Building on Geospatial Information Capacity for Sustainable Development in Africa

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Key words: geospatial information, capacity building, curriculum development, spatial data infrastructure, Earth observation satellite

SUMMARY

A number of geospatial information (GI) specific activities have brought to the front burners the need for pro-active measures for building on existing GI capacity in Africa. The activities include increasing interest of African countries in space science and technology (SST) with four African countries (Algeria, Egypt, Nigeria and South Africa) owning Earth Obaservation satellites, development of regional and national spatial data infrastructures, implementation of unified African (Geodetic) Reference Frame (AFREF), and national land reform programmes. There is no doubt that these activities have impacted positively on the development of GI capacity in Africa. However, the utilisation and further development of the existing capacity is hampered by some challenges.

The paper presents an overview of the aforementioned GI activities and discusses the contending challenges. The paper then discusses the GI education and training requirements for the sustainable development of the region and ways of achieving them such as single campus based education, e-Learning and joint education. Some proposals and recommendations are then made on the way forward towards building on human GI capacity in Africa. The recommendations include: encouragement of joint GI education and web based education/e-learning; participation of national and regional GI institutions of learning and organisations in the capacity building activities and tasks of International GI Organisations to facilitate quick uptake of resulting capacity building innovations that may emanate from the activities; inventory of existing educational institutions offering geoinformatics and related courses in Africa including the curricula, staff capacity and existing training facilities; strengthening of the institutions to enable each country to have capacity for research and developmental efforts; review and standardisation of GI curricula across the continent; and encouragement of in-country execution of mapping and other GI-related projects to facilitate technology transfer.

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1. INTRODUCTION

Provision of readily available, reliable and adequate geospatial information (GI) for sustainable national and integrated regional developments requires availability of critical mass of skilled manpower and an enabling environment. Notable efforts have been made in Africa in the past years to provide enabling environment for sustainable production, management, dissemination and use of GI in Africa through national, regional and international programmes and actions. These include the promotion of the development of, among others, Spatial Data Infrastructure (SDI) in African countries and the new Global Geospatial Information Management (GGIM) initiative of the United Nations (UN), both aimed at making geospatial datasets available, discoverable, better accessible, shareable, interoperable and re-usable.

At national and regional levels, commendable strides have been taken on the implementation of the African (Geodetic) Reference Frame (AFREF) to facilitate unified regional coordinate system for georeferencing and geospatial data integration. Furthermore, the use of Earth Observation satellite (EOS) data to generate development information is rapidly improving in Africa following the launching of EOS by African countries which led to increased awareness of decision makers and civil society in the applications of EOS and geospatial technology. The recognition of the immense opportunities offered by EO systems for regional cooperation and development has also led to the encouraging evolution of the concept of an African Resource Management Satellites (ARMS) constellation programme for which NigeriaSat-2 EO satellite is expected to be the first contribution.

Many African countries are also carrying out national systematic land registration programmes using rapid, relatively low-cost methodology and mostly funded by international development agencies. All the activities highlighted above include capacity building/improvement component and also serve as an indication that a significant capacity exists in Africa for sustainable production and utilisation of geospatial information.

This presentation therefore assesses the current status of GI activities in Africa and the challenges that must be addressed to ensure sustainability. The presentation then discusses some modalities for human capacity building to cope with sustainable production, management, dissemination and utilization of GI in Africa.

2. KEY GEOSPATIAL INFORMATION ACTIVITIES DRIVING CAPACITY REQUIREMENTS IN AFRICA

An assessment of the current status of geospatial information capacity in Africa is a necessary precursor for the development of sustainable action plans to build on the existing capacity in the continent. Unfortunately, a comprehensive study and documentation of the status of GI capacity in the continent is lacking at the moment and perhaps should be one of the priority areas to be addressed in the regional and global geospatial initiatives. However, noteworthy are the commendable efforts made or being made by various international, regional and national organisations such as UNECA, UNOOSA, UNEP, UNDP, AARSE, EIS-AFRICA, etc. to facilitate the uptake of EO and geospatial technology in Africa through the promotion of the development of, among others, the spatial data infrastructure (SDI), unified geodetic reference frame and space science and technology (SST) in African countries. These key activities are briefly discussed in this section.

2.1 Spatial Data Infrastructure Development

Many African countries are at various stages of SDI development with South Africa taking the lead with an already enacted SDI bill and an operational geo-portal. Majority of those that have somewhat commenced the process are at the stage of policy development and acquisition of some fundamental datasets while some are yet to commence any activity. At the regional level, through the efforts of the Geoinformation sub-committee of the UNECA Committee on Development Information, Science and Technology (CODIST-Geo), the following projects were already completed: definition and determination of fundamental geospatial datasets for Africa; catalogue of fundamental geospatial datasets for Africa and gap analysis for all the countries; while the project on “Guidelines for Best Practices for the Acquisition, Storage, Maintenance and Dissemination of Fundamental Geo-spatial Datasets” was in progress, with the outline of the document and document specification completed (CODIST-II, 2011, p.35).

Furthermore, ten themes of fundamental datasets have been defined for the regional SDI but these datasets are either not available at all in many countries or they are largely not available in the form and currency required to contribute to the fundamental datasets of the national or regional SDI. For example, in many countries, 1:50000 topographic maps that serve as base maps are out-of-date and in analog form; cadastral maps/databases are mostly not available; coherent and standardized geographic names are not yet available; while in most cases geodetic controls are not yet unified and adjusted and are not in sufficient density. The situation is similar with respect to the other fundamental datasets.

Further on the SDI initiative, a metadata profile for Africa has been developed but this has to be implemented in a case study to guide adaptation at national level. Many countries have also contributed to the World Health Organisation’s Second Administrative Level Boundaries (SALB) database, which is an important dataset for planning and implementation of development projects at national and regional levels. Another key geographic dataset for a national SDI is the national street address; a very important dataset for all location-based services. A national coverage of this vital dataset is not available in most African countries.

Also worthy of note are the on-going global and regional initiatives such as GMES and Africa, UNSPIDER, GEOSS, AMESD, GGIM and various internationally supported national land reform programmes through which fundamental datasets are being made available and capacity are being built upon, as well as support of international geospatial organisations for regional development programmes such as the ICA's Working Group on MAfA, ISPRS, IAG and FIG.

2.2 African (Geodetic) Reference Frame (AFREF)

Notable progress has also been made on the implementation of AFREF with the AFREF Operational Data Centre (ODC) having access to approximately 110 continuously operating permanent GNSS reference stations (CORS) as at December 2012 (see Figure 1), although (probably due to infrastructure challenges) only 49 of the stations on average, are archiving data daily at the ODC (Wonnacott, 2013). Many countries and states/provinces within countries have also established a number of CORS in their jurisdictions which are yet to be integrated into AFREF; for example, the Nigerian Permanent GNSS Reference Network (NIGNET) at end of 2012 has 15 fully-operational COR stations in various parts of the country (Edozie and Adebomehin, 2013) (see Figure 2) while the Lagos State Gvernment of Nigeria has one and the State of Osun (Nigeria) has three stations.

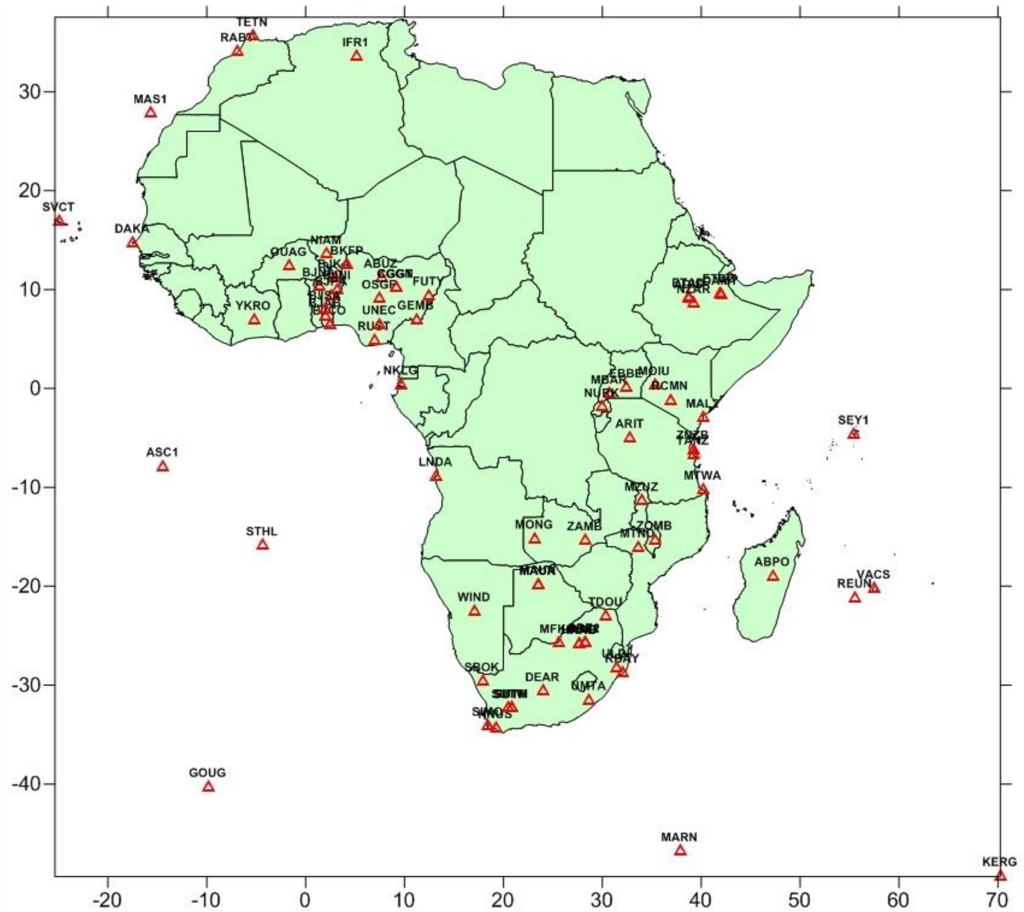

Figure 1: Stations for which data is archived in the AFREF ODC as at 4 January 2013 (Wonnacott, 2013)

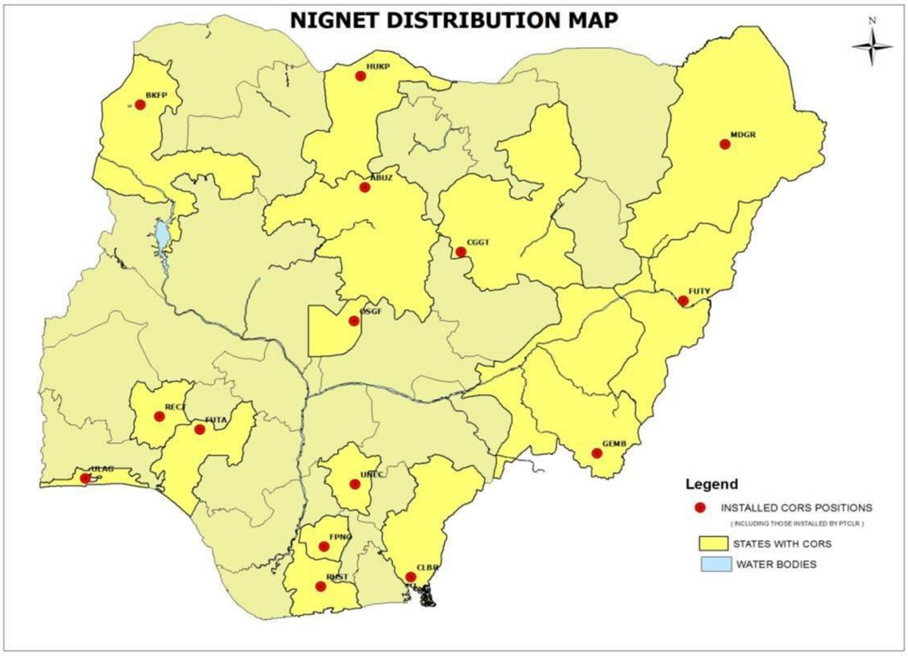

Figure 2: Nigerian Permanent GNSS Reference Network (Edozie and Adebomehin, 2013)

2.3 Space Science and Technology Development

The use of EOS data to generate development information is rapidly improving in Africa as attested to by the 2008 USGS Remote Sensing in Africa Survey (USGS, 2008). This is especially so, following the launching of EOS by African countries – Algeria (AlSat-1, AlSat-2), Nigeria (NigeriaSat-1, NigeriaSat-2 and NigeriaSat-X), Egypt (EgyptSat-1) and South Africa (SumbadilaSat-1) within the last ten years, which led to increased awareness of decision makers and civil society in the applications of EO system and GIS. The availability of free archived Landsat data and SRTM DEMs and cheap alternatives like ASTER data are also making satellite data become more affordable. All these are expected to improve the production of fundamental datasets in Africa provided human capacity is adequate.

Specifically the two new Nigeria's EO satellites, NigeriaSat-2 and NigeriaSat-X, were launched on 17th August, 2011. The NigeriaSat-X was built completely by Nigerian Engineers who were trained at the Surrey Satellite Technology Ltd. The satellite carries two pay loads: a 32m resolution (as continuation of NigeriaSat-1) and another 22m resolution sensor. NigeriaSat-2 is a 300 kg Earth observation satellite with four multispectral channels having 2.5m spatial resolution in panchromatic mode and 5m in multispectral mode (SSTL, 2011). Furthermore, it has capability for stereo imaging. It will therefore significantly boost African capabilities for GI production for developmental activities such as natural resource management, as well as aid disaster risk reduction through the Disaster Monitoring Constellation.

The ARMS constellation programme has also been officially endorsed by the governments of Algeria, Nigeria, South Africa and Kenya, and is open to other African countries that may be interested in joining the venture in the future. The new NigeriaSat-2 satellite is expected to be Nigeria's contribution to the initiative thus signaling its practical implementation with the expected improved availability of satellite images for GI production in Africa.

Furthermore, three African countries have operational Communication satellites, namely Egypt, Morocco and Nigeria, which have the potential to improve ICT infrastructure for GI production, management and use in Africa.

2.4 Land Reform Programmes

Land reform has taken front seat in the national development programmes of many African countries including Nigeria. These programmes are utilizing innovative low-cost, space-based data acquisition method and GIS-based title registration to aid country-wide rapid systematic parcel registration and are contributing to the density of continuously operating reference stations in Africa. Although many personnel have been trained at various levels through their human capacity building programme, such a programme requires incorporation of low-cost methodologies in our education and training curricula for life-long learning and sustainability of the programme itself.

2.5 New Trends

Current advances in space and Geo-ICT technologies offer great opportunities for advancement of GI production, management, dissemination and use in Africa. It is therefore necessary to build on existing capacity for the utilization of the various new and emerging trends including:

i. Cloud computing especially for the storage and processing of high volume geospatial datasets in the cloud.
ii. Use of free and open source software (FOSS) for various GIS applications, metadata catalogue and clearinghouse implementation.
iii. Use of global datasets to generate appropriate fundamental datasets at cheaper rates
iv. Appropriate use of volunteered geographic information (VGI) / Community mapping/ crowd sourcing for continuous data updating
v. Building on mapping capacity for appropriate use of modern mapping technology such as LiDAR (Light detection and ranging), UAS (Unmanned Aerial System), etc.
vi. 3D (geometry and topology) GIS implementation: 3D Cadastre, 3D City Models, etc.

3. GEOINFORMATICS EDUCATION AND TRAINING REQUIREMENTS

3.1 Education Content and Context

Table 1 shows a categorization of capacity building for Geoinformatics of which education and training are part and parcel.

Table 1: Three levels for capacity building (Georgiadou and Groot, 2002)

	PURPOSE	FOCUS
CAPACITY BUILDING FOR GEOINFORMATICS	Human resources development	Supply of technical and professional personnel
	Organizational strengthening	Strengthening the management capacity of organisations; institutionalise geo-ICT solutions (systems and processes) as well as strategic management principles
	Institutional strengthening	Strengthen the capacity of organisations to develop & negotiate appropriate mandates and modus operandi as well as appropriate (new) legal and regulatory frameworks

According to UNECA (2001), "*the future orientation of GIS does not lie in the technology itself* (since this can be said to be mature), *but in its use to process data to support spatial decisions and services.*"

Consequently, GI must be produced according to a common national standard and be made available and accessible for use in diverse fields of national development. However, one of the pre-requisites for being able to achieve this is that sufficient human and technical resources must be available to produce, manage, disseminate and use GI.

Because of the diverse nature of GI applications, experts from one specific discipline can seldom address all aspects involved, more so when the application domains cover a wide variety of fields (natural resources management, agricultural resources management, urban management, environmental issues, land administration, etc.). Consequently, geoinformatics has to be seen in an interdisciplinary context but still requiring specialization to enable professionals to keep up to date with the state of the art in their field of expertise. This means that a single program cannot satisfy all requirements; rather we need a related family of education and training programs, which will enable us to produce experts in diverse application domains.

However, geoinformatics education should be strong at conceptual level so that its graduates can be versed not only in the use of geospatial technology but also in its development. With data acquisition fast becoming a black box, the education program needs to also focus on spatial data analysis, applying more rigorous mathematics and spatial statistics. While noting that data acquisition procedure is fast becoming a black box, reducing the required knowledge to knowing which buttons to press and the teaching of this through particular applications, the need for a fundamental understanding of data quality is recognized by geoinformatics teachers. However, the understanding of data quality in turn depends on understanding the underlying algorithms used to create or capture and process the data (Dale, 1999). Thus, apart from the traditional branches of mathematics studied in surveying and mapping disciplines, new areas of geoinformatics especially aspects of spatial reasoning such as spatial data modelling, also require strong mathematical foundation in areas such as set theory, fuzzy set and fuzzy logic, graph theory, simplexes and complexes, topology, etc.

Again, the growing availability of faster means of data acquisition using black-box technique will continue to lead to proliferation of spatial data of diverse sources, resolution and quality. This has led to the growing need for those who understand spatial data integration issues, understand the propagation of uncertainty in spatial data handling and analysis, can advise on supplementary data collection, know how to communicate spatial information, and have the skills to create and maintain key spatial data infrastructure (Kufoniyi, 2004).
Moreover, they should possess the knowledge of every link and data flow in the geoinformatics process from spatial data collection, through spatial analysis and application, to spatial information communication. They must be able to give advice on alternative approaches and the cost versus quality implications. For any client's spatial information goal, our graduates must know how to achieve it in the most cost-effective way. Thus they require not only ability to find technical solutions but to also construct the business case for any technical solution.

3.2 Levels of Training Requirements

The required geoinformatics education and training programs should be geared towards the following four levels (Kufoniyi, 1999):

(a) High-level policy-makers, which can be achieved through short-term workshops in the fundamental as well as institutional aspects of geoinformatics particularly when GIS implementation is being initiated.

(b) Management and Professional staff: New employees in this category should be already educated in the modern technology while opportunity must be also provided for mid-career training and retraining of those already in employment for the purpose of broadening their outlook and keeping up to date on modern developments in geoinformatics.

(c) Technical Support Staff: Education and training/retraining of technicians and technologists for efficient production, management and use of GI.

(d) General Public: through mass media and public lectures, to sensitise the public on the benefits derivable from GIS and GI production.

3.3 Existing Human Capacity Development Institutions and Organisations

In the area of human capacity development, various institutions and organisations exist and are grouped into the following four categories:

a) Regional Centres: e.g., RECTAS[1] (a bilingual Centre – English & French, offering education and training programmes at technical and postgraduate levels), RCMRD[2]

[1] Regional Centre for Training in Aerospace Surveys (RECTAS), www.rectas.org
[2] Regional Centre for Mapping of Resources for Development (RCMRD), www.rcmrd.org

(short-courses and project training), AOCRS[3] (networking), ACMAD[4] (weather-related courses/projects), ARCSSTE-E[5] (postgraduate courses in English), CRASTE-LF[6] (postgraduate courses in French) and AGRHYMET[7] (short-courses/project training in French);

b) National specialised institutions offering regular and/or short-term training programmes in GI, such as: CRTS[8] (Morocco), CSE[9] (Senegal), CERSGIS[10] and Ghana School of Surveying and Mapping (Ghana), and Federal School of Surveying (Nigeria)
c) Universities and Polytechnics offering courses at diploma, first degree and postgraduate levels – e.g. 13 Universities are offering Surveying & Geoinformatics education in Nigeria apart from many more Geography departments running RS & GIS postgraduate education.
d) Organisations/Professional Networks that regularly organise conferences and workshops such as: AARSE[11], EIS-Africa[12] and African Leadership Conference on Space Science and Technology; also such national networks like Nigerian Insitution of Surveyors (NIS) and Geoinformation Society of Nigeria (GEOSON).

While the Universities and Polytechnics concentrate mainly on regular education courses mostly leading to the production of new graduates, the specialized institutions focus more on manpower development through the education and training/retraining of serving officers. Furthermore, flexibility is possible in the specialized institutions, facilitating running of their programmes in short modules to permit continuing education of serving officers through short courses that are part and parcel of the regular programmes.

4. CHALLENGES FACING CAPACITY DEVELOPMENT AND UTILISATION IN AFRICA

It is clear from section 2.0 that human capacity in geoinformatics is improving in Africa but the quantity, quality and utilisation are still low due to a lot of challenges some of which have been addressed by various authors in different forums e.g., Ruther, 2001; UNECA, 2001; Kufoniyi et al, 2002; Kufoniyi, 2006a. Some of the challenges are still with us and are reviewed in this section before proposing ways of meeting some of them in sections 5 and 6.

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[3] African Organisation of Cartography and Remote Sensing (AOCRS)
[4] African Centre of Meteorological Applications for Development **(**ACMAD**)**, www.acmad.net
[5] African Regional Centre for Space Science and Technology Education in English (ARCSSTE-E), www.arcsste-e.org
[6] Le Centre Régional Africain des Sciences et Technologies de l'Espace en Langue Française (CRASTE-LF) (www.crastelf.org.ma)
[7] AGRHYMET Regional Centre, www.agrhymet.ne
[8] Le Centre Royal de Télédétection Spatiale (CRTS), www.crts.gov.ma
[9] Centre de Suivi Ecologique (CSE) www.cse.sn
[10] Centre for Remote Sensing and Geographic Information Services (CERSGIS), www.cersgis.org
[11] African Association of Remote Sensing of the Environment (AARSE), www.africanremotesensing.org
[12] EIS-AFRICA, www.eis-africa.org

(i) Obsolete curricula and facilities: Many of the institutions of higher learning are running obsolete programs with analogue-dominated, or completely analogue equipment, methods and academic staff such that moving from this phase to a completely digital domain will require a huge capital.

(ii) Continued use of obsolete production techniques in production organisations: Some of the GI-related production organisations still operate in the analogue domain, which means that new graduates who have been trained in a completely modern technology become "misfits" in such organisations due to lack of appropriate equipment and environment for them to work. This creates dilemma for institutions in deciding on whether to go the whole hog of modernizing their curricula or to "hybridize" the obsolete programs.

(iii) Difficulty of releasing many officers for long-term training at the same time: Serving career officers that require retraining are many whereas it is not feasible to allow more than a few to go for a long-term training (within or outside the country), making short-term training a very important component of GI education programmes. This further gives credence to the need for modular curricula that will enable interested persons to join short module(s) of interest and then go back to their jobs. A modularized education programme is however difficult in our institutions, some of which are still teaching subjects that span a whole session.

(iv) Lack of intra-campus cooperation among relevant departments even in the same institution leading to duplication of effort and uncoordinated programmes and courses especially at postgraduate levels. Athough no single program can satisfy all the GI education requirements of all the socio-economic sectors of a country, there are common (core) courses, which should be run in one department such that students from other departments can attend the course rather than duplicating the subject in every department.

(v) Lack of financial resources for overseas training: Many organizations in African countries cannot afford to send many members of staff on training overseas due to financial constraints, especially considering the number of persons to be trained before achieving capacity utilization.

(vi) Absence of uniform academic standard and lack of networking: Uniform academic standard and proper networking would have facilitated sharing of human and other training facilities thereby addressing the problem of inadequate number of trained personnel and lecturers.

(vii) Lack of provision for continuing education and training: This makes African geoinformatics lecturers and practitioners to be out of date quickly and therefore unable to sustain a dynamic curriculum.

(viii) Inadequate enabling technologies: Many of the enabling technologies for modern geoinformatics curricula are in various stages of development in Africa. For example, even though internet is commonplace in some countries, the bandwidth is often too narrow while there are still countries where it is very difficult to come by, consequently developing web-based and e-learning curricula in such countries will not make sense.

(ix) Insufficient capacity utilisation and knowledge transfer: The common practice in many African countries is that GI projects are given to foreign-based organisations for execution with little or no involvement of local expertise even where such expertise exist. More often than not, the projects are completely implemented outside the country and simply locally deployed without any local content even when local implementation is possible. These do not encourage utilisation of skilled local capacity and technology transfer. Moreover, in many cases, personnel that were trained abroad are often assigned to un-related tasks when they return and are not able to utilise or transfer the knowledge gained to others. There is also a lack of participation in relevant international events and organisations due to financial constraint.

(x) Fast evolution of technology: Geospatial and Information & Communication technologies offer tremendous opportunities but changes are often so rapid for organisations and personnel to catch up with usually due to financial constraint to purchase updates or re-train staff. Moreover, due to rapid changes in technology, trained personnel would already require retraining within a period of five years after graduation.

5. WAYS OF ACHIEVING REQUIRED GI EDUCATION AND TRAINING

The situation report and challenges summarized above indicate the daunting education and training tasks that institutions of higher learning in Africa must address. The education and training needs can be addressed through three main options, namely: the conventional *face-to-face* on-campus education and training in a University, polytechnic, or specialized institution; e-Learning and web-based distance education; and joint/cross-border education.

5.1 Face-to-Face On-Campus Education & Challenges

The role of higher institutions of learning in producing skilled manpower in surveying and geoinformatics through the conventional on-campus mode cannot be overemphasized. Unfortunately, many of these institutions are facing a lot of challenges. In Nigeria for example, as at end of 2012, there are 13 Universities and 18 Polytechnics running surveying and geoinformatics programme. But all these universities, due to inadequate training facilities produce on the average, less than 300 geoinformatics graduates at all levels per year while the polytechnics produce less than 500 technicians and technologists per year. Even then, because of the relatively obsolete content of the programme, many of the new graduates require further training before they can be usefully engaged in modern production work. Furthermore, on the average, only about 80 of the University graduates are able to fulfil the necessary conditions for registration by the Surveyors Council of Nigeria per year (Solesi, 2005).

In some countries, the departments face the threat of being closed down due to dwindling students' enrolment as a result of obsolete content, and lack of equipment and personnel to meet accreditation standards. Between 2003 and 2005, RECTAS gave out analogue photogrammetry plotters (which are still accepted as relevant equipment for accreditation in the country) to 12 of the 18 polytechnics and 2 Universities in Nigeria in a situation where RECTAS was getting rid of the equipment in line with the Centre's modernized training curricula.

It is obvious from the foregoing that apart from production organizations, training institutions themselves require capacity building to enable them to meet the training requirements of the various countries and in order to make significant impact through multiplier effect, enhancement of the capacity of the training institutions must receive priority attention than the production organizations.

5.2 e-Learning

Human capacity development can also be improved through e-learning, however, there are many obstacles limiting effective deployment of this method (Kufoniyi, 2010). While open-source software maybe available for participants of this scheme, the enabling environments are usually inadequate. The challenges facing effective deployment of this approach include:

- low human capacity in ICT
- low density of ICT, and
- lack of broadband internet

However, some form of e-learning and distance education can still be incorporated into the capacity development programmes by sending course materials in a CD to the participants.

5.3 Joint Education Programmes and Networks

The positive roles of cross-border education and educational networks in rapid capacity building have been well articulated by various authors (see for example, Molenaar, 2002, Kufoniyi, 2010). The various categories and potential contributions of educational networks have also been well discussed (see for example Kufoniyi et al, 2002 and Kufoniyi, 2006b). To achieve the capacity needs at various levels, the joint education programme can be designed at different levels, including the following:

(a) Master of Science course with a duration of 18 months;
(b) Professional Master or Post-Graduate diploma course with duration of 12 months;
(c) Short term refresher courses; and
(d) PhD by sandwich

These can be implemented using different models. For example, the National Universities Commission (NUC) of Nigeria permits any of the following three models for the provision of cross-border university education in Nigeria (NUC, 2009):

- The Twinning/Articulation Model where a foreign university (recognised and accredited by competent authorities in its home country) collaborates with an approved Nigerian university to offer courses, enrich curricula content and pedagogy and or offer joint or dual degrees through articulation arrangement.

- The Branch Campus Model: This model permits a foreign university to avail itself of the NUC standing procedure for the establishment of private universities, and establishes its campus anywhere in Nigeria. Such a campus must be a replica of the parent institution in the home country and must meet the standards and quality assurance requirements currently applicable to Nigerian Universities.
- The Open & Distance Learning (ODL) Model which involves the provision of quality academic programmes and courses leading to the award of degrees, without the constraints of time and space in line with the stipulations of the guidelines for open & distance learning in Nigerian Universities.

In general, joint education network can be categorized into two (Kufoniyi et al, 2002):

- South-South joint education network
- North-South joint education network

The south-south education network is limited to collaboration among two or more institutions of learning in the south (developing countries) carrying out joint research, education and training programmes thereby sharing facilities. The collaboration can be among institutions that are located in the same country (intra-national) or in different countries (international) but only in developing countries, African countries in this case. Examples of intra-national collaborations exist in various countries. The north-south joint education network on the other hand involves the collaboration of one or more institution(s) in the developing country/countries and one or more institution(s) in the developed country/countries.

Joint education scheme has the advantage of regular update of curriculum including staff and student exchange programmes. It has great potentials to contribute to rapid national and regional development by:

- Providing qualified graduates for immediate employment and productivity.
- Retraining existing personnel for improved productivity and introduction of modern production techniques.
- Retraining academic staff of other institutions.
- Significant saving in foreign exchange through efficient local training and reduced stay abroad.
- Assisting production organizations through well-equipped consultancy services.

6. BUILDING ON EXISTING HUMAN CAPACITY: SOME PROPOSALS

The problems of capacity building for geoinformatics in general, and in the context of education and curriculum development in Africa are complex but not insurmountable. Various authors have already suggested solutions (see UNECA, 2001; Ruther, 2001; Nkambwe, 2001; Kufoniyi et al, 2002; and Kufoniyi, 2011), some of which are re-iterated below:

(a) The starting point is to carry out an inventory of existing educational and training institutions offering geoinformatics and related courses in Africa including the curricula, staff capacity and existing training facilities. A survey of the ad hoc, user oriented short courses being offered outside the traditional geoinformatics community should also be conducted.

(b) Governments at various levels need to strengthen national and regional institutions of learning to enable each country to have capacity for geospatial research and developmental efforts in its national institutions. Overall, the goal should be to build on the existing capacity to enable each country enhance its scientific and technical knowledge and experience in the applications of Geodesy, Photogrammetry, Remote Sensing and Spatial Information Sciences in addressing Africa's needs.

(c) We need to develop unified and standardised geoinformatics curricula at all levels (PhD, MSc, PGD, BSc, Technologist and Technician) for implementation in all higher institutions of learning in Africa. A 'leaf can be borrowed' from the Joint Board of Geospatial Information Societies - JBGIS' Geoinformation Book of Knowledge – GiBoK. While the continent-wide unified curricula are being worked on, the institutions should individually (or nationally, where a regulatory body exists) modernize their curricula to be responsive to long-term education at various levels as well as short-term training and re-training in geoinformatics.

(d) It is recommended to establish an *African Network of Geoinformatics Education* comprising of African universities, regional centres and polytechnics to facilitate joint education, research and training programmes thereby sharing facilities and promoting greater access to the latest geoinformatics technology. The network can be at various levels: network of relevant departments in the same institutions, among institutions that are located in the same country (intra-national) or in different African countries. An appropriate institutional platform for the network is necessary at every level, e.g. relevant division of African Union Commission (AUC) or UN Economic Commission for Africa (UNECA) at regional level, ECOWAS at West-African sub-regional level and the relevant division of an appropriate MDA (Ministry/Department/Agency) at the national level.

(e) The Geoinformatics Education Network should identify a set of pilot applications of geospatial technology in areas of particular relevance and establish outreach programmes to raise the awareness of geoinformatics in potential user communities (medicine, agriculture, transportation, etc.) through posters, leaflets and computer demonstrations of the geoinformatics applications. The network should also establish research projects that will benchmark modern versus traditional methods and assess the economics of geoinformatics. Furthermore, the network and individual institutions need to actively participate in the capacity building activities and tasks of International Organisations such as FIG, ISPRS, GEO, GSDI and ICA to facilitate quick uptake of resulting capacity building innovations that may emanate from the activities.

(f) A coordinating platform for existing African Geospatial Information Societies (AARSE, EIS-Africa, African Leadership Forum on Space Technology, etc.), akin to the JBGIS, is necessary to facilitate the exchange of ideas within and among the existing associations. We should explore the possibility of expanding the existing biennial AARSE and AfricaGIS conferences to cater for the network of Geoinformatics Associations and include selected training modules in the conference. Such a coordinating organ can then be used to sustainably publish a regular regional Geoinformatics journal (e.g. *African Journal of Geoinformatics, AJG*), in English and French, to serve as a tool for distributing information and to build a larger sense of community between the many active national, regional and specialist communities.

(g) Furthermore, in-country execution of mapping and other GI-related projects should be encouraged to the level permitted by availability of infrastructure and capacity within the country. This as well as a “Local Content” clause should be incorporated in the national mapping and geoinformation policies to nurture indigenous talent and facilitate technology transfer. Involvement of indigenous private sector in the production and management of geospatial data through job outsourcing and public-private sector partnerships is also essential to create job opportunities for fresh graduates.

(h) To enable ICT infrastructure support, we need to encourage utilisation of regionally owned communication satellites through special pan-Africa price regime that will contribute to appreciable increase in the density as well as the bandwidth of Internet services to facilitate delivery of web-based education and e-Learning.

7. CONCLUSIONS

Attempt has been made in this paper to highlight the need for enhancement of existing GI capacity in Africa. The paper reviewed the current status of GI and its impact on capacity building; challenges that are facing utilisation of GI capacity within the continent are also highlighted and ways of improving human capacity building and utilisation are proposed. Some of the activities and measures recommended include:

- Encouragement of joint GI education (north-south and south-south) and web based education/e-learning.
- Participation of national and regional GI institutions of learning and organisations in the capacity building activities and tasks of International Organisations such as ISPRS, GEO and FIG to facilitate quick uptake of resulting capacity building innovations that may emanate from the activities.
- Inventory of existing educational institutions offering geoinformatics and related courses in Africa including the curricula, staff capacity and existing training facilities.
- Strengthening of the institutions to enable each country to have capacity for research and developmental efforts.
- Standardisation of the curricula across the continent; and
- Encouragement of in-country execution of mapping and other GI-related projects to facilitate technology transfer.

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BIOGRAPHICAL NOTES

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