Journal of Sustainable Development in Africa (Volume 16, No.4, 2014)
ISSN: 1520-5509
Clarion University of Pennsylvania, Clarion, Pennsylvania

GROUNDWATER RESOURCES IN THE NIGERIA'S QUEST FOR UNITED NATION'S MILLENIUM DEVELOPMENT GOALS (MDGs) AND BEYOND

Olayinka Gafar Okeola[1] and Adebayo Wahab Salami[2]
[1] Department of Civil Engineering, University of Ilorin, Nigeria
[2]National Water Resources Capacity Building Network, University of Ilorin, Nigeria

ABSTRACT

Nigeria is faced with the challenges of sustainable water supply and the pressure is more at the tail end of United Nation's Millennium Development Goals **(**MDGS) which is just two years away. The paper chronicles the current status of the water resources, assessment of present demand, future demand and the deficit. It explores the holistic management approach to sustainable water supply in which groundwater component would be substantial. The paper suggests paradigm shift toward long term sustainable strategies through the principles of Integrated Water Resources Management (IWRM) to be implemented at River Basin Development Authorities (RBDAs) levels. There is still greater opportunity that the integrated development of groundwater and surface water resource can exploit. The panacea to challenges in the sustainable water supply toward MDGs accomplishment and beyond lie entirely in ensuring that the groundwater component of IWRM is boldly spelt out within legislative framework to address sustainable approaches, encapsulate professionalism, data bank management, quality control monitoring, benchmarking, and regulation.

Keywords: Nigeria, Groundwater, Surface water, Challenge, Millennium Development Goals, Sustainability.

INTRODUCTION

Nigeria is the most populous country in Africa and covers an area of 923,768 square kilometres of which 13,000 square kilometres is covered by water (CIA, 2013). Its climate varies between semi-arid in the north to tropical and humid in the south. Nigeria is endowed with enormous surface and groundwater resources. However, the task of providing water supply for citizenry has remained daunting for decades. Several approaches taken by the successive Nigerian governments in search of sustainable water supply provision in the last three decades are provided in Okeola (2005 and 2009). Alfaro et al., (1997) cited some fundamental reasons which are highly applicable to Nigeria water supply poor level of service delivery. The situation has been exacerbated due to (Odigie and Fajemirokun, 2005), demographic pressures coupled with the rising operational and maintenance cost of water infrastructure.

Groundwater is an important feature of the environment and an invisible part of the hydrologic cycle. It therefore requires that an understanding of its role in this cycle if integrated analyses are to be used in the study of watershed resources and regional assessment (Karamouz et. al., 2003). Water supply provision is a major contribution to the Nigerian United Nations MDGs and groundwater component is significantly essential. The MDGs that are related to provision of water supply are :(1) **e**radication of extreme poverty and hunger, (2) reduction of child mortality, (3) combat HIV-AIDS, malaria and other diseases and (4) ensure environmental sustainability. Africa still lags behind in the achievement of most of the MDGs, notably the targets for water and sanitation. Based on the rate of progress towards achieving the MDGs water targets, 22 African countries, all in Sub-Saharan Africa, are among 35 poorest performing countries in the World, and three of these – Nigeria, Democratic Republic of Congo and Ethiopia are among 10 other countries which present the biggest challenge to the global achievement of MDG targets (Habila, 2005).

STATUS OF NIGERIA WATER RESOURCES AND SUPPLY

Nigeria is well drained with reasonable close network of streams and rivers. The nation's rivers can be divided into five drainage basins: The Niger, Benue, Chad, Cross and Atlantic. Almost all the nation rivers in the north invariably drain into either Niger or Benue except rivers Yobe, Ngadda, Yedseram and Goa which drain into lake Chad. In the South-west, rivers Ogun, Oshun, Owena, Oghese and Ose among others drain directly into the sea. In the south-east, the Anambra drains directly into the sea (Adeyemi, 1988). The study on the nation's water resources estimated the surface water resources over the country at 267,300 MCM p.a (Table 2.1). These are definitely large volume of water flowing through the nation's rivers. However, the very finite nature of renewable fresh water makes it critical natural resources to examine in the context of population growth (Engelman and LeRoy, 1993) because population growth increases human water needs.

Table 2.1 Potential Surface Water Resources of Nigeria

River System	Catchment's Area (km^2)	Potential Surface Water (MCM)
River Niger	1,143,400	158,000
South West Region	100,500	35,400
South East Region	73,200	65,700
Lake Chad	188,000	8,200
Total	1,505,100	267,300

Source: FMWRRD (1995)

A renowned Swedish hydrologist, Malin Falkenmark, advanced a widely used indicator of water stress or scarcity, which is based upon renewable water resources per capita. Water scarcity is defined as occurring when the per capita water supply of a country is less than $1,700m^3$. Above this, a country will suffer only occasional or local water problems, while below this level it would be suffering from water stress, as water shortages become more pervasive. Below $1000m^3$/capita a country would be facing water scarcity where water shortages threaten economic development and human health and well-being. Below $500m^3$/capita a country faces absolute water scarcity (Raskin et al., 1997; Feitelson and Chenoweth, 2002). The World Bank and other analysts adopt $1000m^3$/capita benchmark as a general indicator of water scarcity.

However, Falkenmark's higher stress benchmark of about $1700m^3$/capita/year is a "warning light" to nations whose populations continue to grow such as Nigeria. It seems that Nigeria is steadily approaching very serious water scarcity by the year 2025, from $3,203m^3$/capita in 1990 well above $1000m^3$/capita benchmark (Table 2.2). Compared to other West African countries, Nigeria is in worst scenario due largely to her population growth. Therefore, appropriate management systems will have to be developed to cope with the likely increase in water stress resulting from growing population. The nation's population has been growing rapidly and along with the demand for water. The population growth and urbanization are key factors underlying the most enormous growth in water demand. The existing systems of the water supply already fail to provide adequate supply and coverage. Nigeria is currently suffering from water poverty which Feitelson and Chenoweth, (2002) defines as a situation where a nation or region cannot afford the cost of sustainable clean water to all people at all times.

Table 2.2 Fresh Water Availability for West African Countries

	1955		1990		2025	
Country	Population (Million)	Water Availability (m^3/p/yr)	Population (Million)	Water Availability (m^3/p/yr)	Population (Million)	Water Availability (m^3/p/yr)
Cote-d'Ivoire	3.2	22,974	11.97	6,180	36.82	2,010
Equatorial-Guinea	0.24	126,050	0.35	85,227	0.85	35,129

Gambia	0.31	70,288	0.92	23,835	2.10	10,466
Gabon	0.48	343,816	1.15	143,106	2.70	60,808
Ghana	5.76	9,203	15.02	3,529	37.99	1,395
Guinea	2.83	79,972	5.75	39,270	15.09	14,979
Guinea -Bissau	0.52	59,387	0.96	32,158	1.98	15,672
Liberia	0.91	253,829	2.57	90,097	7.24	32,044
Nigeria	37.09	8,303	96.15	3,203	238.39	1,292
Senegal	2.81	12,451	7.33	4,777	16.89	2,071
Sierra -Leone	2.08	76,886	3.99	40,010	8.69	18,412
Togo	1.41	8,487	3.53	3,398	9.38	1,280

Source: Engelman and LeRoy (1995)

The water supply challenges were compounded by the government's dual roles as both the producer and the regulator. The National Water Rehabilitation Project (1999) indicated that the water supply towards the year 2020 will face a serious water shortage problem even if the existing waterworks could supply their full planned capacity. It stresses the need for augmentation and improvement in water supply capacity as well as operating the existing waterworks in a well arranged manner to achieve the water supply target. The water balance in the year 2020 is summarized on regional level in Table 2.3 while Fig. 2.1 (FMWRRD (1995) shows that the water demand will increase nationwide up to the year 2020. Urban water supply will suffer a severe shortage of 16 MLD. It is imperative to holistically address the issue of sustainability of water supply in Nigeria to accomplish MDGs and beyond 2015. The starting point is to make a deliberate synchronization of groundwater resources with the surface water supply in well coordinated way to ensure improved supply and coverage.

APPRAISAL OF GROUNDWATER RESOURCES

Adeyemi (1987 and 1988), Sule (2003), Maduabuchi, (2004), Hanidu, (1990), Rijswlk (1981), Akujieze, et al., (2003), and Gone, (2006) gave empirical figures which suggest high groundwater resources potential for Nigeria. The nation's groundwater resource is abundant and of good quality is estimated at 52,000MCM out of which the sedimentary basins account for 67%. The occurrence of groundwater is greatly influenced by the local geological conditions which ultimately control yields. The geological distribution of Nigeria is divided according to geology, basin, and aquifer occurrence and nature (Table 3.1). Nigeria is located within the West African subcontinent, south of the Sahara, with the Atlantic Ocean bordering the southern coastal region (Fig.3.1) and is bounded in by longitudes 2°50' to 14°20' and from latitudes 4°10'to 13°48'. Geologically, Nigeria is made up of two major rock types: Basement complex and Sedimentary formation. In the northern arid and semi-arid areas of the country underlain by basement crystalline rocks, groundwater is scarce and problematic. Also, exploration for water becomes more challenging in topographically rugged terrains of high relief. Such areas include Sokoto, Zamfara, Kastina, Kano, Kaduna, Niger, Adamawa, Bauchi, Bornu South, Taraba and Gombe states (Fig.3.1). Other semi-arid regions include Bauchi, Plateau, Nasarawa, Federal Capital Territory, Kogi, Kwara and Benue States (Fig. 3.1). Other basement complex areas in the south-western and eastern Nigeria include parts of Oyo, Ondo, Osun, Ogun, Edo North and Cross River State (Akujieze, et al., 2003)

Table 2.3 Regional Water Balance in 2020

	North West	North East	Central West	Central West	South West	South East	Total
Urban Water Supply							
Projected demand	1,010	1,827	2,423	1,510	7,656	3,649	18,075
Actual supply capacity	250	344	516	161	988	379	2,639
Deficit capacity	770	1,491	1,909	1,348	6,668	3,269	15,486
Rural Water Supply							
Projected demand	640	1,069	705	909	816	1,058	5,197
Actual supply capacity	24	34	18	21	24	17	138
Deficit capacity	616	1,035	687	888	792	1,041	5,059
Total							
Projected demand	1,650	2,896	3,128	2,419	8,472	4,707	23,272
Actual supply capacity	275	378	534	182	1,012	396	2,777
Deficit capacity	1,386	2,525	2,597	2,236	7,460	4,310	20,515

Unit: MLD

The average annual rainfall ranges from about 500mm in the north to over 2,000mm in the south. Uneven distribution of rainfall across Nigeria reflects a significant variation in the surplus when viewing different parts of the country. This rainfall distribution generates the arid and semi-arid conditions of the north, the wet south and the coastal aquifer environments of Nigeria. With consideration of the hydrologic cycle, each of these four major environments has their hydrological challenges. While the northern part of Nigeria is dominated by the problems of aridity–semi-aridity, which limits the volume of water available for recharge to the aquifers, the south is saddled with the problems of flooded terrains, saltwater intrusion, and environmental and ground degradation due to the activities of the petroleum industries (Akujieze, et al., 2003).

The traditional institutional separation of surface water from groundwater has created fundamental communication barriers that extend from technical expertise to policy developers, operational managers and water users. These barriers impede the understanding of the processes and consequences of groundwater-surface water interactions (Owen et al., 2008). Considering the nation's River Basin Development Authority (RBDAs) and their associated groundwater basin (Table 3.2) and the river basins and hydrological areas in Nigeria (Fig. 3.2), the disproportionate management of surface

water resources without the groundwater counterpart has contributed significantly to unsustainable and inadequate water supply.

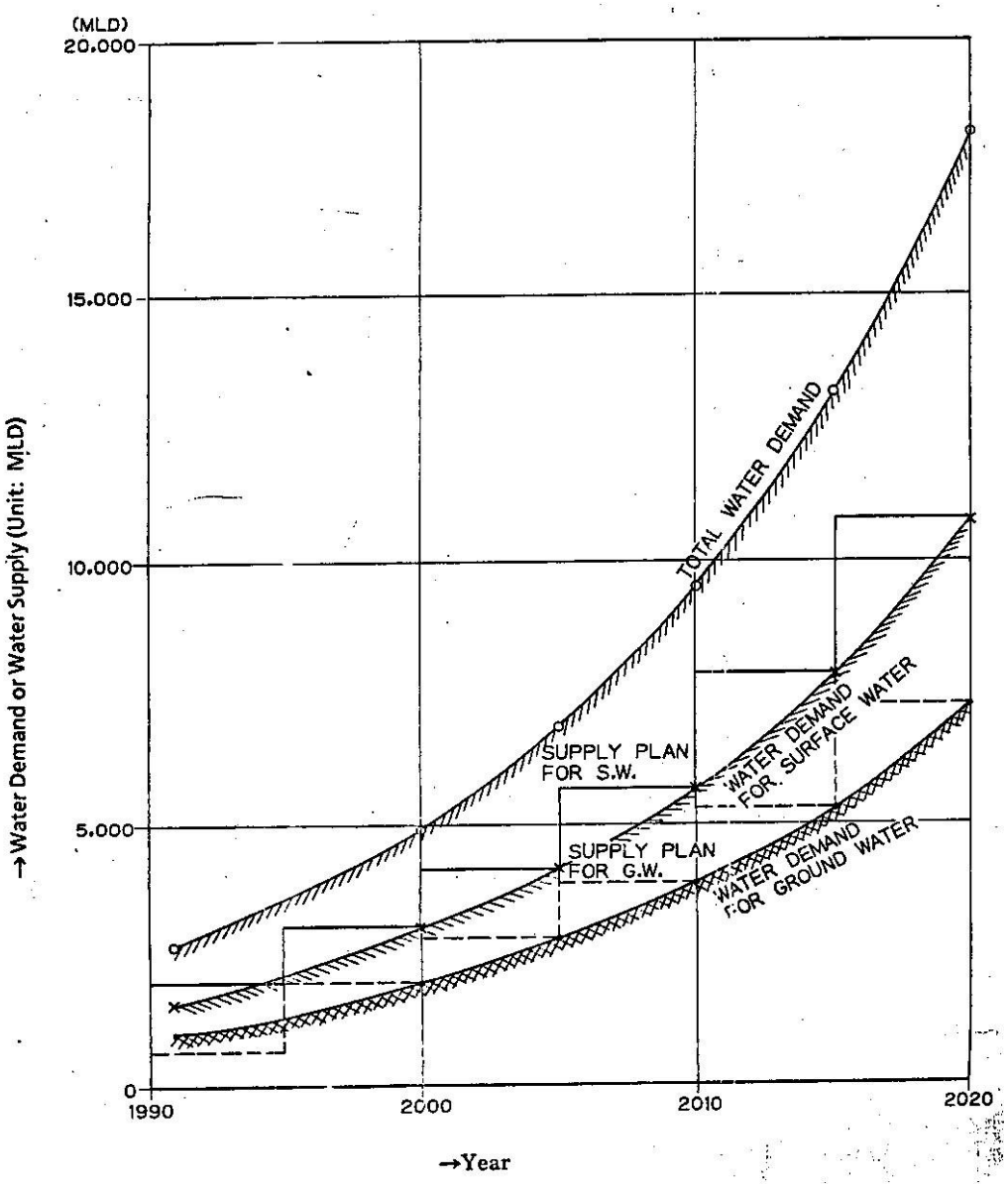

Fig 2.1 Demand-Supply plan for urban water supply

Table 3.1 Hydrogeological Areas of Nigeria.

	Region	Area ($km^{2)}$
1.	Sokoto Basin Area (Sokoto Sedimentary Area)	63,700
.	Chad Basin Area (Chad Sedimentary Area)	120,400
3.	Niger Basin Area (Upper Niger Sedimentary Area)	38,300
4.	Benue Basin Area (Benue Sedimentary Area)	116,300
5.	South Western Area (Ogun / Osun Sedimentary Area)	
6.	South Central Area (Lower Niger Sedimentary Area)	110,300
7.	South Eastern Area (Cross River Sedimentary Area)	29,700
8.	Basement Complex Area (Crystalline Rock Area)	445,100`
	Total	923,800

Source: FMWRRD (1995)

Fig. 3.1: Geographical map of Nigeria

Table 3.2: River basins development authorities and Associated groundwater Basins

River Basin Development Authority	Groundwater Basins
1. Sokoto Rima River Basin Authority	Sokoto Basin (Tertiary) Sokoto Basin (Cretaceous)
2. Hadejia-Jamare River Basin	Chad Basin (Unconfined Part of Basement Complex Part of Keri Keri Basin
3. Lake Chad Basin	Chad Basin (Unconfined) Chad Basin (Confined)
4. Upper Benue River Basin	Part of Keri Keri Basin Part of Benue Basin
5. Cross River Basin	Coastal Sedimentary Cross River Basin
6. Anambra Imo River basin	Part of River Course Alluvium Anambra Basin
7. Niger River Basin	Part of River Course Alluvium Nupe Sandstone Part of Basement
8. Ogun Oshun River Basin	Coastal Sedimentary
9. Benue River Basin	Coastal Sedimentary
10 Niger Delta	Coastal Alluvium Mangrove Coastal Sedimentary

HOLISTIC APPROACH TO THE SUSTAINABILITY OF WATER SUPPLY DELIVERY

It is explicit from the foregoing that sustainable water supply primarily depends on the physical capacity of the hydrologic system; the vulnerability of the system to pollution and contamination; capabilities of the infrastructure for treatment and distribution; operation and maintenance strategies and social-economic and institutional aspect that influence the performance of water supply system. Given all these considerations, it is imperative to consider a holistic management approach to sustainable water supply service in which groundwater component would be substantial.

The essence of holistic approach to water supply is to ensure that all the relevant components and factors are considered in the totality of their effect on the whole process in order to achieve the sustenance goal of the system. Water supply is made up of three main components that are one-way directional and serially complementary in significance and criticality. They are intrinsically linked through design, function, and performance. These are the source, treatment and transmission/distribution. Path dependencies are basic characteristic of water supply system. The paper aims at exploring the sustainability of water resources which are prerequisite to accomplishing the sustainability of the water supply adequacy and accessibility.

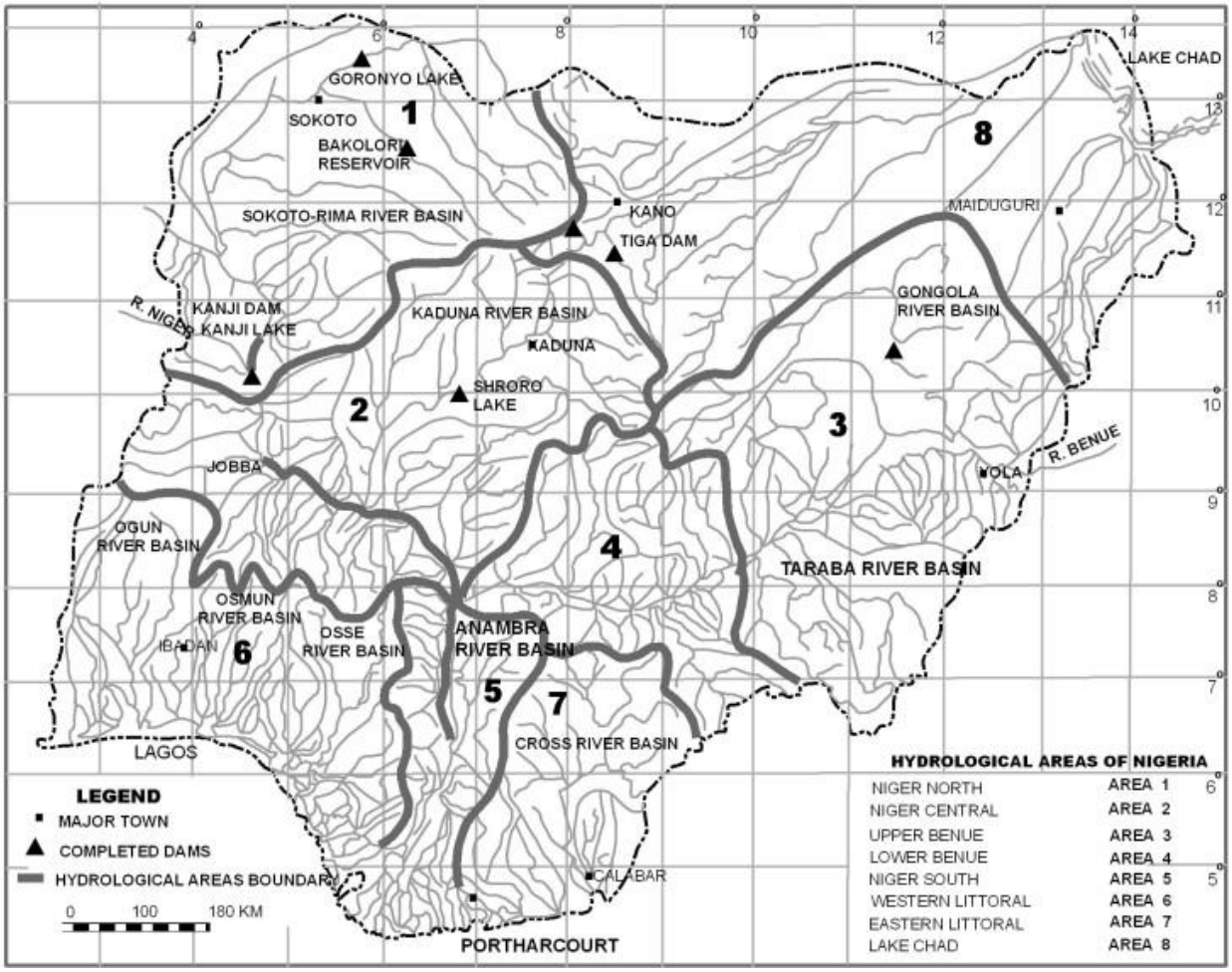

Fig. 3.3. Map of Nigeria showing the river basins and hydrological areas

SUSTAINABILITY OF WATER RESOURCES

Groundwater System

Groundwater management is an integral part of water resources management. While the legislation regulating the water resources planning process does not provide separately for groundwater planning, the aquifer can be singled out as the basic ambit of groundwater planning, on a par with the hydrographic basin (Burchi, 1999). Therefore the effective sustainability approaches for groundwater resources are best based on the physical laws that govern the behaviour of earth system and subsequently entail four premises (Kretsinger and Narasimhan, 2005; Nwankwoala, 2011):

1. Surface water and groundwater constitute a single resource.
2. Groundwater is a finite resource and a component of a larger natural resources system. Actions on one or more system components generally affect the long-term balance of the whole system
3. Groundwater replenishment is strongly influenced by climate variability, as well as natural and enhanced recharge processes. Consequently, groundwater resources development must adapt to the system's varying capacity for renewal.
4. Communities need to share and manage groundwater resources so that the natural resources system retains its integrity for the future.

Quality Management

The deterioration of Nigeria groundwater quality are traced to industrial effluents, poor sanitation system and irrigation water. Studies revealed impairments of groundwater quality through leachates outflow, infiltration from landfill and leaking latrines (Longe and Enekwechi, 2007; Yerima et. al., (2008); Omofonmwan and Eseigbe, 2009; Feighery, 2010; Longe and Balogun, 2010). Areas under the threat of groundwater depletion include the north-western and north-eastern parts of the Nigeria. The protection of groundwater quality is urgently required in the control of overexploitation and pollution of the resources through effective groundwater monitoring management. It is imperative to first carry out various geological conditions to resolve key practical groundwater management questions in order to guide optimum groundwater development and to determine groundwater protection zones around boreholes in fracture rocks (Tindimugaya, 2005).

This is a prerequisite in detecting and understanding changes in quality and quantity of groundwater bodies. Groundwater management and monitoring are inseparable because without monitoring, effective groundwater management is not possible. Groundwater monitoring involves data collection that is purpose-specific. Groundwater monitoring essentially implies monitoring of four processes: nitrification of groundwater, acidification, transportation of contaminants and salinisation (Hoencamp, 1999). Therefore, establishment of national groundwater monitoring network with wells provided all over the country within RBDAs units for coordination are recommended. The objective is to quantify changes in groundwater quality by either pollution or salinisation.

Policy Guidelines

The water policies, institutional and legal framework designed by various government toward a sustainable of nation's water resources are comprehensively reviewed in Adeyemi (1987, 1988), Adeoti, 2007, Gbadegesin and Olorunfemi (2009), Odigie and Fajemirokun (2005) among others. From their discourse the problems are not in the legislations or programmes but are in the overlapping, fragmentation, contradictory and problem-prone coordination. There are several policy guidelines including the Nigeria's constitution on water resources management at the federal level. Akanmu et al., (2007) discuss the conflict of interest between the RBDAs and various state authorities because the interface of roles, functions, and coordinating mechanism were not clearly defined and hence could not be manage properly.

Adeoti (2010) suggested rationalization of the present 12 river basin management framework into four along the natural hydrographical areas (Fig 3.3) after examining river basin water management gap.There exists Water Resources Act 101 which vests rights and control of all water, surface and underground including all water-course affecting more than one state in the Federal Government (FGN, 1993). The Act is made up of 21 sections and section 4 is on control of groundwater. The present water resources Act did not provide deliberate plan use of ground and surface water conjunctively. Ground and surface water bodies are physically interlinked and need to be managed in an integrated way. The present legal frameworks preclude any effective conjunctive water usage.

SUSTAINABILITY OF WATER SUPPLY

Good governance

Lack of good governance principles had a devastating effect on Nigeria water supply. Good governance is participatory, consensus-oriented, accountable, transparent, responsive, effective and efficient, equitable and inclusive and follows the rule of law (Hukka and Katko, 2003). In the Nigeria context, the RBDAs are not the natural geo-political areas of planning and management of nation's water resources. Policy evolutions are political process and other consideration that is outside the hydrological basins. There can never be apolitical to water supply problems. What is important is to raise the political profile of the water issue by users association, NGOs, other stakeholders and increase pressure on politicians to be accountable for good governance. Stakeholders' participation has been recognised and recommended as very crucial in the decision making, strengthen local institutional capacity, increase level of commitment of beneficiaries, management and easiness of enforcement of regulation and control (Gomez and Nakat, 2002; Pittock, et al, 2003; Jaspers, 2003; World Bank, 2003).

UNICEF (1999) documents the issues associated with user participation in rural water supplies. The menace of political party members or their cronies' patronage has been very difficult to curb. This has lead to commissioning unqualified contractors and consultants. However, sharp practises such as the use of substandard groundwater accessories, forge geophysical results, and non compliance with borehole depth and casing depth specification among other are even more challenging to curtail. The effective solutions still lie in informal sectors and stakeholders mounting pressure for good governance and more vigilante community participation.

Financial Sustainability

The Nigerian populace had already adopted various coping mechanism in response to water shortages. Huge averting expenditures are incurred everyday on dug wells, table water, generator, fuel, etc. It was not surprising several studies (Sule and Okeola, 2010; Madhoo, 2007; World Bank, 2002, etc) reported that the Nigerian citizens are willing to pay for improved water supply. Since the role of the government is to ensure that services are provided and not necessary provide services, it is imperative to involve private sector in infrastructure development and service delivery to exploit this citizenry willingly-to-pay but with consideration to the externality issues, non-excludability of water supply and the suggestions by Rivera, (1996), Ibrahim and Musa-Haddary, (2010) etc are required in private sector participation arrangement. Regulatory is cornerstone in any institutional arrangements for roles and responsibilities to be meaningful and effective. A regulatory arm of NIWRMC must be established and empower by law as a watchdog in ensuring compliance with IWRM policies, standards and legal frameworks in all groundwater supplies projects.

Integrated Water Resources Management (IWRM)

The world summit on sustainable development (WSSD) held in 2002 in Johannesburg formally recognised the need for a more sustainable and integrated approach to water management as a key element to attaining the MDGs. The WSSD subsequently set a target for all countries to prepare integrated water resources management and water efficiency plans by 2005. Thus the Nigeria integrated water resources management commission (NIWRMC) established six years after. It is a Federal Government of Nigeria organisation with the following mission: "to provide sustainable, effective, efficient and equitable management of Nigeria's water resources through local, regional and national actions and cooperation.

The authors consider streamlining of all the 17 or more institutions and legal frameworks the first priority of NIWRMC and for implementation under the nation's IWRM but at RBDAs level and sub basin levels. This becomes imperative since each basin is unique; however there is enough commonality of hydrological, geomorphologic and ecological characteristics for them to serve as widely applicable, non-ephemeral, operational landscape units for planning and management, and for maintaining environmental quality and pursuit of sustainable development (Barrow, 1998). It is at the river basins that multiple uses advantage can take place such as planning, monitoring, reconciling competitive use and coordinating the activities of independent agencies and other interest groups.

CONCLUSION

It has been estimated that meeting the MDG for access to safe water will produced an economic benefit of US$3.1 billion in Africa. This is a gain realised by combination of time savings and health benefits. The cost-benefit ratio is about 11 which suggests that the benefits derived from access to safe water are far greater than the costs of providing it (Hutton and Haller, 2004; Banerjee and Morella 2011). Therefore, the nation's 3-tier government, intergovernmental organization and NGOs should sustain the MDGs momentum and focus on long term sustainability strategies of water supply through conjunctive water usage and regular operational assessment within the context of the nation's IWRM. There is still greater opportunity that the integrated development of groundwater and surface water resource would exploit the many positive attributes which include greater water conservation, smaller surface storage, smaller surface distribution system, and increased reliability of water supply (Nyumbu, 1984).

The need for paradigm shift in groundwater management was stressed because underground and surface water are physically interlinked thus call for management in an integrated way. The duplication and fragmentation of several policies and legal frameworks failed to utilize the huge and sustainable groundwater resources for healthcare delivery, environmental harmony and socio-economic progress of the country. The panacea the challenges is in the NIWRMC ensuring that the groundwater component of IWRM is boldly spelt out within legislative framework to address sustainable approaches, encapsulate professionalism, data bank management, quality control monitoring, benchmarking, and regulation.

REFERENCES

Adeoti, O. (2007) Challenges to managing water resources along the hydrological boundaries in Nigeria. Water Policy. (9): pp 105 - 118

Adeoti, O. (2010) Development of river basin organizations in Nigeria. Research Journal of Soil and Water Management. (3-4)1: 91-100.

Adeyemi, S.O. (1987) Water policies for the future. Convocation lecture. University of Maiduguri, Maiduguri, Nigeria

Adeyemi, S.O. (1988) Nation's quest for water. 31st Inaugural lecture. University of Ilorin, Ilorin, Nigeria.

Akanmu, J.O., Eluwa, O., and Ekpo, I. (2007) Chronicles of river basin management in Nigeria. Proceeding of International Congress on River basin Management, Antalya Turkey, pp106-114

Akujieze, C.N., Coker, S.J.L. and Oteze, G.E. (2003). Groundwater in Nigeria. A Millennium Experience – Distribution, Practice, Problems and Solutions. Hydrogeology Journal. 11: 259-274.

Alfaro, R., Blanlot, V., Bradburd, R. and Briscoe, J. (1997) Reforming former public monopolies: the case of water supply.
http:/rg/ESSD/essdext.nsf/18DocByUnid/8EE9EAICA924C185256B5000692751/$FILE/ReformingFormerPublicMonopolies.pdf (26/4/2003)

Banerjee, S.G. and Morella, E. (2011) Africa's water and sanitation infrastructure- Acess, affordability, and alternatives. Directions in development. (Infrastructure). The World Bank

Barrow, C.J. (1998) River basin development planning and management: A critical review. World Development, 26(1). Pp. 171-186

Burchi, S. (1999) National Regulations for Groundwater: Options, Issues and Best Practices.

CIA (2012).The World Fact Book (http:/www.odci.gov/cia/publications/factbook/index.html)

Engelman, R. and LeRoy, P. (1993). Sustaining water: population and the future of renewable water supply. Population Action International, Washington, D.C., U.S.A. 57 pages

Engelman, R. and LeRoy, P. (1995). Sustaining water: an update. Revised data for the Population Action International. Sustaining water: population and the future of renewable water supply. Washington, D.C., U.S.A.

Federal Government of Nigeria (FGN) Water Resources Act 101. Government Press. 1993. Lagos.
Feitelson, E and Chenoweth, J (2002) Water poverty: towards a meaningful indicator. Water Policy. (4); 263 – 281

FMWRRD (1995). The Study on the National Water Resources Master Plan. Japan International Cooperation (JICA) and Federal Ministry of Water Resources and Rural Development, Federal Republic of Nigeria, Abuja.

Gbadegesin, A.S. and Olorunfemi, F.B. (2009) Changing trends in water policy formulation in Nigeria: Implications for sustainable water supply provision and management. Journal of Sustainable Development in Africa. (11)4: pp 266-285

Gomez, J.T. and Nakat, A. C. (2002) Community participation in water and sanitation. Water International. (27)3: 343-353.

Goni, I.B. (2006). The challenges of meeting domestic water supply in Nigeria. J. Min. Geol. 42(1): 51–55.

Habila, O. (2005). Groundwater and the Millennium Development Goals. Groundwater and Poverty Reduction in Africa Seminar. Hydrogeological Group, the Geological Society. Burlington House, Piccadilly, London.

Hanidu, J.A. (1990). National growth, water resources and supply strategies in Nigeria in the 1990s. Water Resources J. Nig. Assoc. Hydrogeol. 1: pp.1-6.

Hoencamp, T.E. (1999) Monitoring of groundwater quality: Experiences from The Netherlands and Egypt. ILRI Workshop: Groundwater management: Sharing responsibility for an open access resources. Pp 127-136

Hukka, J.J and Katko, T.S. (2003) Water privatisation revisited: Panacea or pancake? IRC International Water and Sanitation Centre. Delft. The Netherlands

Hutton, G. and Haller, L. (2004). Evaluation of the costs and benefits of water and sanitation improvements at the global level. WHO. Geneva.

Ibrahim, D.O and Y.G. Musa-Haddary. 2010. Concept of value for money in public infrastructure development. Presentation at The Nigerian Institute of Quantity Surveyors 3-Day international workshop on public private partnership approach to infrastructure development in Nigeria. Abuja.

Jasper, F.G. (2003). Institutional arrangements for integrated river basin management. Water Policy. 5: 77-90.

Karamouz, M., Szidarovszky, F., and Zahraie, B. (2003). Water Resources Systems Analysis. Lewis Publishers. USA.

Kretsinger, V.G., and Narasimhan, T. N. (2005). Sustaining groundwater resources: California's shift toward more effective groundwater management. Southwest Hydrol., 4: 18-19

Linsley, R.K., Franzini, J. B., Freyberg, D. L., and Tchobanoglous, G. (1992) Water –Resources Engineering. McGraw-Hill International Editions. Singapore.

Longe, E.O and Balogun, M.R. (2010) Groundwater quality assessment nears a municipal landfill, Lagos, Nigeria. Research Journal of Applied Sciences, Engineering and Technology. (2)1: 39-44

Longe, E.O. and Enekwechi, L.O. (2007) Investigation on potential groundwater impacts and influence of local hydrogeology on natural attenuation of leachate at a municipal landfill. Int. J. Environ. Sci. Tech., (4)1: 133-140

Maduabuchi, C.M. (2004). Surface and Groundwater Resources Monitoring and Management in Nigeria. Presentation at the United Nations/Austria/ESA Symposium on Space Applications for Sustainable Development to Support the Plan of Implementation of the World Summit on Sustainable Development "Water for the World: Space Solutions for Water Management".

Madhoo, NY. (2007). Estimating the budgetary impact of higher willingness to pay for residential water using CVM: A case study of Mauritius. Asian Journal of Water, Environment, and Pollution. (4)2, pp 57-64

National Water Rehabilitation Project (1999) Report on NWRP-Assessment of water catchment areas for Kwara State Water Corporation. Ciwat Engineers Ltd. Ilorin. Nigeria.

NIWRMC (2011) Status of water resources management in Nigeria. Nigeria Integrated Water Resources Management Commission. Abuja. Nigeria.

Nwankwoala, H. O. (2011). An integrated approach to sustainable groundwater development and management in Nigeria. Journal of Geology and Mining Research (3)5: 123 – 130.

Nyumbu, I. L. (1984) Models for design of conjunctive surface water storage and groundwater utilisation capacity. Proceeding of International Seminar on Water Resources Management Practices, Ilorin, Nigeria. Pgs 293-302.

Odigie, D. and Fajemirokun, B. (2005) Water justice in Nigeria: Crisis or challenge. International Workshop on Water Poverty and Social Crisis, Agadir, Morocco.

Okeola, O.G. (2005) Public-private partnership initiative: A model to accomplish United Nation's MDGs. Proceedings of National Engineering Conference. Kano. Nigeria

Okeola, O. G. (2009) Development and application of multicriteria decision support models for sustainable operation of an urban water supply system. Ph.D. Thesis. Department of Civil Engineering. University of Ilorin. Nigeria

Omofonmwan, S.I. and Eseighe, J.O. (2009) Effects of solid water on the quality of underground water in Benin Metropolis, Nigeria. J. Hum. Ecol. 26(2):99-105.

Owen, R., Mirghani, M., Diene, M., Tuinhof, A. and Taylor, P (2010). Groundwater Management in IWRM Training Manual

Pittock, J. Madgwick, F.T. and Tickner, D. (2003). Establishing river basin organizations for the conservation and sustainable management of rivers. (http:www.assets.panda.org/downloads/riversymposiumpaper.pdf

Raskin, P., Hansen, E., and Margolis, R. (1995) Water and Sustainability. Polestar Series Report 4. Boston, Massachusetts, USA: Stockholm Environment Institute.

Rijswlk, K. (1981). Small Community Water Supplies. IRC Technical Paper Series, No.18. The Netherlands.

Rivera, D. 1996. Private sector participation in the water supply and wastewater sector. Lesson from six developing countries. Direction in Development. The World Bank. Washington, D.C., USA.

Sule, B.F. (2003) Water security: Now and the future. 65th Inaugural lecture, University of Ilorin, Nigeria. Nigeria.

Sule, B. F. and O.G. Okeola. (2010). Measuring willingness to pay for improved urban water supply in Offa city, Kwara state. Nigeria. Water Science and Technology: Water Supply. (10):2 Pp 933 -941.

Tindimugaya, C. (2005) Groundwater development and protection and the rural/urban interface. Groundwater and Poverty Reduction in Africa Seminar. Hydrogeological Group, The Geological Society. Burlington House, Piccadilly, London.

UNICEF (1999) A Water handbook. Water, environment and sanitation technical guidelines series -No 2
(ID No PD/WES/99/1)

World Bank (2002) Water resources sector strategy: Strategic directions for World Bank engagement. Draft. http://inweb18.worldbank.org/ESSD/essdext.nsf/18DocByunid/ (Accessed: 22/7/2004)

World Bank. (2003) Water resources sector strategy: Strategic directions for World Bank engagement. Washington, DC

Yerima, F.A.K., Daura, M.M., and Gambo, B.A. (2008) Assessment of groundwater quality of Bama town, Nigeria. J. Of Sustainable Development in Agriculture and Environment. 3(2): 128-137

ABOUT THE AUTHORS:

Olayinka Gafar Okeola: Department of Civil Engineering, University of Ilorin, Nigeria.

Adebayo Wahab Salami: National Water Resources Capacity Building Network, University of Ilorin, Nigeria.