REVIVING LAKE CHAD THROUGH BENUE RIVER TO CHAD BASIN OF NORTH-EASTERN NIGERIA

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Abstract
Chad Basin is a fertile area with great agricultural potential located within Chad Basin of Nigeria with high scarcity of surface and groundwater. The research is aim at establishing sources of water supply to the Lake Chad basin and revived the agricultural potential by diverting Benue River to the basin as a result of drying up of both surface and groundwater. The study involves collection of previous data on water level followed by detail groundwater level measurement in 2007 and 2012 during which water level in 87 hand dug wells and boreholes were measured using a water level meter or graduated tape. Global Positioning System (GPS) with accuracy ±8m was used to measure the elevation and coordinates of each hand dug wells and boreholes. Results of depth to water level measured from 2007 to 2012 during dry and wet season for Middle and Lower aquifers revealed that, groundwater depletion in Middle and Lower aquifer of the Chad Formation is higher due to lesser recharge from the infiltration of seasonal rainfall or horizontal flows from flowing seasonal rivers, these indicate higher groundwater withdrawal from the aquifer. The rate of groundwater piezometric heads in the Middle and Lower aquifer are falling annually by 0.19 m/a in the rural areas and as much as 0.77 m/a with large drawdown curve where abstractions of groundwater are higher. From the findings, it is expected that, dewatering of aquifers in the Chad Formation will start to shrink from 649 years to come starting from year 2012 in urban centres to 2632 years in rural areas provided that the rate of depletion is not controlled. From the study, it is concluded that, interregional water transfer from the Benue River to Lake Chad basin is the only solution to the basin where irrigated agriculture will be revived again as food basket of Nigeria with great employment opportunity, agro-allied investment and tourism attraction.
Keywords: Chad Basin, Benue River, Inter-regional Water Transfer, Irrigation, Agriculture

INTRODUCTION

Chad Basin is located in the north-eastern Nigeria within latitudes 11° 25' to 13° 30'N and longitudes 11° 35' to 14° 00'E (Figure 1).The principal sources of water supply in the Lake Chad basin are surface ponds, rivers and groundwater, with annual atmospheric precipitation less than 700 mm per annum. According to Schoeneich, (1979), the depth of precipitation decreases from the southern to the northern part of the study with depth of precipitation up to 600 mm confining to the Sahel climatic region (Figure 2) while surface water appear seasonally with surface water of Lake Chad completely shrunk from its normal size in the sixties (Figure 3). The groundwater in hand dugs wells and boreholes in villagers and urban settlement are also drying up within the study area.

The geology of the research area is underlain by Pleistocene sedimentary Chad Formation consisting of sand, clay and diatomite's (Matheis, 1979) deposited on top of pre-Bima unconformable (Avbovbo *et al.,* 1986) The groundwater is found in Chad Formation in the Upper, Middle and Lower aquifer (Barber & Jones, 1960). Groundwater levels are reducing every year from its piezometric head as earlier flowing to the surface from boreholes located within villages and urban cities has now stop flowing. Surface water in ponds and seasonal rivers has dried up including Lake Chad; villagers have to travel far distance in search of water for their domestic and livestock drinking.

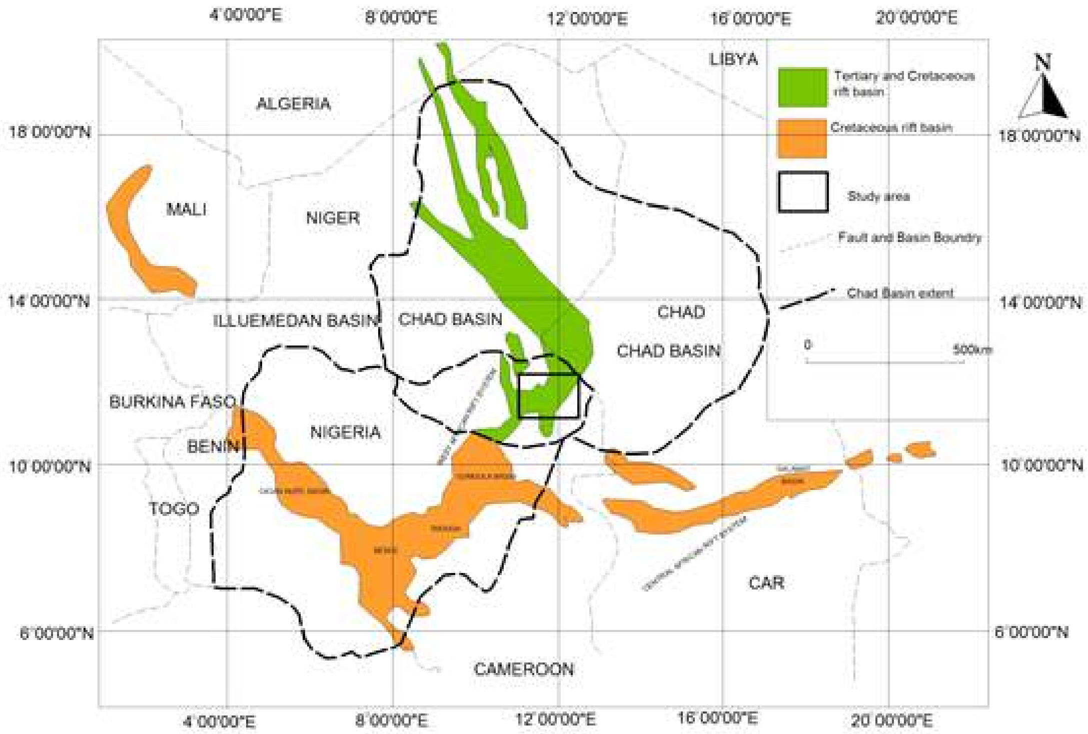

Figure 1: Location map of Borno Basin within regional setting of West and Central African Rift System (after Genik, 1993)

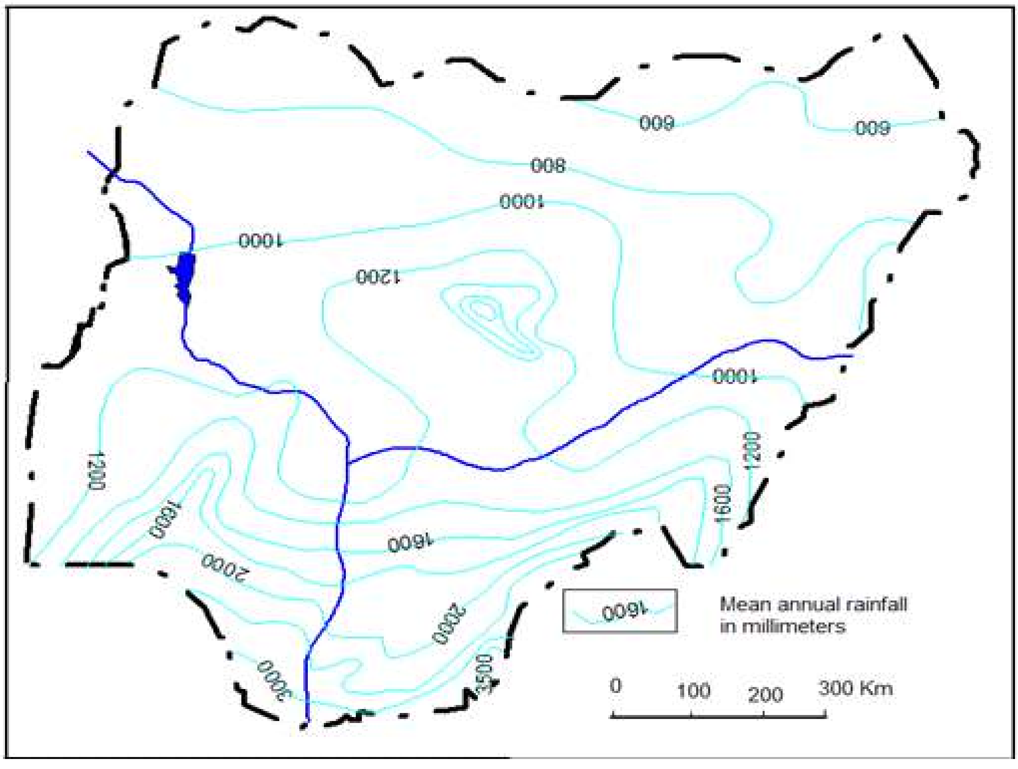

Figure 2: Rainfall map of Nigeria (after Schoeneich, 1998)

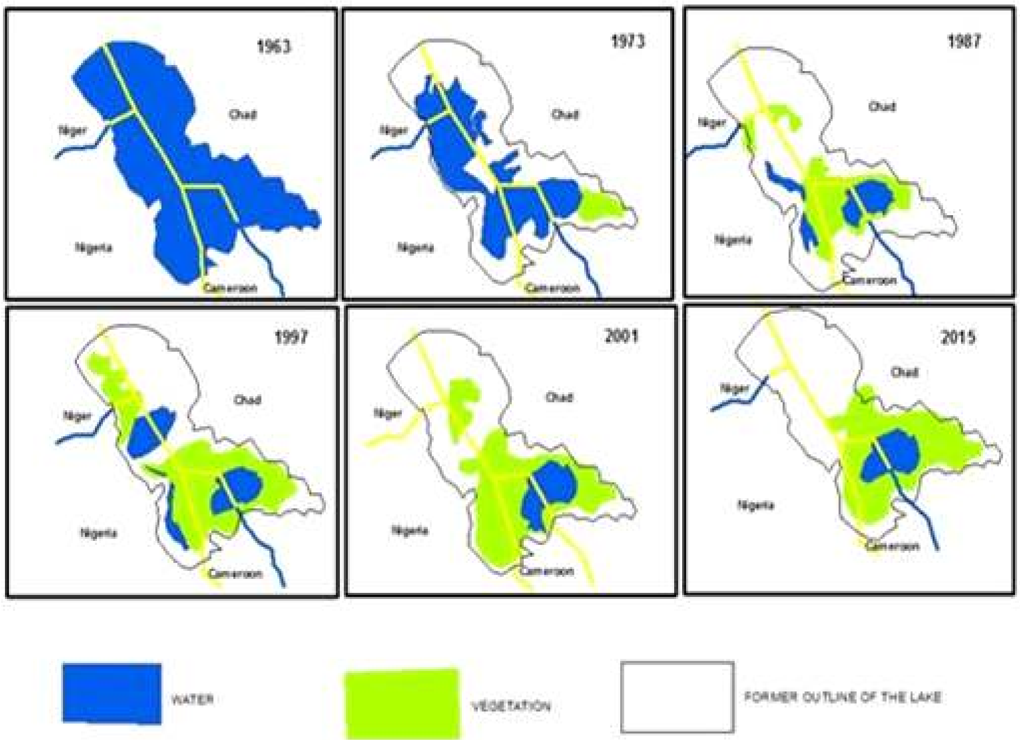

Figure 3: The receding Lake Chad (After Vassolo, 2012 and Sani, 2017)

In the earlier 1933, the Government of Northern Nigeria initiated a programme of hand dug well construction in the study area tapping upper aquifer at the depth of 50 m, 70 m and up to 85 m deep. During the long dry season, when most of the surface ponds and rivers dry up, such wells served as sources of water for the rural population and cattle watering in the study area. Also water for the livestock had to be drawn from deep hand dug wells in leather buckets and transported to villages with donkeys or camels. Sometimes the water drawn from the deep hand dug well is transferred through troughs made from hollow woods (Plate 1).

Plate 1: Villagers withdrawing water with large leather container from 84 m deep hand dug well, tapping Upper Aquifer, "C" subzone at Doilli Gubio. The well is lined with twigs and wood.

MATERIAL AND METHOD

The methodology employed in this study involved four stages; the first part is desk study, followed by field work, laboratory work and evaluation of field data. The desk study involved the assemblage of field equipment and collection of all available information such as topographic map of the study area Sheet 4 on a scale of 1:500,000 produced by Federal Survey Department, Lagos (1953). Additional materials include previous literature on water level measurement including that of Barber & Jones (1960). Other tools include: hand-held Satellite Navigator (Garmin model accuracy ±8m) used in locating position and coordinate of wells and boreholes, field notebook, writing materials, Heron Instrument Dipper-T600rT meter and metric tape were used for measuring water level depth in hand dug wells and boreholes. The research is followed with detail water level measurement in 2007, 2008, 2009, 2011 and 2012 at the end of both wet and dry season covering a period of five years of monitoring the water level.

Plate 2: A borehole at Masu drilled into Middle aquifer. Note: The borehole is now turned into hand-dug well with hope of tapping the lowered water level at a greater depth below the subsurface

83 boreholes tapping the Middle and Lower aquifers (Figure 4) were identified and measured during peak of dry season in April 2007 to 2012, while for the peak of wet season, the depth to water level were measured in August 2007 and 2012 for two years (Plate 2).

RESULTS AND DISCUSSION

From Table 1 below, the results of water level measured from 2007 and 2012 were compared with that of Barber and Jones measurement in 1960. It clearly explains the changes in the water level from 1960 to 2012 with no increase in the groundwater level, but it rather continues to loss water even during rainy season. These indicate that, rate of abstraction is higher than the rate of recharge with no indication of recharge in the study area investigated. Additionally, since 1960 when these boreholes were drilled in the research area, they have being flowing freely to the surface for over fifty-two years without capping them with valves. This has contributed in mining the groundwater in the aquifer leading to declined in head. Additionally, studies revealed that, groundwater in the Middle and Lower aquifer of the Chad Formation is depleting fast from it piezometric flow head, these indicate that, groundwater is receiving lesser recharge from the infiltration from rainfall with higher groundwater withdrawal from the aquifer with large drawdown curve as (Figure 4). Woods *et al*., (2000) used the same method to measure the decline in saturated thickness of the Ogallala portions of the high plains aquifer from the Colorado border. This portion of the aquifer has the lowest recharge. Findings from these two studies can be applied to the present study area investigated to enable monitoring the groundwater in the Borno Basin. The rate of groundwater withdrawal from piezometric wells is falling annually by 0.19 m/a in the rural areas and as much as 0.77 m/a in urban centres with large drawdown in cities of Maiduguri, Damaturu and Bama towns where abstractions of groundwater are higher (Figure 5). From the findings, it is expected that, dewatering of aquifers in the Chad Formation will start to shrink from 649 years to come starting from year 2012 in urban centres to 2632 years in rural areas provided that the rate of depletion is not controlled (Figure 6).

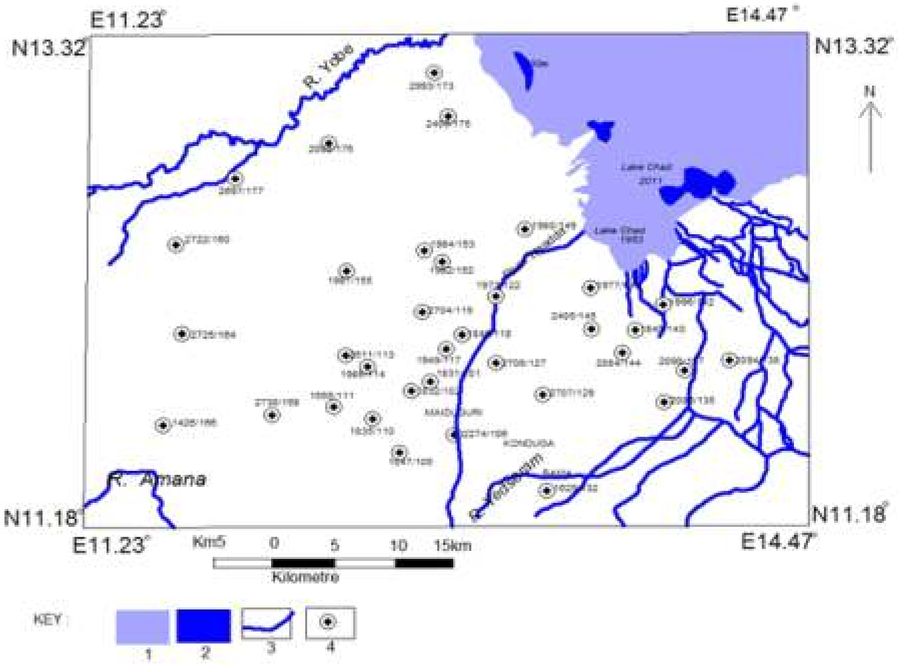

Figure 4: Location map of the study area showing the distribution of the studied hand dug wells and boreholes.

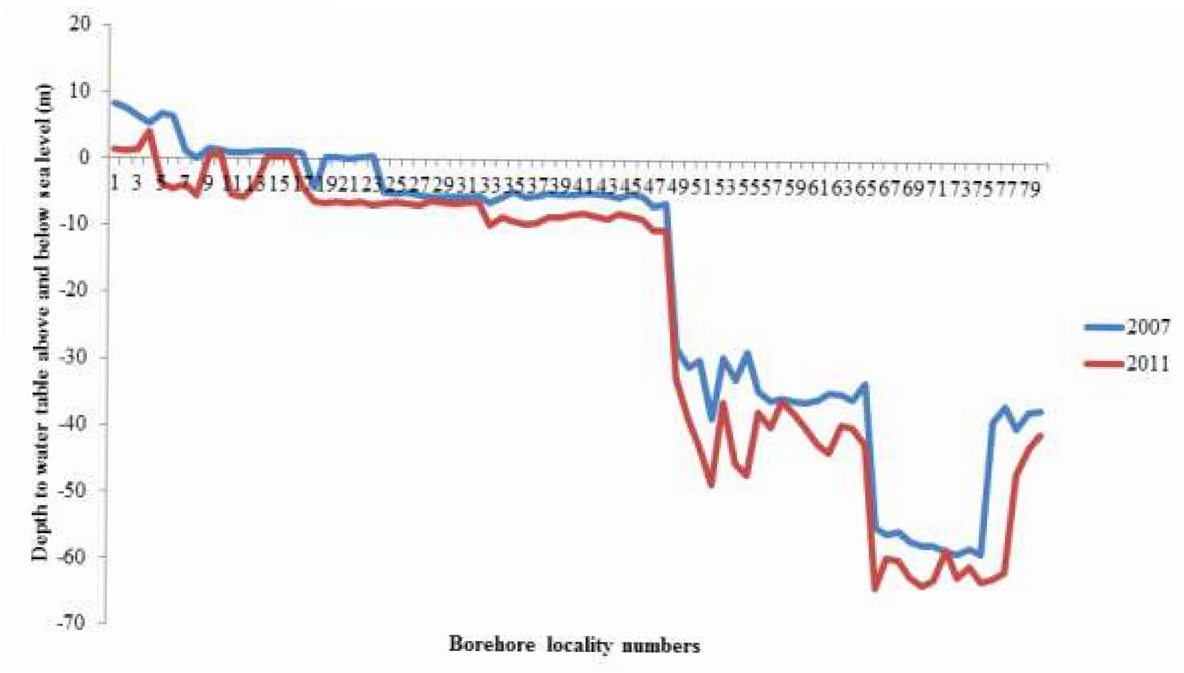

Figure 5: Plots of wet season water table elevation in the Middle aquifer

Table 1a: Change in depth to water level between 1960 and 2007

Well Identification Number		Locality	Depth to water level in meters		Water Table Change from 1960 to 2007		Elevation of Boreholes in Meters	Water Table elevation in meters above sea level in 2007
Barber and Jones 1960	Sani Adamu 2007		Barber and Jones 1960	Sani Adamu 2007	In meters	Meters per Annum		
1831	101	Maiduguri	-4.6	-34.5	-29.9	0.58	309.7	+275.2
1832	102	Chubbal	-1.1	-27.8	-26.7	0.51	317.6	+289.8
1647	105	Dalwa	+8.2	-34.8	-43.0	0.83	334.1	+299.3
2274	106	Dalori	+5.8	-36.2	-42.0	0.81	320.9	+284.7
1835	110	Auno	-9.1	-35.0	-25.9	0.50	327.1	+292.1
1555	111	Kesawa	+25.9	-29.9	-55.8	1.07	342.9	+313.0
2511	113	Magumeri	-22.9	-34.5	-11.6	0.22	339.5	+305.0
1986	114	Kingoa	+8.2	-29.4	-37.6	0.72	324.9	+295.5
1649	117	Kesengela	+9.1	-4.5	-13.6	0.26	307.8	+303.3
1846	118	Masu	+12.2	-5.5	-17.7	0.34	321.6	+316.1
2704	119	Zuntur	+12.2	-5.4	-17.6	0.38	299.3	+293.9
1973	122	Bida	+13.7	-5.0	-18.7	0.36	300.1	+295.1
2708	127	Kilboram	+9.1	-6.8	-15.9	0.31	399.6	+392.8
2707	129	Mafa	+12.2	+1.5	-13.7	0.26	300.5	+302.0
1629	132	Bama	+12.8	-55.1	-67.9	1.31	331.3	+276.2
2086	135	Mazni	+12.2	+1.3	-10.9	0.21	300.2	+301.5
2090	137	Mudu	+12.5	+1.2	-11.3	0.22	300.5	+301.7
2094	138	Kala	+11.0	+0.6	-10.4	0.20	293.8	+294.4
1996	142	Ngala	+12.2	+0.3	-11.7	0.23	290.5	+290.8
1849	143	Logomani	+13.7	+0.4	-13.3	0.26	291.4	+291.8
2084	144	Gajibo	+12.5	+1.2	-11.3	0.22	292.0	+293.2
2405	145	Ala	+15.8	+1.5	-14.3	0.28	290.2	+291.7
1927	146	Marte	+19.2	-5.0	-24.2	0.47	291.4	+286.4
1980	149	Monguno	+20.1	+1.1	-19.0	0.37	288.0	+289.1

Table 1b: Change in depth to water level between 1960 and 2012. Explanation: +4.6 Piezometric flows above sea level -10.1 below the sea level

Well identification number		Locality	Depth to water level in meters		Water table change from 1960 to 2007		Elevation of Boreholes in meters	Water table elevation in meters	Water Table elevation in meters above sea level in year 2012
Barber and Jones 1960	Sani Adamu 2012		Barber and Jones 1960	Sani Adamu 2012	In meters	In meters per annum		Barber and Jones 1960	
1831	101	Maiduguri	-4.6	-39.5	-34.9	0.67	309.7	+305.1	+270.2
1832	102	Chubbal	-1.1	-34.3	-23.3	0.45	317.6	+316.5	+283.3
1647	105	Dalwa	+8.2	-42.4	-50.5	0.97	334.1	+342.3	+291.7
2274	106	Dalori	+5.8	-43.2	-49	0.94	320.9	+326.7	+277.7
1835	110	Auno	-9.1	-43.2	-34.1	0.66	327.1	+318.0	+283.9
1555	111	Kesawa	+25.9	-43.3	-69.3	1.33	342.9	+368.8	+299.5
2511	113	Magumeri	-22.9	-48.9	-26	0.50	339.5	+316.6	+290.6
1986	114	Kingoa	+8.2	-42.4	-50.6	0.97	324.9	+333.1	+282.5
1649	117	Kesengela	+9.1	-9.5	-18.6	0.35	307.8	+316.9	+298.
1846	118	Masu	+12.2	-10.2	-22.4	0.43	321.6	+333.8	+311.4
2704	119	Zuntur	+12.2	-10.2	-22.4	0.43	299.3	+311.5	+289.1
1973	122	Bida	+13.7	-10.2	-23.9	0.46	300.1	+313.8	+289.9
2708	127	Kilboram	+9.1	-10.9	-20.0	0.3	399.6	+408.7	+288.7
2707	129	Mafa	+12.2	+0.7	-11.5	0.22	300.5	+312.7	+301.2
1629	132	Bama	+12.8	-59.7	-72.5	1.03	331.3	+344.1	+271.6
2086	135	Mazni	+12.2	-6.7	-18.9	0.36	300.2	+312.4	+293.5
2090	137	Mudu	+12.5	-6.4	-18.9	0.36	300.5	+313.0	+293.5
2094	138	Kala	+11.0	-6.6	-17.6	3.38	293.8	+304.8	+287.2
1996	142	Ngala	+12.2	-8.4	-20.6	0.40	290.5	+302.7	+282.1
1849	143	Logomani	+13.7	-8.7	-22.4	0.43	291.4	+305.1	+281.1
2084	144	Gajibo	+12.5	+0.5	-12.2	0.23	292.0	+304.5	+292.3
2405	145	Ala	+15.8	+0.5	-15.3	0.29	290.2	+306.0	+290.7
1927	146	Marte	+19.2	-10.9	-20.0	0.57	291.4	+310.6	+280.7
1980	149	Monguno	+20.1	+0.2	-19.9	0.38	288.0	+308.1	+288.2
1982	152	Gajiram	+11.0	-6.4	-17.4	0.33	291.4	+302.4	+285.0
1984	153	Sabsawa	+12.5	-6.8	-19.3	0.37	296.6	+309.1	+298.8
1987	155	Gubio	+3.7	-6.8	-10.5	0.19	302.4	+306.1	+295.6
2722	160	Kusur	-36.6	-65.3	-28.7	0.55	332.8	+296.2	+267.5
2725	164	Bulturi	-37.5	-58.7	-21.2	0.41	350.5	+313.0	+291.8
1426	166	Damaturu	-46.6	-64.0	-15.8	0.30	398.7	+352.1	+336.3
2730	168	Beneshiek	-25.3	-64.0	-38.7	0.74	358.4	+333.1	+294.4
2993	173	Bisku	+15.8	+1.4	-14.4	0.28	293.8	+309.6	+295.2
2406	175	Banowa	+16.3	+1.4	-14.9	0.97	296.0	+312.3	+297.4
2000	176	Zari	+8.8	-4.4	-13.2	0.25	305.4	+314.2	+301.0
2697	177	Ngaltara	+4.6	-5.5	-10.1	0.19	317.3	+321.9	+311.8

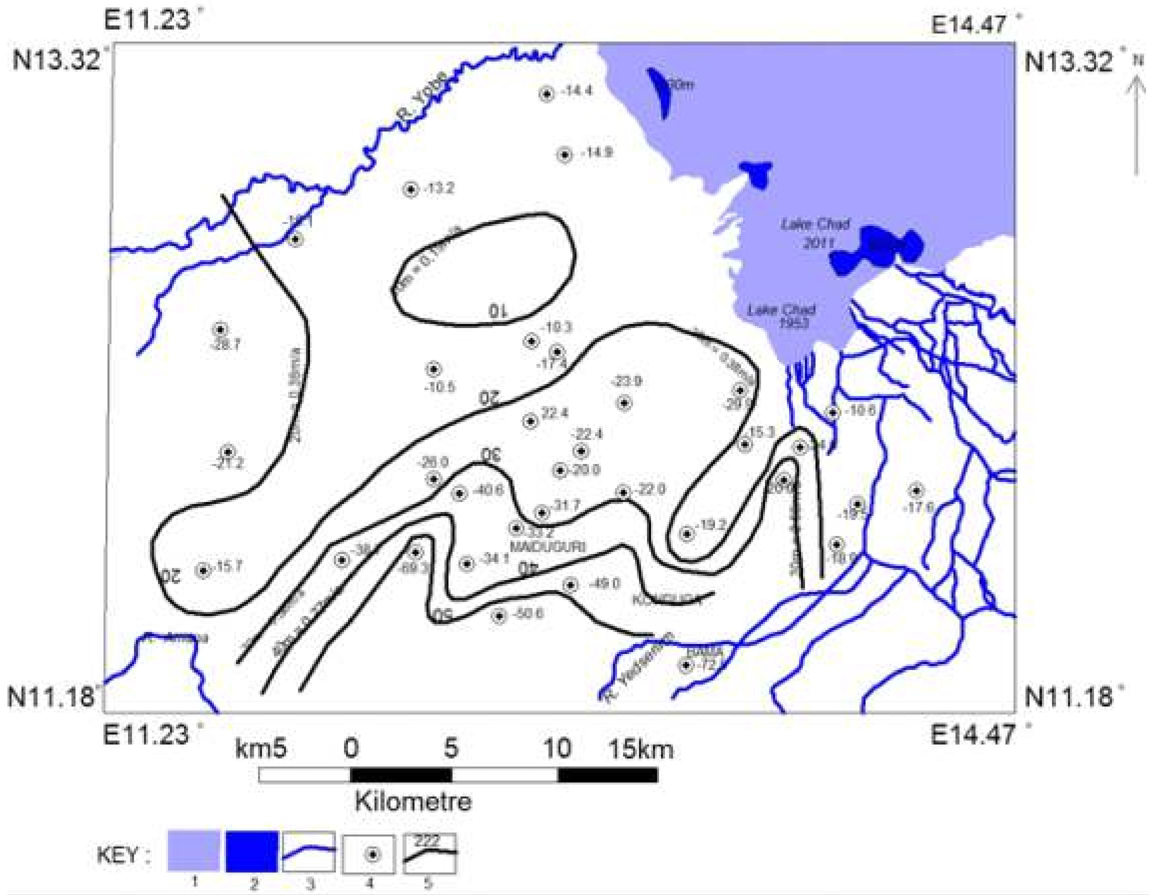

Figure 6: Rate of depletion of the piezometric surface in Chad basin between 1960 (Barbers measurements) and 2012 (Sani Adamu's measurement). Explanation: 1- Lake Chad in 1960, 2-Lake Chad in 2011, 3- River channel, 4–Boreholes and depletion of the water level in meters between 1960 to 2012; 5- Contours of isochron of water table depletion between 1960 to 2012 in meters per year.

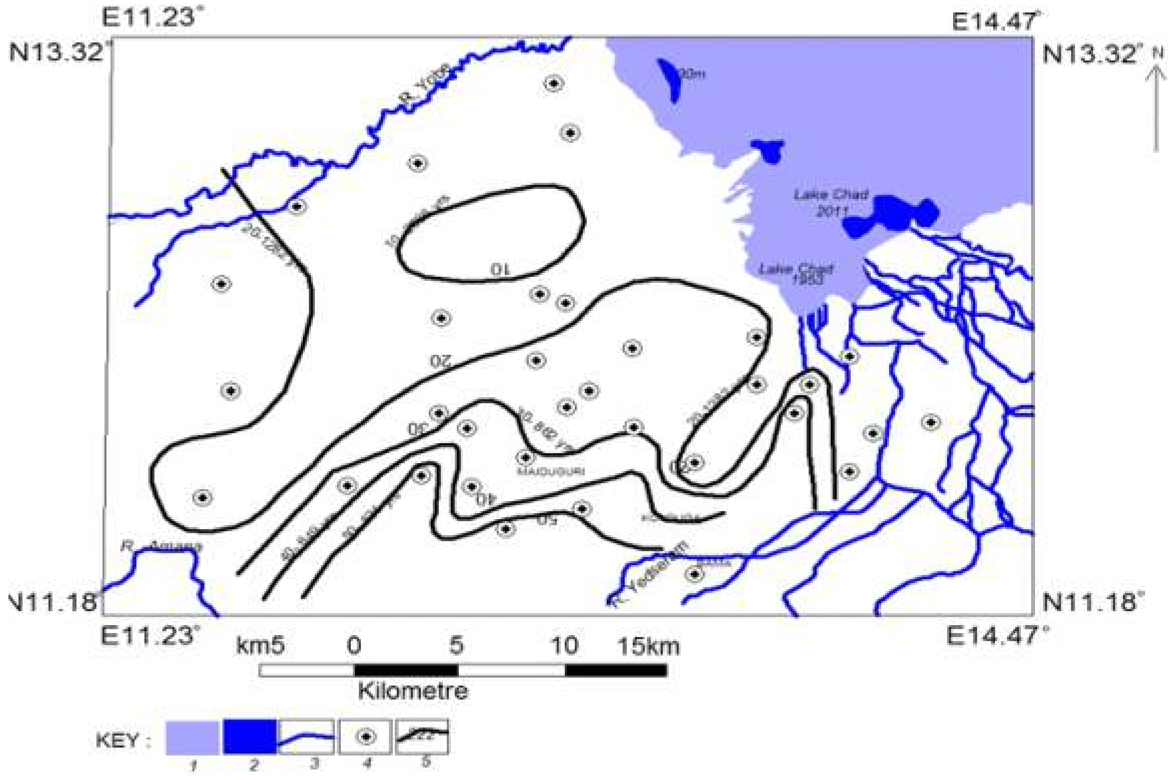

Figure 7: Expected year's groundwater in Middle and Lower aquifers will be exhausted. Explanation: 1-Lake Chad in 1960, 2- Lake Chad in 2011, 3-River Channel, 4- Boreholes used for construction of this map; 5-Isochron in years of expected when all water present in Middle and Lower aquifer will be exhausted Note: 40m/52 years = 0.992 m/per year, = 2632 years to expect complete drying up of the aquifer.

Figure 6: Rate of depletion of the piezometric surface in Chad basin between 1960 (Barber's measurements) and 2012 (Sani's measurement). Explanation: 1-Lake Chad in 1960, 2-Lake Chad in 2011, 3- River channel, 4–Boreholes and depletion of the water level in meters between 1960 to 2012; 5- Contours of isochron of water table depletion between 1960 to 2012 in meters per year.

However from the study, it can be concluded that, the only solution to save this water crises in the Chad basin is the inter-regional water transfer from Benue River to Chad basin through inter river Gongola in Gombe State to inter river Ammana in Yobe State and finally to Ngadda River in Borno State (Figure 8). Through this method, the groundwater and surface water will be recharge and replenished the existing dry land to it glory where irrigation will be active and became the food basket of Nigeria as in eighties again.

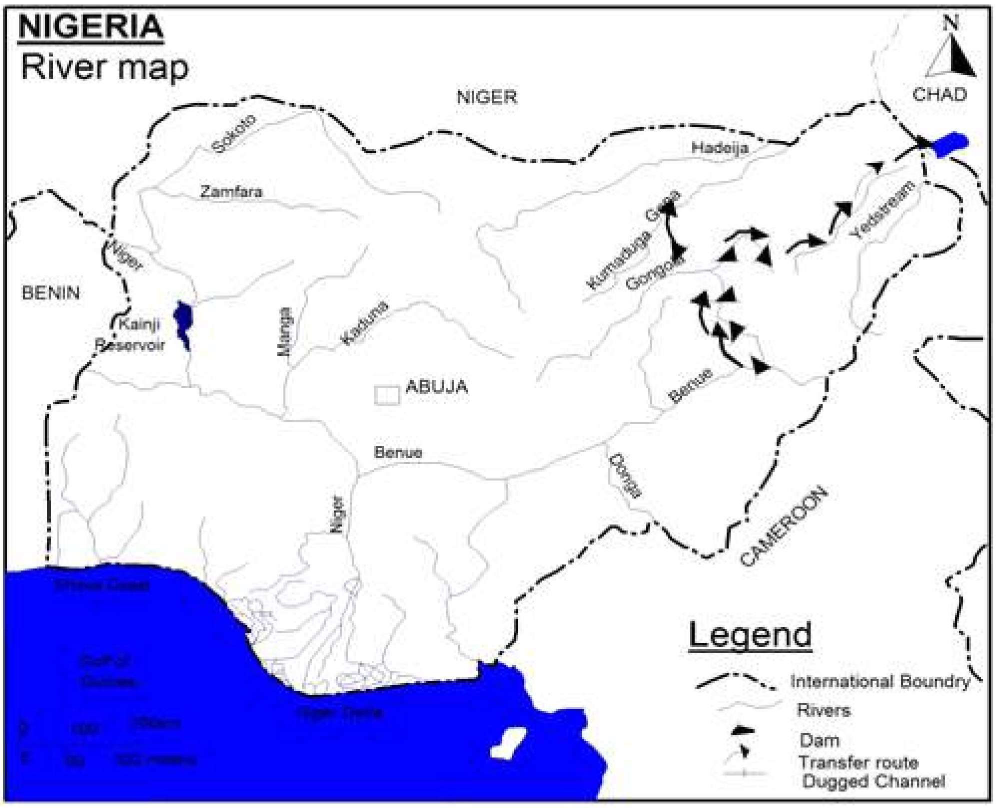

Figure 8: Proposal for interregional water transfer from Benue River to Lake Chad (Base map from *htt//pubs.usgs. Retrived 2014).*

CONCLUSION

From the research, it can be concluded that, Chad basin is drying up, as water in hand dug wells and boreholes are getting deeper and deeper from it water level, surface flow in rivers has dries up with surface water of Lake Chad shrinking from its normal size compared to the sixties. Therefore inter-regional water transfer from Benue River to Lake Chad is necessary to save the drying land and boost the agriculture through irrigation and tourism attraction.

REFERENCES

Avbovbo, A. A., Ayoola, E. O., & Asahon, G. A. (1986). Depositional and structural styles of the Chad Basin of North-eastern Nigeria. *Bulletin of American Association of Petroleum Geologist Volume 70, No.12 pp. 22-27.*

Barber, W. M., & Jones, D. R. (1960). Geology and Hydrology of Maiduguri Borno Province. *Records of Geological Survey, 1958, Bulletin 34.*

Barber, W. (1965). Pressure water in the Chad Formation of Borno and Dikwa Emirate, Northeastern Nigeria. *Geological survey of Nigeria Bulletin No.35.*

Federal Survey Department, Lagos (1953). *Topographic Map of Nigeria on a scale of 1:500,000 Sheet 4 (fifth Edition).*

Genik, G. J. (1993). Petroleum Geology of Cretaceous to Tertiary Rift Basins in Niger, Chad and Central African Republic. *Bulletin of American Association of Petroleum Geologists Volume 3 (77). pp, 1334-1456*.

Matheis, G. (1976). Short review of the geology of the Chad Basin in Nigeria. In Kogbe, C.A. (eds), *Geology of Nigeria:* Elizabeth and Publishing Company, Lagos. pp *288-297*

Schoeneich, K. (1998). *Geology 405 Lecture Notes.* Department of Geology Ahmadu Bello University Zaria.

Sani, A. (2017). Declining groundwater level in the Borno basin of north-eastern Nigeria. Unpublished Ph.D Dissertation *Department of Geology Ahmadu Bello University Zaria.*

Vassolo, S. (2012). Groundwater needs assessment. Lake Chad basin. *Bundesanstalt Fuer Geowissenschaften und Rohstoffe* (BGR) pp. 32-39

Woods, J. A., Schloss, J. M., & Buddemeir, D. H. (2000). Determining the water level change from wells tapping the Ogallala aquifer in the western portion of the high plains aquifer of Colorado border.

http//pubs.usgs.gov/circ1217/.

http//pubs.usgs.Retrived 2014