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REMOTE SENSING/GIS SOFTWARE UTILIZATION AND CHALLENGES – AN EXPLORATORY STUDY IN NIGERIA

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Abstract

The paper is an exploratory study of the use of Remote Sensing/GIS Software particularly by the researchers in tertiary institutions and utilization challenges by the urban managers in Nigeria. Among the questions addressed in the paper are: What are the broad areas of research and topics that are addressed? What type of remote sensing and GIS software are used? What are the sources of satellite images used? What are the types of institutional affiliation and departments of the researchers? What are the utilization challenges? The data used in the study is from an extensive published article search and the administration of 101 questionnaires to public servants. Descriptive statistics are used to analyze the data. The study shows among others that most of the researches are on analysis and applications. Most of the research topics are on land use/land cover. ESRI software products are the most used products. Top on the list of problems affecting use of GIS/Remote Sensing applications is financial problem, followed by power supply (electricity) problem, lack of knowledge about GIS/Remote Sensing applications, lack of incentives and motivation, and technical nature of the applications. Policy implications of the findings are highlighted in the paper.

Keywords: Geographical Information Systems; Remote sensing; Urban manager; Nigeria

Introduction

Dangermond (2011) underscored the importance of GIS applications in our dynamic contemporary world characterized with rapid changes and facing many challenges and difficult problems - such as climate change, urbanization, security, poverty, inequality – which we must deal with and which are affecting us as individual as well as impacting our organizations and governments. He notes that geography has always been a critical type of information that humans – in fact, all animals – collect, organize, and use and place-based information is vital to survival on our planet. According to him as our world has become complex and our ability to understand has grown, GIS technology has evolved to help us process information about place and put it in a context that allows us to act (Dangermond, 2011:7). Observation in the literature show that the areas in which GIS and remote sensing are applied are widespread (Heywood et al, 2006; ESRI, 2006; Dangermond, 2011; Coetzee et al., 2013; Mhangara and Odindi, 2013; Ademola, 2015): land use management, management of traffic, crime control, flood control, fire hazard control, hazardous materials, storm control, urban planning and management, tourism development and management, business and marketing analysis, etc. The aim of this paper is to examine the use of Remote Sensing/GIS software particularly by the researchers in tertiary institutions and utilization challenges by the urban managers in Nigeria. Among the questions addressed in the paper are: What are the broad areas of research and topics that are addressed? What type of remote sensing and GIS software are used? What are the sources of satellite images used? What are the type of institutional affiliation and departments of the researchers? What are the utilization challenges by the urban managers?

The paper is divided into five sections. The first section is this introduction followed by the second section which is an overview of GIS and Remote Sensing in Nigeria. The third and fourth section are the method of data collection and research findings respectively, while the fifth section is the summary and conclusion.

GIS and Remote Sensing in Nigeria – An overview

Geographical Information Systems (GIS)

In Nigeria, the Federal Government is the first to start the implementation of GIS. The Government of the Federation took a bold decision in the year 2003 to embark on complete computerization of the cadastral and land registry of the Federal Capital Territory (FCT) – Abuja. This decision led to the establishment of an agency known as Abuja Geographic Information Systems (AGIS). As stated on the website of the agency (www.abujagis.com), AGIS project includes the introduction of Spatial Data Infrastructure (SDI) for FCT; the computerization of spatially related workflows in selected Federal Capital Development Authority (FCDA) departments and agencies and the buildup of the AGIS Resource Centre. The AGIS Resource Centre is intended to be a service company for spatially related data and services for the FCT and a computerized front and back office ("one stop shop") for FCDA departments. The AGIS projects objective is to establish AGIS as an independent service provider and as the only official source for Geospatial Data on FCT, covering all of FCT. AGIS is to provide a comprehensive, all-inclusive, state-of-the-art, foolproof, computerized, geospatial data infrastructure for the FCT; computerize the Cadastral and Land Registry for the Federal Capital City (FCC), the Area Councils and the Satellite Towns of the Federal Capital Territory (FCT). The AGIS Resource Centre is operating in the AGIS Building as an independent service provider, as a professional GIS/LIS Resource Centre, as the only official source for Geospatial Data on FCT, covering all of FCT. As stated on the website of the agency, the services offered by the agency include: preparation and issuance of Certificates-of-Occupancy and other certificate evidencing titles, preparation and issuance of Right-of-Occupancy, production and printing of Titled Deed Plan(TDP), street naming and house numbering in FCT, provision of Geospatial information infrastructure for FCT, the only official source of Geospatial Data for FCT, textual and graphic data on FCT, including land record, aerial photographs, satellite images, engineering drawing, and scanned pictures of building, property search and verification of land record, and application for land allocation. Some State Governments are also trying to do the same. A number of Government parastatals are also introducing GIS unit or department into their organization.

Also, in Nigeria, a number of institutions have set up a GIS laboratory either for training, consulting or both. Also, there are few private GIS firms in Nigeria. Such GIS private consulting firms includes: Atlas GeoSolutions Limited, E-Sense Technologies Limited, Geographic Integrated Services Limited, MAPIT Nigeria Limited, MapNTL.com, Spatial Technologies Limited, Virtual Vision Visualisation Limited, Third Dimension Technologies and GISKOSULT, etc.

Remote Sensing

In an attempt at building remote sensing capabilities in Nigeria, in 1993, the National Agency for Science and Engineering Infrastructure (NASENI) set up a committee to formulate a National Space Science and Technology Policy for the country. The policy recommended among other things the creation of centres of excellence for the development of space science and technology; and the enhancement of the capabilities of institutions offering space related courses of study in the country. In 1999, the National Space Research and Development Agency (NARSDA) was established to pursue the development and application of space science and technology for the socio-economic benefits of the nation. In 2001, the government approved the National Space Policy and Programmes to serve as roadmaps for transforming Nigeria from the status of a consumer nation to active participant in space technology and allied fields. The objective of the National Space Policy and Programmes was to make space research and development activities part of the overall strategies for sustainable national development. The main thrust of the National Space Policy and Programmes were: development of human resources and capacity building in various areas of space science and technology; to develop and build competence in space technologies of direct relevance to national development; to develop strategies and space applications; to undertake national resource management; defence, national security and law enforcement; study of the earth environment; communication and information;

education and training; provide support for universities and other academic institutions in space related research and development projects; promote private sector participation in the space industry; promote international cooperation. In order to achieve these, six centres were created to act as the operational limbs of the National Space Research and Development Agency (NARSDA). These NARSDA's centres are:

a. Centre for Satellite Technology Development (CSTD): this centre has the primary focus on satellite technology development with indigenous critical mass of engineers and scientists in all rudiments of satellites technology – building, launching, telemetry, tracking and control of all kinds of satellites such as earth observation, communication, weather, scientific research, etc.

b. National Centre for Remote Sensing (NCRS): the centre is charged with the sole responsibility of harmonizing research and development in space science and technology application for sustainable socio-economic development in the country.

c. Centre for Space Science and Technology Education (CSSTE): this centre is affiliated to United Nations African Regional Centre for Space Science. Its main function is to develop curriculum, skills and knowledge of university educators, research scientists and train other professionals and personnel in applications of satellite remote sensing, meteorology, communication and geographic information system to sustainable development.

d. Centre for Space Transport and Propulsion: the centre focuses on rapid advances in the science and technology of rocketry, which are the main transportation vehicles.

e. Centre for Geodesy and Geodynamics (CGG): this centre was established to facilitate capacity for geodetic surveying and mapping, as well as monitoring of coastal deformation and subsidence due to excessive oil and gas exploitation, floods and global mean sea level rise and other related seismic and geodynamic phenomena including implementation of international agreements with respect to satellite laser ranging (SLR), very long baseline interferometry (VLBI) and cooperative international GPS network.

f. Centre for Basic Space Science (CBSS): the centre is mandated to provide a sound education, research and knowledge in basic space science, astronomy/astrophysics, rocketry and balloons, geomagnetism, etc as well as designing and fabricating appropriate systems and instrumentations and telescopes.

Method of data collection

The data used in the study is from two sources. The first source of data is from extensive published article search from 2009 to 2013. The total number of articles used in the study is seventy-seven (77). The second source of data is from administration of 101 questionnaires to urban managers - public servants who are in environmental related professionals such as town planning, architecture, estate management, surveying, etc. - in the five local governments in Ibadan metropolitan area and at the Oyo State Government Secretariat in 2015. Descriptive statistics is used to analyze the data. Descriptive statistics used include frequencies and percentages.

Research Findings

In GIS and remote sensing, there are diverse research areas, topics and topic applications. All these diverse areas of research can be broadly divided into two which are method development and analysis/application. The articles used in the study are sorted into these two broad areas of research. It is observed that all the seventy-seven articles focus on analysis/application and none of the article focus on method development (Table 1). Observation from the literature shows that there has been low scientific research output contribution from African countries. For instance in East African countries, the greatest knowledge, skill and productivity gap identified is developer (Simons, 2013). It is also observed from a concept note of a recent workshop on "expanding and sustaining excellence in doctoral programmes in Sub-Saharan Africa: what needs to be done?" organized by South Africa's National Research Foundation and the Carnegie Corporation of New York held in South Africa that while rapidly expanding economies elsewhere had more than doubled their rates of scientific publication in the past decades, Sub-Saharan Africa contributed only 0.7% to World scientific output and this percentage was decreasing and only three countries in Africa – South Africa, Egypt and Nigeria – produced three quarters of Africa's output (McGregor, 2013).

Table 1: Findings on some of the research issues

	Title	**Category**	**%**
1	Broad Areas of research (n = 77)	Analysis/Application	100.0
		Method Development	0.0
2	Broad Topics (n = 77)	Land use/land cover	87.0
		Socioeconomic	5.2
		Disaster Management	7.8
3	Broad topics applications (n = 77)	Change detection/use and cover patterns	42.9
		Damage assessment/vulnerability	9.0
		Population	1.3
		Urban and regional planning	18.2
		Agriculture	7.8
		Health	1.3
		Geology	11.7
		Climatology	6.5
		Energy	1.3
4	Software used (n = 82*)	Arcview 3 (18.3)	40.2
		ArcGIS 9 (19.5)	
		ArcGIS 10 (2.4)	
		ENVI	2.4
		ERDAS IMAGINE	8.5
		Idrisi	13.4
		ILWIS	35.4
5	Sources of satellite images used (n = 54)	United States National Aeronautical and Space Administration (NASA)	5.6
		National Centre for Remote Sensing, Jos, Nigeria	13.0
		Global Land Cover Facility (GLCF) of the University of Maryland, Maryland, USA	18.5
		National Space Research and Development (NARSDA), Abuja, Nigeria	16.7
		Google Earth imagery	18.5
		www.digitalglobe.com	3.7
		Institute of Food Security, Environmental resources and Agricultural Research (IFSERAR), University of Agriculture, Abeokuta (UNAAB)	1.9
		National Population Commission of Nigeria	1.9
		Ministry of Agriculture and Rural Development, Federal Department of Forestry (FORMECU), Nigeria	7.4
		Regional Centre for Training in Aerospace Surveys, (RECTAS) Obafemi Awolowo University, Ile-Ife, Nigeria	3.7
		Department of Geography, Ahmadu Bello University, Zaria	1.9
		Department of Geography, Obafemi Awolowo University, Ile-Ife	1.9
		United States Geological Survey EROS Data Centre	3.7
		National Emergency Management Agency (NEMA)	1.9
6	Department of Researchers (n = 166**)	Department of Urban and Regional Planning	9.0
		Department of Geography/ Geography and Environmental Management/ Geography and Planning/ Department of Geographic Information System	47.0
		Department of Environmental Management/ Environmental Management & Toxicology	4.8
		Department of Surveying and Geoinformatics	4.8
		Department of Geology and Mineral Sciences /Department of Applied Geology/ Earth Science/Geoscience	9.0
		Department of Physics and Solar Energy/ Pure and Applied Physics	2.4
		Research Institutes/Agencies/Centres	12.1
		Others	10.8

7	Types of Institutional affiliation of the Authors (n = 166**)	University	81.3
		Polytechnic	1.8
		College of Education	0.0
		Research Institute/Agences/Centres	12.1
		Others	4.8

* In some of the articles more than one type of software were used (that is why the total frequency number of software used is 82). **Total number of authors

When these articles are further sorted into broad areas of topic and topic applications (see Table 1), three broad areas of topics are identified which are land use/land cover, socioeconomic and disaster management, while nine topic applications are identified which are change detection/use and cover patterns, damage assessment/vulnerability, population, urban and regional planning, agriculture, health, geology, climatology and energy. Majority of the researches are on land use/land cover (87.0%) followed by disaster management (7.8%) and socioeconomic (5.2%). Also most of the topic applications are on change detection/use and cover patterns (42.9%) followed by urban and regional planning (18.2%), geology (11.9%), damage assessment/vulnerability (9.0%), agriculture (7.8%), climatology (6.5%), population (1.3%), health (1.3%), and energy (1.3%) in that order.

It is observed that researchers use diverse kind of remote sensing and GIS software as shown in Table 1. In most cases researchers used more than one type of software. Overall, the table shows that in Nigeria, ESRI software products are the most used products. Also, table 1 shows that the sources of images used by the researchers are from diverse sources prominent among which are Global Land Cover Facility (GLCF) of the University of Maryland, Maryland, USA (18.5%); Google Earth (18.5%); National Space Research and Development (NASRDA) Abuja, Nigeria (16.7%); and National Centre for Remote Sensing (NCRS) Jos, Nigeria (13.0%).

Furthermore, Table 1 show the department of the researchers and institutional affiliation of the researchers. The Table show that majority of the researchers are from Department of Geography/ Geography and Environmental Management/ Geography and Planning/Geographic Information System (47.0%), followed by those from Research Institutes/Agencies/Centres (12.1%), Department of Urban and Regional Planning (9.0%), Department of Geology and Mineral Sciences/ Applied Geology/Earth Science/Geoscience (9.0%), Department of Environmental Management/Environmental Management & Toxicology (4.8%), Department of Surveying and Geoinformatics (4.8%), and Department of Physics and Solar Energy/ Pure and Applied Physics (2.4%). The table also shows that majority of the researchers are from University institution (81.3%), followed by those from Research institutes/Agencies/Centres (12.1%), and Polytechnic institution (1.8%).

Table 2: Urban managers' responses to questions relating to their interest in GIS and Remote Sensing.

S/N	Questions	Response	Percentage % (n = 101)
1	Do you have interest in GIS/Remote Sensing?	Yes	77.2
		No	22.8
2	What are the constraints you have in building your knowledge in GIS/Remote Sensing?	Financial constraint	58.4
		Time constraint	60.4
		Lack of interest	20.8
		Lack of permission from the place of work	43.6
		Lack of access to computer	17.8
		Others	1.0
3	Do you have interest in GIS/Remote Sensing training/retraining programmes?	Yes	80.2
		No	19.8
4	What do you think are your constrain in attending GIS/Remote Sensing training/retraining programmes?	Financial constraint	60.4
		Time constraint	63.4
		Lack of interest	19.8
		Lack of permission from the place of work	41.6
		Lack of access to computer	16.8
		Others	0.0

Source: Field survey, 2015

Table 3: Problems affecting use of GIS/Remote Sensing application

Response	Percentage (%) (n = 101)
Lack of knowledge about it	75.2
Technical nature of the applications	65.3
Financial problems	86.1
Lack of incentives/motivation	66.3
Power supply (electricity) problem	79.2
Lack of interest	33.7
Others	1.0

Source: Field survey, 2015

In the questionnaires administered, urban manager respondents were asked as to whether they have interest in GIS/remote sensing. The result of the analysis of the response (Table 2) shows that majority (77.2%) of the respondents have interest in GIS/remote sensing. When asked about the constraints they have in building their knowledge in GIS/Remote Sensing, the result shows that time constraint (60.4%), financial constraint (58.4%) and lack of permission from the place of work (43.6%) are the top three constraints they encountered. Respondents were probe further as to whether they have interest in GIS/Remote Sensing training/ retraining programmes. The result shows that majority (80.2%) of the respondents have interest in GIS/remote sensing training/retraining programmes. Again, when asked about what they think are their constraints in attending GIS/remote sensing training/re-training programme, the result of their response shows that time constraint (63.4%), financial constraint (60.4%), and lack of permission from the place of work (41.6%) are the top three constraint they encountered.

Table 3 shows the problems affecting urban managers' use of GIS/Remote Sensing applications. The table shows that financial problems (86.1%) is top on the list, followed by power supply (electricity) problem (79.2%), lack of knowledge about GIS/Remote Sensing applications (75.2%), lack of incentives/motivation (66.3%), technical nature of the applications (65.3%), and lack of interest (33.7%).

Summary and Conclusion

This study examined remote sensing/GIS software utilization and challenges in Nigeria. The study shows among other things that most of the remote sensing researches in Nigeria are on analysis/applications, most of the broad research topics are on land use/land cover, and most of the broad topics applications are on change detection/use and cover pattern. The most used remote sensing and GIS software is ESRI products. Sources of images used are from diverse sources prominent among which are Global Land Cover Facility (GLCF) of the University of Maryland, Maryland, USA, Google Earth, National Space Research and Development (NASRDA) Abuja, Nigeria, and National Centre for Remote Sensing (NCRS) Jos, Nigeria in that order. The study reveals that majority of the researchers are from Department of Geography/Geography and Environmental Management/Geography and Planning/ Geographic Information System, and, majority of the researchers are from university institutions. The result of the questionnaires administered show that majority of the urban managers have interest in GIS/Remote Sensing training/re-training programme; time, finance, and lack of permission from the place of work are the three top constraints in building their GIS/Remote Sensing knowledge. Top on the list of problems affecting urban managers' use of GIS/Remote Sensing applications is financial problems, followed by power supply (electricity) problem, lack of knowledge about GIS/Remote Sensing applications, lack of incentives/motivation, and technical nature of the applications.

In order to improve utilization of GIS and Remote Sensing software in Nigeria, there is the need for improvement in power (electricity) supply. There is also need for motivation and encouragement of the urban managers by the government through financial support for the training/re-training of urban managers in GIS and Remote Sensing educational programmes.

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