Pathways in the Implementation of National Spatial Data Infrastructure in Nigeria and Kenya

* Maurice O. Oyugi & Adepoju K. Adewale

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Abstract

Recommendations on the development of the National Spatial Data Infrastructure (NSDI) in Nigeria and Kenya invite public organizations to harmonize spatial data sharing policies for the spatial data plays crucial role in national development. This provides justification for governments to investment and prioritises the development of the infrastructure. However, the significance of the infrastructure can be realised through regular update of the geospatial data and availing the same to consumers through the decentralisation of the services to ensure that the technology penetrates every aspect of society. In this regard, this paper analyses the achievements made so far in the development and utility of NSDI in Nigeria and Kenya. This is based on the realisation that in most of the African nations, the NSDI has been well conceived with national and various sub-committees inaugurated with donor support yet the incorporation of the infrastructure in the national strategic development policies is minimal. This paper raises the question of what ideally should constitute NSDI as the main objective as well as finding out to what extent the components of the NSDI has been implemented in Nigeria and Kenya. The paper is based on document review on the theoretical basis of the NSDI, the implementation position of the infrastructure in Africa in general, Nigeria and Kenya in particular. To arrive at the conclusions on the implementation status of the infrastructure in Nigeria and Kenya, the performance levels of the various components of the infrastructure is analysed. Towards this end, the study found out that there is still greater need for geospatial data producers to transform themselves to suit the requirements of the industry as the practices which are currently being undertaken in the industry betrays the very foundation of data sharing which the NSDI is meant to instil. It is further revealed that there is adequate government and stakeholders' goodwill for the NSDI development in the two countries yet various components of the infrastructure are inadequately implemented. This is happening despite the opportunities which the two countries have which manifests through the availability of indigenous earth observing and communication satellites, outlay of highly trained human resource in geospatial technology and collaboration opportunities for the implementation of the NSDI. This study recommends that the two countries should harness inputs of external players by considering how the international efforts and donor funding can be used in developing the NSDI nationally and regionally. In this regard, the two countries should develop collaboration with the National Aeronautics and Space Administration (NASA) and the European Space Agency (ESA). This is because the above stated organisations have developed critical infrastructure for geospatial data collection, storage and dissemination. The national NSDI lead agency should also urgently enforce the usage of geospatial data standards which conform to the ISO standards to assist users understand how to apply the developed standards.

Key words: sustainable development, national spatial data infrastructure, spatial data, Nigeria and Kenya

INTRODUCTION

The underdevelopment in Africa is rooted in inadequate information and infrastructure for resource planning, utilisation and management (Akinyede & Boroffice, 2004). This was also emphasised in the 1992 Rio-de Jenairo's United Nations Conference on Environment and Development (UNCED) which endorsed the Action Plans for the 21st Century also known as the Agenda 21. Chapter 40 of the Agenda 21 entitled Information for Decision-Making notes that inadequacy of geospatial information is a fundamental problem to development planning (United Nations, 1992). The conference noted that policy-makers in Africa have inadequate access to accurate information needed to make rational decisions. This has led to escalation in disasters and slow uptake of economic opportunities by the developing countries.

These manifests in form of famines, environmental degradation, poverty and disease outbreaks, inability to penetrate the international market as well as the inability to meet the Millennium Development Goals (Meyerman,

*Corresponding author:
Maurice Onyango Oyugi; Lecturer of Urban Management, Department of Architecture and Building Science, University of Nairobi.
Email: maurice.oyugi@uonbi.ac.ke

2004). The utility of the information is determined by the degree of its dissemination which entails information sharing between organizations preferably over the internet which is a global information infrastructure. It is therefore imperative to distribute the geospatial information on the internet enabled repositories. This facilitates access and permeability of the information to every sector of the society at the right time and format which is synonymous to creating information market-place (Matambanadzo, 1999).

The need to distribute the spatial information in the internet enabled repositories has been occasioned by increased awareness on the application of geospatial information in decision-making. In this regard, a number of African countries notably Nigeria and Kenya have made efforts to mainstream geospatial data infrastructure in their development agenda through the creation of NSDI and development of space technology programmes.

However, the organizations involved in building geospatial data infrastructures are inward looking thus they fail to share the data with other organisations. This has been the bottleneck for the mainstreaming of the policy in various national sectors (UNECA, 2001). The costs involved in the collection, transformation and dissemination of geospatial information necessities the decentralisation of the effort at various levels notably; at the local, state, national, regional and global levels. Depending on the level, such data infrastructure has come to be known as Local Spatial Data Infrastructure (LSDI), State Spatial Data Infrastructure (SSDI), National Spatial Data Infrastructure (NSDI), Regional Spatial Data Infrastructure (RSDI) and Global Spatial Data Infrastructure (GSDI). Achievement of a successful spatial data information infrastructure at all levels requires coordination and cooperation within and among organisations.

THEORY

Basis for the National Spatial Data Infrastructure Development and Enactment

Spatial data is data relating to the land, sea and air that is referenced or can be referenced to a position on the earth's surface to support planning and sustainable management of resources (The Bathurst Declaration, 1999). According to Phillips (1999), much of this data is transient and cannot always be collected when needed. This necessitates the need to collect and store such data in commensurate databases for use and re-use by many users. As more organisations become involved in sharing the datasets, the cooperation becomes more complex with datasets starting to acquire an "infrastructure" status. In this regard, the Bathurst Declaration further defines spatial data infrastructure as fundamental spatial datasets, the standards that enables integration, the distribution network that provides access, the policies and administrative principles that ensure compatibility between jurisdictions of the agencies creating the datasets, providers of the networks and the data users at large. Matambanadzo (1999) notes that the concept of information infrastructure integrates and interconnects a wide range of computer equipment and peripherals including network standards and transmission codes that facilitates interconnection and interoperation between networks as well as enhance privacy of the persons and the security of the information carried. This makes the geospatial data, computer hardwares, computer softwares and the human resource(s) involved in the network crucial in the creation of the geospatial data infrastructure (Coleman & MacLaughlin, 1995).

According to Coleman et al., (1997), geospatial data describes locational, temporal and attributes of a phenomenon relative to earth surface. However for NSDI, the term geospatial or spatial data has been adopted instead of geographic to indicate that the information for the NSDI extends from the surface of the earth to outer space. Further, the word data is used in lieu of information for the multi-usage nature which requires repackaging of the data into information by the users to fit their own needs while infrastructure is used as an underlying foundation of the system.

The objective of NSDI is to provide users with the means to access, share and exchange spatial data across the regions using appropriate standards. This can be realised through taking advantage of the advancements in the telecommunication sector and earth observing techniques notably improvements in the satellite imagery and aerial photography. However, the development of the NSDI requires an understanding of the organisations involved in the information sharing as well as the nature of the information being shared if the NSDI is to play its crucial role of national development (Petrie, 1995 and Goodchild, 1995).

The components of a spatial data infrastructure include sources of the geospatial data, the data, databases, metadata, data networks and technology. The sources of spatial data are aerial photographs, topographic maps and the satellite imageries. Databases and metadata are sets of organized spatial information about a phenomenon such as where the phenomenon is located, how the data was collected and is maintained, by whom, how it can be accessed and its characteristics such as the spatial coverage (McLaughlin & Nichols, 1990).

The Data networks are the communication highways

in various forms such as telephone lines, local area networks and broadband integrated service networks which link the databases, the sources and the users. The technology component of the spatial infrastructure deals with data collection, management and presentation. These are basically the data conduits, equipment and procedures that facilitate optimisation and management of the databases at the source so as to enhance the application of the data by the users. The institutional arrangements is the co-ordination agency of the organizations involved in the NSDI development and maintenance while the policies and standards are the data communication rules, conventions, protocols and critical policies addressing socio-economic issues such as privacy and pricing. The end users are individuals and organizations that access and use the infrastructure to acquire data and process the same into information (Groot, 1997).

The NSDI consist of management, user, systems, information and communication layers. The management layer of the NSDI relates to all those functions concerned with administration, interoperability, integrity and security as well as provision of data access and database creation policies (Matambanadzo, 1999; Ostensen, 1995). The user layer is concerned with various application software normally integrated to Geographic Information Systems (GIS) software to enable analytical operations such as trend and cost-benefit analysis. The analytical operations are imperative for resource mapping and planning, land and infrastructure management, environmental impact assessment and transportation modelling among others.

Systems layer details out technical characteristics of the computer hardware and software capabilities. This is significant as systems standards are needed to facilitate interconnection within and among different networks from different vendors (Croswell, 2000). The systems layer consists of computers, servers, clients, Local Area Network (LAN), internet tools and documentation management. It provides an interconnection of built up layers from physical connections with cables and satellite connections via logical networks based on standardised protocols (Ostensen, 1995). An Open System Interconnection (OSI) Referenced Model and Microsoft TCP/IP protocols among others are popular networks standards for free exchange of information.

The information layer deals with definition, encoding, structuring and storage of spatial information in a NSDI through data catalogs, data warehouses and clearinghouses and custom digital maps on demand and extranets (Coleman & McLaughlin, 1995). The custom digital maps on demand are on-line GIS databases providing custom just-in-time maps of a given spatial coverage and thematic overlays (Katic, 1998). A data clearinghouse is an electronic network of geospatial data producers, managers and users which is meant to minimize duplication of effort in spatial data collection and to foster cooperation in digital data collection activities. Clearinghouse focuses on devising innovative methods to meaningfully and efficiently structure metadata that describes database contents, data storage and compression, geo-referencing, indexing of the stored information and application protocols for facilitating interaction between users and data providers (Radwan et al. 1997). The clearinghouse uses internet to link computer nodes that contain geospatial data (Figure 1).

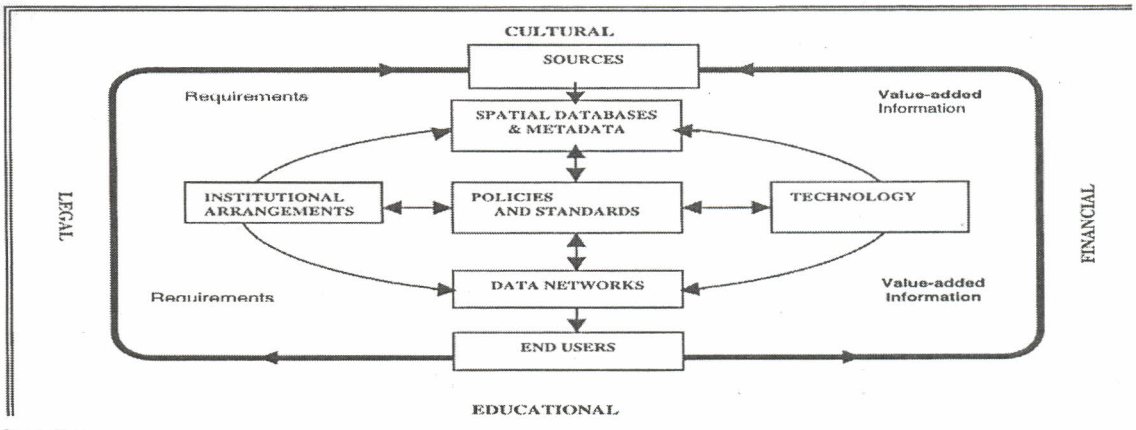

FIGURE 1
The National Spatial Data Infrastructure Components
Source: Woldai 2002a

The data warehouse is a read only repository of data held in one or more locations. The warehouse data are accessible on-line and may be down loaded across the internet.

The main differences between a data clearinghouse and warehouse is that in clearinghouse, all kinds of information are held and additional information on the type of data is provided through the metadata-base while warehouses has synthesized data stored so as to help user solve specific geospatial problems such as flood disaster or urban sprawl (Figure 2; Groot, 1997). Therefore, the data stored in a data warehouse is selected according to predefined criteria through a process known as data staging which involves data cleaning, filtering and transformation (Simon, 1996).

The communication layer is a collection of autonomous equipment and physical media viewed as one whole that interconnects more computers. The layer consists of communication satellites, fixed network systems and cellular communications which enhance communication between systems through creation of local and wide area (backbone and access) networks. The backbone network supports information exchange across a wide geographic area of the national and global scale while an access network supports information exchange within the site and is largely received by local area network technologies such as Ethernet and token-ring. The access network as an important component of the NSDI subsystems is usually owned, administered and used by a single organization covering a limited geographic coverage (Provost, 1995).

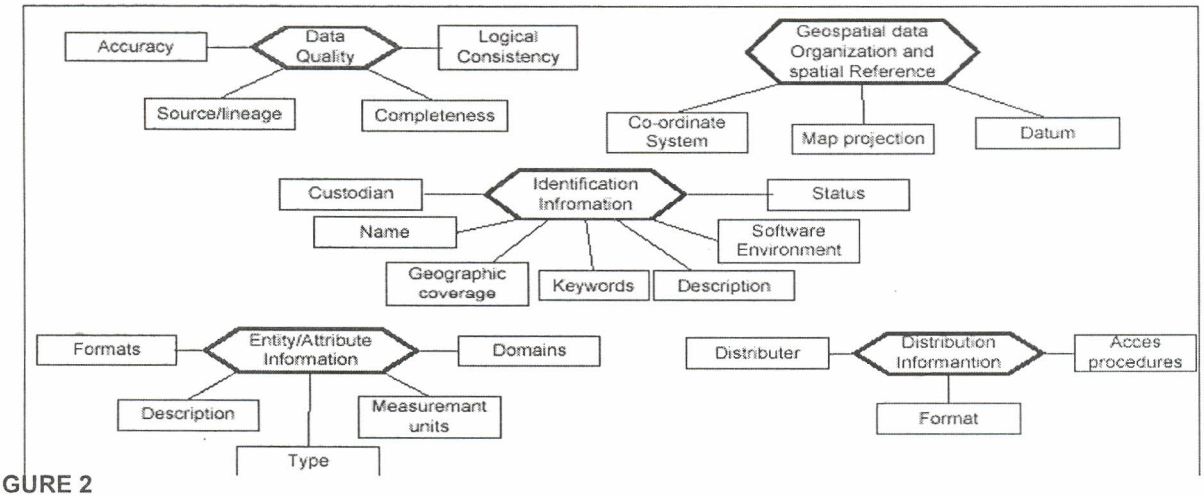

FIGURE 2
An Example of Metadata Base Content
Source: Croswell 2000

The Status of NSDI Components in Africa

Despite the concept of NSDI being least promoted and developed in Africa, a couple of African countries have either developed or are on their way towards developing a sustainable NSDI. These countries include South Africa, Nigeria, Egypt, Algeria, Morocco, Tunisia, Kenya, Botswana, Zimbabwe, Namibia, Zambia, Uganda, Ethiopia, Lesotho and Swaziland (Longley et al., 2009; Onsrud 1998; Bassole et al., 2001; Ezigbalike et al., 2000). The promotion of NSDI at the continental level has been spearheaded by United Nations Economic Commission for Africa (UNECA) while at sub-regional level it has been promoted by political and economic groups such as the New Partnership for Africa's Development (NEPAD), Economic Community of West African States (ECOWAS), The Southern African Development Community (SADC), The Intergovernmental Authority on Development (IGAD) and the Common Market for Eastern and Southern Africa (COMESA) through collaborative efforts of various national mapping organizations.

The assessment of NSDI initiatives in Africa reveals inadequate political goodwill as occasioned by low awareness levels among the principal ministries and relevant institutions on the significance of spatial data infrastructure, confusion surrounding the definition and/or composition of NSDIs, weak policy and coordination arrangements, inadequate capacity (human and physical resources) as well as complexity of national issues such as the political, cultural and economic positions of most countries (Longley et al., 2009).

Lack of political goodwill is explained by scarce financial resources in many African countries and the fact that benefits from investments in spatial data projects are

long term. This makes politicians and administrators prioritise the utilisation of funds on projects that yields immediate results and therefore having positive impact on their electoral fortunes and performance appraisal targets.

Even in the African countries where there is semblance of true NSDI, the definition and purpose of the same has not been uniform. Some nations put emphasis on the creation of data, sharing of the available data and use of prescribed standards for data creation. This fails to prescribe order in which the different components of NSDI can be implemented. Some implementing agencies choose to start with clearinghouse so as to present and sell the concept to potential stakeholders. This state of implementation anarchy stems from the fact that the previous support approaches by various development partners including United Nations Agencies were mainly project based. This has led to fragmentation and uncoordinated development of NSDI, consequently leading to rivalry and competition among various national institutions (Woldai & Schetselaar, 2002).

The biggest source of spatial data in Africa is the analogue maps from the national mapping agencies and the municipal authorities. This is augmented by thematic datasets from agencies such as the Forestry Departments, Natural Resource Boards, Departments of Wildlife Managements, Departments of Agricultural and Extension Services, the Environment and Remote Sensing Institutes and the Central Statistics Offices which provides socio-economic data. The base maps for these datasets are sourced from the national mapping agencies mandated with mapping and provision of topographic and cadastral maps.

As earlier stated, much of the geospatial data in Africa are in the forms of maps and paper records. However, there has been a realization that the use of computers in spatial data management necessitates digitising of the data. In this regard, there is significant effort in countries like Nigeria, Kenya, Tunisia, Egypt, South Africa and Morocco to create digital databases through digitisation of the analogue maps. In Tunisia, projects are on going to implement geographical databases alongside the creation of geographical repository and spatial data warehouses especially in national organizations such as Agriculture and Environment. This initiative provides the framework for a research project called the Global Information System Relative to the Air, the Earth and the Sea. The aim of this project is to offer the participants access to accurate and up-to-date spatial data.

In Botswana, the Department of Surveying have made attempts at producing digital cadastral and topographic databases for the principal towns. This has enabled the Department of Town and Regional Planning (DTRP) to acquire digital databases to support land use compliance monitoring. The Department has fairly undertaken digitisation of land inventory and have developed a comprehensive database of allocated plots in urban areas (Ezigbalike & Nkwae, 1999; Manisa & Maphale, 1999). In Lesotho, the Mapping Agency introduced production of large-scale (1:2,500) digital maps for urban areas alongside a project to digitise the scale 1:50,000 map series for the entire nation. In Kenya, similar project has been conceived within the national land policy framework whose inception has been lacklustre due to inadequate political goodwill (Mulaku, 2006).

The data networks and technology conduits such as the computers and the internet which supports NSDI are not well developed in a majority of the African nations. This is because the utility infrastructure supporting NSDI such as electricity and telecommunications have limited reticulation with notable concentrations in the urban centres. This has left large portions of the countries without services yet the rural areas are the main subjects of the spatial data infrastructure. This is because environmental and natural resource data which is the main subject of NSDI are largely about the rural areas. Further, the rural areas bears the heavy burden of environmental disasters such as floods, draught and locust infestations. As such, environmental data with strong spatio-temporal components on the rural areas are imperative for the national developmental.

In majority of the African countries, even where electricity is available, the supply is not constant and the frequent power outages and associated surges results in damages to computer parts and equipment which support the spatial data infrastructure. The cost of computerisation and the creation of the NSDI therefore include costs of ancillary equipment for power stabilisation and standby generators. These costs are not incurred in the developed countries.

It is noted that the spatial data infrastructure users are integral part of the infrastructure for some of the users transform the original data into new datasets or information for the consumption of other users. In this regard, it is imperative that the users should possess appropriate knowledge and skills in data provision, transformation and management. However, the skill base as described above is still low in Africa. This has consequently led to scenarios whereby spatial data that should be digitised still being held in analogue format. This hampers the realisation of full potential of the data resources. As earlier stated, the general computer literacy in Africa is still low. This makes the value of

electronic mail communication and the World Wide Web and other relevant aspects of the internet like file transfer protocols and remote computing be regarded with awe and are only beginning to be appreciated in some African countries.

Telecommunications infrastructure is either expensive or poorly developed in the majority of the African countries. This is corroborated by the majority of the citizens of the African countries still lacking access to telephones and the waiting lists for phone services are long. Telecommunications agencies, which are still mainly government monopolies are struggling to provide voice lines to more people and therefore provision of data-enabled high bandwidth lines to support often voluminous spatial data consisting of graphics and images is not a priority. However, there are exceptional cases to this annunciation as exemplified by Kenya, South Africa, Nigeria, Egypt and Tunisia among others where the costs of telecommunication has drastically gone down over the last decade and the broadband internets on cell phone connections is readily available to a larger percentage of adult population.

Even though most African governments recognise the need for land management, this has been hampered by the fact that governments through relevant departments legally mandated to provide leadership on such issues are lacking capacity and goodwill for the purpose. Even within the government, data management is still fragmented with little co-operation between different agencies. This has made information flow between government ministries and departments poor.

The foundation to this problem is that many countries are still living in the mapping era which emphasises on map management process where the national mapping agency chairs cartographic committees. In the digital age as occasioned by NSDI, emphasis should shift from the map management process to information management in which maps only provide a graphical presentation of the spatial information. This endeavour requires a dedicated agency mandated with the management of the spatial information resource for the good of all in a corporate manner. It is envisaged by many scholars that this mandate should not be vested with either a major producers or consumers of the information so as to avoid scenarios where the systems evolve over time to favour the agency.

However, the agency should be independent from the users and should also sit in the higher echelons of the national decision-making so as to enable it effectively participate in policymaking for the spatial data infrastructure.

Positive steps for the creation of NSDI are taking shape in some African countries. In Tunisia the adopted steps consists of creation of the Office of the National Director of Geomatics. This Office is mandated with the identification of geomatic programmes and actions that should be concretised in the short and medium terms for the implementation of geospatial data infrastructure. Lesotho has also made attempts of implementing the same through the establishment of a Committee on Environmental Data Management which is an inter-sectoral body mandated with promotion of environmental data exchange alongside undertaking advisory functions to the National Environmental Secretariat on environmental database management. This entails enactment of quality standards and indicators for the analysis of environmental quality trends.

Formulation and enactment of policies and standards as components of NSDI requires participation of all the stakeholders coupled with strong political goodwill to ensure that the policies and standards obtain legal legitimacy for their enforcement. The policies give guidelines on data formats, standards, communication rules, protocols and conventions for combining diverse information resources. They also grant privacy on information relating to individuals and protection of the information from misuse which ensures that values are respected. The policy also details out the economic issues such as copyright protection, rights of custodianship, transparent pricing and distribution mechanisms, confidentiality of commercially sensitive information as well as liability on errors (Aalders, 1999).

These issues have not yet been addressed formally in most of the African countries and where they have, they are not adhered to because the value of the spatial information is yet to be realised. In countries where there is satisfactory implementation of the NSDI, this has been undertaken by the national mapping agencies with assistance from the donor community and regional agencies.

RESEARCH METHODS

This study was guided by critical thinking research method which involves critical analysis of literature on a phenomenon to enable researchers draw conclusion(s) on whether a claim is always true, sometimes true, partly true or false. In this sense critical thinking means discerning judgment based on the extensive body of literature presented on a particular phenomenon. Critical thinking is an important component of research in most professions, although there is debate among scholars about its precise meaning and scope. The skills for critical thinking as a research method entail observation, interpretation, analysis, inference,

evaluation, explanation and meta-cognition (Brookfield, 2000). There is consensus that critical thinking establishes truth or judgment through observation, context skills, relevant criteria as well as the applicable theoretical constructs for understanding the problem and the question at hand. Critical thinking employs not only logic but broad intellectual criteria such as clarity, credibility, accuracy, precision, relevance, depth, significance and fairness (Edward, 1971).

The critical thinking as a research method relies on desk study or review of pertinent (relevant) literature both as methods of data collection and data analysis. In this case, the pertinent literature analyzed here entailed theoretical basis of the NSDI, the implementation status of the infrastructure in Africa with an in-depth analysis of the same for Kenya and Nigeria. The analytical process of this study progressed through the identification of the problem which in this case is the NSDI implementation path and status in Kenya and Nigeria. To arrive at the conclusions, various arguments advanced by the relevant literature gathered were subjected to evaluation on the validity and reliability of the data they present, the logic and the coherence of the arguments as they are advanced by the scholars. This was paramount to recognize the existence or non-existence of logical relationships between propositions to enable drawing of conclusions and generalizations. The main sources of literature for this study were the National Space Research and Development Agency (NASRDA) of Nigeria and the Survey of Kenya (SoK) documentations on the process. These were also augmented by other scholarly postulations from various Authors.

RESULTS

The Experiences of Building NSDI in Nigeria and Kenya

The two countries have fairly committed resources for NSDI development and are grouped among the average performers in the NSDI development in Africa and thus provide lessons on which other regional counterparts can draw from (Longley et al, 2009). In an endeavour to promote NSDI, Nigeria is currently the only sub-Saharan state which has successfully launched an indigenous medium and high resolution earth observing satellites (NigeriaSat-1, NigeriaSat-2 and NigeriaSat-X) and has re-launched communication satellite NigComsat-1R. The country has been aggressive in the development of both earth observing and communication satellites. Nigeria has played prominent role in the regional NSDI development as corroborated by her involvement in the African Resource Management Satellite (ARMS) Project which is a cornerstone of the African Satellite Constellation. Nigeria has undertaken this jointly with South Africa and Algeria who are highly ranked in terms of NSDI development. Kenya's efforts in implementing the NSDI is illustrated by her ability to comprehensively implement the details of the NSDI within a short period of time. This proves that the country has a positive attitude coupled with political goodwill and the country's advancement in telecommunication technology (Akinyede, 2004 and Survey of Kenya, 2002).

The Nigerian National Spatial Information Policy and the Developments in the Satellite Technology

The programme of launching satellite in the outer space was conceived in the 1970s. This was envisaged to be launched in 1976. However, this was not executed. In September 2002, the Nigerian Minister of Science and Technology inaugurated a 10-man Committee to draft a Geospatial Information Policy to guide the implementation of the NSDI in the country. The draft Policy was circulated to stakeholders for comments and was a subject of an international workshop of stakeholders held in Abuja, Nigeria in February 2003. The stakeholders in attendance included Surveyors, Scientists, Engineers, Students, Journalists, Policy and Decision-Makers and Business Executives from national and international organizations such as the United Nations Economic Commission for Africa (UNECA), United States Geological Surveys (USGS), Environmental Information System-Africa (EIS-Africa) and International Institute for Earth Observation and Geo-Information Science among others. The goal of the Workshop was to provide a forum for the participants to take critical look at the draft policy with the aim of providing road map for its implementation. The workshop was guided by objectives that entailed creating awareness and promotion of public access to standard and coordinated spatial data at various levels in the country, identifying and recognizing major stakeholders in the production, management and utilization of spatial information in Nigeria. The workshop appraised the participants on the various on-going NSDI related projects and programmes in the country as well as articulated of the roles of stakeholders in the development of NGDI.

The NASRDA, an agency under the Ministry of Science and Technology is the NSDI implementation Agency in Nigeria. The organisation has undertaken this mandate through the successful launch of Nigeria's first medium resolution earth observing satellite NigeriaSat-1 on the 27th September 2003. The satellite whose life span was five years captured high quality images thus stimulating countrywide geospatial technology awareness, goodwill as well as demonstrating commercial value of the technology. This has also stimulated research in Nigeria. The spatial resolution of the NigeriaSat-1 is 32m and swath width of 640km. The NigeriaSat-1 has spatial resolution almost similar to Landsat TM+ bands 2, 3 and 4 with spectral resolution similar to SPOT. The satellite

is 100kgs in mass with imageries stored in a 1-gigabyte solid-state data recorder and returned via an 8-Mbit/s S-band downlink. NigeriaSat-1 has image scenes as large as 640 x 560 km, providing unparalleled wide-area, medium-resolution data. The data obtained by this satellite is useful in monitoring pollution, land use/ land cover change detection and other medium-scale phenomena. The temporal resolution of NigeriaSat-1 makes the imageries it has so far procured since its inception timely. However the bureaucracies the potential users of the imageries have faced in obtaining the imageries from NARSDA has made the prospects of utilising the imageries poor. Owing to the resolutions of this satellite, it has potentials for data acquisition for the NSDI and subsequent application areas as documented by Akinyede (2004).

Five satellites have been launched by the Nigerian government into outer space. The NigeriaSat-1 was the first Nigerian satellite and built by a United Kingdom-based satellite technology Surrey Space Technology Limited (SSTL) Company under the Nigerian government sponsorship for $30 million. The satellite was launched by Kosmos-3M rocket from Russian Plesetsk spaceport on 27 September 2003. Nigeriasat-1 was part of the world-wide Disaster Monitoring Constellation System (Akinyede, 2004).

The objectives of the Nigeriasat-1 were to give early warning signals of environmental disaster, to help detect and control desertification in the northern part of Nigeria, to assist in demographic planning, to establish the relationship between malaria vectors and the environment that breeds malaria and to give early warning signals on future outbreaks of meningitis using remote sensing technology, to provide the technology needed to bring education to all parts of the country through distant learning and to aid in conflict resolution and border disputes by mapping out state and International borders. NigeriaSat-2 and NigeriaSat-X (Nigeria's third and fourth satellites) have since been built and launched as high-resolution earth observing satellites.

The two satellites each have 300kgs mass with 2.5-metre spatial resolution on panchromatic band, 5-metre high spatial resolution on multispectral near infra red, blue, green and red bands. They further have 32-metre medium resolution multispectral near infra red, blue, green and red bands. The NigeriaSat-2 and NigeriaSat-X spacecraft were launched into orbit by Ukrainian Dnepr rocket from a Yasny military base in Russia on 17th August, 2011.

NigComSat-1, a Nigerian satellite ordered and built in China in 2004, was Nigeria's second satellite and Africa's first communication satellite. It was launched on 13th May 2007 aboard a Chinese Long March 3B carrier rocket, from the Xichang Satellite Launch Centre in China. The spacecraft was operated by NigComSat and the Nigerian National Space Research Agency (NASRDA).

On 11th November 2008, NigComSat-1 failed in orbit after running out of power due to an anomaly in its solar array. It was based on the Chinese DFH-4 satellite bus. It carried a variety of transponders notably 4 C-band; 14 Ku-band; 8 Ka-band; and 2 L-band. The satellite was designed to provide coverage to many parts of Africa. The Ka-band transponder was also designed to cover Italy. On 10th November 2008, the satellite was switched off for analysis and to avoid collision with other satellites. On 19th December 2011, a new Nigerian communications satellite (NigComSat-1R) was launched into orbit by China in Xichang. The satellite according to Nigerian President Goodluck Jonathan was paid for by the insurance policy on the NigComSat-1 which de-orbited. The NigComSat-1R is expected to have positive impact on national development in various sectors such as communications, internet services, health, agriculture, environmental protection and national security. The features of the satellite include 20-hybrid transponders with a 15 year life span. The spatial coverage of the satellite includes African, the Middle East and Europe.

The satellite has high speed and bandwidth backbone carrier installed at the NSDI apex clearinghouse while the master server for databases is installed at the NSDI node agency. The satellite is envisaged to provide the much-needed broad bandwidth, both down and up-links for information transfer. However, it would be wise if the management of the country code top level domain is handed over to the National Information Technology Agency to ensure that it is utilized for public interest and also to give the country a presence in the global network which is necessary for the development of reliable and standardized geo-information system (Ajayi, 2004).

Having submitted the policy to the Federal Executive Council (through the Minister of Science and Technology) for effective passage into law, NASRDA satisfactorily implemented the recommendations arising from the Executive Council. This is corroborated by the successful inauguration of the NSDI 27-Member Committee on 27th September, 2004. The Committee was mandated with guiding the establishment and implementation of the NSDI in line with the Policy. The Committee members are drawn from the academia, public organizations, Non-Governmental Organisations and the private sectors (whose work involves the utilisation of the spatial data), universities, polytechnics and federal states representatives, NASRDA, Federal

Ministries and agencies whose mandates involves spatial data acquisition and utility. The NSDI Chairman is elected in rotation among the Committee members for a maximum of two consecutive terms of one year each while each member can serve for a maximum of two terms of two years each. The Committee is tasked with the responsibility of coordinating the spatial data infrastructure related activities. These activities includes but not limited to policy development, streamlining and enforcement of standards for the spatial data infrastructure among the various stakeholders as well as appraising the manpower potentials in all the national sectors for successful realization of the same.

Other areas include mobilization of funding and technical assistance as well as creation of sub-committees to undertake specific tasks for successful implementation of the spatial data infrastructure. At the inaugural meeting of the NGDI Committee, six sub-committees were created based on the recommendations of the stakeholders' meetings. The sub-committees are responsible for addressing the geospatial datasets, standards, clearinghouse and metadata, capacity building and awareness creation, legal issues as well as resource mobilisation.

In line with the policy, NASRDA in collaboration with the Nigerian Federal Surveys Department has made attempts at providing network of geodetic controls all over the country. This is essential for the processing of the satellite imageries to ortho-rectified images. This aids the Federal Surveys Department, the Surveyors Council of Nigeria and the universities to increase surveying adjustment accuracies for effective NSDI development. Currently, progress is being made by the Federal Surveys Department to digitise the existing analogue scale 1:50000 topographic map series.

The NASRDA has also carried out some users' needs (dataset) assessment and analysis on hardware and software capacity, data flow parameters, staffing requirements and organizational dimensions. The reviews also captured the use of geospatial data within the data producers, co-producers, users and other stakeholders. This has been done alongside undertaking media publicity to increase the stakeholders' awareness in the NSDI initiative. However, an assessment of the level of synchronization between existing data and desired data is yet to be carried out.

In order to demonstrate the power of NSDI and by extension geographical information systems in planning and decision making, NASRDA has continued to collaborate with National Electric Power Authority and the Nigerian National Petroleum Corporation on specific geospatial projects such as the application of the technology in the planning of energy generation and distribution as well as oil and gas facility mapping and monitoring. These projects have been expanded to incorporate updating of the land use/land cover mapping of Nigeria using the NigeriaSat-1 imageries in constellation with other satellites. This project was instrumental in aiding the National Emergency Management Agency develop early warning system for flood mitigation.

As earlier noted, Nigeria is currently involved in the African Resource Management Satellite Project jointly with South Africa, Algeria and any other interested African country. This is one of the flagship projects in the NEPAD's Science and Technology Ministerial Programme initiatives for sustainable technology development in Africa. The project is meant to be the cornerstone of African Satellite Constellation. The initiative is proposed by South Africa and supported by Nigeria as documented in a joint space technology project proposal between South Africa and Nigeria.

The aim of this project is to build capacity to support space programmes in Africa (Mostert et al., 2003; Kufoniyi & Akinyede, 2004). Such a programme should benefit Nigeria in realising her space policy objectives and the development of vibrant NSDI. The initiative will also benefit partner nations by learning from Nigeria on the development of earth observing satellites by indigenous engineers. Each satellite operating in constellation will have a high-resolution payload with a 2.5 meters spatial resolution in panchromatic mode and a 5m spatial resolution in multi-spectral mode within 6 spectral resolution bands. The satellites will be phased and accessed through the integration of individual country's ground stations.

Despite Nigeria having met the resolution requirements through the launching of NigeriaSat–2 and NigeriaSat-X, the current average internet bandwidth in Nigeria is inadequate in meeting the needs of the NSDI. It is imperative to note that the development of a GIS Portal requires fast processing computers with huge random access memory for online processing of geospatial data. For ground stations to fully process online images that are being downloaded and to transmit them in real-time to users in the format required by the user, there is need for enormous random access memory resources with fast processors beyond what is commonly used in Nigeria. As earlier noted, Nigeria has re-launched Nigerian Communication Satellite the NigComsat-1R to replace NigComsat-1. This satellite has complete communication technology to provide the bandwidth requirement for the telephony and broadcasting needs of the country. The telephony is the driving force behind the capture, processing, storage, management and

developed alongside the terrestrial geodetic control using Cassini-Soldner (Clarke 1858 Ellipsoid) and UTM (Clark 1886 Ellipsoid) pillars. It is imperative to note that several geodetic controls used to spread all over the country but a number of them have since been destroyed. In this regard, efforts to re-establish and secure them as well as to increase their density are prioritised. The levelling network for survey in Kenya uses datum at Kilindini harbour at the coast of Mombasa. This is available in both analogue and digital formats. The utility datasets available under the NSDI include international, national, trunk and primary roads, telecommunication lines and railway lines of the country.

Having taken cognizance that spatial data need to be shared and made easily accessible to users as an economic justification for investments, mechanisms of disseminating geospatial data to potential users have been put in place. Resources for disseminating spatial data includes the high speed carrier capable of providing data on demand, computer hardware, relevant GIS software, the data, metadata, human capability, clearinghouse or GIS Portals and servers as well as access protocols. Alongside with the above, development of policies and guidelines for data sharing have been achieved at varying degrees.

High speed carrier cables of higher bandwidth for internets connections have been successfully implemented across the country. The country has also since 2003 zero rated the VAT on the information and communication technology products which is a move geared towards promoting the adoption and utility of the technology in the country. The NSDI clearinghouse when finally operational will provide user's access to spatial data complete with metadata and will also facilitate search and access protocols in data retrieval. This will facilitate data sharing, minimise duplication of effort in data acquisition as well as provide a one-stop access for spatial information.

Policy formulation and guidelines on spatial data dissemination was envisaged to have been accomplished by the year 2005 (Kalende & Ondulo, 2006). The policy was to address pertinent issues on data and metadata quality, software and hardware standards, governance arrangements (legal framework for data sharing and copyright issues), pricing of data, national and personal security alongside training of GIS users. Towards this end, curriculum for GIS users was designed to address the users' needs and to complement existing courses in national colleges as opposed to duplicating them. This stemmed from survey carried out to find out the training needs of the GIS stakeholders. The survey revealed that there were potential GIS users who had been trained in GIS but had not gotten the opportunity to apply the knowledge gained due to lack of software and hardware at their work places. Further, there were existing GIS users who had access to hardware and software but were using less than 5 percent of the functionalities of the software. This necessitated the need to design two types of courses for the two categories of which the potential users were introduced to QGIS and ILWIS Open Source software and basic GIS courses while the existing users were taught how to optimize the functionalities of the software. Until recently, there were follow ups of more advanced GIS courses being offered by JICA through Video conferencing which has significantly contributed to the development of human resource in GIS among the stakeholders.

Challenges in the National Spatial Data Infrastructure Implementation for Nigeria and Kenya

It is evident that Nigeria and Kenya have given in-depth consideration to the utility of geospatial information in decision making despite the problems which the two countries have encountered in instituting the same. Most geospatial data in the two countries are still in analogue format which limits the ability to update them.

The inability to update information limits their utility in solving the problems of time-critical spatial phenomenon such as floods, draught and fire disasters. Besides this, there are cases where few copies of such data were printed which limit their circulation and utility. There are embedded inconsistencies among organisations involved in geospatial data collection and production in the areas of data coding, classification systems, scaling, formatting as well as projections used. This has consequently led to scenarios whereby datasets produced are incompatible and may not enable data sharing, comparisons, integration and modelling. For example, overlay of rivers and topographic maps acquired by different agencies often result in rivers crossing contour lines and even watershed boundaries. Similarly, a city map overlaid by rivers or roads data often show rivers and roads running over buildings.

Additionally, it is not unique to find that interpretations and field notes for aerial photographs and other datasets are either lost, unavailable or resides in an inaccessible format which discourages information sharing (Woldai & Schetselaar, 2002). This problem has since been appreciated by both the countries and has necessitated the need to develop mapping guidelines and other quality control measures. Unfortunately, to date most mapping agencies have not internalised these standards in their practices despite many incentives to achieve this.

It is evident that there is duplication of efforts among

the mapping agencies in the two countries. They use expensive equipments to generate datasets which are not shared with other organisations in dearth of information. Data security is still inadequate in both the countries as all resources are stored in central location notably the Surveying Department. The problem which is likely to emanate from this practice is that recovery of data becomes difficult in case of a calamity. Enormous data in these countries have either been destroyed due to poor storage or are in the shelves of high ranking state officials and are unavailable to the public. The above stated problem is further compounded by reluctance among organisations to share the available analogue and digital maps in their custody. This is in contrast to the genuine cooperation and willingness required in the development of NSDI to facilitate sharing of information for decision making.

Other problems associated with NSDI development in the two countries are the operational policy and coordination paradigms used in the two countries. This manifests in the uphazard coordination among ministries, organizations and agencies involved in the geospatial data production.

This has made users of the geospatial technology suffer due to bureaucracy in obtaining the data. There is also lack of accountability and transparency on the part of the employees involved in the data collection and information production. As such, they view the data and the information as personal which consequently lead to misuse or loss of data and/or information (Kufoniyi & Akinyede, 2004 and Kalende & Ondulo, 2006).

CONCLUSION

The sustainability of NSDI for Nigeria and Kenya is determined by the availability of quality spatial data as well as the governments' goodwill. The governments' goodwill should further facilitate the development of the NSDI policies and collaborative framework with spatial data based international organisations. This is imperative in enabling the acquisition of quality data at an affordable cost. Therefore, the Nigerian and Kenyan governments' decision making bodies have greater challenge and responsibilities of ensuring that gains in NSDI are realised and sustained. This compels Nigeria and Kenya to develop a vision and strategy for a co-ordinated approach in building spatial datasets and the allied infrastructure to facilitate NSDI's utility. The goodwill must also involve expansion of education and training opportunities for the spatial data users for their continued capacity building alongside budgetary allocations for spatial data acquisition and storage activities in the two countries.

RECOMMENDATIONS

The analysis of the state of NSDIs in African countries alongside with the analysis of the same in Kenya and Nigeria corroborates the need for spatial data producers to transform themselves to suit the requirements of the industry. This should be done in concert with advocacy centred on addressing the macro-environment affecting the data production and dissemination such as political goodwill, economic, socio-cultural and technological factors. The development of NSDI in Nigeria and Kenya still depends on the government and stakeholders' goodwill. This necessitates awareness creation at national and regional levels on the significance of spatial data on sustainable development.

However, this requires government funding for the development of basic infrastructure which facilitates the functionality of the NSDI. Therefore it is imperative to convince the governments and allied donors that return on investment in spatial data will outweigh the costs in the long term. In addressing the need for resources, it is also useful to consider harnessing inputs of external players by considering how the international efforts and donor funding can be used to build NSDI nationally and regionally (Longley et al., 2009). This is significant when development is looked at on regional basis in the context of ECOWAS and East African Community which are the major treading blocks for Nigeria and Kenya respectively. As such, utility and sharing of the spatial datasets among the member states of the two treading blocks must be encouraged for majority of the spatial data is trans-boundary in nature and they support development efforts of the member states.

Stemming from the analysis of the Nigerian and Kenyan NSDI policy implementation, key issues to be considered in adopting the technology are inauguration of the NSDI Councils, setting up NSDI Committees and working groups. These bodies are important in the implementation of the NSDI for they create collaborative network with main government ministries mandated with collection and storage of the spatial datasets.

Other issues to be considered include carrying out regular surveys on geospatial data users' requirements, undertaking an inventory of the existing spatial datasets, resources and their standards. Together with the above, it's also imperative to make provisions for immediate production of non-existent but essential datasets by the agencies legally mandated to produce the datasets in accordance with the NSDI standards. Decisions on dataset schema and who should be the custodian(s) of the dataset(s) should be made alongside making the metadata available to the NSDI clearinghouse. Development of spatial data standards which conform

to the ISO standards together with the establishment of standard services should be undertaken to assist users understand how to apply the developed standards. In relation to the above, it is important to take into consideration the definition of the metadata content and the implementation guidelines.

The implementation of NSDI is incomplete without clearinghouse. As such, efforts must be geared towards establishment of clearinghouses in the NSDI node agencies to entre the certified metadata, facilitate adoption and legalisation of all agreements and protocols relating to NSDI operations, putting in place high-speed and high-bandwidth backbone carrier in the clearinghouses, promoting submission and early passage of bills related to the NSDI and to promote synergies among the spatial information related policies through liaising with key national ministries.

The NSDI node agency should also undertake resource mobilisation for spatial data acquisition. This is imperative in ensuring that there are adequate financial provisions and funding for the NSDI. The governments should also consider investing in the spatial education, training and awareness creation in centres of higher education to create critical mass for the technology.

However, the enactment and implementation of the NSDI is incomplete without guiding policies and legal framework for the enforcement of NSDI activities such as spatial information sharing and manpower development as well as investment in publicity on the availability of the technology and how to access it. The NSDI administrative framework should be multidisciplinary, inter-agency and inter-sectorial in nature with lead agency undertaking the coordination role. The lead agency should be the government ministry legally mandated with collection and storage of spatial data. However, the agency should work in collaboration with other relevant global, regional, national, state (county) and local governments' spatial data producing organisations (Kent, 1978 and Loudon, 2000).

Developments of indigenous satellite technology and the constellation have fostered and ushered in the prospects for sustainable NSDI development which should be taken advantage of. The activities of the major players in the earth observation field notably NASA and ESA grants better prospects for the advancement in geospatial data technology. The two organisations have developed high quality sensors for IKONOS, ASTER and Quick Bird with improved spatial, radiometric, spectral and temporal resolutions at relatively fair cost. The multispectral one-meter spatial resolution imageries for IKONOS, ASTER and Quick Bird have enormous applications in resource management. The imageries can serve as detailed base map upon which thematic map layers such as land use, land cover, soil types, hydrology and other activities related to elevation features can be extracted to populate multiple GIS layers (Woldai, 2002b). This indicates that the future of spatial data now turns to space-borne remote sensing and GIS technology at a time when the cost of personal computers have continued to drop. Computerized data capture and analysis using Global Positioning Systems, field spectrometers and other field sensors connected to laptop computers aids in ground truthing and have become critical inputs to systematic spatial data acquisition.

Other mapping tools such as pen stylus, laser range finders and digital cameras, have also continued to be available in Nigeria and Kenya. They facilitate efficient and effective production of topographic maps and colour-orthopotos which are useful sources of spatial data for NSDI development. Therefore it is significant that Nigerian and Kenyan governments should develop collaboration with NASA and ESA towards facilitating sustainable NSDI development. This should be done in concert with streamlining the macro-environment affecting the spatial data production and dissemination, strengthening the NSDI Councils, Committees and working groups to undertake awareness creation on the significance of geospatial data on sustainable development, carrying out regular surveys on geospatial data users' requirements, undertaking regular inventory of the existing geospatial datasets, resources and their standards as well as making provisions for immediate production of non-existent but essential datasets.

This is because these organisations have developed critical infrastructure for spatial data collection, storage and dissemination. In this regard, the collaboration will aid Kenya to acquire the data without necessarily developing their own satellites. For the case of Nigeria, this is crucial in helping the NARSDA undertake satellite constellation comprising of the IKONOS, ASTER and Quick Bird, Nigeriasat -2 and Nigeriasat -X.

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