

# Spatial Data Infrastructure for Sustainable Developing in Nigeria

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## Abstract

The expanding human requirements and economic activities are placing overwhelming pressures on the resources and ecosystem, creating conflicts, risk situation and resulting in suboptimal use of both land and natural resources. Broad sustainable development goal aims to provide a just balance economic, ecological and social development on the basis of comprehensive planning and decision process. The implementation of sustainable development goals requires that all decisions are made with accurate, timely and reliable referenced data. Spatial data infrastructure (SDI) can leverage a better way to manage these data. SDI is often used to denote the relevant based collection of technologies, policies and institutional arrangement that facilitate availability and access to spatial data. SDI also provides a basis for spatial data discovery, evaluation, data sharing and application for users and providers (Nebert, 2004). This paper reviews the geospatial data handling environment and SDI implementation in the study area to expose current state of SDI handling/geospatial data sourcing and the weakness of implementation strategies thereby providing the needed strategy and approach that can fast track the development of SDI in the study area.

**Keywords:** Spatial Data Infrastructure, Sustainable development and Geo-information Policy

## 1. INTRODUCTION

The last few years have witnessed an upsurge in the development of Spatial Data Infrastructures (SDIs). Spatial data plays vital role in developmental activities, whether natural resources management or socio-economic development. Spatial Data Infrastructure (SDI) facilitate and coordinate the exchange and sharing of spatial data between stakeholders in the spatial data community. The significance of SDI is demonstrated by the numerous initiatives all over the world and the large sum of money invested in it over the years. The term "Spatial data infrastructure" (SDI) is often used to denote the relevant base collection of technologies, policies and institutional arrangements that facilitate the availability and access to spatial data (Nerbert, 2004). Spatial data infrastructure provides a basis for spatial data discovery, evaluation, and application for users and providers within all levels of government, the commercial sector, the non-profit sector and by citizens in general (Nerbert, 2004).

In regions of the world (United states, United Kingdom, Canada etc.) where geospatial information are readily available and are used as a decision support tool, critical issues of social, environmental and economic importance are addressed in better ways because of the availability of quality and timely data (Nerbert, 2004). "Many of the challenges of contemporary society, such as protecting the environment, unbroken security, better transport, 'socially just'

or sustainable development and enhanced services to citizens, require decision makers to identify where need is greatest. To effectively target intervention, monitor outcomes and assess impacts, access to geographic information (GI) is crucial. Ideally, it should be easy to identify who owns GI, whether it is fit for the purpose in hand, how it can be assessed and integrated with other information”.

This is quite different from most developing countries like Nigeria where information is a scarce resource; particularly, accurate, timely and quality information. In addition, the political will and resources to fully make use of this information may be lacking. The major causes of underdevelopment and economic woes of many third world countries like Nigeria could stem from number of factors such as corruption, political instability, legacy of colonialism, geopolitical situation that exploits resources at low value, trade barriers, poor quality data collection, organization and management practices including lack of adequate infrastructure and skilled human capacity to develop its economy in a sustainable manner. The consequences of these are: food insecurity, air and water pollution, poor sanitation, social insecurity and environmental degradation among others (Kufuniyi and Akinyede, 2005).

It has been argued that the “engine of growth and sustainable development of any nation is the nation’s access to reliable, adequate and timely geographic information.”

Spatial information (or data specific to location on the earth’s surface) provides the common language and reference system to establish linkages and balance between economic, environmental and social capital in order to improve upon the basis for societal response. Access to Spatial data, and the policies governing access, is crucial in shaping policies, programmes and projects. (Lance, 2004). Spatial data forms an essential part of the knowledge available in modern information and communication science. It is required at all levels of administration, the economy, science and by the public at large. It is the basis for planning in so many fields. It aids agencies, governments and communities in providing information to ensure critical infrastructure, protect the environment and satisfy issues as well as day-to-day resource management decision making (Lance,2004).

## **2. SDI AND SUSTANAIBLE DEVELOPMENT**

Sustainable development is generally considered a new development model that emerged during the late 20th century, however in reality the concept of sustainable development is much not new (Tom et al., 2011). Problems, ideas and practices that we currently classify under the sustainability umbrella have roots that can be traced back for many thousands of years. The search for a balance between demand for raw materials for food, clothing, shelter, energy and the environmental limits of the ecosystems is a consistent concern throughout human history.

The United World Commission on environment and development also known as the “Brundtland Commission” defined sustainable development as the development that meets the needs of the present without compromising the ability of the future generation to meet their own needs(WCED, 1987). In addition to the Brundtland definition, other definitions have been proposed and have gained acceptance. The ‘caring for the earth definition’ by the International Union for the Conservation of Nature and Natural Resources brings into consideration the capacity of the ecosystems: “Improving the quality of life while living within the carrying capacity of supporting ecosystems” (IUCN, 1991). The World Business Council for Sustainable Development (WBCSD, 2000) proposed the concept of “eco-efficiency”, it is based on the concept of creating more goods and services while using fewer resources and creating less waste and pollution . In its preamble, the earth charter states the people of the world “must join together to bring forth a sustainable global society founded on respect for nature, universal human rights, economic justice, and a culture of peace” (ECI, 2008). It further stated that humanities choice is to “form a global partnership to care for the earth and one

another or risk the destruction of ourselves and biodiversity of life”. Therefore, according to the charter preamble, what is needed is a “shared vision of basic values to provide an ethical foundation for the emerging world community (ECI, 2008). The 16 sustainability principles of the earth’s charter exactly serve that purpose. They are clustered in four categories, and should be considered together: (1) Respect and care for the community of life (2) Ecological integrity (3) Social and economic justice, and (4) Democracy, non-violence and peace.

Despite the differences in definitions, a key theme that emerges is that sustainability needs to be incorporated in many if not all of the activities that people undertake (Rosen, 2009). Holger Magel (2003) amalgamated the different definitions, development goals (Millennium development goals) of the United Nation and other supportive declarations and posited that sustainable development goals aim to provide:

- i. A Just balance of economic, ecological and social development on the basis of a “comprehensive planning and decision process”;
- ii. More democracy, decentralisation and deregulation, more participation and transparency. etc. according to the “good Governance principles”;
- iii. Improving on sustaining quality of life of all species, sustainable use and management of natural resources, especially our more and more scarce land;
- iv. To implement sustainable development goals, all decisions must be made with reliable, accurate, relevant and timely referenced data. Spatial data infrastructures (SDIs) can provide a better way to manage these data.

Almost all the definitions of sustainable development require that we see the world as a system. A system that connects space and a system that connects time (WCED, 1987). There are lots of sustainable development challenges facing developing countries that require spatial data and information. These challenges manifest in areas like agriculture, economy, education, health, energy, emergency preparedness, waste management, transportation, water, tourism, natural resources, land use and urban issues among others.

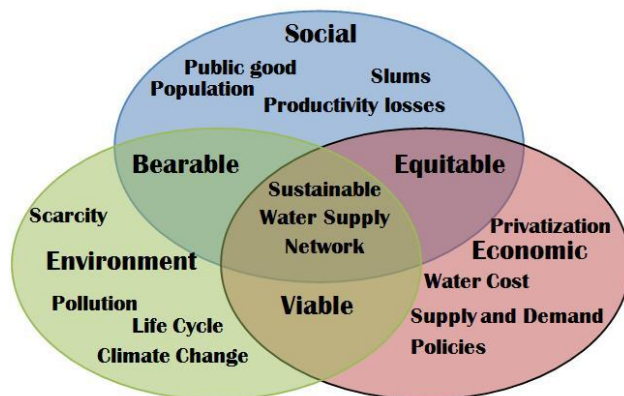


Figure 1. Sustainability chart (Helene Finidori 2013)

### 3. SDI EFFORT IN NIGERIA

The National Geospatial Data Infrastructures of Nigeria (NGDI) is an NSDI initiative that among other objectives is to promote the production, dissemination and use of geospatial information for poverty alleviation, food security, job creation, improvement of quality of life, good governance, education and health care delivery, water resources management, environmental and disaster management, transportation, tourism, communications, gender mainstreaming, national defence and security, economic planning and natural resources management.

Other objectives include the discovery, harmonization and standardization of geospatial data production and management, and the provision of a platform for data sharing thereby eliminating data duplication and conserving cost and time spent in producing already available data, (Agbaje and Akinyede, 2005). An efficient functioning NGDI and the associated GI Policy is regarded as vital requirements for sustainable national development.

### **3.1. NGDI and the National Geo-information policy**

Due to the increasing awareness of the use of GI for decision-making over the past years, coupled with the expected availability of primary dataset from the Nigerian Satellite, the country has realized the need to adopt policies for promoting greater awareness and public access to standard and coordinated geo-spatial data production, management and dissemination by all sectorial institutions and the need for the establishment of a Geospatial Data Clearinghouse at various levels in the country (local, state and federal) and linkages with the private sectors.

Other driving forces include: New Partnership for Africa's Development (NEPAD)-provision of relevant GI to facilitate national development and regional integration, call of the United Nations Economic Commission for Africa (UNECA) to establish SDI, and Information and Communication Technology as it permits GI sharing and growth. In September, 2003, the final draft of Nigerian Geo-information Policy was formulated by the Federal Ministry of Science and Technology, Abuja. The vision of the GI Policy is to enhance optimal use of Geospatial Information as a critical resource in all phases of sustainable national development for the alleviation of poverty and improvement of quality of life of the people of Nigeria. (Agbaje and Akinyede, 2005)

### **3.2. The NGDI Organisation**

The mission of the NGDI, among others is to generate and disseminate geospatial databases, which are vital for development at the National, State and Local levels in Nigeria by facilitating cooperation and collaboration among GI stakeholders. To achieve these objectives, the National GI Policy has provided for the establishment of NGDI Council, the NGDI Committee and the NGDI Sub-Committee.

#### **3.2.1. The NGDI council**

According to the National GI Policy, government shall establish a National Geospatial Data Infrastructures (NGDI) Council whose function shall be to develop all policy guidelines on NGDI with the Vice President of the Federal Republic of Nigeria as the Chairman and the Federal Ministry of Science and Technology as its Secretariat.

#### **3.2.2. NGDI committee**

A 27- member committee was inaugurated on the 9<sup>th</sup> September, 2004 by the Honorable Minister of Science and Technology. The Committee members are drawn from the academia, public organizations, and GI related NGOs, and private sectors. The Committee members are well spread in terms of stakeholders and geographical distribution across the country in order to enforce partnership and create an enabling environment for data access and dissemination. The National Space Research and Development Agency (NASRDA), is the lead Agency while other GI Producers shall be NGDI node agencies.

#### **3.2.3. The NGI Sub-committee**

At the inaugural meeting of the NGDI Committee, the following six sub-committees were created in line with the recommendations of the Stakeholders/Users meeting of February

2003. They include: Geospatial Datasets Sub-Committee, Standards Sub-Committee, Clearinghouse and Metadata, Capacity Building and Awareness, Legal Sub-Committee, and Sustainability and Funding Sub-Committee.

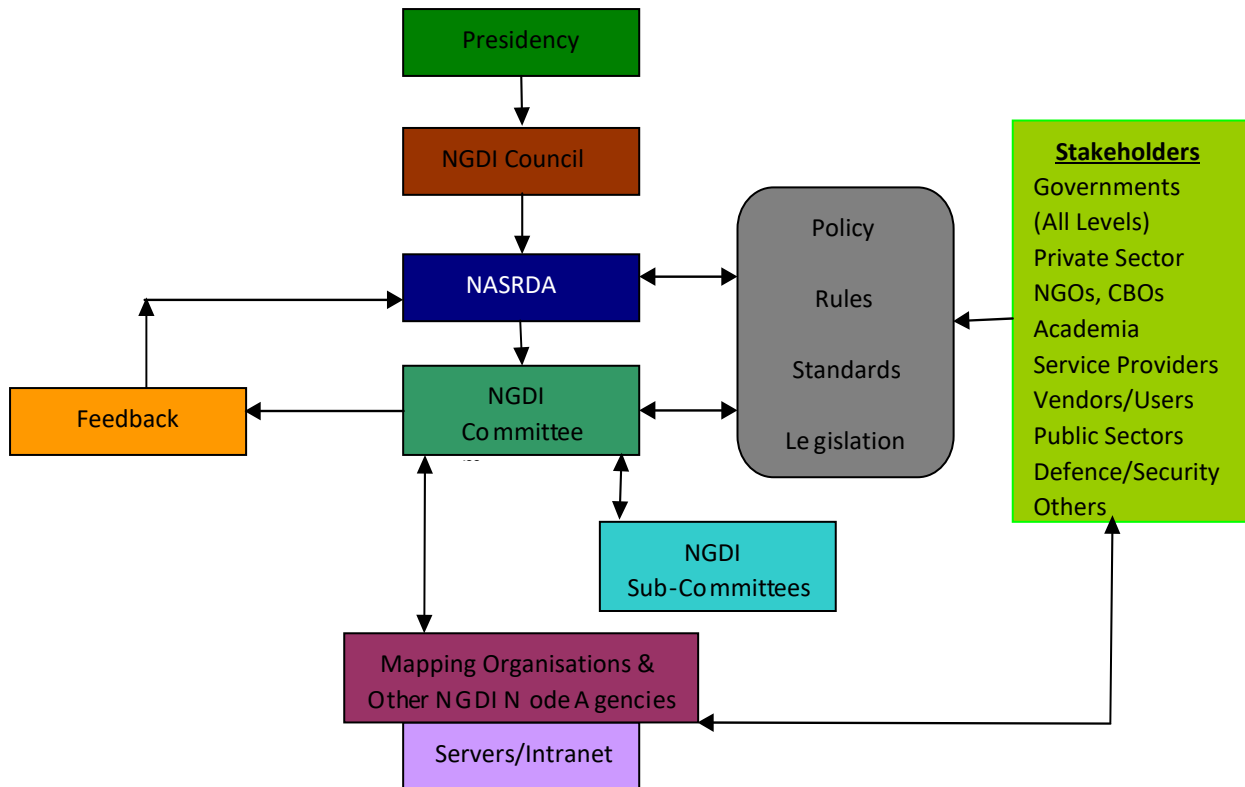


Figure 2: Organizational Framework of Nigeria NGDI (National Geoinformation Policy, September, 2003)

#### 4. NIGERIAN GEOSPATIAL DATA INFRASTRUCTURE COMPONENTS

##### The Fundamental Datasets

The following datasets constitute the fundamental datasets for the NGDI: Geodetic control database, topographic database/DEM, digital imagery and image maps, administrative boundaries' data, cadastral databases, transportation data, hydrographic data, land use/land cover data, geological database, and demographic database, the list is subject to periodic review in accordance with national needs (Agbaje, G.I., 2011). Thematic Datasets on the other hand are derivative datasets from fundamental datasets.

##### 4.1. Access Network

The National GI Policy has a comprehensive statement on metadata of which the main ideas can be summarized as the following, "Every geospatial data producer shall provide metadata for each of its data holdings; the metadata of any dataset shall be updated whenever the dataset is updated; the metadata produced shall conform to the national standard; the metadata structure shall strive to conform to the ISO metadata standard (ISO TC211); metadata shall accompany the dissemination of all geospatial data. The importance of metadata cannot be overemphasized, as it gives descriptive information about the available data.

The apex Clearinghouse shall be at NASRDA as coordinating agency with Clearinghouse nodes at other geospatial data producing agencies (Fig.3); there shall be free access under a legal framework (protection of copyright) to other community and private datasets, and each geospatial data-producing agency shall establish a metadata database server as a NGDI node, linked to the apex Clearinghouse. The availability of clearinghouse catalogue is paramount in any NSDI, and can be used as a yardstick in measuring the extent to which the NSDI is advanced.

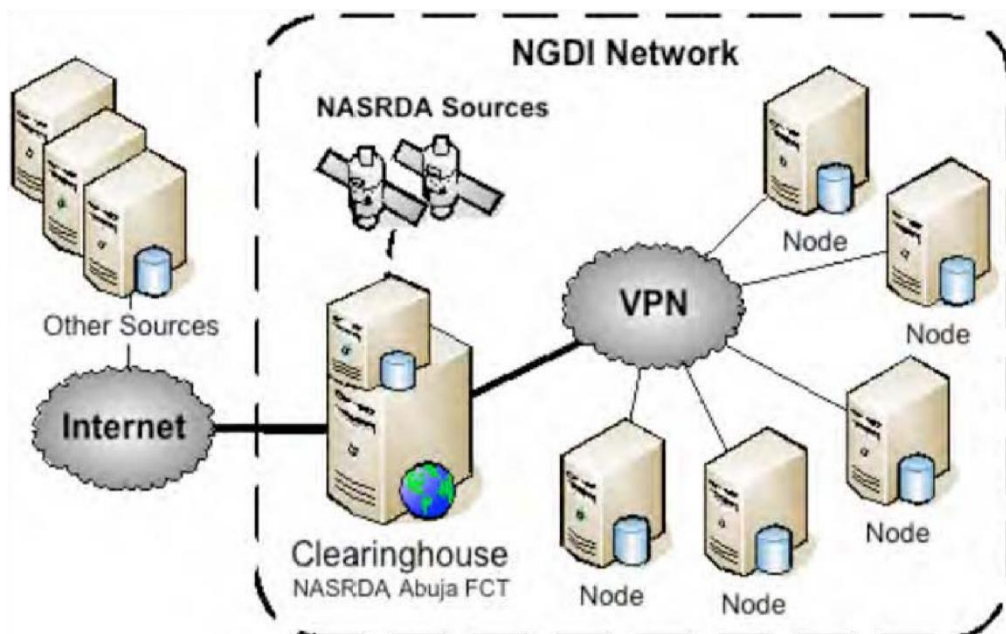


Figure 3: A Proposed Model of NGDI Network with a common Clearinghouse.  
Source: Agbaje et al, 2008.

#### 4.2. Standards

Standardization is of paramount importance to NGDI in information sharing, interoperability of data and connectivity of information systems. Policy Statements pertaining to standards covers the following areas: data structure, data quality, data format, classifications, feature coding and metadata content, and ISO standards (e.g. ISO 15046). The identified areas has to be endorse by the Standard Organization of Nigeria (SON). The NGDI Committee through the lead agency shall prescribe a set of common standard file formats (e.g. DXF, DLG, TIFF and JPEG) as the National Standard Exchange Format to facilitate easy transfer/exchange of data.

#### 4.3. Policy

The NGDI has an advantage of having a national policy establishing it. The policy addressed all the components of the NGDI including funding issues. According to the policy NGDI lead agency and the NGDI Committee shall actively promote funding of all NGDI node agencies and work out further mechanism of obtaining fund for NGDI. The NGDI funding model is highly skewed towards government patronage. In the policy the budgetary provision for NGDI implementation is outstanding on paper since the national assembly is yet to ratify the bill into law; it addresses means of funding of all NGDI components. The fund shall accrue from: minimum 2.5% of annual budget (The national budget for 2015 is \$20,000,000,000 and 2.5% of this is \$500,000,000); 10% of national ecological fund; 0.5% profit after tax of private organization; and all income generated from access charges and data sales; and international fund and grants [Kufoniyi, O and Agbaje, I, 2005].

#### **4.4. Institutional Arrangements**

The NGDI Project in Nigeria has administrative/organizational framework that is multidisciplinary, interagency and inter-sectorial network of institutions coordinated by the lead Agency, National Space Research and Development Agency, (Figure 5). NASRDA shall work in close collaboration with the relevant National, State and Local Government Legislative Committees and Geospatial data producing organizations. (NGDI Council, Committee and Sub-committee have been highlighted). This arrangement will remove the institutional barriers that have in the past inhibited GI sharing among the producers and users.

The coordinating Agency shall have powers to enforce rules and standards. Because the GI Policy is yet to be signed into law (The bill has gone through second reading with the current senate, its hoped that it would be passed within this tenure of the current senate), this power of NASRDA to enforce rules and standards is not yet achieved. Government at different levels and organization are still creating spatial data for their own use and according to their own need. The stakeholders that would collectively ensure the successful realization of the NGDI vision shall include but not limited to: Government at all levels, Private Sector Agencies, Non-Governmental Organizations (NGOs), Academic and Research Community; Service Providers/Vendors and End users, Public Sector Agencies, Defence/Security Agencies.

#### **4.5. Capacity Building**

There are strategies for capacity building such as ensuring that all GI related projects are locally implemented to a minimum of 75%. There has been significant progress in this direction as geographical information systems is now introduced into geography curriculum in the secondary schools. However, much work is still needed as professionals presently with relevant GI skills are very few. This can be improved by in-service training, and sending some GI staff for advanced degree programmes.

### **5. SDI CHALLENGES IN NIGERIA**

In Africa, formal SDI's have been developing but at a seemingly slow pace (Lance and Bossole, 2006). SDI initiatives in Africa are mainly pioneered by government agencies, this is similar to many other places in the world. Makanga and Smith (2008) in their study on the status of SDI implementation on the African continent showed that SDI is still in its infancy with most countries still trying to establish the basic frameworks upon which their SDIs will be implemented. There is very little political support for formal SDIs initiatives on the continent and although there are several SDI coordinating bodies, their SDI projects don't seem to take off the ground (Clark, 2009).

The assessment of NSDI initiatives in Nigeria and most African countries reveals inadequate political goodwill as occasion by low awareness levels among the principal ministries and relevant institution on the significant of SDI, 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 financing resources in many African countries and the facts that benefits from investment 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 impacts on their electoral fortunes and performance appraisal targets (Oyugi and Adewale, 2013).

Most African countries are faced with challenges to put in place policies, resources and structures to make available geographic information easily accessible to decision makers and

the community. According to P. K. Singh (2009), the main challenges in implementing SDI are:

1. Financial resources mobilization.
  2. Political interest among decision and policy makers.
  3. Institutional capacity; partnering numerous regional and continental bodies
- There are numerous challenges with spatial data production, handling and coordination in the developing world, especially Africa, where some of the challenges are:
- There are embedded inconsistencies in the production of geographic information resulting in different positional accuracies, coding and classification systems, different scaling, packaging, formatting system and projections within the study area, this makes data integration difficult;
  - Geospatial data often are not collected or automated to standards that would make the data useful in multiple applications;
  - Requirements for positional accuracy, information context and geographic coverage of the geospatial data vary significantly among users and producers of geospatial data;
  - Lack of official digital baseline maps consequently leading to various datasets collected being incompatible to enable comparison, integration and modelling. The overlay of rivers and topographic map acquired by different agencies for example often result in rivers crossing contour line and even watershed boundaries, similarly a city map overlaid by river or road data often show the river or roads running over the buildings (Oyugi and Adewale, 2013);
  - There is duplication of effort, costly equipment and datasets emanating from standalone heterogeneous systems;
  - Data sharing/exchange for improved analyses and decision is lacking, there is the need to foster co-operation and willingness to share data;
  - Inadequate coordination exist among ministries, organisations and agencies in spatial data business as a result of government bureaucracy;
  - Demands for digital geospatial datasets are increasing much faster than budgets for data collection and management;
  - Fundamental datasets recorded in the field such as aerial photographs, interpretations, field notes as well as data collected from other studies are either lost, unavailable or residing in inaccessible formats, such as notebooks or reports disaggregated from their positional attributes and fragmentally distributed within the syntax of human language (Woldai and Schetselaar, 2002);
  - Other limitation includes inefficient processes for purchasing spatial information, lack of skilled personnel to establish and manage the infrastructure (Bishop et al., 2000).

## **6. CONCLUSION AND RECOMMENDATION**

Spatial data play crucial role in national and sustainable development, for these reasons, it is expected that the Nigeria Government invest more resources and prioritise the development of spatial data infrastructure, the country has relative stakeholder's goodwill for the NSDI development, there is availability of indigenous earth observing satellite, relative number of trained human resources in geospatial technology yet some components of the NSDI are not properly implemented

In Nigeria, the absence of wide spread telecommunication and internet access are still limiting NSDI developments. Main challenges with respect to NSDI development are Political support, legal status and leadership (Lance, 2003). "Although many African countries have initiated NSDI, it is not prominent on the Political agenda due to more critical issues such as poverty, HIV/AIDS, drought, flooding, environmental disaster etc."



There is an urgent need to hasten the implementation of National Spatial Data Infrastructure in Nigeria. Again, there is the need to step up awareness creation on the significance of spatial data on sustainable development.

The sustainability of National SDI in Nigeria is dependent on the availability of quality spatial data and government goodwill. Government of Nigeria should develop a vision and strategy for a coordinated approach and the allied infrastructure to facilitate NSDI utility. There should be expansion of education and training opportunities for spatial data users for their continued capacity building alongside budgetary allocations for spatial data acquisition and storage activities.

The implementation of NSDI is incomplete without clearinghouse. As such, efforts should be geared towards the establishment of clearinghouses in the NSDI node agencies to enter the certified metadata, facilitate adoption and legalisation of all agreements and protocol relating to NSDI operation. High speed and high-bandwidth backbone carrier in clearinghouses should be put in place.

The government of Nigeria should play more major roles by providing and increasing financial assistance for NSDI development. This can be done through increased budgetary allocations. Other alternative sources of funding like private sector funding and donor agencies should be explored.

## 7. REFERENCES

Agbaje, G. I., & Akinyede, J. (2005). NGDI Development in Nigeria: Policy issues on information access and information dissemination. In United Nations Economic Commission for Africa, *CODI-1V*. (April 23-28, 2005).

Bishop, I. D., Francisco, J. E., Sadaswan, K., Williams, T., & Yates, P. (2000). Spatial data infrastructures for cities in developing countries-lessons from the Bangkok experience. *Cities*, 17(1), 85-96.

Clarke, D. (2001). Development of the Australian spatial data infrastructures. International symposium on spatial data infrastructures, 19-20 November, 2001, University of Melbourne, Australia.

Holger, M. (2003) 'Spatial information management for Sustainable development', *Public Lecture: The Jamaican conference*. Kingston, Jamaica.

IUCN (1991) *Caring for the earth*. Available at: <http://www.ciesin.org/ic/iucn/caringDS.html> (Accessed 08/07/2015).

Kufuniyi, O., & Akinyede, J. (2005). Mainstreaming Geospatial data for sustainable national development in Nigeria (2005).

Lance, K. (2004) *Spatial Data Infrastructure in Africa*. Nigerian Journal of Surveying and Geoinformatics.

Lance, K. and Bassole, A. (2006). SDI and national information and communication infrastructure (NICI) integration in Africa. *Information Technology for Development*, 12, 333-338.

MaKanga, P. and Smit, J. (2008) *A Review of the Status of Spatial Data Infrastructure Implementation in Africa*. In *GSDI News*, (<http://www.gsdi.org/newsletters.asp>), December 4, 2008.

Nebert, D. (2004).SDI cookbook. (<http://gsdi.org/gsdi/docks2014/cookbook/cookbook02.pdf>) (Accessed 07/08/2015).

Oyugi, M., O., & Adewale, A., Pathways in the implementation of national spatial data infrastructure in Nigeria and Kenya (2013). *Africa Habitat Review* 7, p537-550.

Rosen, M.A. (2009) "A crucial Quest for Humanity", *Journal of Sustainability*, 1(1-4), p. 10, WBCSD (2000) *World Business Council for Sustainable Development*. Available at: [http://www.wbcsd.org/web/publication/eco\\_efficiency\\_creating\\_more\\_value.pdf](http://www.wbcsd.org/web/publication/eco_efficiency_creating_more_value.pdf) (Accessed 06/08/2015).

WCED (1987) 'Our common future' *World Council on Development*. Oxford: Oxford University press.

Woldai, T., & Schetselaar, E. ((2002)). Design and implementation of 'factual' databases to support GIS analyses of earth systems, developments and technology transfer in geomatics for environment and resource management. *ISPRS Commission Workshop V1*. Dares Salaam, Tanzania.