International Academic Research Consortium Journals (IARCJ)
International Journal of Agricultural Science and Technology
ISSN: 2360-9888. Volume 8, Number 4
Pages 98-106 (December, 2020)
www.iarcj.org, www.arcnjournals.org

An Appraisal of Ground Water Management System in Chad Basin Area of Borno State Nigeria

Abdullahi Abba Mamman[1], Mukhtari Mohammed Adamu[2] and Yahaya Yusuf Shallangwa[3]

[1]Department of Agricultural Engineering, School of Engineering, Ramat Polytechnic Maiduguri Borno State Nigeria | Tel: +2348035822447 | Email: abbamamman@gmail.com

[2]Department of Urban and Regional Planning, School of Environment Studies, Ramat Polytechnic Maiduguri Borno State | Tel: 08036422824, 08095245933 | Email: mukhtarimohammedadamu@gmail.com

[3]Department of Agricultural Engineering, School of Engineering, Ramat Polytechnic Maiduguri Borno State Nigeria | Tel: 08036558913 | Email: yyshallangwa@gmail.com

Abstract: *This paper on "Appraisal of Ground water management systems in chad basin area of Borno state".Studied the ground water system in Chad Basin with a view to identifying problems associated with the management techniques. It described the nature of ground water in the chad basin area, examined the ground water management system in the area, identified problems associated with the management system and Proposed future management perspective for improvement. The study adopted qualitative research method that focused on literature, consulted written texts namely seminar and conference papers, journals, magazines, books, internet materials among others. The paper identified general over exploitation of the aquifer, falling water level in the area, reduction in borehole yield, expensive pumping of water and some shallow wells and boreholes are put out of the system as problems associated with the management system. Proposed future perspective that involved: Proper definition of a framework for ground water resources management, ground water conservation measures, demand management, source enhancement, provision of adequate legislations, stakeholder inclusion, increased investment and funding in the water sector and institutional integration for the improvement in ground water management system in Borno state.*

Keywords: *Aquifer, Appraisal, Chad Basin, Ground water, Management System*

1.0 INTRODUCTION

Groundwater plays a vital role in the socio-economic development of urban and rural areas in Nigeria. Out of the current population of about 168 million, more than half depend directly on this natural resource for their daily water needs (Bakari *etal*, 2014). With a rapid population growth of about 2.5% per annum, the demand for water supply in chad basin area has progressively increased over the last three decades. The provision of safe drinking water has actually deteriorated; access in urban areas fell from 55 million people to 27 million people in 2002 alone largely due to poor management, inadequate technical capabilities, lack of investment and insufficient manpower and their training. Furthermore, the institutions responsible for water supply are both ineffective and fragmented, thus a transition is needed to bring about a thorough and holistic change to the current system. This change requires a long period of time to be effective, and into the future it can only be achieved by empowering and engaging the relevant stakeholders in groundwater management issues.

However, rapid population growth and uncontrolled urbanization further aggravates the increasing trend of above ground human activities that potentially affect the quality and quantity of the underlying groundwater by radically changing both recharge and abstraction, thus adversely affecting groundwater quality (Foster, 2001). Urbanization, dense population concentrations and human activities all severely affect groundwater quality especially in developing countries of sub-Saharan Africa where the urban expansion is poorly planned(Chilton 1999, Wakida and Lerner 2005, Naik *etal* 2008, Putra and Baier 2008 and Eni *et-al* 2011).

These problems pose a significant threat to the upper unconfined system of the Chad Basin around Maiduguri in Northern Nigeria. The aquifer in the Chad Basin is the major water supply source for the city and it is hydraulically connected to the Ngadda River which drains the city. River Ngadda – groundwater system is threatened by incessant waste disposal in recharge areas by residents and local businesses, uncontrolled pit latrine construction and other non-point sources of contamination across the city.

The negative impact is most significant in some of the areas in Maiduguri where tons of residential and commercial solid wastes are inappropriately dumped into the River Ngadda. The hydraulic connectivity that exists between the river and the upper aquifer serves as a pathway of groundwater contamination. This consequently poses unacceptable health risks to the local population, most especially the urban poor who largely depend on the groundwater without any form of treatment.

According to Bunu (1999), Dami *et-al*(2011)and Adkins (2007),the Lake Chad basin extends over areas in the countries of Niger, Chad, Cameroun and Nigeria. Total area extent within Nigeria is about 200,000km2, out of which Borno and Yobe States cover about 58 percent. Groundwater is the predominant source of water supply for domestic and other uses, while surface water is used mainly for irrigation purposes. Groundwater abstraction from boreholes for water supply has a long history. As many as 100 boreholes have been drilled and operated in Maiduguri town alone for water supply and over 2,000 boreholes have been drilled and operated within the two states. Many more are still being drilled and operated by many agencies.

There is generally a high rate of abstraction without matching recharge. A general decline in rainfall for the area has led to the over-exploitation of groundwater and the available groundwater reassure is on the decline. Water levels in boreholes have fallen and borehole yields have drastically declined over the years. Groundwater resource management must be approached systematically (Bunu 1999).

1.2**Aim and Objectives**

The aim of the study is to examine ground water in Chad Basin area with a view to identifying problems associated with the management system and propose future management perspective for improvement.

The specific objectives are to:

- Describe the nature of ground water in the chad basin area.
- Examine the ground water management system in the area
- Identify problems associated with the management system.
- Propose future management perspective.

2.0 NATURE OF GROUND WATER IN THE CHAD BASIN AREA

The area has many small rivers and streams and most of them are ephermal, flowing for about three to four months a year. Some of them rise locally, while others have their tributaries outside the area. The climate is semi-arid with a long dry season and a short rainy season lasting for 2 – 3 months. Temperature value of about 32 C. Rainfall is generally low with a mean annual value of about 625mm, while the mean annual evaporation rate is about 1600mm (Marte1986,Bonsor and Macdonald 2010,Vassolo 2012 and Lake Chad-HYCOS 2015).

The hydrology of the area is dominated by the Chad formation, Exploitable aquifers occur at depths of up to 650m and comprise the upper, middle and lower zones which correspond to the phreatic, lower Pliocene and terminal continental aquifers described by the Lake Chad Basin Commission (LCBC) for the entire basin. Potential deep aquifers at depths greater than 700m are unlikely ever to become economically feasible in the study area or elsewhere in the basin. For all practical purposes the development of groundwater resources is limited to the currently exploited aquifers to depths of about 650m. The upper zone is termed the upper aquifer system because it is a heterogeneous body comprising more than one aquifer intercalated with less permeable beds. The middle and lower zones are termed separate aquifers since each is sufficiently isotropic as to be considered an individual hydro-geological unit. The geometry, lithology and hydrogeology of the aquifers are fairly well known due to the greater number of boreholes drilled in and around Maiduguri (Bumba *et al.*, 1985, Vassolo et al 2009, Vassolo, 2012and Lake Chad-HYCOS 2015).

The groundwater resources of the area come from the three aquifers of the Chad formation and to a lesser extent are supplemented by the basement complex and the Fikashales.

The upper aquifer system

The upper aquifer system consists of at least three zones in and around Maiduguri. These zones referred to as A, B and C are found at depths of 10-40m, 40-70m and 78-99m, respectively. They are usually screened under a multiple screening arrangement in the borehole where they are found to exist together. The yields from these boreholes range from 2-5 litres per second (l/sec). recharge to this aquifer system occurs through vertical infiltration of rainfall as well as seepage along rivers and streams. (Bunu1999 ,Vassoloetal 2009,Global Water Partnership 2013,Yusuf 2015 and Usman *etal* ,2016)

The Middle aquifer system

This is the most widespread and best exploited confined aquifer in the Nigerian sector of the Chad Basin with a surface area in excess of 50,000kmsq. Its depth ranges from about 200 to 350m. Lithologically, it is the most varied aquifer, consisting mainly of sand and gravels with silt and clay intercalations. Recharge to this aquifer is reported to occur by horizontal inflow around the ridge of the rocky areas fringing the Chad basin and also by vertical percolation from a ridge popularly referred to as the Bama ridge. Yields of boreholes tapping this aquifer range between 5 and 10 l/sec
(Bunu 1999,Bonsor and Macdonald 2010, Global Water Partnership 2013 and Yusuf 2015).

The Lower Aquifer System

The lower aquifer system is found at depths of 420-650m, with varying yields according to location ranging from about 15 l/sec to as high as 30 l/sec. Initially, it was thought that the aquifer was mainly confined to the Maiduguri area but a recent geophysical survey indicates its presence beyond Maiduguri. Not much is known about the recharge to this aquifer but it is believed to be far from this area (Bunu 1999 , Global Water Partnership 2013 and Yusuf 2015).

The rate of abstraction of groundwater in the area has been analyzed by Ndubuisi (1990). Although, many new boreholes have been drilled and added to the system, the total may not have changed greatly. This is mainly due to the implementation of a surface water supply scheme for Maiduguri in 1992 and the closing down of many of the operational boreholes. (Bunu, 1999)

The boreholes are designed with diameters of 150mm or more with pump chambers up to 130 m deep in the case where a tapered design is used. The piezometric levels are below 50m deep in some of the boreholes tapping the middle and lower aquifers for which the average setting depth of the pumps are between 80 and 90m.

3.0 GROUND WATER MANAGEMENT SYSTEM IN THE AREA

Realizing dangers posed by over exploitation and the imposed operational difficulties, some form of informal management practice has evolved. It consists of isolated uncoordinated efforts by individuals trying to understand the system through research on a personal level, mainly for academic purposes. No well documented policies on water resources management are in place. However, the efforts have somehow become a way of managing the groundwater resources of the area. Borehole siting criteria, pumping tests of competed boreholes, selection of appropriate pumping equipment for boreholes, though not properly documented are being used systematically by the staff of the Borno and Yobe State Water Boards, the organizations responsible for the development, operation and maintenance of water supplies (Bunu 1999 ,Yusuf 2015 and Ngamdu, 2015).

Due to the frequent loss of submersible pumps in boreholes, especially during the 1980s and the associated difficulty of fishing the pumps due to the small size of the boreholes, the diameters of the boreholes have been standardized to 150mm. With this design concept, it is easy to fish out pumps when they fall into the boreholes. Again, on the advice of experts in the late 1970s, a surface water supply scheme for the town of Maiduguri has been implemented. Similarly, other surface water supply schemes have been recommended for some of the major towns in the area. Researchers in this part of the world and elsewhere have made valuable contributions. However, in spite of these many contributions, the majority of findings have not been implemented and there do not seem to be concrete plans for implementing them in the future. Worst of all, even those involved in the actual exploitation of water resources of the area do not seem to be fully aware of the issues involved. In short, water resources management is neither scientific nor systematic (Hanidu 1990, Bunu 1999, and Yusuf 2015).

4.0 PROBLEMS ASSOCIATED WITH THE MANAGEMENT SYSTEM

According to Bunu (1999) , Jacobsen *et-al* (2012) and Idu (2015) with more than 2,000 boreholes tapping the various aquifers in the area, further water level decline is expected. Groundwater resources have been and are still the main source of potable water supply for domestic, livestock and industrial use in this area. The largest demand is for domestic and livestock consumption which account for over 80 percent of the groundwater use. There is general over exploitation of the aquifers as indicated by the falling water levels and the reduction in boreholes yields.

Economic implications

Generally, the decline in groundwater level caused by over exploitation has produced high pumping heads necessary to abstract water from these aquifers. This has steadily and increasingly made pumping more expensive in the area (Ndubuisi1990,Bunu 1999 and Idu 2015).

Environmental implications

The environmental implications of over abstraction are many. Some shallow wells and boreholes have dried up and have been abandoned and put out of the system. There is a need to take precautions in order to safeguard the effects on the whole aquifer and Maiduguri has already been designated as one of the subsidence prone areas of the country (Bunu 1999 and Jacobsen *et al* 2012).

From the above it can be deduced that problems associated with ground water management include the following:

- General over exploitation of the aquifer.
- Falling water level in the area.
- Reduction in borehole yield.
- Expensive pumping of water.
- Some shallow wells and boreholes are put out of the system.

5.0 FUTURE MANAGEMENT PERSPECTIVE FOR IMPROVEMENT

Groundwater resources have played and will continue to play an important role in meeting the water requirements, especially for domestic and livestock consumption in this area. The scientific management of groundwater resources of the area is absolutely essential for sustainable groundwater development and economic advancement. The following measures are suggested as a basis for a proper groundwater management strategy:

- Proper definition of a framework for water resources management: Water resources management involves a sequence of activities and decisions including needs assessment, problem analysis, resource allocation, planning and design, implementation, operation and maintenance, all of which are interrelated in a complex way. These activities are also based on other sub activities, which provide the basic information for decision making. Each decision is based on information on available alternatives and their anticipated outcomes and effectiveness. For proper management, well-coordinated water resources studies need to be undertaken. It is necessary to quantify all aspects of demand and relate it to available resources. Where the demand exceeds available resources, steps should be taken to either cut the demand to match the available resources or increase the supply. This will maintain a favourable balance between water demand and water supply while satisfying the various constraints of quality, technology, availability, sustainability and environmental and economic factors.

  Rigorous quantitative hydrogeological studies, geophysical investigations, assessment of aquifer parameters, evaluation of well and aquifer hydraulics to determine safe yields, optimum borehole spacings, water quality testing and economic analysis to determine optimum yields are important prerequisites for scientific management of groundwater resources.

  Extensive need exists for adequate and reliable data for water resources planning and management. In order to obtain such data, deliberate policies need to be put in place by the concerned authorities to provide the necessary financial backing and a conducive atmosphere to enable water experts and operators to become responsive and responsible to these tasks. The studies and activities that need to be carried out should consist of, but are not limited to the following:

- Groundwater monitoring and establishment of a groundwater database: These activities mainly consist of collecting data on boreholes (an inventory), abstraction rates (quantity), water quality, water demand, water level monitoring etc. One simple method of doing this is through the establishment of a groundwater monitoring network from which data on the occurrence, movement, quantity and quality of the groundwater could be obtained and analyzed (Oluboye, 1995).
- Understanding the aquifer characteristics of the groundwater system: Another related issue is understanding the aquifer characteristics of the groundwater system. Although the aquifer characteristics have been fairly well known, their practical application to estimate recharge has not been defined. It is necessary to understand the aquifer behaviour and interactions with infiltrating and deeply percolating water. There is also a need to investigate further and establish areas of possible recharge to the aquifers and recharge capacity.
- Creation of a forum for dissemination of research findings on groundwater: The history of water resources planning and development in this area in general has been characterized by ad-hoc solutions. It is unfortunate that since the first free flowing (artesian) boreholes were sunk during the colonial era in the late 1950s, no concrete plans
- For the management of the Chad Basin aquifers has emerged. Many have failed to understand the importance of proper groundwater resources management. It is the responsibility of water resources professionals to emphasize to public policy makers the importance of groundwater resources management. As a first step, the water industry operators themselves need to be properly educated on these issues. The improved management of the state water agencies should be precisely targeted so that staff can appreciate their position in relation to the need for the combined development and conservation of water resources.

➢ Ground water conservation measures: groundwater conservation is of paramount importance. Non-structural measures of water resources conservation are a real alternative in water resources management and should be considered and evaluated alongside the structural measures. The following water wastage reduction measure can be considered.

i) Leakage detection and repairs: The repair of visible leakages on water mains, at well heads, consumer connections, taps, etc. and detection and repair of invisible leaks will greatly enhance the water availability.

ii) Rationing of water supplies: Water rationing is another way of augmenting the water supply for a given area. Water rationing involves the imposition of water cut off to some selected areas on a rotational basis (the process is referred to as shifting). This practice is aimed at forcing consumers to collect and conserve water until their next turn to get the supply.

ii) Creation of water scarcity awareness: A campaign strategy needs to be initiated to create awareness among consumers regarding the scarce nature of water resources and the need for its quality protection and quantity conservation.

iii) Control of free flow (artesian) boreholes in the area: There are many artesian boreholes in the area, which waste water continuously. This is a serious situation that need to be address with immediate effect.

- Demand management: One way of augmenting water supplies is to reduce the pressure on water demand through restriction of water use. There are a variety of ways through which this can be achieved.

5. Metering of consumers: Water metering of consumers can reduce water usage greatly. A metered system can save water more than unmetered one. As much as a 50 percent reduction in water demand can be achieved by metering consumers in large cities. Only major consumers are being metered now while the metering of small consumers is not cost-effective. However, with increasing awareness of the water scarcity situation and increased cost of water, the economic viability of metering small consumers can also be considered.
6. Improvement of water use effectiveness: Improvement of water use effectiveness can be achieved through the imposition of high prices for water for domestic use as well as other purpose. Water rates should be such as to convey the scarcity value of the resource to the users and to foster the motivation for economic use of water. Regular leak detection and repairs of faulty pipe and plumbing facilities in pipe distribution systems and at houses could become routine conservation practices of consumes are made to pay for water equitably.

- Source enhancement: Source enhancement comprises structural measures aimed at improving the source of water. These may consist of rehabilitation of existing facilities or the provision of entirely new facilities, or their combination.

i) Rain water harvesting: rainwater harvesting comprises not only the collection and storage of rainwater in surface and subsurface reservoirs for future use but prevention of water so store from evaporation and in other artificial storage structures.

ii) Artificial recharge: Artificial recharge of ground water through surplus water resources is achieved by induced recharge, spreading and injection methods.

iii) Internal inter-basin water transfer: This refer to the inter-basin water transfer schemes where the source and the receiving basins are within the same country, in this case Nigeria. They are relatively of lesser scope and hence cost. Likewise, political and environmental considerations are less complex and their related problems are easier to solve than the external ones. Two such transfer schemes have so far been identified which are the Hawul-Ngadda and the Dindima transfer schemes. Government report on these are available and need to be pursued to their logical conclusions.

iv) External inter-basin transfer: This refer to the inter-basin water transfer schemes for which the source of water to be transferred does not originate or lie within the country to which the water will be transferred. Such transfer schemes are usually of higher dimensions involving long distances and possibly repairing various large structures to facilitate transfer and they have higher costs.

- Provision of adequate legislations: current legislations require more robust laws that will ensure sustainability of water resources. Some interviewees are of the opinion that even if the current legislations are adequate, their enforcement will be a daunting task for the authorities concerned as this will require the cooperation of the citizens.
- Stakeholder inclusion: involving local communities in water projects will address many problems from the onset. The exclusion of stakeholders in water management was evidenced by the unsustainability of most water projects under the auspices of the

rural water supply programme and host of other previous water projects initiated various past governments across the state.

- Increased investment and funding in the water sector: adequate investments in physical infrastructure and human capital will greatly contribute in the management.
- Institutional integration: Most institutions have different programmes and are independent of one another in tackling a particular societal issue. Contrastingly, coordination among the local communities is moderate to strong depending on a particular community. This is because of the traditional alignment of addressing vital issues among key members of the community.

6.0 CONCLUSION

The study has essentially examined ground water management system in the study area and identified problems associated with the management system that included; general over exploitation of the aquifer, falling water level, reduction in borehole yield, expensive pumping of water as well as some shallow wells and boreholes are put out of the system. The study suggested proper definition of a framework for ground water resources management, ground water conservation measures, demand management, source enhancement, provision of adequate legislations, stakeholder inclusion, increase investment and funding in the water sector and institutional integration to improve management system.

REFERENCES

Adkins, C. (2007) Groundwater Recharge History and Modern Recharge in the Lake Chad Basin: Sources of Salinity and FlFluidFlFlow in a Disappearing Lake, Lake Chad, Africa (cadkins@hwr.arizona.edu).

Bakari, A., Akunna1 J. and Jefferies, C. (2014) Towards Sustainable Groundwater Management in the South-Western Part of the Chad Basin, Nigeria: A Stakeholder Perspective. In British Journal of Applied Science & Technology.SCIENCEDOMAIN international. At www.sciencedomain.org

Bonsor, H. C and Macdonald A. M. (2010) Groundwater and Climate Change in Africa: Review of Recharge Studies. Groundwater Science Programme.British Geological Survey Internal Report, IR/10/075.

Bumba, J.H., M. Kida and Z. Bunu (1985). Exploitation of underground water in the Chad formation. Maiduguri as a case study in N.M. Gadzama, F.A. Adeniji, W.S. Richards and G.G.R. Thambiyahpillay (ed) Arid Zone Hydrology and Water Resources, Ibadan: University of Maiduguri, Nigeria, pp. 89-98

Bunu, M.Z. (1999) Groundwater Management Perspectives forBorno and Yobe states, Nigeria. In the Journal of Environmental Hydrology Volume 7 Paper 19. The Electronic Journal of the International Association for Environmental Hydrology. On the World Wide Web at http://www.hydroweb.com

Chilton J. (1999) Groundwater in the urban environment- selected city profiles. Balkema, Rotterdam.

Dami A, Adesina F. A and Garba S. S. (2011) Adaptation Strategies to Environmental Change in the Nigeria's Section of the Chad Basin in Journal of Geography and Geology Vol. 3, No. 1 www.ccsenet.org/jgg;

Eni, D.I, Obiefuna, J.N, Oko, C and Ekwole, J. (2011) Impact of Urbanization on Subsurface water Quality in Calabar Municipality, Nigeria. International Journal of Humanities and Social Science. Volume 1 number 10 : Page167-173.

Foster, S.S.D. (2001). The interdependence of groundwater and urbanisation in rapidly developing cities. In Urban water volume 3 number 3 page:185-192.

Global Water Partnership (2013) Trans boundary Groundwater Factsheet .the lake chad basin aquifer system. Global Secretariat ,Drottniggatan, Stockhom Sweden. At www.gwp.org.

Jacobsen, M, Webster, M., and Vairavamoorthy, K. (2012).The future of water in African cities. Why waste water? Direction in Development, Washington, DC, World Bank.

Hanidu, J.A. (1990). National growth, water resources and supply strategies in Nigeria in the 1990s. Water resources J. Nigeria Association of Hydro geologists, 1:1-6

Idu A. J (2015) Threats to Water Resources Development in Nigeria. Geology and Geophysis. At http://dx.doi.org/10.4172/jgg.1000205.

Lake Chad-HYCOS (Hydrological Cycle Observing System) 2015.Project document.Annex 5

Marte, M.A. (1986). Groundwater exploitation and drilling technology in Arid areas of Nigeria, Borno as a case study. Proceedings of the First annual Symposium and Training workshop on Groundwater resources in Nigeria, University of Lagos, Nigeria pp. 141-173

Naik, P.K, Tambe, J.A, Dehury, B.N and Tiwari, A.N (2008) Impact of urbanization on the groundwater regime in a fast growing city in central India. Environmental monitoring and assessment.

Ndubuisi, O.L. (1990). Managing groundwater resources of the Lake Chad Basin in Nigeria. Proc, of the First Biennial National Hydrology Symposium, Maiduguri, Nigeria pp. 429-440.

Ngamdu, M. B. (2015) Challenges of Adaptive Water Management in the LakeChad Basin. International Journal in Management and Social Science (IJMSS) Volume.03 Issue-09. http://www.ijmr.net.in

Oluboye, M.O. (1995). Groundwater monitoring network as an aid to averting some ecological disaster: The Case for Chad basin area. Water Resources (Journal of Nigerian Association of Hydrogeologists), 6, 57-60.

Putra, D and Baier, K. (2008) Impact of Urbanization on Groundwater Recharge – The Example of the Indonesian Million City Yogyakarta , In: UN Habitat- United Nations Settlement Programs: Fourth session of the World Urban Forum, Nanjing, China, Documentations of Germany's Contribution to a Sustainable Urban Future.

Usman, Y. M., Mohammed A., Ibrahim, B. and Saleh1, B. A. (2016) Assessment of Groundwater Quality status along River Ngadda in Maiduguri, Nigeria. In The International Journal Of Engineering And Science (IJES) Volume 5 Issue 1 www.theijes.com

Vassolo, S.Bila, M and Hamit, A. (2009) Sustainable Water Management: A Review of the Groundwater Situation in the Lake Chad Basin.Project Activities -Report N° 2.

Vassolo, S. (2012) Groundwater Need Assessment Lake Chad Basin. BY Bundesanstaltfür Geowissenschaften und Rohstoffe (BGR).

Wakida, F.T and Lerner, D.N. (2005) Non-agricultural sources of groundwater nitrate: a review and case study. Water research.

Yusuf, A.K. (2015) Groundwater Resource Management Strategy in the Nigerian Sector of the Chad Basin. In Journal of Natural Sciences Research.Volume.5, No.14.www.iiste.org