UNDERSTANDING CLIMATE CHANGE AND IT'S IMPACT ON RIVER BASINS – CASE STUDY OF THE LAKE CHAD.

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ABSTRACT: Straddling the borders of Chad, Nigeria, Cameroon and Niger in West Africa, the Lake Chad river basin has provided freshwater and supported livestock, crops and fisheries for people in these countries for thousands of years. But Lake Chad's popularity is contributing to its decline, and the lake is slowly disappearing due to a variety of factors such as overuse of water resources, climate change, poor enforcement of environmental legislation, and weak capacity for water resources management. This paper takes a closer look at climate change, global actions against climate change and the sustainable development goal number 13 on climate change with a view to understanding it from the proper perspective, it's general impacts and specifically, it's impact on the Lake Chad. The study approach here was a careful review of available literatures, position papers and presentations at the just concluded International Conference on the Lake Chad held at the Transcorp Hilton Hotel, Abuja Nigeria sometimes in January, 2018. Findings revealed that the desert is encroaching on what once was one of the largest water bodies in Africa. The latest information tells us that the lake's water level and size has shrunk a massive 90% compared with what it was in the 1960s, while its surface area has decreased from a peak of 25,000 square kilometers to approximately 1,350 sq.km today. Climate changes, which have resulted in more droughts and less rainfall, have helped to create conditions leading to the Lake's general decline. Collaboration of border countries, inter-basin water transfer, restoration of peace, sustainable agricultural best practices and reinvigorated afforestation were recommended amongst others to help reverse the disastrous trajectory of the Lake Chad and prevent it's associated crisis including food shortage and massive rural-urban migration.

Keywords: Climate Change, Lake Chad Basin, Impact, Carbon Emission, United Nations

INTRODUCTION

The Earth's atmosphere has generally been in chemical balance. The increasing global demand for energy and natural resources to meet the need of the ever growing population is believed to be upsetting this atmospheric balance, and thus giving rise to climate change (Aizebeokhai, 2011). Climate change and variability has received increased global attention in the last three decades. This, in recent time, has caused continuously increasing temperatures in most parts of the world, and changes in precipitation patterns have increased the frequency of extreme climate events such as drought and flooding (National Academies of Sciences, Engineering and Medicine, 2016). All countries are susceptible to climate variability, but developing countries are much more severely affected in terms of the percentage of economics losses in relation to their gross Domestic Products (World Bank, 1993). All life on Earth, water and energy resources, agriculture, vegetation, air quality and sea level are significantly influenced by climate change and variability (US Geological Survey, 2007). According to IPCC, climate change is attributed directly or indirectly to human activities that alter the composition of the global atmosphere and which are in addition to natural climate variability observed over comparable periods of time (Bates et al., 2008).

One of the major challenges with climate change is its impact on water resources and extreme hydrological events. Extreme precipitation is projected to increase significantly, especially in regions that are already relatively wet under present climate conditions, whereas dry spells are predicted to increase particularly in regions characterized by dry conditions in present-day climate (Christensen et al., 2007; Sillmann and Roeckner, 2008). Semiarid regions of the developing world, which are already poor and face major water resource management and food security problems, are likely to be the most severely impacted. Climate change is foreseen to increase water stress in some parts of the world and increase river discharge in others (Arnell, 2004). This emphasises the need to assess and take consideration to climate change impacts in the adaptive management of water resources. As proposed by the United Nation Development Programme (UNDP), an essential step in the integration of climate change in water resources management is to assess the potential effects of climate change on water availability and extreme hydrological events in different regions in order to better understand the consequences on vulnerable sectors and societal groups and promote and implement appropriate response measures (Losjo et al., 2006). Understanding climate change and variability is vital for society and ecosystems, particularly with regard to complex changes affecting the availability and sustainability of surface-water and groundwater resources (US Geological Survey, 2009).

This study is solely a desk-based review paper work. The report is structured to deal briefly with understanding climate change and it's impact, the description of the Lake Chad Basin including its geography, physical features, and hydrological events, social and economic boundaries. The study also gives brief overview of the climate variability and its impacts on the basin's natural resources, livelihoods of the riparian communities, and the resulting environmental implications. The paper identifies some potential strategies for reducing the vulnerability in the basin by means of improving adaptive capacity and resilience of the system.

Climate Change

Climate Change refers to a change in global or regional climate patterns, in particular, a change apparent from the mid to late 20th century onwards and attributed largely to the increased levels of atmospheric carbon dioxide produced by the use of fossil fuels (UNFCC, 2017).

Climate Change may also be defined as a long-term change in the earth's climate, especially, a change due to an increase in the average atmospheric temperature. For instance, melting glaciers imply that life in the Arctic is affected by climate change.

Climate change is most times used interchangeably with global warming and greenhouse effect. It has therefore become pertinent to clarify these assertion.

Global Warming is a gradual increase in the overall temperature of the earth's atmosphere, land and water generally attributed to the greenhouse effect caused by increased levels of carbon dioxide, CFCs and other pollutants. It is also the observed century-scale rise in the average temperature of the earth's climate system and its related effects (UNIPCC, 2017; Akuboh, 2018).

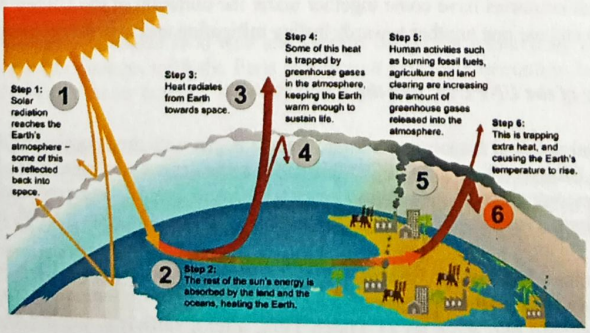

Figure 1: Indicators of Climate Change

The IPCC does not undertake new research, but examines published and peer-reviewed literature to develop a comprehensive assessment of scientific understanding, which is published in IPCC Assessment Reports.

The Lake Chad Basin (Location, and Description)
The Lake Chad basin (LCB) is located between 12° 20' and 14° 20' latitude and 13° and 15° 20' longitude in the centre of Africa, on the Southern edge of the Sahara desert (see Figure 3). The LCB was formed by extensional tectonic depression forces during the Cretaceous period with the geological and geomorphological development by the rifting of the Central and west African Rift System. The LCB is characterized by a thick sequence of Cretaceous, Tertiary and Quaternary sediments deposited due to tectonic subsidence accompanied by sedimentation. The most important regional aquifer is the Quaternary aquifer. It consists of inter-bedded sequences of sands, clayey sands and sporadically gravel-sands (Ngatcha, 1993; Djoret, 2000)

In its original form and state, the LCB was about 2.5 million km^2 (about 8 percent of the surface area of Africa-) and was shared among Algeria, Cameroon, Chad, Central Africa Republic (CAR), Libya, Niger, Nigeria and Sudan. The region is bounded to the north by the Ahagger Mountains in Algeria. From this summit, the border descends southwards towards the Tibesti Highlands that forms the border between Libya and Chad and continues to about 19 North near the Djabel Mara volcanic mountains in Sudan. The southern borders is defined by the Mongos hills in CAR and the Adamawa mountains at about 6^0 N and further west by the Mandaras in northern Cameroon at approximately 10^0 N. The Jos plateau marks the western boundary in the Nigerian sector of the basin (UNEP GIWA, 2004).

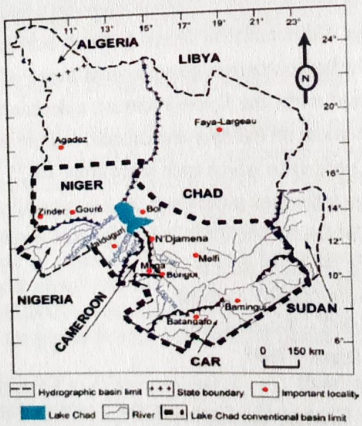

Figure 3: The Lake Chad Basin Countries (Ngatcha, 2009)

HYDROLOGY OF LAKE CHAD BASIN

The Lake Chad basin is drained by three main drainage systems; the Chari-Logone River subsystem (CAR); the Komadugu-Yobe (KY) river subsystem (Nigeria); and the Yedsaram/Ngadda River Subsystem (Cameroon). The almost total lack of relief in the region causes flooding to spread over a large area of the basin (Ovie and Emma, 2011; Ngatcha, 2009).

The Chari-Logone river subsystem, with a basin area of about 650 000 km^2, rising from Cameroon Mountains, contributes over 95 percent of the Lake Chad basin water each year. This river system which is about 1 400km in length, has a single annual flood regime occurring at the end of the rainy season, and lasting from August to September. It feeds the extensive Waza-Logone floodplains (about 8 000 Sq.km) and the Yaeres in Cameroon. A number of minor tributaries such as the Pende, Vina, El-Beid and Mbere feed the Chari-Logone subsystem. The Maga dam is a major reservoir built on the Chari –Logone system (Ovie and Emma, 2011).

The KY subsystem has a basin area of about 1 400 km^2 but contributes less than 2.5 percent of the total inflow into the Lake Chad. The KY subsystem, which forms the border between Nigeria and Niger over the last 60 km, is the only perennial river that flows into the northern pool of the Lake Chad. The Jamaáre River which rises from the Jos Plateau and the Hadejia River which flows from around Kano are the major tributaries of the KY River system and are the two principal rivers that feeds the Hadejia-Nguru wetlands (about 6,000 km^2) in Nigeria. The

Peak flows to the wetlands occur in August resulting in extensive shallow flooding. Like the Waza-logone floodplain, the Hadejia-Nguru wetlands is a major economic hob for pastoralists, fishing, flooded rice production, flood recession farming and a major source of non-timber and fuel wood resources (Ovie and Emma, 2011). The third major drainage subsystem, the Yedseram/Ngadda river subsystem consists of the Yedseram and the Ngadda rivers- the former rising from the Mandara Hills in Cameroon and the later from Northern Nigeria. The Ngadda river contains the Alau lake located downstream of Maiduguri town in Nigeria (Ovie and Emma, 2011).

Historically, three main cycles have characterised the hydrology of the Lake: the Mega or Greater Chad phase (over 300,000-400,000 km^2), the Normal Chad phase (18,000-25,000 km^2), and currently the Small or Lesser Chad phase (2,000-9,000 km^2), which began after the drought of 1972-1973 (Roche, 1973; Beadle, 1981). The Lake surface area was reduced drastically from 25,000sq.km in the 1960s to 2,500 sq.km in 1976; therefore, about 90% of the originally inundated area has been exposed. Lake Chad still provides water to about 38 million people for irrigation and other needs, even though its surface area has been reduced. According to Olivry et al. (1996) the volume of water in the Lake decreased from (40 -100) x10^{9}m^3 in 1962 to (7-45) x10^{9}m^3 in 1990.

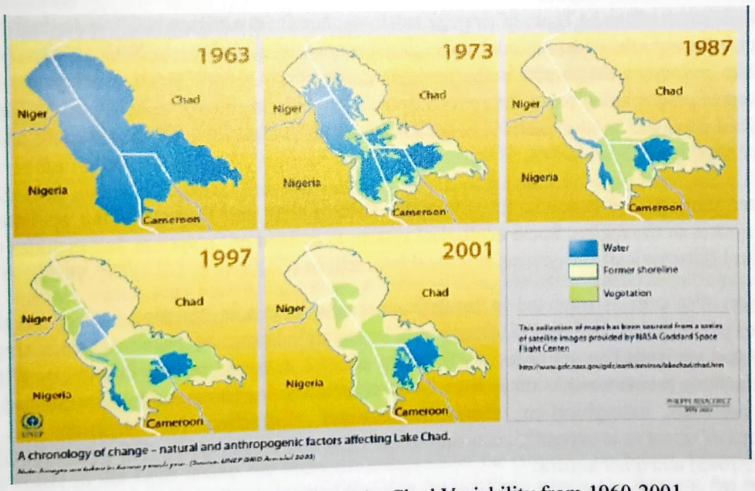

Figure 4: Chronology of the Lake Chad Variability from 1960-2001

Source: UNEP-GRID Arendal, 2003. In: UNEP-GIWA, 2004.

CLIMATE CHANGE AND VARIABILITY EFFECTS ON LAKE CHAD BASIN

According to FAO (2004), the LCB is unique in the sense that "nowhere else in the world is such a large freshwater reservoir found so far from seas and oceans and in such a hot and arid climate. The lake has always been a point of attraction for human, animals and plants, all of which have had to learn how to leave in balance with a fragile environment that is changing over time in response to both slow and fast variables".

The impacts of climate change and variability on water resources are well recognized globally and have been identified as a major issue facing the availability of fresh water resources. Climate change and increased

anthropogenic pressure on earth–atmosphere interactions affect water quantity, quality, and water-related processes, such as sediment yield, on local, regional, and global scales (Kouchak et al, 2015; Castle et al, 2014). Understanding the mechanisms and geographic patterns by which anthropogenic climate change is impacting water resource variability is of critical importance to sustainable development, environmental management, and human health (Li and Urban, 2016).

Many studies have been conducted to simulate the impacts of Climate Change in the basin. The Decadal variation in the hydrological status of the lake as shown in Figure 2, Clearly indicated that there has been a significant reduction in the lake area over the years, leading to what is now popularly known as the '**shrinking Lake Chad**'. Water loss from the lake is principally through evaporation and minor marginal leaks (Ovie and Emma, 2011). The most recent information tells us that the lake's water level and size has shrunk a massive 90% compared with what it was in the 1960s, while its surface area has decreased from a peak of 25,000 square kilometers to approximately 1,350 sq.km today. Climate changes, which have resulted in more droughts and less rainfall, have helped to create conditions leading to the Lake's general decline. Generally, the hydrological regime of the lake is determined, in the main, by prevailing climatic factors, but man's activities such as irrigation and dam construction also make important contributions to the shrinking or drying of the Lake Chad. The Lake Chad Basin has two seasons: wet and dry seasons. Rainfall varies from about 200 mm in the northern basin to about 300 mm in the southern basin. UNEP GIWA (2004) however, put rainfall at 1500mm to less than 100mm in the southern and northern basin, respectively. By contrast, evaporation from the lake surface was estimated to be 2 000 mm/annum thus creating a huge deficit that contributes to the gradual but steady reduction in lake water and area.

Effect on LCB Natural Resources

The natural resources of the LCB are of strategic socio-economic importance not only to the immediate riparian communities but also to the wider national and regional economies (Béné *et al.*, 2003c; Neiland *et al.*, 2005). The LCB countries are among the poorest in the world as exemplified by the Human development index (HDI) and the percentage of people living below the poverty line is high with less than 1 or 2 US$ a day. The LCB, including the Lake Chad itself has been experiencing socio-ecological fluctuations, the most severe and apparent being severe water shortage (UNEP-GIWA, 2004).

Severe water shortage has exacerbated community vulnerability and threatened the resilience of the socio-ecological system of the region. Socio-ecological system is defined as "a system that includes societal (human) and ecological (biophysical) subsystems in mutual interactions (Gallopin *et al.*, 1989; Allison *et al.*, 2007).

Reduced river discharge is expected to result in enormous losses in aquatic biodiversity globally by 2070 (Xenopoulos *et al.*, 2005). Reduced discharges are for example known to disconnect main river channels from floodplains and wetlands that are necessary for many species to complete their life cycles (Xenopoulos *et al.*, 2005). Interactions between reduction in river flow, temperature increases and human induced impacts such as industrial pollution, eutrophication, channelization/water abstraction for irrigation and other physical modifications of rivers as is currently occurring in the LCB will further stress fish stocks (UNEP GIWA, 2004; Ficke *et al.*, 2005) and other aquatic.

Effect on Agricultural Activities

Increased temperatures and evaporation and reduced precipitation have reduced water availability and adversely affected not only fisheries, but other agricultural practices in the LCB. According to Wamuongo et al (2014) climatic vulnerability and impacts has dramatic effects on food and livestock production systems. The abrupt changes in rainfall are general phenomenon for the LCB leading to high variation of outputs from agricultural production and fishing activities. The Water shortages have affected land based activities resulting in higher food prices. According to Ngatcha (2009), fish production decreased from 140,000 tons in 1966 to 70,000 tons in 1983. Water shortages in the Lake Chad have been worsened through the modification of river flows by dam construction for irrigation, the change from low water intensive crops (wheat) to high water intensive crops (rice), as well as an increase in population growth in the area. It is acknowledge that social stability depends on food and water.

Environmental Challenges

In the Lake Chad Basin, there is significant environmental stress caused by climate change impacts. The region experience frequent prolonged droughts, resulting into less water and arable land to go around the riparian communities. Climate change impacts result in environmental challenges such as deforestation, habitat destruction, water pollution and soil degradation in the basin region. This effect affects the water quality and quantity supply in the LCB. Apart from the direct impact of climate change on water chemistry, indirect impacts to environmental water quality arising from attempts by other sectors to mitigate the impacts of water shortage could be significant. The use of fertilizers, herbicides and pesticides have had negative consequences for water quality leading to potential impacts on fish survival, growth, income as well as human health.

Climate change is a threat multiplier (catalyst) by worsening existing risks and making the solution hard to achieve. Over the past 40 years, the Lake Chad has experienced fluctuations in climatic and environmental conditions that have led to significant changes in the distribution of aquatic habitats (Bénéch *et al.*, 1979 1983).

Impacts on Human

As climate change and variability leads to declining water environment with impacts resulting in reduced economic power, poverty and hunger are inevitable. This increases vulnerability to sexually transmitted diseases (such as HIV/AIDS) and other diseases among the people in the basin region. More so, there have been studies linking human diseases (e.g. cholera and meningitis) to changing environmental temperature (Colwell, 1996; Harvel *et al.*, 2002) and climatic factors. Generally, there is increased spread of vector-borne diseases in the region.

Impacts on Economy

Reduced rainfall, stream flow modification leading to shrinking of fishing grounds and habitat modification, would lead to declining fish catch, fish trade, income, food/ nutrition security, labour generation and increased poverty (Ovie and Emma, 2011). For instance, Human development index (HDI) said the LCB countries are among the poorest in the world, and the percentage of people living below the poverty line is high with less than 1 or 2 US$ a day. The fluctuations as a result of climate change in the Lake Chad Basin have major economic consequences on the region. In the LCB, reduced water levels have not only led to decreased fish catch but also increased productive capital of fishers. This has not only increased productive capital considerably, but also the cost of fish.

Increased Presence of Pathogens and Pests

In the tropics, warmer waters may increase the susceptibility of fish (and other hosts) to pathogens because they are already expending energy dealing with thermal stress (Harvell *et al.*, 2002). In the LCB, there has been a proliferation of pests due to droughts and water management practices. Between 1986 and 1988, farmers in the LCB had been plagued by desert locusts (*Schistocerca gregaria*). Declining water also provided the opportunity for the proliferation of hydrophytes (plants that grow in wet conditions) in shallow waters and marshy habitats.

Communal Conflict and Migration

The lesser the water in the LCB means the more the competition for survival, increased desperation, more and extreme poverty, and more account of exacerbated tensions for conflicts among the farmers, the pastoralists and the fishers. Climate change impacts in the LCB have increased migration of pastoralists to other areas for viable lands and water sources, resulting into constant clashes between herders and farmers. This is one of the main reasons there is insurgency in the region, which is interwoven with issues of religious indoctrination/extremities, poverty and environmental degradation.

MEASURES FOR MITIGATING CLIMATE CHANGE IMPACTS IN THE LCB

The management of the impacts of climate change in the LCB requires integrated approaches. The following are recommended areas of focus to reduce the climate change effects on the LCB:

i. Due to the Climate change effects causing increased evapo-transpiration and reduced precipitation of the LCB, there is need for the riparian countries to involve in reforestation and planting adequate vegetation in the region as prevention and correcting measures.

ii. Farming as part of agricultural activities in Lake Chad region has become a very important component of the economy of the LCB. Therefore, as there is large reduction in the Lake Chad water volume due to climate change, also there is need for increases integrated farming activities, by the use of drought resistant crop species in response to the increased drought. To maximise benefits from agriculture and as a strategy to respond to increasing environmental change in the LCB, inter-cropping should be often practiced.

iii. Pest control must be given proper consideration. The birds can be controlled by massive aerial spraying of toxic chemicals.

iv. Though it is difficult to manage water resources under the LCB changing conditions, but to mitigate the water shortages, water resource managers need to build resilience and adaptive measures for better

v. understanding of the role of natural processes on the Lake Chad. This is a likely prerequisite for sustainable water resources management in the future. Likewise, there is need for the development of a reliable data base to support water management decisions and monitoring guidelines in the Lake Chad basin. Water conservation measures like switching from water intensive crops (such as rice) to less water demanding ones (such as sorghum, millet) can be applied.

vi. Proactive enlightenment is needed to encouraging and supporting preventive measures and activities in changing conditions on incorrect land use and on human diseases that could increase vulnerability and conflict. There is need for increased sensitisation by member states against frequent migration to avoid further conflict. There is need also for conflict resolution mechanism to alleviate any crisis due to land use. The promotion of education, training and research is of necessity in or to support conservation and sustainable development of the LCB.

vii. Inter-basin water transfer as recommended in the Lake Chad Basin Conference held at the Transcorp Hilton Hotel, Abuja in February, 2018 will help replenish the water in the Lake.

viii. There is need for common legislation or coordinated policy decisions by all member states in the Lake Chad region. This will bring about harmonized water laws and regulations among the riparian countries and by extension strengthen the Lake Chad Basin commission (LCBC) efforts. Stronger political union and cooperation with international bodies in dealing with climate change issues is highly recommended. There is need for the strengthening of cooperation between member states of LCBC through coordinated research, planning and management of mutually shared resources in the LCB.

ix. Proactive and continuous monitoring of global weather and climate conditions at all levels with the aim of achieving disaster risk reduction, sustainable development and climate change adaptations.

CONCLUSIONS

The Lake Chad Basin, shared by the republics of Cameroon, Chad, Central Africa, Niger and Nigeria, represents a huge reservoir of natural resources being influenced by climate change. This study was a review of collection of papers focusing on a range of research relating to the influence of climate change and variability on the LCB, and helping with suitable strategies for mitigating and adapting to the impacts. In the LCB, water and land use remain the most deficient resources linked to be the causes of other problems. These problems ranging from changes in water levels, stream flow, sediment yields, and water quality in lakes, rivers, watersheds, and estuarine systems in the LCB. It is understood that poorer countries, such as those of the LCB, are likely to suffer most from climate change impacts, while the development of strategies to cope with climate change and biodiversity losses are also more likely to be hampered by poverty and governance issues in these countries if necessary and relevant leverages for mitigating impacts are lacking (Smith *et al.*, 2003).

An understanding of climate change and variability can be integral to successful management of water resources in the LCB. It is observed that the current tools to facilitate integrated appraisals of adaptation and mitigation options across multiples water-dependent sectors are inadequate. Hence, more research on the influence of climate change and variability in the LCB is required so as to improve our understanding and modelling of climate changes related to hydrological systems at scales relevant to decision making.

Ogunmade (2018) reported in "this day newspaper" of July 25, 2018 that at the moment, the report of an international conference held on Lake Chad earlier in the year 2018 which proposed $14.5 billion for transfer of water to the lake from Congo Basin to safe the Lake Chad from totally disappearing is being considered by the Federal Executive Council of Nigeria. This is a step towards providing adequate finance for the replenishment of the Lake Chad and ensuring adaptation measures are put in place.

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