

- Department of Federal Surveys which should concentrate largely on topographic, cadastral and township mapping activities. The Department should invest heavily on aerial photography including multispectral aerial photography, Landsat TM, SPOT and comparable systems such as MODIS, active remote sensors such as RADAR, LIDAR, GPS, etc. The Department of Federal Surveys would need to liaise with and work in collaboration with such other units, departments or ministries, which are responsible for geological survey, solid minerals, civil engineering, utilities, urban and regional planning to name a few obvious examples. A case could be made for the Geological Survey to constitute a distinct geospatial activity centre and collaborate with units dealing with oil and gas, solid minerals, hydrogeological, coastal environment etc. Even so, there would still be need for close collaboration with the Federal Surveys Department.
- Nigeria Meteorological Services which should focus on weather and climate, water resources, natural hazards, drought and desertification, climate change, pollution. The relevant

geospatial technologies would include GOES, NOAA AVHRR, MODIS, RADARSAT, TERRASAR-X, among others. The activities at this centre would be of interest to other departments responsible for water resources, river basin development, oceanography, flood control, disaster management, etc.

- Federal Department of Forestry, which should concentrate on such themes as vegetation and land use, nature reserves, agroforestry, deforestation, fire, wildlife, pests and disease ecology, tourism, wetlands. It would certainly need the cooperation of all units with interest in these areas. In addition to Landsat TM., SPOT, this activity centre would benefit from investments on other multispectral satellite sensors (IKONOS, MODIS, ASTER, AVHRR) and hyperspectral sensors (ARIES, AVIRIS, HYPERION, WORLDVIEW).
- Soil Survey of Nigeria activity centre would focus on soil mapping, soil moisture, agriculture, soil erosion and land degradation, irrigation, wastewater, land reclamation, etc. Again, aerial photography, multispectral satellite imageries and hyperspectral sensors would variously be useful to the activities of this centre.

Each activity centre must quickly establish the infrastructure for database creation and management together with it's complement of spatial information systems for the different aspects of the environment and natural resources. In procuring the required hardware and software, each activity centre must strive to deal directly with the manufacturers and developers. This is particularly important with respect to software: there is a lot of pirated material being distributed by vendors which create problems for users down the road.

However, while we are looking up to the skies, there is a great deal we should be doing on the ground to complement and derive maximum benefits from the space technologies. Nigeria's territorial space is too sparsely instrumented to make optimal use of the space technologies. We need satellite receiving stations, meteorological satellite receiving stations, instrumented river networks, and remote data collection platforms. It is sad that weather forecasting is still grossly underdeveloped in Nigeria: by now our news channels should be able to give real time, up to the minute, weather forecasts as is done in southern Africa. The meteorological satellites are there: the real problem is with the paucity of ground receiving stations and infrastructure. Furthermore, there have been remarkable improvements in surveying equipment to make it possible to improve Nigeria's datum and network of geodetic control points for topographic mapping and ground surveys and to

embark on a vigorous program of cadastral survey and mapping throughout the country. Total station (a theodolite with an EDM or electronic distance measuring device), satellite positioning systems such as the global positioning system (GPS), and the light and laser rangefinder (LIDAR, LADAR) are some of the major modern day additions to land surveying technology. Perhaps, the greatest need in Nigeria today is to update and convert to the metric system Nigeria's topographic map coverage.

Nigeria's topographic map coverage is a highly commendable heritage of the colonial administration and of the glorious years of the Federal Surveys Department. The topographic surface has changed drastically and there is urgent need to produce new up-to-date topographic maps, and township maps or orthophotomaps. Furthermore, in order to derive maximum benefits from the space based geospatial data in the analysis and interpretation of the Earth's vegetation cover especially in studies on land degradation, drought, desertification, pollution, pests and disease vectors such as mosquitoes, we need to focus on certain ancillary data derivable from remotely sensed imagery. There is an increasing number of environmental indices e.g. normalized difference vegetation index (NDVI), enhanced vegetation index (EVI), narrowband greenness, vegetation health indices, vegetation condition index, temperature condition index, to name a few, that we need to adopt and test their applicability to our environment and circumstances(e.g. Huete *et al.*,1994). There are climate models that seek to predict climate change both in the near and distant future and what the implications would be for various human activities especially crop farming (Tachie-Obeng, 2011). We must encourage our research students to do more fundamental research on these and other environmental indices.

5. Conclusion: Networking in Applications of Geospatial Technology

Ladies and gentlemen, all that I have said so far especially on the revitalization of the government departments responsible for resource mapping and development, should not be misconstrued to mean there is no room for the activities of individual professionals, researchers and research groups or teams. Indeed, such activities generate a great deal of data and information not only on the resource elements but also on the capabilities of different geospatial technologies that would greatly enhance the work of the government agencies. However, to achieve the best results, Nigerian researchers and professionals in the fields of environment, resources and geospatial technology should learn to work together in teams.

Networking by researchers, experts, and professionals working on particular subjects or fields of study is the common practice nowadays and developments in the electronics media and information systems have made this networking much easier. International expert group meetings and conferences can now be held through the internet without people having to travel and gather at a particular location. Networks may be local/country specific or international. Some of the more well-known networks existing in parts of Africa include those on food (e.g. FOODNet), fire(e.g. FIRENet Listserve- International Association of Wildland Fire), water(e.g. WATERNet, Southern Africa), family early warning system (e.g. FEWSNet), global warming and climate change(e.g. Climate Action Network of NGOs; Climate Change Network, Nigeria; Climate Exchange Network for Africa). There is too much unhealthy rivalry between professionals in the disciplines related to geospatial technology which has greatly stultified growth. We need to be talking to each another and sharing experiences, data and information. No one group has all the answers and no one group should seek to dominate and corner such a big field: to seek to do so is quixotic and inadvisable.

Resource development by its very nature requires such a collaborative approach. By resource development we are referring to the management and utilization of Nigeria's natural resources in a sustainable manner to ensure that we do not allow flitting, short-term benefits to blind us to the long-term benefit and interests of the people and the environment and resources in general. Geospatial technologies and information systems are specifically designed to aid decision making in resource development. These geospatial technologies make it possible to consider resource development within a variety of contexts, ecological, economic, socio-cultural, political and technological and present for the consideration of decision makers alternative solutions or routes to resource development issues. Resource development activities must not only be economically feasible they must also be socially acceptable and environment friendly and sustainable.

Geospatial technologies make it possible to come up with different scenarios on every conceivable approach to achieving given ends in resource development so that decision makers have as many options as possible to choose from. This is the more reason why a multidisciplinary approach must be adopted in applications of geospatial technologies in resource development and why all the disciplines related to geospatial technology should be promoted and given a chance to participate and contribute their own quota to the development of environment and resource mapping and management in Nigeria. Indeed, in some other

parts of the world and, indeed, in some parts of Africa, there is increasing interest and pursuit of indigenous knowledge and participatory approaches in the application of geospatial technologies in resource mapping and development (Mulalu, 2011, Mulalu & Veenendaal, 2007, 2011; Maphanyane, 2012). The local people are being engaged to participate at different stages of the resource mapping process so that local indigenous knowledge and preferences could be brought to bear on the outcomes and their subsequent use to aid decision making at the rural grassroots level, for example.

In conclusion, ladies and gentlemen and colleagues, the field of geospatial technology is becoming more interesting and challenging as it is being opened up to accommodate as many players as possible and as it is being brought to bear on decision making on livelihood issues at the rural grassroots level. We need to do the same in Nigeria and popularize geospatial technology applications in all areas of human endeavour.

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