

NIGERIA'S SATELLITE DATA UTILISATION FOR SUSTAINABLE DEVELOPMENT

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ABSTRACT:

The fuel driving the engine of growth and sustainable development of any nation is the nation's access to reliable and adequate geospatial information (GI). Over 80% of socio-economic and environmental management decisions are based on quality and accurate information on natural resources and other geospatial data. On the other hand, the roots of under-development of the third world countries, such as Nigeria, 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. The consequences of these are: food insecurity, air and water pollution, environmental degradation, etc. This paper therefore, examines in detail the above features in terms of the challenges of data utilisation in Nigeria if the nation must attain rapid sustainable socio-economic development. The significant role of space technology for comprehensive, reliable and real-time geospatial data acquisition and utilisation are discussed. The paper also presents highlights of the NigeriaSat-1 data utilisation and efforts made so far in the establishment of a well structured National Geospatial Data Infrastructure (NGDI). The NGDI is expected to facilitate efficient production, management, dissemination and use of geospatial information for sustainable national development.

1. INTRODUCTION

1.1 Sustainable Development and its Challenges

The term "sustainable development" has been popularised by the World Commission on Environment and Development (WCED), in its 1987 report entitled, "Our Common future". 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". Sustainable development stands on three pillars in terms of its definition for the 2002 World Summit on Sustainable Development (WSSD): Social development, economic development and environmental protection. In 1972, the first World United Nations' (UN) Conference on Human Environment took place in Stockholm, Sweden, consequent upon the recognition of environmental problems as a global issue. Subsequent UN conferences and reports looked at issues of environment and socio-economic development and how to sustain them for the benefits of the present and future generations. It is against the foregoing principles that the 2002 WSSD focused on top ten strategies for the successful achievement of sustainable development. These are:

- Making globalization work for sustainable development
- Poverty eradication and sustainable livelihoods
- Changing unsustainable patterns of consumption and production.
- Promoting health through sustainable development
- Access to energy and energy efficiency
- Sustainable management of ecosystems and biodiversity
- Managing the World's freshwater resources
- Finance and technology transfer

- Sustainable development initiatives for Africa
- Strengthening the system of international governance for sustainable development.

The achievement of the foregoing, with targets set by the UN through the Johannesburg political declaration to haul the World's 2 billion poorest out of misery and restore/nurture the damaged environmental web that sustains all of its life, creates scenarios among Nigerian geo-information community for mass acquisition of reliable data about the nation's natural resources and environment.

The pre-occupation of visionary leaders of any nation and its people should be how to preserve these live support systems to the benefit of present and future generations. Accordingly, many societies around the globe, including Nigeria, are embarking on initiatives and developing agenda that could address/redress the problems of poverty, food security, protection from man-induced disasters and affordable health and housing.

There is the urgent need to develop and apply the most practical tools possible to tackle the challenge of boosting sustainable food production, and of assessing, quantitatively, the extent and rates of desertification and deforestation and their impact on food and livestock production. According to Mostert *et al* (2003), an initiative of this magnitude can only be fulfilled with African governments taking active roles to support and utilize the benefits of the relevant programmes. To achieve this, adequate attention must be paid to the provision of relevant Geo-Information (GI) to facilitate national development and regional integration.

Towards achieving the objectives stated above, Nigeria has recently been making conscious efforts to mainstream GI in its

national development strategies through development of space programmes and the national geospatial data infrastructure (NGDI) in order to ensure that geospatial information (GI) are readily available for sustainable development activities

2. SPACE APPLICATION SUPPORT FOR SUSTAINABLE NATIONAL DEVELOPMENT

A prerequisite for the effective management of any development is essentially our ability to monitor the environmental status and its variations in both time and space. Earth observation, communication and navigation satellites play a vital role in the collection and dissemination of information, in a very timely manner providing crucial inputs required for carrying out operationally viable strategies. The following subsequent Sections highlight Nigeria's programmes and projects towards realising a sustainable development for the country.

2.1. Nigerian National Space Policy and Programmes

Within the framework of the foregoing objectives and to meet the sustainable development challenges and Nigeria's aspiration to utilize space assets for the improvement of the quality of life of its people, the Government of Nigeria approved a National Space Policy and Programmes and the establishment of a National Space Research and Development Agency (NASRDA). NASRDA was mandated to conduct appropriate research and development activities and also consolidate all space science and technology-related activities to make a greater impact on developmental efforts in Nigeria, particularly in sectors of the economy such as transports, agriculture, communication, education, cadastre and urban development, rural health care delivery, solid mineral development, water resources, defence and security, and protection of the environment.

2.2 Nigeria's Satellites Projects

2.2.1 NigeriaSat-1: The first Nigerian satellite, a micro-satellite called NigeriaSat-1, was successfully launched into low earth orbit on 27th September 2003. To date, NigeriaSat-1 has captured high quality images, using the six cameras on board the satellite, and demonstrated good commercial value. The launch has generated wide spread national attention and stimulated countrywide space and GI awareness, especially among stakeholders and users of satellite data for GI acquisition for socio-economic activities in Nigeria. Similarly, decision makers have shown a great interest and have been highly optimistic about its application potentials. The fact that data from NigeriaSat-1 is timely accessible and entirely owned by Nigeria has stimulated research and development by many relevant institutions of government and the private sectors in Nigeria. Further benefits of the availability of real-time data from NigeriaSat-1 include:

- Opportunity for sharing knowledge and solving the problems of digital divide in Africa.
- Ground sampling distance (GSD) or spatial resolution of 32m with an economic swath width of 600km; it has a minimum of five years life span.
- Great potential for broad spectrum of data acquisition for the National Geospatial Data Infrastructure (NGDI),

an initiative for GI-based economy that will improve the quality of life of Nigerians and alleviate poverty.

- With the linkage of the other satellites in the DMC, through Internet facility to permit sharing of data, NigeriaSat-1 offers a great potential for disaster management and monitoring such as oil spillage and environmental degradation in the Nigerian Delta area and any other part of the world.
- Provides opportunity for an array of applications in many areas of socio-economic development and environmental management such as: oil pollution monitoring, land use/cover dynamics, environmental degradation in the Niger delta area, drought/desertification studies, influence of urbanization/urban sprawl on socio-economic activities, water resources development, coastal/beach erosion studies, etc.

2.2.2. Nigerian Communication Satellite [NigcomSat1]

Ineffective communication systems are usually one of the greatest drawbacks to the socio-economic development of developing countries. The implementation of a functional Information Communication Technology (ICT), as a driving force behind most development activities, particularly in the capture, processing, storage, management and communication or sharing of geospatial dataset, has been considered as part of the comprehensive benefits of a communication satellite. Consequently and as a follow-up to the successful launch of NigeriaSat-1, the government of Nigeria has started the implementation of a Nigerian Communication Satellite called NigcomSat-1. The project is intended to provide the bandwidth requirement to address the telephony, broadcasting and broadband needs of the country. NigComSat-1 includes 40 hybrid transponders with 15 years life spans and coverage of the African continent, Middle East and part of Europe and expected to be launched in 2006/2007.

The implications of NigcomSat-1 to socio-economic development in Nigeria include the following:

- (i) enhance increase in telecommunication growth rate to an annual minimum of 13.5% such that 10% of the rural communities is served in the short term, 30% in medium terms and 60% in the long term.
- (ii) achieve a tele-density of over 10% by 2010 according to ITU standard and a tele-distance of less than 5km per telephone.
- (ii) enhance the capabilities of Nigerian engineers and scientist in the design, manufacture, operation and maintenance of communication satellite through strategic partnership with technical partners.
- (iii) provide a platform for operation of a public services telecommunication networks in Africa providing linkages to educational institutions, regional organizations, and government in Africa, to facilitate developmental activities.
- (iv) provide enabling environment for African ICT business industry to have a fair share of the World telecommunication market currently projected to hit \$110 billion dollars by the year 2010.
- (v) provide a platform for community and regional integration through social and cultural dissemination, promoting peace and stability in the Africa region.

2.2.3 African Resource Management Satellite Project –

[NigeriaSat-2]: It is a joint satellite programme of South Africa, Nigeria and Algeria and Kenya would form the cornerstone of the African Resource Management (ARM) Satellite Constellation, laying the foundation of sustainable technology development in Africa. The ARM initiative was proposed by South Africa and supported by Nigeria as documented in a joint space technology project proposal between South Africa and Nigeria (Mostert *et al*, 2003). The project is one of the key flagship projects in the NEPAD Science and Technology Ministerial Programme areas. The countries involved would collaborate in building capacity to support space programmes in Africa. Such a programme would benefit Nigeria in advancing the realization of the objectives of its space policy. The space segment of the system will consist of identical satellites to be built together by participating African engineers. Each satellite will have a high-resolution payload with a 2.5 meters resolution in panchromatic mode and a 5m resolution in multi-spectral mode in 6 spectral bands. The satellites will be phased to operate in constellation and will be accessed through the integration of the individual ground stations.

2.3 Monitoring of the Nigerian Environment

The implications of the Earth's Observing System (EOS) to sustainable development, according to Obasi (2002), include the delivery of increasingly accurate and reliable data and warnings of severe events related to weather, water, climate and natural environment and ensuring that the warnings reach their target audience in a timely and useful manner, as well as the enhancement of the relationship between meteorological factors and the quality of agricultural production, water resources management, aviation and marine navigation services and environmental protection.

To actualize the implementation of the EOS-related programmes in Nigeria through the provision of awareness on the usefulness of the weather observations and environmental data services, the Nigerian Government established a National Meteorological Services Agency (NIMET) to provide the appropriate meteorological services for Nigeria. Furthermore, NIMET is to facilitate efficient linkage and cooperation with the Integrated Global Observing Strategy Partnership (IGOSP) to enable Nigeria derive maximum benefits from its various programmes such as the Global Ocean Observing Systems (GOOS), Global Climate Observing System (GCOS), etc.

Taking advantage of sharp images of the changing weather from the recently launched meteorological second generation (MSG-1) satellite, for example, all countries in Africa, including Nigeria, have agreed under a unique partnership to transform the data to useful information in support of sustainable development. Accordingly, a task force on preparation for the Use of Meteorological Generation in Africa (PUMA) and African Monitoring of the Environment for Sustainable Development (AMESD) projects has been set up to provide better network of data and services for early warning of disasters, improved food security, better health management, more efficient water and energy use and safer transport.

3. NIGERIASAT-1 DATA UTILISATION

The launch of NigeriaSat-1 generated widespread national attention and stimulated a country-wide space awareness, especially among stakeholders and users of satellite data for geoinformation acquisition for socio-economic activities and sustainable national development. Presently a number of research projects have been carried out using images from NigeriaSat-1.

3.1 Highlights of Major on-going projects based largely on NigeriaSat-1 Data

i. Urban And Rural Landuse/Landcover Mapping of Nigeria

Study Area: The Study Area covers mostly 4 LGAs – Ijero, Ekiti West, Efon and Ekiti South-West of Ekiti State.

Objective: The major objective of the pilot study is to evaluate the potentials of NigeriaSat-1 in the generation of urban and rural landuse (LU) and landcover (LC) data.

Result: The result of the study shows that LU/LC maps at the primary class level are derivable visually from the image even up to a scale of 1:100,000. This can be improved to 1:50,000 scale if adequate image pre-processing is performed on the image to fully exploit its inherent spatial resolution. Unsupervised classification at the primary level proves promising in digital LU/LC mapping.

ii. Gully Erosion Mapping/Monitoring in Parts of South Eastern Nigeria

Gully Erosion is the most prominent feature in the landscape of the South Eastern Nigeria and it has constituted a major problem in agricultural land development and other socio-economic development in the area. The States mostly affected are Anambra, Abia, Enugu, and Ebonyi and Imo.

Study Area: The Study Area is located within the severely gullied parts of Anambra State. lying between Latitudes 6°00'N and 6°11' N and Longitudes 6°56'E and 7°07'E, which covers parts of Anaocha, Aguata, Orumba North, Nnewi North Nnewi South, Idemili North and Idemili South Local Government Areas. The total area is about 400 Km² (625 * 625 pixels of NigeriaSat-1 image). The Area is heavily populated with many residential houses located in the proximity of gully sites.

Objective: To identify and measure the geometric characteristics of the gullies in the study area, as well as assessing the impact of these spreading gullies on the immediate environment and other factors of gully erosion formulation.

Result: The result of the pilot study showed that with NigeriaSat-1 data, major gullies can be correctly identified and delineated at scale of 1:100,000. The scope of study is being extended to cover more study areas and to develop a RS and GIS model for monitoring gully development and gully erosion disasters early warning system.

iii. Mapping Flood Hazards/Risk Along Kaduna River And Shiroro Dam In Kaduna/Niger States

The study was informed by the annual flooding of settlements and farmlands around Kaduna River and Shiroro Dam due to a variety

of factors, which include impeded drainage, land use, rainfall and topography.

Objective: The project goals for the flood hazards/risk assessment along Kaduna River and Shiroro dams comprise the following:

- i. Map risk areas
- ii. Identification of vulnerable structures and/or areas
- iii. Predict floodability
- iv. Model flood occurrence
- v. Quantify areas flooded

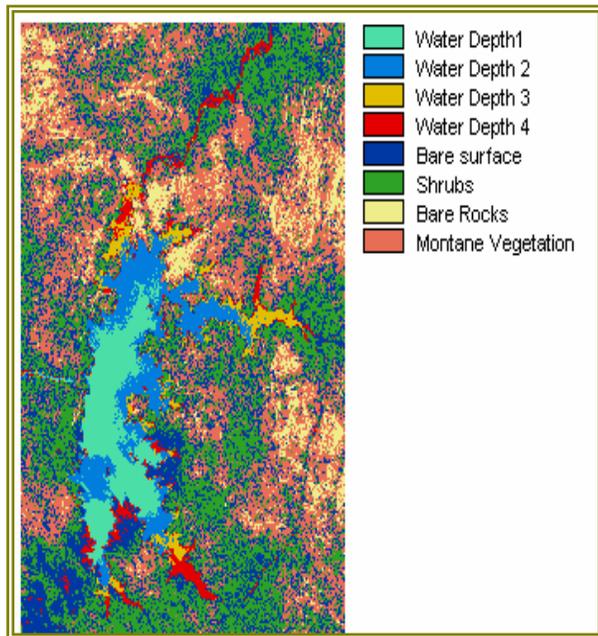


Figure 1: Land Use and various water depths, Shiroro Dam, using NigeriaSat-1 satellite imagery

Source: Halilu, 2003

Result: The reservoir water depth was classified using supervised classification scheme (Figure 1); the spectral band which best described water level variations was identified and hydrological data were analyzed to identify patterns in the reservoir water levels. This study is presently being extended with the following objectives:

- To use simulation models to generate flood-condition scenarios
- Demonstrate utility of models as early-warning and risk management decision-support tools

iv. Deforestation in Nigeria and its Implication on Biodiversity

Forest degradation in Nigeria is occurring at an alarming rate and becoming a threat to socio-economic development. Previous studies have shown that our tropical forest belt now covers about 2% of Nigeria, and its reducing at the rate of 3.5% per annum.

Objective: To determine/monitor deforestation in Nigeria and its implications on the biodiversity.

Study Area: To covers selected forest reserves across major ecological zones; the present pilot study covers Shasha forest reserve, South Western Nigeria.

Result: The pilot study, which is now being extended to cover more areas of the country, shows that:

- Forest zone in Nigeria is experiencing rapid encroachment of the savanna belt; declining at a rate Of 0.99% pa between 1963 and 2003.
- Regressive succession is already taking place on the forest fringes in Nigeria.
- A downward shift in Savanna belt has been noticed.
- Suggested global rate of deforestation is 1-2%, World Bank estimate for 3rd World is 1-1.5% and FAO rate for Nigeria is 0.76%. The rates obtained in this pilot study are higher than the national estimate given by FAO.

Other On-Going Projects Using Nigeriasat-1 Data

- i. Settlements Mapping Project
- ii. Using Nigeriasat-1 Data and other Satellite Data for Early Warning for Food Securities In Nigeria.
- iii. Development of Remote Sensing and Geographic Information System Predictive Model for Desertification Early Warning.
- iv. Spatio-Temporal Assessment of Climate and Human-Induced Impact on Ecosystem Degradation and Water Resources Management using Remote Sensing Technique: A Pilot Study of Kainji Lake Area of Nigeria.

3.2 Use of NigeriaSat-1 Data as part of the Disaster Monitoring Constellation (DMC) Satellites

As part of the agreements to work in constellation and provide effective services to users globally, the DMC established a commercial sale out-let for the DMC data namely, the Disaster Monitoring Constellation International Imaging (DMCII) which is located in the U.K. in October, 2004. The DMC has been responding to the requests for images positively from clients around the world. The DMC has secured substantial sales of its products within 3 months of data distribution. Customers included companies from many countries requiring the DMC data for various applications such as Agric Monitoring, Country Mosaic, Forest Monitoring, and Wetland Monitoring.

The DMC responded immediately to the disaster in the Asian Tsunami disaster by acquiring satellite images of the affected countries/areas to RESPOND, a European Space Agency (ESA) project ((Global Monitoring for the Environment and Security (GMES)), which is charged to produce and deliver maps to aid agencies managing the disaster. Images from the DMC satellites, including NigeriaSat-1, were also available to other managers of disaster such as UNOSAT of Geneva, Map Action of UK, SERTIT of France, and KeyOBs of Belgium

4. DEVELOPMENT OF NGDI

In order to streamline interaction between space technology and the objectives set by the Federal Government of Nigeria for the improvement of the quality of life of its people, the Space Application Support for Sustainable Development (SASSD) programme was devised in addition to the earlier stated initiatives. Realisation of these objectives depends on availability and speedy access to real-time data and availability of relevant infrastructures for data acquisition, processing, standardisation and data sharing.

This is only achievable through the development of a National Geospatial Data Infrastructure (NGDI).

The NGDI Project in Nigeria under the National Space Research and Development Agency (NASRDA) has as its main objectives, the discovery, harmonisation and standardisation 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.

Towards a final realisation of the objectives of the NGDI, the implementation of which has commenced a draft Geoinformation Policy had already been submitted for the Federal Executive Council approval. Also a 27-member NGDI Committee that would see to its successful establishment was inaugurated in September 2004. The policy is expected to guide the realization of the NGDI in the country. The full GI Policy document and further information can be found at www.rectas.org, www.nasrda.gov.ng and in Kufoniyi, 2004; NASRDA, 2003a and UNECA, *et al* 2003).

Some of the Policy implementation strategies that will ensure easy data access and dissemination are:

- Establishment of Clearinghouse in the NGDI node agencies and loading of certified metadata of data producers.
- Creation of metadata for existing dataset(s) by the custodian(s) of the dataset(s) and making the metadata available to the NGDI clearinghouse.
- Define the metadata content and structure for the NGDI and produce detailed metadata implementation guidelines, including practical advice on maintenance and use of metadata
- Develop ISO-compliant geospatial data standards for the NGDI.

The GI Policy sets out to achieve an NGDI administrative/organisational framework that is multidisciplinary, inter-agency and inter-sectoral network of institutions coordinated by the lead Agency – NASRDA. This arrangement will remove the institutional barriers that have in the past inhibited GI sharing among the producers and users.

At the inaugural meeting of the NGDI Committee, the following six sub-committees were created in line with the recommendations of the NGDI Stakeholders/Users meeting of February 2003: (i) *Geospatial Datasets* (ii) *Clearinghouse and Metadata* (iii) *Capacity Building and Awareness* (iv) *Legal* (v) *Standards* (vi) *Sustainability and Funding Sub-Committees*.

The multidisciplinary, inter-agency and inter-sectoral network of institutions that forms the administrative/organisational framework shall focus on the production, management, sale, and use of geospatial information. The stakeholders would collectively ensure the successful realisation of the NGDI vision.

5. CONCLUSIONS

The launch of NigeriaSat-1 remains a watershed and a major breakthrough in the history of space application and space technology development in Nigeria and West Africa sub-region,

particularly in the enhancement, of sustainable development efforts in Nigeria. Since this historic achievement, the Nigerian stakeholders and users of satellite data have shown greater interest in Nigeria's space agenda, taking into account the reality of direct access to affordable, real-time and reliable space-derived data for use in geoinformation acquisition and socio-economic development.

To further exploit the opportunity of the availability of NigeriaSat-1 data, NASRDA has commissioned a number of major research projects, based on the use of data from NigeriaSat-1, which are strategic to national development and have direct impact on the life of every Nigerian. Many other research works have been facilitated or enhanced through the supply of NigeriaSat-1 images on requests and through the provision of consultancy services, awareness workshops and capacity building.

Access to the right data at the right time can lead to good decision-making which may translate to good governance. NigeriaSat-1 data, with 32m resolution, synoptic swath width of 600km and daily revisit and multi-spectral characteristics are available in both various digital formats which are being used to address numerous socio-economic problems and sustainable development issues in Nigeria.

The new NigeriaSat-1 earth observation satellite has generated much interest at all levels and in all sectors in the country adding impetus to the decision of government to launch a communication satellite in 2006. The national GI policy as an essential backbone for efficient realisation of the NGDI has been submitted to government for approval; the policy is expected to facilitate respect and trust among all stakeholders, apart from its other benefits. With the medium resolution satellite already in place, when NGDI with the sustaining policy are properly implemented in the country, the essential GI will consequently become part of the national infrastructure that will facilitate a rapid improvement of the national economy including an efficient management of the nation's natural resources and environment.

REFERENCES

- Abiodun, A.A., 2002. Space Technology and its Role in Sustainable Development. Presented at the Annual Meeting of the British Association for the Advancement of Science, University of Leicester, Leicester, U.K.
- Akinyede, J. O., 2003. Nigeria and its Space Mission. *GIM International*, 17(2), pp. 13 – 15.
- Akinyede, J. O., 2004. Geoinformation Acquisition for National Development: The Role of NigeriaSat-1. *NASRDA News*, A quarterly Magazine of National Space Research and Development Agency, 1(1), pp. 6 – 7 and 21.
- Halilu, A. S., 2003. The Use of Nigeriasat-1 Data in the Mapping of Flood Hazards/Risk along Kaduna River and Shiroro Dam in Kaduna/Niger States. A paper presented at the NigeriaSat-1 validation workshop, Abuja, Nigeria 2003.
- Kufoniyi, O., 2004. Geospatial Information Policy Development, an essential backbone for SDI implementation in Africa. In:

Proceedings of the 7th International Conference on Global Spatial Data Infrastructure, Bangalore, India, 14p.

Mostert, S, Akinyede, J. O. and Adeniran, S.A., 2003. African Resource and Environment Monitoring System (ARMConstellation). Joint Space Technology Project Proposal between South Africa and Nigeria, 18 pages.

NASRDA, 2003a. Draft Geoinformation Policy for Nigeria. National Space Research and Development Agency (NASRDA), Federal Ministry of Science and Technology.

NASRDA, 2003b. Action Plan for the Optimal Utilization of NigeriaSat-1 and future developments for the Nigerian's Space Programme. Report prepared and submitted to the Federal Government of Nigeria as highlights of NASRDA's immediate and future plans, 37 pages.

Obasi, O.P., 2002. Overview on Global Observing Systems in support of Sustainable Development. Keynote address presented on the World Summit on Sustainable Development (WSSD), Forum on Science and Technology innovation for sustainable development, Johannesburg, South Africa.