DYING LAKE CHAD: ADAPTIVE STRATEGIES TO CLIMATE CHANGE AND WATER SCARCITY OF THE LAKE CHAD BASIN

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ABSTRACT

The current situation of over 90% shrinking of Lake Chad has been described by the Food and Agriculture Organization (FAO) as an “ecological catastrophe”. As noted by a former Nigerian President, Olusegun Obasanjo in 2015, Lake Chad may no longer exist in 30 years’ time. Hence, we must ensure that the 47 million people who depend on this lake for survival are prepared for the worst possible scenario. There is an indication that the Nubian Sandstone Aquifer (NSA) which extends to Chad could be the sustenance of the lake. Rather than propose further huge expenditure in efforts to recharge the dying lake by inter-basin water transfer, it is realistic to face the fact that regardless of whether the lake level rises, is maintained or completely dries out, the basin is foreseen to experiencing increasing desertification, which in turn will result in increased food insecurity in the region. From robust water harvesting, adoption of water-saving agricultural practices, fishing and fishery activities regulation, water policy formulation and implementation to aggressive awareness of climate change, there is the need to prepare the dependent populace for the unpleasant economic, agricultural and political implications. Analyzing the current condition of the lake in comparison with other existing and preexisting surface and groundwater aquifers, combined with available research findings, this paper outlines adaptive strategies for the populace around the Lake Chad-with and without water.

Keywords: Lake Chad, Adaptive Strategies, Nubian Sandstone Aquifer, Groundwater, Hydraulic flow, Sustainable Livelihood.

1. INTRODUCTION

In recent decades, the water surface area of Lake Chad has reduced from approximately 25000 km² in 1963, to less than 2000 km² in the 1990s, heavily impacting the Basin’s economic activities and food security. In the Sahelian zone, direct infiltration from rainfall through the unsaturated zone is usually very small. This is the case in the Lake Chad drainage basin, where recharge into the phreatic aquifer is due mainly to infiltration from the water courses, floodplains and from the edges of Lake Chad. For a normal Lake Chad condition at 280m altitude, it is estimated that the water volume removed annually from the lake via seepage is 8.8 billion m³ (i.e. 18% of the mean annual water inflow into the lake: Eric, 2006). Like everywhere in sub-Saharan Africa, the overwhelming majority of the population of the Lake Chad Basin (LCB) is rural, poor and depends on agriculture for its livelihoods. Seventy-five to 80 percent of the farming population consists of traditional smallholders, producing mainly staple foods for household consumption and with relatively marginal connections to market (IFAD-FAO, 2008).

The resources of the Lake and its basin provided for the livelihood of about 47 million people (Hamidu, 2016), most of whom are farmers, fishermen and livestock breeders. But today the resources are fast diminishing as a result of several decades of droughts

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and desertification caused by declining rainfall, high winds and temperature rise in the Sahel region. Sections of population along with their herds have migrated southward.

1.1 The Lake Chad Basin & the Lake Chad

The Lake Chad Basin is unique, being such a large freshwater reservoir found so far from seas and oceans and in such a hot and arid climate. The hydrographical basin area is 2,381,631 km$^2$, which is approximately 8% of total surface area of Africa, with an active basin area of 966,955 km$^2$ (UNEP, 2004). The basin is shared by the Republics of Chad (45%), Niger (28%), the Central African Republic (CAR) (9%), Nigeria (7%), Algeria (4%), Sudan (4%), Cameroon (CMR) (2%) and Libya (0.5%). Although Chad and Niger are those with the largest share of the basin territory but three quarters of the lake water comes from the CAR and Cameroon.

For development, conservation and planning, the LCB has been subdivided into eight planning units: (1) Lake Chad including Kanem lakes, (2) Lower Chari, (3) Lower Logone including the Yaeres and El Beid, (4) Mayo Kebbi and other Mandara Mayos/rivers, (5) Borno Drainages, (6) Komadugu-Yobe, (7) Northern including Bahr el Ghazal, and (8) Lake Fitri as shown in Figure 1 below:

![Figure 1](Image)

**Figure 1.** The Lake Chad Basin showing the main contributing rivers and the Lake Chad

The boundaries of which watershed divides or other major ecological divisions based on surface water flow. Global Water Partnership (GWP) in 2013, subdivided the LCB into two main hydrological sub basins:

(a) The Chari-Logone subsystem, which covers approximately 650,000 km$^2$ and hosts the Chari River and the Waza-Logone flood plains contributing about 95% of total water inflow into the lake (FAO, 1997)

(b) The Komadugu-Yobe subsystem, which covers 148,000 km$^2$ but contributes only 2.5% of the total riverine inflow into Lake Chad.
The Lake Chad is considered as a Ramsar site because of its biodiversity.

1.2 Livelihood around the Lake Chad

Generally, the Lake Chad region is relatively less industrialized, however the commencement of oil exploitation in southern Chad may trigger industrial development. Virtually all the wetlands in the region are either dried up or on the verge of drying up. This has led to serious environmental degradation in the basins such as loss of biodiversity, modification of ecosystem, desertification and sedimentation of the water bodies.

The Lake itself supports:

(1) a major fishery shared by all nations either adjacent to its shores or who engage in trade and a major livestock industry which depends on seasonal entrance into the lake bed for forage;

(2) a variable transport industry that occurs mostly at high lake levels;

(3) an undocumented gathering "production system" based on doum palms subirrigated by the lake, aquatic plants, and salt flats;

(4) a morribund irrigated agriculture along the shores of the Nigerian side of the lake that pumped water from the lake for irrigation and the cooling systems for electricity generation;

(5) a wildlife heritage and possible tourist industry consisting of wetland birds, crocodiles, hippos, elephants, and the sitatunga in the Nguru wetlands;

(6) a passive "pollution" control system keeping the water from becoming too saline;

(7) a groundwater recharge system that is little understood but may supply the polder agricultural developments on the northeast shores of the lake;

(8) Residual moisture (polder) cultivation of wheat, sorghum, maize, potatoes, cowpea and vegetables;

(9) Exploration and exploitation of mineral resources including gold and crude oil;

(10) Manufacturing, especially cotton ginning, leather work/tannery, milling etc.

Table 1. Economic livelihood and the Chad Basin contribution to riparian countries

| Distribution of: (a) Basin household income by sector (Million USD) |
|------------------------|-----------------|-----------------|-----------------|-----------------|
| Fishing                | Rain-fed & flood recession cropping | Animal husbandry | Small irrigated areas | Large Irrigated areas |
| 45.1                   | 26.6            | 14.7            | 10.8            | 9.4             |

(Source: Adapted from Nami, 2002)

<table>
<thead>
<tr>
<th>(b) Land area and Gross National Income (GNI) by country</th>
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<tbody>
<tr>
<td>Basin Portion (%)</td>
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<tr>
<td>--------------------------------------------------------</td>
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<tr>
<td>GNI per Capita (US$)</td>
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<td>GNI per Capita (US$)</td>
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(Source: Adapted from Eric, 2002 and FAO, 1997)
2. DYING LAKE CHAD

The exploitation of the LCB and the groundwater abstraction have been increasing since the middle of the 20th century. Nowadays, both because of overexploitation and reduced recharge flows, groundwater level is declining in the Upper, Middle and Lower Chad Formation, (from -19.8m, +11.2m and +5.8m to -33.1m, +0.1m and -61.81m (Yusuf, 2015). A high dependency rate is closely linked to drier climate and agriculture-based economy (GWP, 2013). The lake experiences a close interaction between rainfall, evaporation, lateral inflow, groundwater leakage under the body of the lake and human abstraction. The water balance of the lake is highly variable, resulting in dramatic expansion and contraction of lake water surface area over geologic and recent history (World Bank, 2002b). The LCB particularly faces physical water scarcity, due to its location in the semi-arid region; and economic water scarcity, because the region has not developed appropriate technologies to effectively use its water resources. Unsustainable exploitation or use of water resources of the lake by both the upstream and downstream residents of the basin is among the factors driving the lake to extinction as can be seen in Figure 2 below. Large and unsustainable irrigation projects and impoundments built by Niger, Nigeria, Cameroon and Chad which have diverted substantial amounts of water from both the lake and the Chari and Logone rivers have greatly contributed to the shrinking of the lake. A number of challenges that limit effective integrated management and development of the LCB therefore became obvious. These included the conservation of available limited water resources, restoration of the lake level and its ecosystem, tackling the problem of drought and desertification arising from rainfall deficits, inefficient system of data collection, and regional cooperation.

2.1 Climatic features, Climate Change and Water Scarcity

Aside from the drop in annual rainfall, overgrazing, bush burning and deforestation are major factors contributing to desertification around the LCB. The range of mean annual precipitation has varied from 1,400 mm down to less than 500 mm (Yusuf, 2015).

The major concern of high temperatures is their impact on evaporation and transpiration rates in plants. Relative humidity, used to assess the evaporative demand of the atmosphere is influenced by two factors: the advance and retreat of the rain belt, and the large bodies of surface water. The dry season in the LCB is characterized by hot and dry winds from northeastern directions. In the rainy season, the south-westerly monsoon winds are predominant.

Evapotranspiration is extremely high in this region, reaching 2,300 mm/year. However, the high rate of evaporation in the lake due to its proximity to the Sahara Desert has, paradoxically not affected the salt content of its waters. Lake Chad has low levels of salinity because the more saline waters sink and exit the lake through subterranean path probably in the north, among other things where heavy duty pumping has been going on in Libya. Although still speculative, reports on the evapotranspiration rate around the lake and the “constancy” of the salinity of the lake water over time suggest that infiltration and underground seepage may have been accounting for the lake water losses that have been given credit for. Water outflow by infiltration or underground seepage with the salt may be escaping together with the lake water to wherever the latter goes.

It is however believed that the lake is been recharged from the Nubian Sandstone Aquifer (NSA) which stretches across over 2000000km$^2$ across sub-Saharan Africa including TChad. There is every possibility that the huge water project northwards of the lake, especially the Great Man-Made River project in Libya which is expected to drill 1300 wells over 500m deep into the aquifer pumping up to 6500000m$^3$ of water...
per day over a 4000km distance could pose huge strain on the interconnected aquifers.

Figure 2. Chronology of Lake Chad variability 1963-2007

2.2 Challenges to Human, Natural and Water Resources

The Lake Chad region is trying to cope with mass poverty. The percentage of poor households in the region is likely to be 60% or more (IMF 2003). Standards of health in the region are overall very poor. However, there is a great disparity between the northern countries of Algeria and Libya, which have far higher standards of health than the sub-Saharan nations. According to Kindler et al. (1990), the Basin exhibits a socio-historical unity based on a history shared by the established population groups some of which straddle national boundaries.

Women represent about 52% of the population and have a heavier workload but have lower access to education, information, agricultural extension services, inputs and credit as compared to men. Despite their huge involvement in activities ranging from cultivating cereals to processing of harvested fish, considerable land-related gender disparities still exist. Women in the Nigerian zones of the project own only 4% of the lands. For all practical reasons, surface water resources do not exist north of Lake Chad owing to the extremely low rainfall, high evaporation rates, and high infiltration capacity. The main collection areas for water which feed the lake are:

- upper catchment of the Logone rising in the CAR and Cameroon, and converging at Lai. (Figure 1) and
- upper catchment of the Chari river rising in the CAR and Southeastern TChad, in particular the Bahr Sara tributary which joins with other tributaries downstream of the city of Sahr. (See Figure 1)

The lower reaches of the above rivers act as dispersal zones in which uncontrolled irrigation and flood recession cropping is widely practiced.
Table 2. Major environmental problems in the Lake Chad Basin

<table>
<thead>
<tr>
<th>Environmental Problems due to lake’s Geographical location</th>
<th>Environmental Problems due to economic development activities</th>
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<tbody>
<tr>
<td>Aridity (4 climatic zones: hyper arid, arid, semi-arid, and sub-humid)</td>
<td>Deforestation and uncontrolled bush burning</td>
</tr>
<tr>
<td>Climate variability</td>
<td>Habitat and community modification</td>
</tr>
<tr>
<td>Persistent droughts (1970-1980s)</td>
<td>Unsustainable agricultural practices</td>
</tr>
<tr>
<td>Desertification</td>
<td>Mining activities (gold)</td>
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<tr>
<td>Water shortage</td>
<td>Agro-chemical and oil exploration triggered pollution</td>
</tr>
<tr>
<td>Erosion</td>
<td>Sedimentation of rivers and water courses due to unsustainable farming practices</td>
</tr>
<tr>
<td></td>
<td>Proliferation of invasive flora and fauna</td>
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<tr>
<td></td>
<td>Groundwater exploration projects North of the lake as far as Libya.</td>
</tr>
</tbody>
</table>

(Source: Ayuba, 2009)

2.3 Implications of Dying Lake to Livelihood

Although many boreholes have been drilled in the area for urban and rural water supplies, exploratory drillings for oil, feasibility studies for various projects, etc., data available are still not sufficient to resolve several controversies that have arisen over the hydrogeology of the basin. For Lake Chad, vulnerability is shaped by a growing population that is pursuing limited resources at the same time. The decreasing volume of the Lake Chad since 1963 has reduced access to water, culminated in crop failure, led to livestock death and collapsed fisheries as well as destruction of wetlands, services, loss of livelihood. It has also caused unemployment, increased poverty, criminality, facilitated forced migration, and increased hydro-political conflicts within and around the LCB. If this situation persists or worsens in future it will have significant impact on the local economy, the lake and its tributaries (Chari and Logone).

(a) The Lake’s wildlife and riparian populations incessantly migrate in search of areas with water around the lake and as such, overcrowding consequently results in reduced standard of living due to high competition for limited resources.
(b) Scarcity of food and water for the animal herders have forced mass emigration to other parts of the countries in search of greener pastures.
(c) Conflict over limited and diminishing natural resources has become the order of the day for dwellers around the lake across countries and between users
(d) With available water, this area was chief source of livelihood to nearby urban cities such as Maiduguri which depends on activities around the lake for her livelihood. Drastic lake recession gradually overturned into hike in food prices.
(e) Due to unavailable pasture, herders have shifted from rearing grazing animals.
(f) As the lake gradually dries up, groundwater cost becomes unbearably high as the head required becomes higher and higher and so does the cost.

3. ADAPTIVE STRATEGIES TO SUSTAINABLE LIVELIHOOD

Although it can be argued that there is not much left to be managed, the little left has to be protected. Sustainable livelihood lays emphasis on the livelihood system of marginal groups, particularly the poor, and the way in which they adapt to maintain their livelihoods under conditions of environmental, socio-economic and political stress. A livelihood is therefore perceived to be sustainable ‘when it can cope with and
recover from shocks and stresses and maintain and enhance its capabilities and assets both now and in the future, whilst not undermining the natural resource base. Humans have been adapting to changing climatic conditions and to the impact of extreme climate events in the LCB for several centuries. Much of this adaptation occurred gradually and spontaneously and the economies of many local communities in the basin to this day still depend on sophisticated production and social systems adapted to manage climate risk and variability. These adaptive systems included finding alternative opportunities; liquidating assets; gathering and selling of non-timber forest products; intensification of farming, often associated with rapid and unsuccessful sowings of the principal crops at the onset of the rains and application of manure. The first option for tackling water scarcity in the LCB will require better management of existing water resources. Productivity could be increased without necessarily expanding the amount of land or the amount of water available. This means more crop per drop’ (IFPRI, 2009). Another option is to levy charges on bulk water users such as irrigation farmers using water pumps and bottling companies amongst others. Water pricing can give users an incentive to use water more efficiently, and thus reduce overall demand.

3.1 Economic Livelihood

Water saving at one place is likely to reduce return flows to other users in the basin and it is important to note here that water conservation may not necessarily lead to increased water productivity and cost is not as important here as the livelihood of millions. The economic stresses and regional conflicts that are arising in water short regions point to water scarcity as the most serious challenges faced by the international community. A critical problem facing mankind today is how to manage severe competition for water between the traditional agricultural sector, expanding urban and industrial centers and in stream water uses dictated by environmental concerns.

3.1.1 Animal and Crop Husbandry

Conservative agriculture is very little known in West and Central Africa. It can be difficult for many people to accept it because it goes against many of their cherished beliefs. How can crops be grown without ploughing the land? Overcoming this mindset of the need for ploughing is a major step in achieving successful conservative agriculture systems. It is more difficult to accept in arid and semi-arid regions where livestock is a dominant activity and crop residues are used to feed animals.

(a) Reduction in per capita domestic water use, reduction of losses caused by pollution and increasing the efficiency of irrigation, through use of drip irrigation, micro/mini sprinkler, PVC pipes, tube wells and wrapped filter.

(b) Irrigation under water scarcity conditions will have to be practiced on large scale as population explosion is foreseen in the arids. A policy promoting judicious use of water in agriculture has to be framed for irrigated areas. The principal element of such policy is to maximize production per unit drop of water or per unit of land, depending on whether water or land is more restricting.

(c) Measures to recycle and reuse of lower quality water have to be pursued. Strategies have to be devised for proper crop planning to match water availability and to introduce water stress tolerant crops.

(d) Rain water harvesting, floodwater and groundwater harvesting, recycling of drainage water.
The development and implementation of regulations to control livestock rearing and herd-based migration around the Lake Chad.

Encouraging hay farming, harvesting and ranching as an alternative to free ranging (Nomadism) and the challenges it poses to animal life and the ecosystem.

Optimum use of surface water and groundwater for irrigation as well as optimize the use of non-water inputs such as fertilizers and pesticides.

Reducing non-beneficial depletion and adoption of optimal cropping pattern.

Dissemination and adoption of Integrated Pest Management (IPM) techniques to minimize loss and return to biological/refined traditional methods of weed and pest control.

Integrated agriculture to maximize crop yield and hence profit by using animal waste as organic manure with little or minimal damage to soil structure.

Optimal irrigation times and scheduling to minimize water wastage and losses, improving flood defensives and strengthening of banks from erosions.

**3.1.2 Fishery and Aquaculture**

As can be seen in Table 1(a) above, in order of dependence on water, fishery is the highest. To control this overexploitation, there is need to identify and implement pilot projects to explore best practices and tools that can be used for implementing practical actions for adaptation to climate change.

- **(a)** Re-afforestation of deforested areas and reduction of deforestation levels through community awareness projects should be incorporated into better post-harvest processing. For example, a programme should be created to ensure re-planting of trees, from which wood is used in drying and smoking fish.

- **(b)** Conversion of river banks to vegetable gardens; promotion of modern fish drying techniques and improvement of market infrastructure to reduce post-harvest losses; implementation of water conservation measures during droughts; and awareness raising amongst fishers on responsible fishing and best practices for reducing inappropriate and damaging use of fishing gear.

- **(c)** Improving the production and value chain systems through the improvement of fish post-harvest processing and preservation methods, strengthening and financing (“climate proofing”) aquaculture initiatives and improving access to credit scheme.

- **(d)** Aquaculture should be encouraged as a possible adaptation measure. There is need to increase financing and initiatives in aquaculture, to diversify revenue streams from fisheries and to promote wider diversification of livelihood.

- **(e)** An awareness and communication strategy to educate the fishing communities on climate change and possible mitigation measures (e.g. destructive fishing methods) and to develop and implement regional actions on poverty reduction and alternative livelihoods especially in aquaculture and skill acquisition in non-fish enterprises by promoting the diversification of sources of income for fishers.

- **(f)** Regional cooperation on actions for poverty reduction and alternative livelihoods should be considered important as a policy support to address the lack of knowledge regarding exposure and impact of climate change on the fisheries communities.
3.2 Socio-Cultural and Policies

With a global drive towards sustainability, water is chief among natural resources under consideration. Policies should be formulated with sustainability as a priority. Conflicts among water users are not necessarily bad. This friction should create energy which should be harnessed more to spark constructive light than to generate destructive heat. Climate change causes widespread vulnerabilities and significant impacts on water resources. It is a high priority to implement sustainable water management along with empowerment of stakeholders in water governance for climate change adaptation. Planning for adaptation cannot rely solely on conventional engineered infrastructure, but should incorporate restoration and management of the natural infrastructure provided by ecosystems.

(a) Building an investment prospectus to attract contributions from the public and private sectors to long-term trust fund.

(b) Integrated Water Resources Management (IWRM) involving all the stakeholders

(c) Judicious allocation of water to all sectors and better water governance.

(d) Water Charter, water policies and laws should be formulated that enables transparent definition of rights, roles and responsibilities, including sufficient allocation of water to sustain healthy ecosystems.

(e) Dividends from investing in watershed services need to account for the benefits of ecosystems and water security for livelihoods and economic development.

(f) Mass literacy programme targeted at creation and consolidation of women’s and youth entrepreneurship, where communities are empowered to act as their own advocates with locally owned knowledge.

(g) Formation of policies aimed towards reducing gender disparities in the LCB to facilitate the women’s participation in the programme and their access to land security, decision-making and investment, on the one hand, and by enhancing the organizational capacity of women’s producer groups. This is an area where gender inequality is very high currently.

(h) Vulnerability to climatic is shared across other types of vulnerability; therefore, reducing vulnerability in general will assist in reducing vulnerability to climate change.

4. CONCLUSIONS

A critical precondition for effective water resources management is proper understanding of the source of the groundwater. In spite of the lack of knowledge on basic hydrogeological parameters of the aquifers and piezometric data, environmental isotopes will enable the identification of the provenance of different types of recharge. The mechanism of the recharge for wells along the Lake Chad is not uniform. To improve the supply and guarantee for a given water demand, much more needs to be known about the interactions between groundwater and the surface water (Lake Chad, local ponds), from the hydrodynamic and hydro-geochemical point of view.

First, countries within the basin have to be supported with funds to prepare National Adaptation Action Plans for sustainable development vis-à-vis, the expected climate change impacts. Second, the International community could assist in the provision of insurance against climate risks. Individuals, communities and countries within the LCB
have no insurance against extreme weather events and the private insurance industry is poorly developed. Initiatives in this regard could spread risk, ensure continuity of government operations after a severe loss event, and most important, help to ensure that adequate adaptation measures are taken (Yohe et al 2007). The need is to develop public-private partnerships to expand insurance against climate-related events in the region. Such initiatives, according to Yohe et al., the objective of insurance in this case will be to reduce vulnerability by encouraging, facilitating, or even mandating the adoption of adaptation measures.

Much can be achieved by mainstreaming climate adaptation into development planning in the LCB. Long-term economic growth cannot be sustained without ensuring that emerging patterns of agriculture and trade do not impinge on ecological health and resilience. Adaptation to climate should be integrated into development project, plans, policies and strategies. In this vein, all stakeholders within the LCB Community-based organizations, non-governmental organizations, Governments through its Ministries of Environment, Water, Agriculture, Research Institutes and Departments of Meteorology, need to raise more awareness of the changes in climatic through extension services, radio and televisions, farmer’s associations and input and output dealers, amongst others.

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