Current Trends in Nigeria's Space Development Programme to Facilitate Geospatial Information (GI) Sharing and Implementation of the NGDI

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ABSTRACT
Barely seven (7) years to the deadline for the attainment of the Millennium Development Goals (MDGs), which is meant to haul the world's 2 billion poorest out of misery; promote human dignity and equality; and achieve peace, democracy and environmental stability; it is becoming clear that a number of developing countries especially in Africa will fail to achieve the MDGs. The root cause of this emanated from a number of factors which include poor quality data collection, organization and management practices including lack of adequate infrastructure and skilled human capacity to develop the natural resources and manage the environment in a sustainable manner.

Recognising the significant role of space technology for the attainment of rapid sustainable socio-economic development, the Federal Government of Nigeria embarked on satellite system development which resulted in the launch of the NigeriaSat-1 in September 2003 and Nigcomsat-1 in May 2007 while NigeriaSat-2 is expected for launch in 2009. Nigeria is also committed to the building of the African Resources & environmental Management Satellite Constellation (ARMS). All these activities will serve as catalyst to the development of the country's national geospatial data infrastructure (NGDI).

The paper will discuss the current trends in Nigeria's space programme (satellites development); examine the institutional arrangements in place to facilitate geospatial information (GI) sharing among organisations in Nigeria as contained in the National Geoinformation Policy; examines the progress made so far in the implementation of the NGDI. When fully operational, the NGDI will serve as the fuel for the effective implementation and attainment of the Millennium Development Goals by 2015.

1.0 INTRODUCTION

1.1 Sustainable Development and the MDGs Target

The term "sustainable development" has been popularised by the World Commission on Environment and Development (WCED). In its 1987 report entitled, "Our Common Future" (WCED, 1987) the Commission defined sustainable development as "the development that meets the needs of the present without compromising the ability of future generation to meet their own needs". Fifteen years later the World Submit on

Sustainable Development (WSSD) in Johannesburg, South Africa (WSSD, 2002) identified top ten strategies for the successful achievement of sustainable development some of which are: poverty eradication and sustainable livelihoods; changing unsustainable patterns of consumption and production; access to energy and energy efficiency; finance and technology transfer, etc. The Johannesburg WSSD came at the heels of the adoption of the eight (8) Millennium Development Goals (MDGs) in September 2000, when all member States of the United Nations agreed to articulate policies, strategies and plans which will facilitate the achievement of the Goals by 2015 in order to address the problem of poverty and promote sustainable development (MDGs, 2000). This agreement could be seen as a defining moment for global cooperation in the 21st century especially in the science and technological skills required to achieve these laudable goals.

At the midway point between the adoption of the MDGs in 2000 and the 2015 target date to achieve them, the 2007 UN report shows that sub-Saharan Africa is not on track to achieve any of the Goals. The report further states that 'although there have been major gains in several areas and the Goals remain achievable in most African nations, even the best governed countries on the continent have not been able to make sufficient progress in reducing extreme poverty in its many forms' (UN, 2007). This was earlier pointed out in 2005 by the United Nations Commission on Science and Technology for Development (UNCSTD) and ASADI (2005) which states that 'without significantly improved application of Science and Technology to tackle the socio-economic problems, a number of developing countries will fail to achieve the MDGs'

The main strategies for achieving MDGs and WSSD initiatives include technology and skill acquisition, natural resource management, infrastructure development, and public private partnership. Accordingly, many societies around the globe are embarking on initiatives and developing agenda towards achieving these goals. However in Africa, poor quality data collection, organization and management practices including lack of adequate infrastructure and skilled human capacity to develop the natural resources and manage the environment in a sustainable manner are identified factors that may make the Goals unrealizable. Various geospatial data that could lend itself to sustainable development planning are either outdated or unavailable. Also in respect of data availability, Africa is the least imaged continent in terms of high resolution satellite imageries. Where available, the cost of acquisition of these imageries is prohibitively high for most African economies. In addition, there is shortage of the required technical skills to utilize the data.

The current trend in making geospatial data accessible for sustainable development is by establishing a Geospatial/Spatial Data Infrastructure (GDI/SDI). Unlike most developed countries where manual cataloguing exists prior to the SDI trend, most African countries geospatial data (where available) are not well organized and difficult to access for any meaningful development planning.

In order to assist African countries to establish Spatial Data Infrastructures (SDI) in their respective countries and hence ensure that geospatial information (GI) are readily

available for sustainable development, the UNECA Committee on Development Information, Science and Technology (CODIST)–Geo published an SDI Implementation Guide (UNECA *et al*, 2003). The focus is to assist stakeholders in African countries to understand the institutional and technical issues involved in SDI implementation similar to the SDI Cookbook published by the Global Spatial Data Infrastructure (GSDI).

Nigeria is one of the countries in Africa that have taken steps towards establishing a National Geospatial Data Infrastructure (NGDI). The NGDI system and data holdings will effectively address Nigeria's geospatial data needs which are germane to her socio-economic development. Accurate geospatial products and the NGDI capabilities and benefits provided by a common standardized geospatial clearing house accessible by key government agencies and regional governments within the country will be used for infrastructure, contingency, and security planning, environmental monitoring (especially in the Niger Delta), etc.

2.0 NIGERIAN SATELLITE PROGRAMME AS A CATALYST TO NGDI PROGRAMME

2.1 Focus of the Nigerian Space Programme

Nigerian Space Agency – the National Space Research and Development Agency [NASRDA] was established with a mission to pursue the development and application of space science and technology for the socio-economic benefits of the nation and the Nigerian space programme constitutes an important component of the national strategy for socio-economic development through space application and participation in the global industry.

The overall agenda of the Nigeria's space agenda is geared towards sustainable national development and security including the development of new resources, understanding of our environment and the maintenance of national security. The National Geospatial Data Infrastructure [NGDI] coordinated by [NASRDA], will facilitate efficient production, management, dissemination and use of geospatial information for the attainment of the Millennium Development Goals (MDGs) and the 7-Point Agenda of the current Nigerian government, which are:

- Sustainable growth in the real sector of the economy
- Physical Infrastructure: Power, Energy & Transportation
- Agriculture
- Human Capital Development: Education & Health
- Security, Law & Order
- Combating Corruption
- Niger Delta Development

In order to attain rapid sustainable socio-economic development, the Federal Government of Nigeria took a bold step by embarking on satellite system development which resulted in the launch of her 1st earth observation satellite (NigeriaSat-1) in September 2003.

2.2 Nigeriasat-1

The first Nigerian earth observation satellite - NigeriaSat-1 built by Surrey Satellite Technology Limited (SSTL) of UK was successfully launched into Low Earth Orbit (LEO) from Plesetsk, Moscow, on the 27th of September 2003 off the Kosmos Rocket along with two other Disaster Monitoring Constellation (DMC) micro-satellites - UK DMC, and BILSAT (Turkey satellite) at about 06:09hrs GMT.

NigeriaSat-1 is an Earth-Observation micro-satellite with a circular sun-synchronous orbit at an altitude of 686Km. It is a 100kg spacecraft with Push-broom scanning technology, and designed for 5 year minimum lifespan. It has a swath width of 600Km and the imaging payload is 3-band multi-spectral imager in the green, red and near-infrared bands (0.52-0.62(Green), 0.63-0.69(Red), 0.76-0.9(NIR) and has Ground Sampling Distance (GSD)/Spatial resolution of 32m. The spacecraft has on-board data storage capacity of 2 x 0.5Gbyte SSDR to support imaging activities with a store and forward communications system (Akinyede (2003), Chizea (2005), NASRDA (2004)).

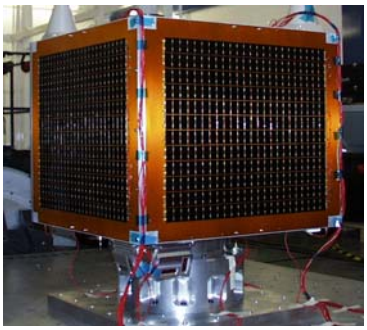

Figure 1: NigeriaSat-1 (SSTL, 2003)

Nigeriasat-1 data continue to enhance sustainable development and support disaster management in the country and other parts of the world. The data is currently being used to address key socio-economic problems in the country, for example revision of the Land Use/Land Cover, which was last revised in 1995 using SPOT imageries; Satellite-based Environmental Change Research in the Niger-Delta area; Development of Predictive Models for Desertification Early Warning; Mapping and Monitoring of the Impact of Gully Erosion in South-Eastern part of Nigeria; Settlements and Major Roads Mapping Project; Flood Mapping in the Kainji Lake Area; Deforestation in the South-Western part of Nigeria etc.

NigeriaSat-1 is one of the five (5) satellites of the Disaster Monitoring Constellation (DMC) built to address the need for daily revisit and global coverage to monitor natural disasters and other dynamic phenomena. DMC images are made available free of charge for disaster management. As part of the Disaster Monitoring Constellation (DMC), Nigeriasat-1 images have been used in various part of the world for disaster management e.g. Asian Tsunami disaster (20 of 300 X 150 Km supplied); Huricanne Katrina etc. In 2007, Nigeriasat-1 data through **International Charter** has been used to respond to floods in Argentina/Parguay, Uruguay,North Korea, Pakistan, China, Vietnam, North Korea, New York, West Africa; volcanic eruption in Nevado, Columbia, Yemen; oil spill

in Lyme-Bay, UK; fires in California; locust threat in Algeria, Syria etc. These images along with other DMC images are made available free of charge for disaster management. In conjunction with other DMC satellites, Nigeriasat-1 has also been used for various mapping campaign e.g. the Amazon, Vietnam coastal areas, European Union States (April – October 2007), Australia etc.

While Nigeriasat-1 is reaching its end of life, Nigeria had started building her 2nd Earth Observation satellite – Nigeriasat-2.

2.3 Nigeriasat-2

Nigeria is consolidating on her achievements with Nigeriasat-1 by developing a high resolution Earth Observation satellite – Nigeriasat-2. The satellite is designed to have 2.5m and 5m spatial resolution in panchromatic and multi-spectral respectively, with four spectral bands in the RED, GREEN, BLUE, Near Infra-red (NIR). To ensure data continuity, NigeriaSat-2 will carry the 32m multispectral payload of NigeriaSat-1. to meet the requirements of a variety of applications which include large-scale mapping and precision agriculture.

The new 300kg satellite (Figure 2), with the design life of 7years is billed for launch in 2009. It will provide Nigeria with valuable geographically referenced high-resolution satellite imaging for applications in large-scale mapping, water resources management, precision agricultural, population estimation, health hazard monitoring and disaster mitigation and management etc.

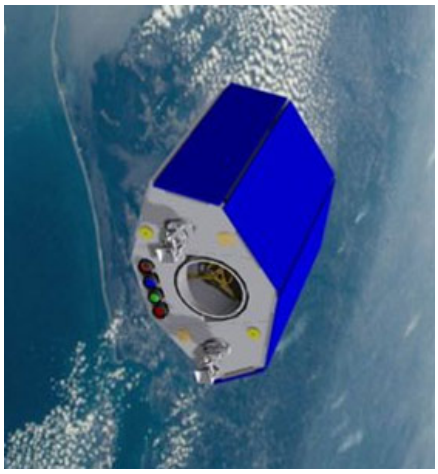

Figure 2: NigeriaSat-2 Model/Impression (SSTL, 2007)

2.4 Nigeriasat-X EMS100 (Enhanced Micro Satellite 100)

Capacity building is central to the implementation of the Nigeria Space Programme. As part of the Know-How Technology Traning (KHTT) on the NigeriaSat-2 satellite project is the development of a training model (TM) named – NigeriaSat-X. The TM will be used to give the KHTT's hands on experience in the requirements specification, project

management, system engineering, manufacture, test, assembly / integration and final system testing of a spacecraft. Unlike the NigeriaSat-1 TM, NigeriaSat-X will be built to flight specification and will be launched along with NigeriaSat-2. Twelve (12) Nigerian Engineers and Scientists are currently involved in the building of the satellite using SSTL facilities since September 2006. NigeriaSat-X EMS100 key features include:

- 22m next generation imager with improved resolutions and optics over the same swath areas as DMC+;
- Max swath 600km @ 8bits
- High rate X-band downlink set to 20MBps
- Low rate S-Band 8MBps
- 2 x 2Gbyte data recorders

The Nigeriasat-2 sensor will provide imagery at 3 resolutions – 2.5m panchromatic, 5m multi-spectral (RGB, NIR) and 32m multi-spectral. The Nigeriasat-X sensor will provide 22m multi-spectral (RGB, NIR) imagery. The volume of imagery expected from Nigeriasat-2 is about 250 images per day. A long-term storage for approximately 7.2 years of steady collection and processing capacity for 100 images per day is being planned. The imagery volume from Nigeriasat-X has been estimated to be a handful of images per day, sharing many of the same storage and processing capabilities from the Nigeriasat-2 system.

2.5 Nigeria Communication Satellite – NIGCOMSAT-1

Access to information has become a weapon of mass socio-economic development, as information underscores all developmental effort be it in education, provision of health services, marketing, construction industry, tourism, defence etc.

Communication Satellite, with its instant ubiquitous coverage, offers cost-effective solutions and affordable access to information and communication technology which is becoming not only critical but highly essential to the basic needs of our daily life.

Subsequent to the successful launch of the NigeriaSat-1 and recognising the importance of ICT as a major tool in the socio-economic development of the nation, the Government of Nigeria approved the Nigerian Communication Satellite Project (NIGCOMSAT-1) as a national priority project on the 12th November 2003. This bold and strategic step in the development of a key ICT infrastructure will forever change the destiny of not only Nigeria but the entire Africa. The project becomes imperative as the world is undergoing information revolution with pervasive impact in all spheres of human endeavour making it mandatory and critical for any nation to have access to information.

The main aim of the Nigcomsat-1 project is to provide a critical and innovative collaboration for capacity building and development of satellite technology for quantum transformation in the telecommunication, broadcasting and broadband industry in Africa, while providing new opportunities and challenging platforms for business in rural and remote regions through access to strategic information in the new world economic order (Boroffice, 2004).

NigComSat-1 was successfully launched into geostationary orbit (42.5° E) from Xichang Satellite Launch Centre, Sichuan Province, China on 14 May 2007. The NigComSat-1 is a geostationary satellite with over 5 tons wet mass, carrying 40 transponders (28 active) in the Ku, C, Ka, and L-bands. The satellite has a design life-span of 15 years and provides coverage over Africa, Middle-East and Europe. Fifty-five (55) Nigerian Engineers and Scientists were trained in China under the project. Figure 2 shows the NigeriaSat-1 model.

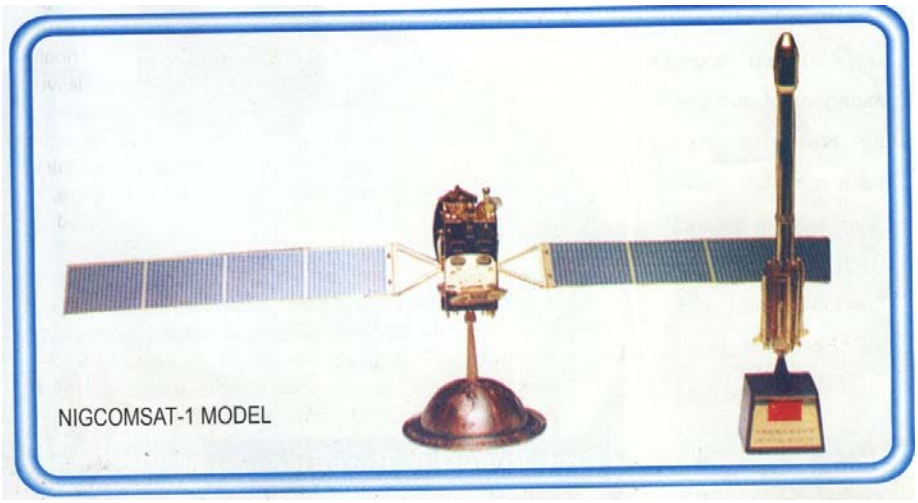

Figure 3: NigComSat-1 Model

NASRDA's Telemedicine and Tele-education projects in collaboration with the Federal Ministry of Health and the National Open University of Nigeria respectively are examples of Nigcomsat-1 application projects recently commissioned by the Federal government.

Nigcomsat-1 will provide the required ICT backbone for geospatial data sharing and improved access not only in Nigeria but in most part of Africa, parts of Middle East and Europe.

In implementing these space development programmes, human capital development has always been an essential component. So far 95 Engineers and Scientists have been trained and are currently manning various positions in the Space Agency.

2.6 African Resources & environmental Management Satellite Constellation (ARMS)

Nigeria is also committed to the development of the African Resources & Environmental Management Satellite Constellation (ARMS) project. ARMS is proposed to be one of the key flagship projects in the NEPAD Science and Technology Programme Areas.

This initiative will provide Africa with rapid, unrestricted and affordable access to satellite data thereby ensuring effective indigenous resource management in Africa by Africans. The approach to the development of satellite technology is by collaborative work in which each member nation will assist others in the realization of individual nation's space objectives as spelt out under NEPAD.

All these activities (space programmes) will serve as catalyst to the development of the Nigeria's National Geospatial Data Infrastructure (NGDI).

3.0 NGDI – NIGERIAN MODEL

3.1 The Vision

There is a strong economic justification for national investment in the collection and management of fundamental GI as component of National Information Infrastructure. This view has been corroborated by the World Bank's African privatisation expert (Meyerman, 2004) who blamed the inability of the African countries to compete in the international market to the lack of infrastructure in spite of the huge resources at their disposal. He noted that infrastructure is one of the biggest challenges to meet the millennium development goals (MDGs) in Africa. According to him, "Africa would need $15 billion a year in infrastructure financing to achieve seven percent economic growth in order to halve extreme poverty by 2015 and to reach the millennium development goals."

The vision therefore is to ensure that GI permeate every aspect of the society and that they should be available to people who need them, when they need them, and in a form that they can use them to make decisions with minimal pre-processing (UNECA, 2001) by integrating GI into the centre-stage of national information and communication infrastructure (NICI). The most efficient and effective way to achieve the above is through the implementation of a national geospatial data infrastructure (NGDI).

Due to 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 earth observation satellites, 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 sectoral institutions.

3.2 The NGDI System

NGDI as a system will provide the hardware, software, and processes necessary to house, manage, produce, share, distribute, and utilize Geospatial Products and Services. The NGDI will include a metadata catalog describing the holdings within NGDI; storage capabilities to house significant quantities of geoinformation; mechanisms to enable timely access and sharing of the holdings; and tools to enable analysts and other end

users to use the NGDI holdings to address sustainable development. The NGDI will be implemented as a phased development.

The developmental strategy for NGDI follows an incremental approach to allow NASRDA effectively address evolving stakeholder needs. This allows the creation of the clearinghouse, the population of the clearing house with base datasets such as a countrywide orthomosaic, and the establishment of a production system for generation and maintenance of geospatial products (Agbaje *et al.*, 2008). Central to NGDI is a Spatial Data Clearinghouse that will contain the overall network's spatial metadata with linkages to each remote node. The Clearinghouse will be hosted at NASRDA's Headquarters, along with image processing capabilities, and implemented during the first phase. In subsequent phases, several remote nodes will be located at various government ministries. All of these nodes will be linked to the Clearinghouse through a combination of new and established communication links (Figure 4). The Clearinghouse provides visibility into the overall NGDI network's holdings and access to its physical content.

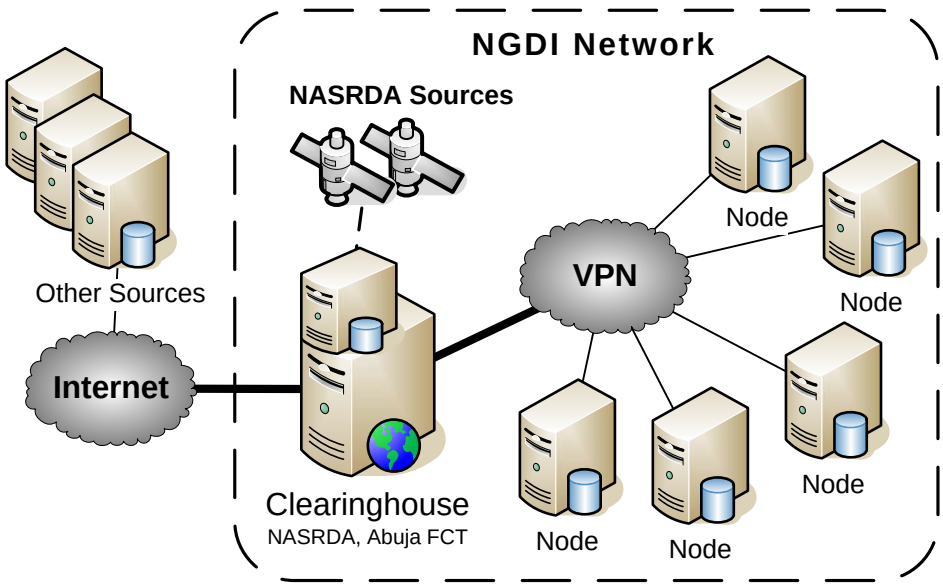

Figure 4: The NGDI Network Supports Distributed Holdings with a Common Clearinghouse.
Source: Agbaje et al. (2008)

The institutional arrangements in place to facilitate geoinformation sharing among organizations in Nigeria; issues such as data access; the linkage between NGDI and each of the MDGs objectives; the National Geoinformation Policy, and the NGDI organisational and technical structures have been subjects of discussion by different authors in the past (Agbaje and Kufoniyi, 2005; Kufoniyi, 2004; Agbaje and Boroffice, 2006, NASRDA, 2003 and UNECA, et al. 2003).

The metadata standards and service-level interfaces will adhere to recommended specifications from the Global Spatial Data Infrastructure (GSDI) Association and the related suite of standards specified by the International Standards Organization Technical Committee 211 (ISO/TC 211). These specifications will enable NGDI to interface with other SDI's and utilize many of the standards-compliant COTS tools. In addition to these interfaces, NGDI will implement specialized services for data ingest, processing, exploitation and dissemination in a Services Oriented Architecture (SOA).

3.3 Access and Retrieval.

The NGDI Clearinghouse will have service interfaces for accessing metadata and retrieval of the core data. Many of the access interfaces will be facilitated through the utilization of Open Geospatial Consortium (OGC) standards, primarily through the use of Catalogue Services – Web (CS-W). This catalogue interface will be the primary discovery mechanism for NGDI's metadata and services (Agbaje, *et. al.*, 2008; Figure 5).

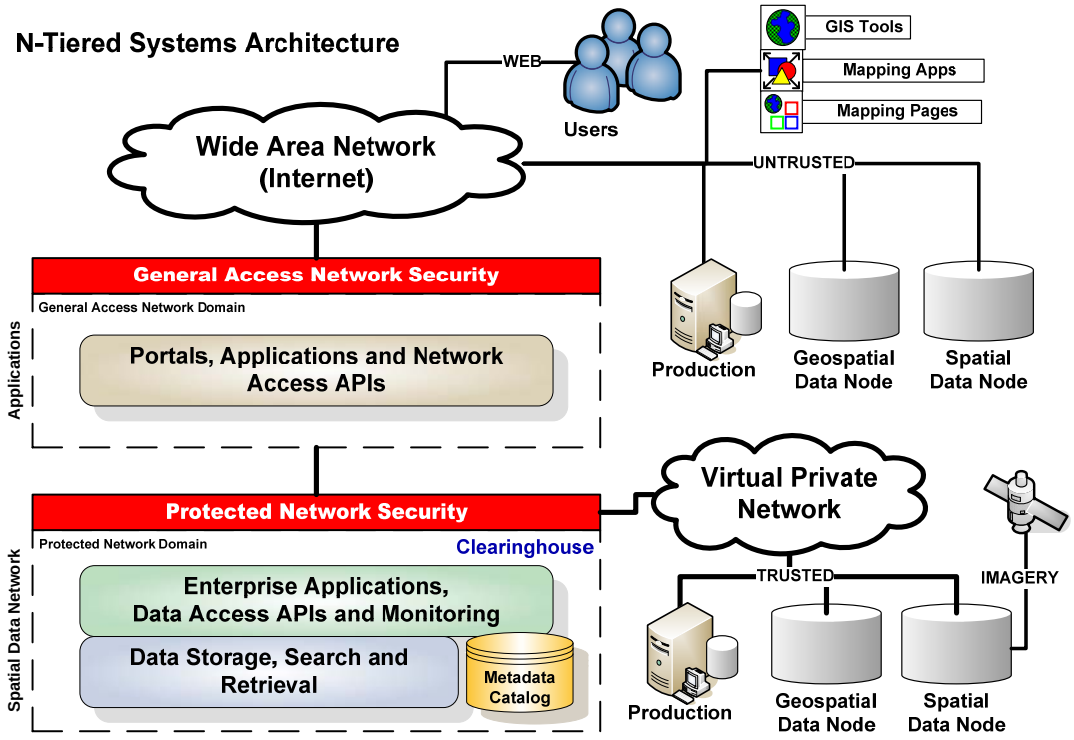

Figure 5. NGDI's Robust N-Tiered Systems Architecture Is Built for Growth
Source: Agbaje *et al.* (2008)

3.4 NGDI Implementation

To date the Nigerian Geoinformation Policy that will guide the implementation of the NGDI was developed in 2003 (copy available at www.nasrda.net). The strategies meant to foster data sharing among geoinformation producers and users are well articulated in the Policy.

Also a 27-member NGDI Committee drawn from the academia, public organizations, and GI related NGOs, IGOs and private sectors are in place. In addition six sub-committees (Geospatial Datasets, Standards, Clearinghouse and Metadata, Legal, Sustainability and Funding, and Capacity Building and Awareness) have been formed with associated Working Groups.

A User Requirement Survey has been carried out, but can be said to be inconclusive. NASRDA intend to finalise this prior to commencing the infrastructural development phases of the 'project' starting this year. The project phases can be summarized as (see Agbaje et. al. 2008):

i. Phase 0: Programme Definition Phase
ii. Phase 1: Creation of the NGDI Clearinghouse, to be hosted within NASRDA's Digital Databank and Library Building;
iii. Phase 2: Deployment of NGDI nodes to stakeholder organizations in the Federal Capital Territory; training and production of geospatial datasets and metadata;
iv. Phase 3: Continue the expansion of the NGDI communications network, deployment of remote nodes, training and the increasing utilization of NGDI holdings

NASRDA is currently partnering HARRIS Corporation, USA to implement the Phase 0 of the NGDI 'project'.

4.0 CONCLUSION

Poor quality data collection, organization and management practices including lack of adequate infrastructure and skilled human capacity will make the realization of the MDGs by most African countries unachievable. In this modern era, establishing a Geospatial/Spatial Data Infrastructure (GDI/SDI) is germane to achieving sustainable development.

The Nigerian Space Programme which has resulted in the launch of the NigeriaSat-1 in September 2003 and Nigcomsat-1 in May 2007 with NigeriaSat-2 and Nigeriasat-X expected for launch in 2009, will serves as catalyst to the development of the country's national geospatial data infrastructure (NGDI).

The NGDI as a system will provide the hardware, software, and processes necessary to house, manage, produce, share, distribute, and utilize Geospatial Products and Services. Since it is unrealistic to implement the entire scope of NGDI at once, the implementation is being achieved in phases (Phases 0 -3). The NGDI Clearinghouse will have service interfaces for accessing metadata and retrieval of the core data.

The NGDI being established in Nigeria when fully operational will serve as the bedrock for the effective implementation and attainment of the of the 7-point socio-economic development agenda of the current government and hence the MDGs, because of the

capabilities and benefits provided by a common standardized geospatial clearing house accessible by key government agencies and state governments within the country.

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