THE IMPACT OF HYDROLOGICAL INFORMATION SERVICES ON INTEGRATED WATER RESOURCES MANAGEMENT AND DEVELOPMENT: NIGER RIVER BASIN CASE STUDY

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Abstract: River Niger is the third longest river in Africa and 9th in the World with total length of about 4,200 km. Its initial catchment area of about 2,100,000 sq Km covering 10 Countries namely Algeria, Benin, Burkina, Cameroon, Chad, Cote D’Ivoire, Guinea, Mali, Niger and Nigeria, has now being reduced to an active catchment area of about 1,500,000, without Algeria, as a result of the effect of climatic and Sahara movement southwards.

In 1963, the 9 Countries now covered by the river basin, formed the River Niger Commission (RNC), with the view of fostering cooperation among members states in use and management of the basin resources. The RNC was changed to the Niger Basin Authority (NBA) in 1980 with additional mandate towards enhancing integrated water resources management and development of the basin, among others.

Since the last 4 decades the river Niger basin has been experiencing series of climatic changes that has resulted in the persistent drought causing the Sahara desert movement southward towards the Atlantic Ocean; erosion and river siltation causing flooding with its attendant loss of lives and properties; continued low flow that reduces reservoir storage capacity with consequences of acute water shortage and increasing water demand; pollution, weed encroachment and increasing water borne diseases that are now ravaging the river system; increasing mortality rate, famine and high rate of urban migration and poverty.

The lack of adequate hydrological information for planning, management and integrated development of the basin resources by the NBA member Countries was identified among the major constraints in mitigating the impact of climatic, hydrological and environmental disasters that are adversely affecting the socio-economic development in the region.

In 1984, the UNDP, OPEC, EEC and the NBA member countries funded the establishment of 65 hydroclimatological data collection platforms (DCPs) along the river Niger and its major tributaries through the Hydroniger project. The DCPs transmit real time hydro-climatological data through Satellite with reception by the Argos Direct Satellite Receiving (ADSR) station installed at the Hydroniger IFC in Niamey and at the National Forecasting Centres of some NBA member states.

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Information received from the DCPs are processed, analysed and stored in the NBA data bank for the use of its member countries in their water resources planning and development and for the use of the stakeholders of the river Niger, Universities, Research Institution etc. Hydrological forecast is also carried out and together with the data, published in the NBA Monthly Bulletin and Technical Notes, as additional source of information on River Niger. The information is also published in the Websites of the NBA and that of the Hydrological Circle Observing System for West and Central Africa (AOC-HYCOS) for global circulation.

The AOC-HYCOS pilot project is financed by the French Government and hosted by the consortium of NBA and AGRHYMET in Niamey, to ensure rapid hydrological information dissemination to member Countries and worldwide through the use of Internet facilities. This paper takes a critical look at the use of hydrological information services as a tool in fostering integrated water resources planning and management for socio-economic development of the Niger basin, bearing in mind the various physical, climatic and environmental problems in the basin and the numerous challenges facing the NBA.

**INTRODUCTION**

River Niger is the third longest river in Africa and 9th in the World with a total length of about 4,200 km. Its has an initial catchment area of about 2,100,000 sq Km covering 10 Countries namely Algeria, Benin, Burkina, Cameroon, Chad, Cote D’Ivoire, Guinea, Mali, Niger and Nigeria. This has now being reduced to an active catchment area of about 1,500,000 (without
Algeria) as a result of the effect of climatic changes and persistent drought, see Figure 1.

The population in the basin is estimated as 106.5 millions in the year 2000 with a growth rate of 3%. About 64% of the people are living in the rural areas and the rest in the urban. The socio-economic activities of the people is therefore subsistent farming.

Since the last 4 decades, river Niger basin covering 9 Countries in West and part of Central Africa, has been experiencing the impact of climatic changes, that resulted to persistent drought with its attendant acute shortage of water, causing huge loss of lives, social and economic problems that the concerned Governments have serious difficulty in responding to. Besides the persistent drought and the movement of Sahara desert southwards towards the Atlantic Ocean, the Niger basin also faces the problem of soil erosion and river siltation; flooding of flood plain areas with its attendant loss of lives and properties; continued low flow that reduces reservoir storage capacity leading to acute water shortage and increasing water demand; pollution, weed encroachment within the river system; water borne diseases, high mortality rate, famine, increasing urban migration and poverty. It is believed that adequate hydrological data and information are also a major prerequisite for better understanding, awareness, planning, management and development of integrated water resources up to the grass root in the basin. This was why in 1984, the UNDP, EEC, OPEC and the NBA member Countries, established hydrological forecasting system and 65 Data Collection Platform (DCP) stations within the entire river Niger system across 8 Countries in the basin, under the framework of HYDRONIGER Project for Niger Basin Authority, to monitor the river Niger flow and constantly observe the impact of hydrological changes in the basin.

**THE NIGER BASIN AUTHORITY (NBA)**

In 1963, the 9 Countries within the Niger River basin formed the River Niger Commission (RNC), with the view of fostering cooperation among member states in the use and management of the basin resources. The RNC was changed to the Niger Basin Authority (NBA) in 1980 with additional mandates towards enhancing integrated water resources management and development of the basin as well as collectively tackling the physical and environmental problems facing the river basin. Despite the additional mandates, the NBA could still not meet up with yearn and aspiration of its member States to the extent that some member had to signify their intention to changing their membership to an observer status while others merely attend the meetings with scepticism. Presently, the NBA in conjunction with International Donor Organisations are now making efforts towards achieving the new mandates through the development of a shared vision for the enhancement of a sustainable integrated water resources management of the basin resources.

*Major Problems facing the Niger Basin*

Besides the desertification encroachment, the following are some of the major problems associated with the development of the River Niger basin:

- Continuous reduction of flow within the river Niger system
Water weed encroachment

Reduction in vegetative cover and biodiversity leading to shrinking of the ecosystems and reduction in their productivity

Erosion and silting of water courses

Pollutions such as from industrial chemicals and urban origin and

Rapid population growth.

Major Institutional Problems Faced by the NBA

1. The major institutional problem faced by the NRC and later the NBA could be summarized as follows
2. Insufficient clear defined objectives and suitable regional strategies based on clear shared vision or master plan acceptable among riparian Countries for the development of the basin.
3. lack of legal and institutional mechanism for benefit sharing for the prevention and management of water related conflicts.
4. Inadequate and clear framework defining institutional objectives and policies.
5. Inadequate institutional and operational capacities for planning design and execution of projects.
6. Lack of Community involvement in project participation from grass root project planning and execution.
7. Weak Institutional capacity and vision for planning and coordinating the implemented action.
8. Insufficient cooperation of riparian or member countries
9. Insufficient mechanism for consultation among stakeholders
10. Lack of adequate knowledge of national policy, activities and orientation of water resources project at national level
11. Insufficient cooperation and adequate consultation between stakeholders, inter-government organization and donor agency.

ROLES OF HYDROLOGICAL INFORMATION SERVICES ON INTEGRATED WATER RESOURCES MANAGEMENT

Besides the provision of information used in monitoring of Sahara desert’s movement southward towards the Atlantic Ocean, hydrological information provides immediate knowledge and understanding on the roles and effects of climate change, environment, agriculture and the river system which are among the basic parameters in the planning, management and development of integrated water resources of basin.

Information on Climatic Change
From the isohyetal map of the basin in Fig 2, the mean rainfall of 200 mm to 1000 mm recorded in 1950-67 was observed to have move southwards for about 100 km between 1968-95 as a result of the impact of climatic change. This is also in agreement with the Newsletter of the International Year of Freshwater’s report for 2003, that about 1/3 of the Earth’s land surface is threatened by desertification, and over 250 million people are directly affected by it. 24 billion tons of fertile soil disappear annually. From 1991 to 2000 alone, droughts have been responsible for over 280,000 deaths; they accounted for 11% of all water-related disasters. It also shows that within the Sahelian zone, the persistent drought conditions leads to human pressure on the available land and water that often gives rise to conflicts while human activities such as bush burning could also contribute to desertification.

Figure 2. The Isohyetal Map of Sahelian Part of Niger Basin
Environmental Context

The Niger River provides habitat for wide range of species including a wide variety of fish, hippopotami, crocodiles, and sea cows. Vegetal cover provided barrier against desert encroachment and tree planting is extremely encouraged particularly in arid zones.

However, the high rate of bush burning and poor agricultural land management coupled with the harsh climatic change are the major causes of soil erosion and siltation of the river consequently affecting the ecosystem.

Figure 3. The different Type of Pollutions along the River Niger

Hydrological information provide insight on river pollution from industries, human and animal wastes carried through rainfall runoff which are also rampant and causing diseases and high mortality rate (see Fig. 3).
Agricultural Context

The agricultural potential of the basin is not fully known but is estimated to be 2.5 Million hectares of irrigable lands, about 20% of which are presently exploited. Irrigation along the flood plains is the most traditionally practiced with rice as the major crop. Farmers take the advantage of flood recession and the soil water moisture to plant crops. A UNDP study carried in 1995 estimated the flood plain irrigation potential as 700,000 ha, while the actual irrigation potential could reach about 2.5 million ha. The low agricultural land use was also attributed to inadequate integrated water resources management in the region. Fishing activities have for long constituted a major socio-economic activity for the riparian populations of the River Niger basin, most especially in Mali, Niger and Nigeria. Hydrological information also recently revealed that Fish production has been on a serious decrease because of the reduction of water resources as a result of the persistent drought in the recent years. Although the majority of the population in the basin are farmers however, migration to urban areas is rapidly taking over as a result of unfavourable climate (poor rainfall, desert encroachment) and famine.

Information on the River Niger System

The flow within the river Niger and its tributaries has been reducing since the last 50 years. In 1984/85 hydrological years the river Niger was completely dry along its main course in Niamey for the first time, as shown in Figure 4.
Similarly hydrological information showed that river transportation which is one of the major means of accessibility to remote areas thereby opening up socio-economic development, abruptly stops from February to June each year because of inadequate river flow, with most of the tributaries running dry during the period. Also flood hazard during rainy season is also becoming a major problem for the teeming population leaving close to the river boundaries or flood plains.

**METHODS OF COLLECTION OF HYDROLOGICAL INFORMATION**

The Argos and the Meteosat are the two hydrological information equipments used for gathering a wide variety of parameters such as the river gauge height, rainfall and temperature. These equipments provided image acquisition and dissemination; environmental data collection and distribution; the relay of hydrological information from various centres; the extraction of hydrological products from imagery and their subsequent distribution; the relay of images from foreign satellites; and data archive and retrieval service. The collection and distribution of hydrological data is achieved through the Data Collection System (DCS) by which the satellite
provides a data relay service for data transmitted from sensors located on the surface of the earth and within the atmosphere, see Figure 5

**Figure 5. DCP Satellite Information Collection System**

The system operates through the Data Collection Platform (DCP) which serves as transponder or data relay to provide essential information such as water level, rainfall and temperature accurately and in real time to the receiving stations. This type of DCP station is usually self-contained, i.e. it does not normally require any external ground-based infrastructure such as a power supply, and needs infrequent visits for maintenance purposes.

When using the meteosat system messages from the DCPs are processed in Darmstadt in Germany and distributed via the Global Telecommunication System (GTS) of the World Meteorological Organization (WMO) to all meteorological centres requesting the data.
The Establishment of Hydroniger IFC

The Hydroniger Interstate Forecasting Centre (Hydroniger IFC) of the NBA was established in 1985, after the establishment of 65 DCP stations in 1984, within the framework of HYDRONIGER Project, to effectively monitor the flow of the river Niger and its major tributaries as well as the hydrological changes within the Niger basin with financial assistance from the UNDP, EEC and OPEC while the WMO was the executing agent. The DCP stations transmit real time data through Satellite with reception by the Argos Direct Satellite Receiving (ADSR) that were installed at the Hydroniger IFC in Niamey and at the National Forecasting Centres (NFC) in the NBA member states. The Hydroniger IFC and NFC have their primary objectives to assist the riparian countries in protecting the life and goods of their citizens, to ensure food security and hydropower generation and to minimise the catastrophic effect of drought and flood. It’s immediate objective was to establish a real time hydrological forecasting system covering river Niger and its major tributaries.

The Hydroniger IFC therefore provides real time hydrological data and information through its ADSR. It is the major source of vital data for Rural, Regional and National Water Resources Development, for socio-economic activities, effective utilisation of existing infrastructures and planning new ones. The Hydroniger IFC is presently mostly equipped with an Argos Station Direct Receiver (ASDR) which, through NOAA satellites using ARGOS teletransmiting system, receives numerical signals emit by the Data Collection Platforms (DCP) that were stationed along the river Niger and its major tributaries. These DCP continuously measures the fluctuation of river stage (depth) rainfall and temperature. The frequency of reception by the ASDR from NOAA satellite is usually between 3 to 5 times daily.

The AOC-HYCOS

The consortium of NBA and the Regional Centre for Agricultural, Hydrology and Meteorology (AGRHYMET) are currently hosting the pilot scheme of the WMO Hydrological Circle Observing System for West and Central Africa (AOC-HYCOS) in Niamey, Niger Republic. It is hosted at the Hydroniger IFC because of the importance and performance of the Hydroniger IFC in the region. The first phase of the project dealt with the collection of data from Hydroniger Network stations, the GHENIS, ONCHO stations and manually collected data from the participating Countries. A website http://aocycos.ird.ne has been established to ensure global dissemination and in real time, of hydrological information.

Distribution of DCP Stations within the Niger Basin

The 65 DCP stations so far been established along the river Niger and its major tributaries are distributed in the following proportion in different Countries; Guinea (7), Mali (21), Burkina-Faso (1), Niger (9), Cote D’Ivoire (2), Benin (2), Cameroun (5) and Nigeria (18) as shown in Fig. 6. The distribution was based on the degree of geographical spread of the basin in different Countries.
Methods of Dissemination of Hydrological Information in the Basin

The real time hydrological data received are processed and stored in the Hydroniger IFC data bank for the use of the NBA member countries and worldwide. The information are disseminated through the:

- Publication in the NBA Monthly Bulletin on River Niger which is distributed worldwide
- Publication through the NBA Websit: http//www.abn.ne and on the website of the AOC-HYCOS: http//aochycos.ird.ne
- Production of hydrological year book
- Publication of technical notes to give insight on the possible hydrological changes and Prediction on the flow of river Niger.
- Quarterly production of NBA-Info.

Direct contact by member Countries and individuals with the NBA.
Problems Associated with the Argos Telemetric Systems

The following are some of the problems associated with the Argos telemetric system in Niger basin:

- Old age of DCP equipment on the field
- Lack of spare parts from Manufacturers
- Progressive abandonment of Argos Systems
- High cost of maintenance of equipment

NBA’s Actions for Improvement

The NBA adopted the following measures as part of its persistent efforts to improve its information collection systems:

- Identification and selection of National Priority Stations i.e. minimising the number of stations
- Removal of parts from less priority and collapse stations to the more priority stations to make them functional
- Encouraging the National Forecasting Centre to carry out the maintenance of the DCP Stations themselves to minimise cost;
- Procurement of available spares parts for the NFC maintenance activities.
- Provision of some financial assistance to the NFC
- Upgrading of some of the NFCs with the provision of new computer systems.
- Gradual change to the use of Meteosat Telemetric system

SECTORS BENEFITING FROM OF HYDROLOGICAL INFORMATION SERVICES WITHIN THE NIGER BASIN

Information Services within the Niger Basin

Hydrological Information in Niger basin has the advantage of providing the following:

- Real Time Data Collection on the river Niger at its major catchment areas
- Monitoring and evaluation of river Niger flow characteristic
- Monitoring of Flood and Drought event
- Supply of adequate and reliable data for Water Planning and Management
- Provision of adequate and reliable forecast on the river Niger
- Enhancement of valorisation of Hydroniger IFC products and services;

Similarly the hydrological information services also enhance;
Provision of adequate and reliable data for water resources development by the NBA member countries and other users.

Rapid irrigated food crop production

Adequate management of hydro-infrastructures such as dams

Safeguard and protection of aquatic life downstream

Improvement in river transport e.g. Navigation

Provision of adequate water supply for the teeming population

Flood and draught mitigation

However, the following are the major sectors benefiting from hydrological Information services.

Major Hydropower Stations along the river Niger

The Hydroniger IFC provides real time Hydro-Climalogical data for an effective Reservoir operations to the major Hydropower Stations namely; Lagdo (Cameroon), Dabola (Guinea), Selingue and Sotuba (Mali), Jebba, Kainji and Shiroro (Nigeria).

Hydrological information are also made available to the following potential hydropower stations; Fomi (Guinea), Tosaye (Mali), and Kandadji (Niger).

Water Supply Dams and Water Treatment Station

The Hydroniger IFC supplies real Time Data to Water Supply dams and Treatment Stations for their reservoir operation.

Since most of the NBA member countries have their domestic water supply dams and infrastructures located along the main course of the river Niger and/or its tributaries, they needed real time Hydrological information which are regularly supplied to them. Some of these institutions charged with domestic Water Supply Dams and infrastructures are SNE in Niger, EDM in Mali and Water Boards and River Basins in Nigeria.

Irrigation Projects

Quite a number of irrigation projects are located along the flood plains within the river Niger basin. Regular hydrological data and information are supplied to the institutions charged with the operation and development of irrigation schemes in the various countries. Such institutions are the River Basin Development Authorities (RBDA) in Nigeria namely the Upper Niger RBDA, Sokoto Rima RBDA, Ogun-Oshun RBDA, Lower Niger RBDA, Niger Delta RBDA, Benin-Owena RBDA, Anambra-Imo RBDA, Upper and the Lower Benue RBDAs and also the ONNA in Niger, Office du Niger in Mali etc.
Navigation Development

Many Navigation Agencies are now operating along the river Niger and its major tributaries. These include the National Inland Waterways Authority (NIWA) of Nigeria that has protocol Agreement with the NBA for the enhancement of joint cooperation that also involve information dissemination on the river Niger.

Other Navigation Agencies are the COMANAV and the CATEMARE in Mali and Guinea.

Tourism

It should be noted that Navigation activities are time dependent because of seasonal variability of flow of the river Niger. Hydrological information from the Hydroniger IFC tend to provide more information for the improvement and optimisation of operation and security as well as navigation Calendar for tourism.

National Games Park

National Games Parks are mostly within the river Niger basin. Institution such as the Kainji Games Park in Nigeria, the W Park in Niger, Burkina Faso and Benin Republic and Park WAZA for Chad and Cameroun are served with the Hydroniger IFC data and information on river Niger.

National Hydrological Service

National Hydrological Service Departments countrywide also use hydrological data and information from the Hydroniger IFC particularly in updating their data bank.

The Universities and Research Institutions

Many Universities and Research Institutions and individual are provided with information on the river Niger from the Hydroniger IFC, for their research programs. Some of the Universities are the Ahmadu Bello University Zaria, University of Sokoto University of Ilorin, University of Oslo, Norway etc. Some of the Research Institutions are the National Čereal Research Institute, Bidda, Nigeria, the National Fishery Research Institute, New Bussa in Nigeria to mention but a few.

The NBA also supplies data to the Global Runoff Data Centre (GRDC) at the Federal Institute of Hydrology in Germany that collects and disseminates global runoff data for the hydrological and climatological research communities worldwide.

River Basin Organisation Worldwide

Information on Niger basin are also distributed to River Basin Organisation worldwide. Presently the NBA is in the process of signing a protocol agreement with the Zambezi River
Authority (ZRA) that will enhance joint cooperation and information exchange between the two river Basins.

CONCLUSIONS

The lack of information and knowledge on hydrological phenomenon in the Niger basin, has always contributed to the increasing erosion and river siltation; flooding along the river flood plains with its attendant loss of lives and properties; continued low flow that reduces reservoir storage capacity leading to acute water shortage and increasing water demand; pollution, weed encroachment within the river system; water borne diseases, high mortality rate, famine, increasing urban migration and poverty.

To overcome the various problems and the challenges facing the Niger basin and the NBA respectively, the NBA in collaboration with the World Bank, are developing a strategic action plan based on a shared vision that could enhance a sustainable integrated management and development of the basin and consequently the realisation of NBA mandates for its member Countries. This is why International communities, Donor Agencies and Organisations are called upon to assist the NBA in realising this objective which will also ensure adequate and timely hydrological information for the development of water resources infrastructures in basin that will particularly ensure adequate and safe drinking water to the teeming population. While the general public can respond to the rising fuel price by switching to alternatives such as public transportation, bicycles and finally by walking, they cannot do the same when it comes to drinking water. For water there is no alternative!

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