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# PUB and water resources management practises in Nigeria

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**Abstract** The drastic decline in the hydrometeorological network in developing countries since 1980 has marked another major phase in the application of computing and information systems to hydrological science. The computing era has brought about the development of a more reliable hydrological information system, complex mathematical and statistical modelling and simulation in hydrology and the PUB approach. This paper examines the prospects of the NigeriaSat-1 data for hydrological model parameterization towards sustainable water resources management in Nigeria

**Key words** NigeriaSat-1; predictions of ungauged basin; water resources management

## INTRODUCTION

The economic development of most countries, particularly in Africa, depends on the characteristics and proper management of available water resources. Thus strategic water resources development and management in the 21st century and beyond depend on improved knowledge of global, regional and local water resources availability, consumption and withdrawal through a thorough water resources assessment scheme.

Unfortunately, water resources assessment has been greatly affected by pressure of economic stringency through insufficient budget allocation and varied neglect of water resources assessment infrastructure. Also the ground-based observation network which is the main source of hydrometeorological data for hydrological information has been noted by Rodda (1998), to be steadily declining worldwide since the 1980s. Oyebande (2004) also established the fact that the World Bank-supported Sub Saharan Africa (SSA) Hydrological assessment has confirmed that there has been a serious decline in the networks of hydrological observing stations and in the quality of data being collected within the SSA countries.

This paper therefore discusses the prospects to be derived from the usage of NigeriaSat-1 data towards the enhancement of the quantity, quality and reliability of water resources data for hydrological model parameterization in a data-scarce country like Nigeria. This is necessary if the available water resources are to be sustainably managed in Nigeria

## WATER RESOURCES MANAGEMENT IN NIGERIA

Nigeria has a total land surface of 923 768 km$^2$ (an estimated 1200 km from east to west and about 1050 km from north to south) and is endowed with abundant water

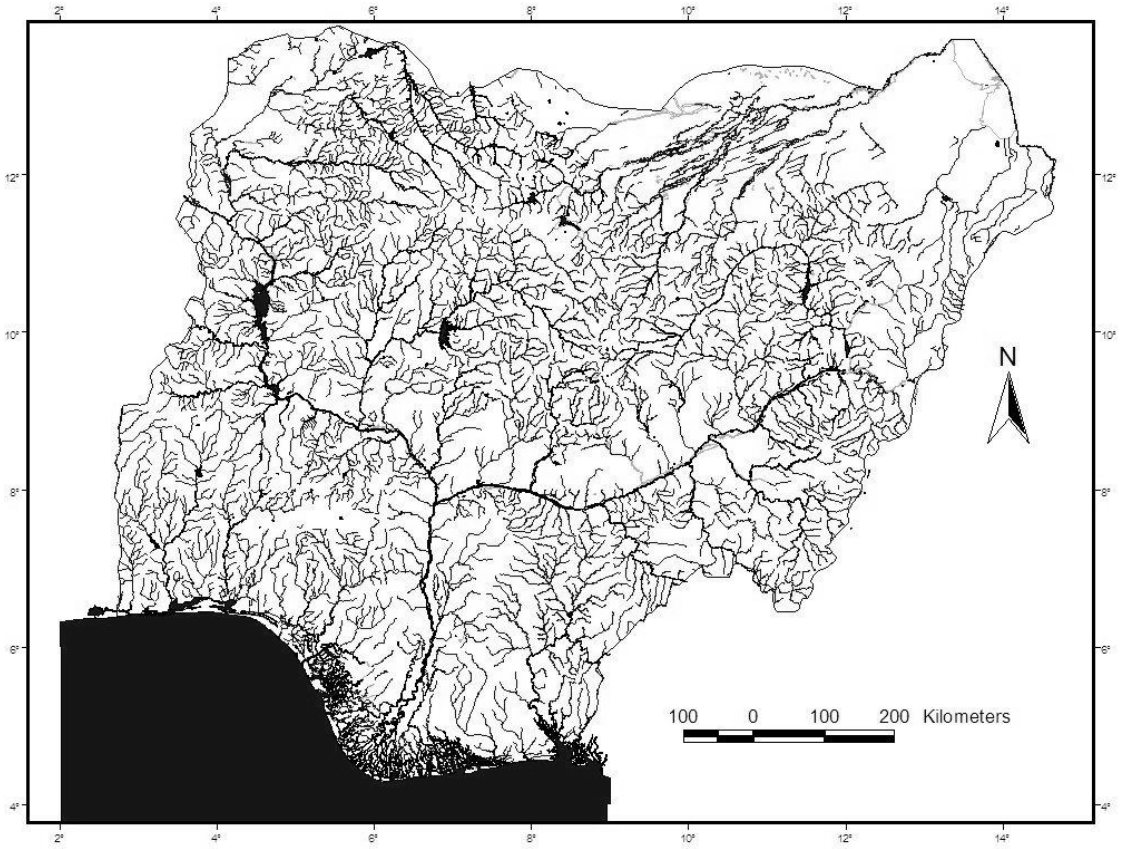


**Fig. 1** Major river network in Nigeria.

resources (Fig. 1), since the extent and distribution of the nation's surface water resources reveals a close network of rivers and streams. This portrays the nation's natural drainage facilities, while several of her underground aquifers are still awaiting exploitation.

However, it should be noted that the abundant water resources are unevenly distributed over space and time. The highest annual rainfall of about 3000 mm occurs in the Niger Delta and mangrove swamp areas of the southeast, where rain falls for more than eight months a year. There is a progressive reduction in rainfall northwards, with the most arid northeastern Sahelian region receiving as little as 500 mm annually from about 3–4 months of rainfall. Also, widespread flooding occurs in the southern parts of the country, while the northern parts experience chronic water shortages during the dry season when rainfed springs, streams and boreholes dry up.

The four major drainage systems (Fig. 2) in the country are:

(1) The Niger River Basin Drainage System with its major tributaries of Benue, Sokoto-Rima, Kaduna, Gongola, Katsina-Ala, Donga, Tarabe, Hawal and Anambara rivers.
(2) The Lake Chad Inland Drainage System comprising the Kano, Hadejia, Jama'are Misau, Komadougou-Yobe, Yedoseram and Ebeji rivers.
(3) The Atlantic Drainage System (east of the Niger) comprising the Cross, Imo, Qua Iboe and Kwa rivers.

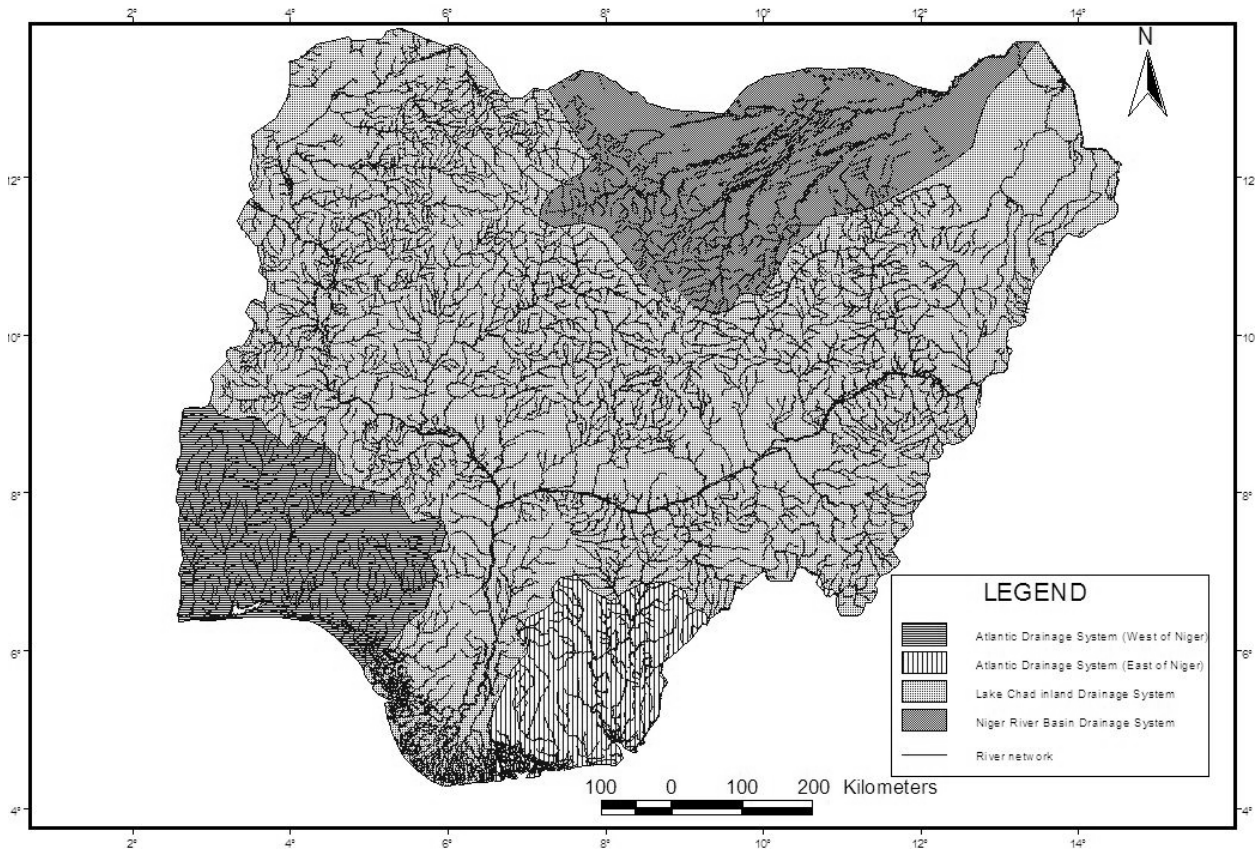


**Fig. 2** Drainage systems in Nigeria.

(4) The Atlantic Drainage System (west of the Niger) made up of the Ogun, Oshun, Owena and Benin rivers.

All the drainage systems terminate in the Atlantic Ocean with an extensive network of delta channels except the Lake Chad Inland Drainage System.

The groundwater resources are limited by the geological structure of the country with more than half of it being underlain by the Pre-Cambrian Basement Complex, composed mainly of metamorphic and igneous rocks. However, there are fairly extensive areas of fractured schists, quartzites and metamorphosed derivatives of ancient sediments from which water is often available at great depth. The sedimentary formations such as the Tertiary deposits of the Chad-Sokoto basins, the Cretaceous deposits of the Niger and Benue troughs, and the sedimentary formation of the Niger Delta, yield groundwater in varying quantities.

The turning point for water resources development and management in Nigeria occurred after the severe drought of the 1960s. The Government's response to the catastrophe was the initiation of strategies for coordinated and effective water resources development, culminating in the mid-1970s in the creation of the Federal Ministry of Water Resources and the River Basin Development Authorities. The activities of these institutions were further strengthened in 1981 by the establishment of the National Committee on Water Resources, and by the Water Boards at the state level. These bodies were charged with taking an inventory, and ensuring rational and systematic planned management and conservation, of the country's water resources.

In the 1970s and early 1980s, water resources management in Nigeria was faced with a lot of problems which slowed down the development of the resource. Some of these problems included:

- The deficiency of the resource itself.
- Unnecessary duplication and overlap in organizations, structures and functions of the relevant bodies.
- The ill-defined and uncoordinated roles of the Federal, State and Local Government agencies responsible for water resources development.
- Failure to recognize the inter-relationship between surface and groundwaters, and between water resources and land use.
- Lack of effective water and environmental protection laws, and the means to enforce the already existing laws.

In order to address these problems, during the late 1980s a national body was created to co-ordinate all environmental protection activities in the country and a comprehensive national environmental policy was formulated which, among other things, addressed the issue of water resources through promulgation of various Decrees by the government in 1988 and 1993 (FGN, 1988a,b, 1993).

## REMOTE SENSING FOR WATER RESOURCES ASSESSMENT, MANAGEMENT AND DEVELOPMENT IN NIGERIA

The term remote sensing was first coined in 1960. According to Lillesand & Kiefer (1994) remote sensing is the science and art of obtaining information about an object, area or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area or phenomenon under investigation.

The gathering of the scientific information about the Earth's surface is usually carried out from great heights and over broad areas, using the electromagnetic radiation (EMR) sensors mounted on aircraft or orbiting space vehicles. The remote sensing data can be collected, analysed and displayed as both continuous and discrete images.

The application of remote sensing in hydrology according to Viessman *et al*. (1989) became a common hydrological tool in the developed nations of the world since the 1960s. The principal value of remote sensing in hydrology, as in the other fields, includes its ability to provide regional coverage, spatio-temporal and multi-spectral as well as multipurpose image data of the Earth's surface. The remote sensing data is also cost effective in the area of real-time data and change detection as well as monitoring and management of Earth resources. The compatibility of the data with other geo-based data is an added advantage of remote sensing technique.

Prior to the launch of NigeriaSat-1, the Federal Ministry of Water Resources and other Water Resources Development Agencies in Nigeria have made use of remote sensing technologies for water resources assessment, management and development.

Recorded cases of remote sensing usage towards water resources planning and management in Nigeria include:

- Preparation of the National Water Resources Master Plan by the Ministry in collaboration with Japanese International Cooperation Agency (JICA);

- Production of the Hydrologic & Hydrogeologic Maps of Nigeria;
- Telemetric-Hydrometric data collection of the HydroNiger Project along rivers Niger and Benue;
- Application of Isotope Techniques in Water Resources Management in Wurno Irrigation Project area, Sokoto state;
- Oju and Obi (Benue State) Water Supply & Sanitation Project;
- Fracture Trace Analysis for Groundwater Prospecting in the Nigeria Sector of Chad Basin;
- Gurara Dam and Water Transfer to the Federal Capital Territory (FCT); and
- Inventory and Monitoring of Surface Water Bodies-A Case Study of Lake Chad

## NIGERIASAT-1 AND WATER RESOURCES MANAGEMENT IN NIGERIA

NigerSat-1 project is an opportunity for Nigeria to jump-start a beneficial space program, which provides the understanding needed for land, air and water resources and problems associated with them. It also deals with meteorological factors, the study of atmospheric and weather sciences. The use of the NigerSat-1 satellite data will therefore facilitate the effective management of Earth resources and the environment at large.

The NigerSat-1 is a microsatellite weighing 90 kg. It has a hi-tech earth imaging camera which provides 32 m resolution imaging in three spectra bands (NIR, red, green) with an extremely wide imaging swath of 600 km on the ground that enables a revisit of the same area anywhere in the world at least every 4 days, with just a single satellite.

The advantages of the NigeriaSat-1 project according to Oyebande (2004) are as follows:

- it is affordable by small or low-income countries;
- it has scientific and technical advantages.

Though small, it can perform large tasks. Nigeria's first Earth observation micro satellite (the 80–100 kg low orbiting micro satellite was developed and launched with the backing of survey satellite Technology Ltd (SSTL). It has a resolution of 32 m and a swath of 600 m. The work done so far included a feasibility study for Nigeria's Sat 2, a geostationary communication satellite based on the 400 kg class SSTL) at a cost of N13 million to achieve certain objectives such as:

- enhancing national security against natural hazards such as floods, droughts, pollution, etc through monitoring and information gathering;
- topographical mapping 1:1000 to 1:100 000 monitoring of water bodies and irrigated areas;
- terrain classification, land use land cover change assessment;
- monitoring of forestry logging, etc.;
- soil and surface geology survey.

NigeriaSat-1 will also serve as part of Multinational Disaster Monitoring Constellation that will include satellites owned by Algeria, China, Turkey and the UK. Vietnam and

Thailand also plan to participate. The constellation of six satellites will cover a distance of 3000 km.

Such data are therefore an important source of data and information for hydrological modelling and other water resources problems. Also the data offers a unique way of measuring, mapping and monitoring hydrological characteristics of a basin towards a better understanding of the basin and global hydrological balance.

The satellite advantages include global coverage in constellation with six other satellites and daily revisit with provision of real-time data. This provides the opportunity to develop appropriate payloads to solve local problems and bridge the digital divide within and across Africa. Also, the satellite has the potential of providing pre, on-time and post avalanches of geo-information for thematic mapping, environmental monitoring, watershed management, siting and designs of water resources systems and hydrological extreme event planning (NASRDA, 2003). Also, the availability of the imagery at an affordable price will impart some impetus to environmental monitoring and survey as well as mapping, including transborder events and processes.

## CONCLUSIONS

The inadequacy of water resources data for planning and design of water related projects in Nigeria is due to the increasing occurrence of ungauged basins at the expense of increasing per capita water demand. There is therefore the need to benefit from the PUB initiative in order to understand the complexity of basin hydrological systems, most especially in developing countries like Nigeria.

NigeriaSat-1 data will provide the basis for active usage of remote sensing techniques to manage the country's hydro-meteorological data stations towards effective water resources project management, as well as to recapture vital hydrological information that is unavailable but is crucially needed for effective management of existing and future water related projects. Also, basic information derivable from the NigeriaSat-1 data can provide the basic indices needed for a PUB approach in the area of water resources management in Nigeria.

In order to achieve this aim, the spectral and radiometry resolution of the imageries needs to be improved in subsequent NigeriaSat-1 imageries. There is also the expectation that the present and planned satellites should be adapted to generate real time or near real time hydrological data sets like those currently available under the World Hydrological Cycle Observing System (WHYCOS), which was initiated in 1993 by the World Meteorological Organization (WMO), in association with the World Bank.

Finally, there are lots of benefits from the spatial information being provided by space technology application like NigerSat-1 satellite imagery. This is necessary, if a workable water resources development and management scheme is to be developed for the country. Such a scheme is important towards resolving water related challenges as it affects water availability for various uses in the country.

## REFERENCES

Federal Government of Nigeria (FGN) (1988a) Federal Environmental Protection Agency Decree no. 58, 30 December 1988. Government Press, Lagos, Nigeria.

Federal Government of Nigeria (FGN) (1988b) Harmful Wastes Decree no. 42, 30 November 1988. Government Press, Lagos, Nigeria.

Federal Government of Nigeria (FGN) (1993) Water Resources Decree no. 101, August 1993. Federal Government of Nigeria. Government Press, Lagos, Nigeria.

International association of hydrological science (IAHS) (2000) Strawman for Recommendation for Decade of Prediction of Ungaged Basins (PUBs), http://www.cig.ensmp.fr/-iahs.

Lillesand, T. M. & Kiefer, R. W. (1994) *Remote Sensing and Image Interpretation*, 3rd edn. John Wiley & Sons, New York, USA.

National Space Research and Development Agency (NASRDA) (2003) Technical report on NigeriaSat-1, a medium resolution Satellite for Earth Observation.

Oyebande, L. (2004) Advances in Hydrometry and Nigeria's microsatellites. In: *International Workshop on Nigerian SAT 1 as a New Tool for Economic Empowerment Nigerian Union of Planetary and Radio Sciences (NUPRS)* (16–19 August, Lagos, Nigeria).

Rodda, C. J. (1998) Hydrological networks need improving! Water: a looming crisis? (ed. by H. Zebidi) *International Hydrological Programme* (IHP) **18**, 91–102.

Viessman, W. Jr, Lewis, G. L. & Knapp, J. W. (1989) *Introduction to Hydrology*, 3rd edn. Harper & Row, New York, USA.