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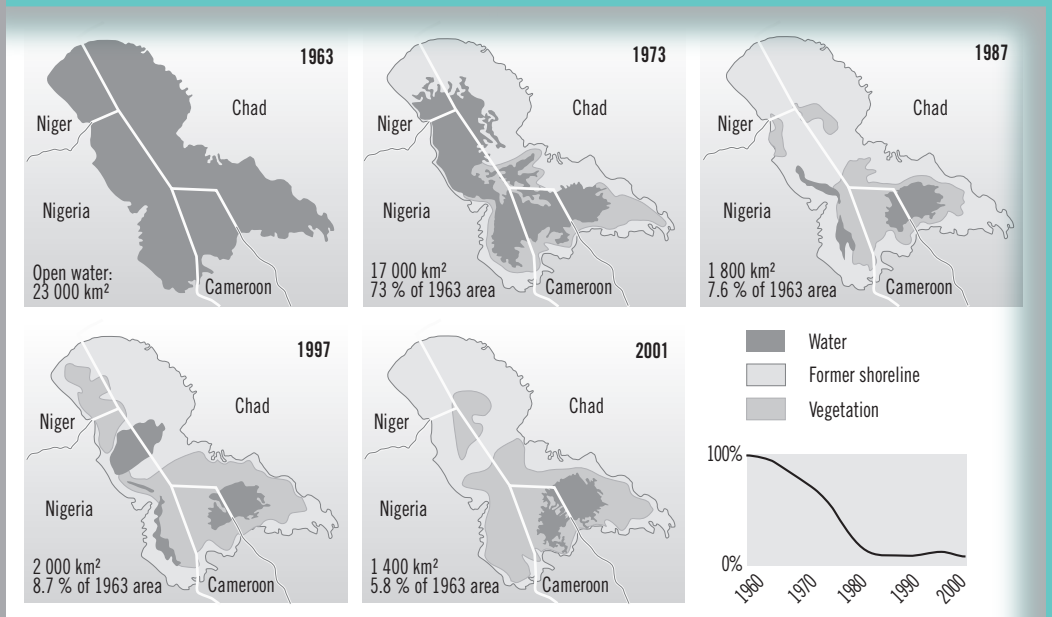
Climate change implications for fishing communities in the Lake Chad Basin

What have we learned and what can we do better?

FAO/Lake Chad Basin Commission Workshop
18–20 November 2011
N'Djamena, Chad



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Preparation of this document

These Proceedings present the outcome of the Workshop on climate change implications for fishing communities in the Lake Chad Basin: What have we learned and what can we do better? The Workshop was hosted by the Lake Chad Basin Commission (LCBC) in N'Djamena, Chad, from 18 to 20 November 2011. It was financed through a Japanese-funded, and Food and Agriculture Organization of the United Nations (FAO)-implemented project on Fisheries management and marine conservation within a changing ecosystem context (GCP/INT/253/JPN), in collaboration with LCBC. Further support was provided by consultants Dr S. L. Ovie and Dr E. Belal and Nordenfjeldske Development Services (NFDS) Africa.

The contributed paper has been represented as submitted.

Abstract

These Proceedings include (1) the report of and (2) the background paper prepared for the Workshop on climate change implications for fishing communities in the Lake Chad Basin: What have we learned and what can we do better? The Workshop was hosted by the Lake Chad Basin Commission (LCBC) from 18 to 20 November 2011, attended by the Lake Chad Basin countries of Cameroon, Central African Republic (CAR), Chad, Niger and Nigeria, and financed through a Japanese-funded, and Food and Agriculture Organization of the United Nations (FAO)-implemented, project component on *Fisheries management and marine conservation within a changing ecosystem context* (GCP/INT/253/JPN), in collaboration with LCBC. Presentation topics included: the hydrology of the Lake Chad region, national contexts of climate change and fisheries, identification and reduction of climate change vulnerability in the fisheries of the Lake Chad Basin and an overview of current projects on Lake Chad. Discussions largely focused on: hydrology and climate trends of the Lake Chad basin, national perspectives on impacts and adaptations of climate change, current natural resources projects in the Lake Chad Basin and recommendations for actions to increase adaptability and resilience to be carried out. The Workshop recommended that there is more coordinated action and information sharing regarding natural resources, and increased cooperation between LCBC member State governments to support and strengthen existing political commitments in the Lake Chad Basin for effective aquatic resource use management to ensure sustainable development of land and aquatic based activities in the basin.

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Abbreviations and acronyms

ACEEN	Cameroon Association for Environmental Education
AGHRYMET	AGRrometeorology, HYdrology, METeorology
CAR	Central African Republic
CBD	United Nations Convention on Biological Diversity
CBO	Congressional Budget Office
CCRF	Code of Conduct for Responsible Fisheries
CSO	Civil society organization
EAF	ecosystem approach to fisheries
FAO	Food and Agriculture Organization
GDP	gross domestic product
HIV/AIDS	Human immunodeficiency virus/Aquired immune deficiency syndrom
IMP	integrated management plan
LCBC	Lake Chad Basin Commission
MCS	monitoring, control and surveillance
MINEPIA	Cameroon Ministry of Livestock, Fisheries and Animal Industries
MOU	Memoranda of understanding
NAPA	National Adaptation Programme of Action
NFDS	Nordenfjeldske Development Services
NGO	non governamental organization
NIFFR	Nigeria National Institute for Freshwater Fisheries Research
PaCFA	Partnership on Climate, Fisheries and Aqualculture
PRODEBALT	Lake Chad Sustainable Development Programme
PRS	poverty reduction strategy
RDS	rural development strategy
REDD+	Reducing Emissions from Deforestation and Forest Degradation in developing Countries
SAP	Strategic Action Plan
UNFCCC	United Nations Framework Convention on Climate Change

Workshop summary

1. OPENING OF THE MEETING AND ARRANGEMENT OF THE SESSIONS

On behalf of the Food and Agriculture Organization of the United Nations (FAO), Mr Germain Dasylva welcomed the participants. He spoke of the growing importance of fisheries globally and the need for sustainable fisheries initiatives. He urged Lake Chad Basin Commission (LCBC) member States to take action against the current trend of water reduction in Lake Chad by raising awareness amongst communities of existing adaptation strategies. These require bilateral and regional cooperation and must form part of the future roadmap for reversing the negative trends in the Lake Chad Basin (LCB). He also stated that the FAO promotes an ecosystem approach to fisheries (EAF) with regard to the decision making process of fisheries management, and this approach has social and economic dimensions, especially of relevance for this region. He further thanked the participants and asserted that he felt the Workshop would be productive in identifying and discussing suitable adaptation measures for the fisheries of the LCBC region.

On behalf of the Executive Secretary of LCBC, Mr Sanusi Imran Abdullahi, Acting Executive Secretary, Mr Mana Boubakari welcomed the participants. He thanked them for their attendance and stated that the LCBC was proud to host this Workshop, which was in line with the Strategic Action Plan (SAP) of the LCB – a long term vision for the Lake. Mr Boubakari noted that the objectives of the Workshop were to outline the importance of the fisheries in light of the effects of climate change. He stated his belief in a positive outcome, given the importance of this issue for the communities living around the Lake. He thanked Japan for financing the project, as well as the FAO and the resource persons for their support and guidance.

2. INTRODUCTION OF PARTICIPANTS AND AGENDA

The participants introduced themselves (see Annex 1) and Mr Minde Ngakougnou, from Chad was elected as Chair. Cassandra De Young, FAO, was appointed the facilitator with the assistance of Ms Sandy Davies, Nordenfjeldske Development Services (NFDS). Ms Sinéad Sheridan, NFDS, would act as rapporteur with assistance from the LCBC and countries. The agenda was then discussed and amended (see Annex 2).

3. BACKGROUND AND OBJECTIVES OF THE WORKSHOP

Ms De Young outlined the FAO's approach to climate change, focussing on the implications for fisheries, aquaculture and food, nutrition and livelihoods security. She noted that the fisheries sector is being influenced by multiple drivers of change, affecting biophysical approaches as well as human behaviour and choices. Climate change is one of these drivers and will impact the sector directly through, for example, changes in productive capacity and cycles of aquatic species, increased risks to health and life, increased risks to infrastructure and production systems as well as indirectly through, for example, displacement and conflict, water allocation needs, market impacts and adaptation and mitigation costs to society at large. Fortunately, the sector is already equipped to prepare and respond to these impacts by implementing adaptation actions through broader vulnerability reduction. This would include reinforcing ecological, economic and social resilience through: 1) adaptive management strategies within the ecosystem approach to fisheries and aquaculture and the FAO Code of Conduct for Responsible Fisheries (CCRF); 2) available tools such as livelihood diversification,

implementation of flexible access rights, finding the right mix of public and private insurance to spread risks; 3) depending on technological innovations, such as in vessel and port designs, availability of resistant species, information sharing mechanisms, post harvest methods; and 4) planning for adaptation and ensuring policy coherence across sectors including disaster preparedness. The sector also has a role to play in mitigation strategies by 1) supporting the aquatic systems' natural abilities to remove and store greenhouse gas emissions by reducing 2) providing renewable aquatic biofuels to avoid emissions; and 3) reducing the sector's dependence on fossil fuels through increased energy efficiency. She noted the ongoing coordinated effort in addressing climate change in the fisheries sector through the Global Partnership on Climate, Fisheries and Aquaculture (PaCFA) and highlighted the overall importance of communication and cooperation in dealing with climate change. Ms De Young outlined the thematic areas of the FAO Fisheries and Aquaculture Department's climate change strategy, including:

- improving awareness of impact pathways, vulnerabilities and supporting adaptation potentials;
- understanding green house gas (GHG) emissions from the aquaculture and fisheries sectors as well as supporting mitigation efforts;
- communicating and advocating for these sectors in global, regional and national climate change forums;
- making the bridge between science and policy; and
- coordinating efforts as well as collaborating with concerned stakeholders and partners.

Furthermore, Ms De Young explained that, the LCBC Workshop had been funded through a Japan-funded project aimed at increasing awareness of potential adaptation measures and strategies globally. It involves six regional case studies of which the Lake Chad is one. The goals of the Workshop were to:

- bring fisheries and climate change partners together to develop a shared plan for addressing climate change impacts in the LCB;
- identify drivers and impacts of change, including their effects on LCB fisheries and the communities that depend on these resources;
- identify short- to medium-term actions to improve the resilience of the LCB aquatic systems and the adaptive capacity of the fishing communities; and
- agree on scope for a follow-up funding proposal within the LCB.

4. HYDROLOGY OF THE LAKE CHAD BASIN

Mr Abdou Ali, from AGHRYMET (AGRrometeorology, HYdrology, METeorology), a regional centre for climate monitoring, based in Niger, presented an historical overview of the hydrology of the LCB. This took into account: localised features of climate variability in the Sahel, current trends in climate, impacts on water resources and climate outlook for the LCB. Firstly, Dr Ali gave a summary of the importance of analysing historical weather data, noting that it can be used to predict future changes and trends in order to develop better management strategies in dealing with climate change issues facing the LCB, such as unpredictable rainfall and drought. Furthermore, he explained that there are many different potential scenarios, and stressed that it is necessary to base hypotheses (on which models are formed) on historic data and accurate analysis. Some important climatic factors to consider in the region were noted to be:

- There is a huge variability in climate across the region of the Sahel, from west to east and across countries, which is reflected in sub-regional trends in rainfall, temperature and other factors. Adaptability strategies must take this variability into account in both models and actions.
- It has been shown, that historically the eastern region of the Sahel is wetter than the west, this trend persists today.

- Analysis suggests that a longer period of drought brings increased weather related problems in the rainy season, including rapid rise in floods early in the season.
- Data from 1915 of water flow in the river Niger has shown that since 1995 flow rates of the upstream Niger are always below the median for this period (1915 to present), in comparison to the downstream region where they have been above the median for the same period.

Mr Ali further explained that, in order to manage seasonal variability, capacity to forecast effectively and accurately needs to be strengthened. He proposed that although it is important to develop forecasting strategies for the next 50 years, it may be more pertinent to focus on mid-term, rather than long term strategies. In conclusion, Dr Ali noted that the main areas of current focus in the LCB are; the regional variances in weather conditions, the significance of drought in the west but not in the east, and that more, and improved, forecasting is required in the future in order to effectively adapt to variability and change.

5. NATIONAL PERSPECTIVES ON FISHERIES AND CLIMATE CHANGE

Each of the five participating countries (Cameroon, Central African Republic, Chad, Niger and Nigeria) presented national perspectives on climate change and fisheries. Certain climate change impacts, and issues compounding these impacts, were raised across the presentations and included the following:

- Reduction in water volume in Lake Chad and in the main rivers Chari and Logone as well as smaller tributaries and in most cases permanent disappearance of ponds in the dry season. This is exacerbated by irrigation for agriculture around the Lake and evapo-transpiration, further reducing water volume on the Lake and leads to increased pressure on water resources.
- Increased migration of fishers searching for better fishing grounds and increased movement of pastoralists searching for water sources moving both nationally and throughout other member states. This has increased localised conflict in the region over natural resources and land use.
- Increased spread of vector-borne disease.
- Encroachment of aquatic weeds which disrupt ecosystems and access to the fishery resources through blocking of transport routes.
- Lack of or poor information dissemination nationally on fishery resources. This includes a regional lack in ecological and climate related data.
- Deforestation and habitat destruction (including erosion of river banks and silting of the Lake).
- Use of destructive fishing methods, such as using poisons, or setting up net traps in bottle necks in water channels.
- Lack of adequate laws, including fishery laws to regulate activities on the Lake and the associated management systems to implement the law.

On behalf of **Cameroon**, Messrs. Djonwe Gaston and Banga Clair Rene gave the National presentation. They noted the following:

- Fishing is of great importance to communities in the five main catchment areas of Cameroon, which support a fishery industry valued at US$ 180 million. Aquaculture produces 700 tonnes of fish annually; is mostly carried out in the tropical southern region, where there is more access to water. Lake Chad forms part of a network of rivers and lakes running throughout Cameroon.
- A study carried out in 2009 by the Cameroon Association for Environmental Education (ACEEN), stated that there has been intensified migration, increased nomadic behaviour and a lower contribution of the fishing industry to the local economy. In order to adjust, local fishers have begun to adopt destructive fishing methods such as using narrow channels to create bottlenecks to catch all fish moving from rivers to ponds in the rainy season and fish aggregating devises.

- Cameroon has adopted several international agreements and conventions, such as the United Nations Convention on Biological Diversity (UNCBD), the African Convention on the Conservation of Nature (the Algiers Convention) and the United Nations Framework Convention on Climate Change (UNFCCC).
- The Government has already put in place some measures to support fishing communities, including training of fishermen, cooperative programme of support with Japan, and increase in aquaculture development. These can support capability development to increase resilience in fishers against the effects of climate change through measures such as improving fishing methods to reduce ecosystem destruction.
- It was concluded that climate change impacts are a reality for the fishing communities in Cameroon and it will be necessary to increase financing and initiatives in aquaculture, to diversify revenue streams from fisheries and to promote wider diversification of livelihood. Broadly speaking, it was suggested that the means for improving the current situation in Lake Chad should include: tackling overgrowth of aquatic plants, reforestation of the basin, developing communication strategies to raise awareness amongst fishing communities on climate change, as well as to agree on a common regional strategy to fight the effects of climate change.

On behalf of the **Central African Republic** (CAR), Ms Blandine Gahoro and Mr Sylvère Sombo made the national presentation. They noted the following:

- CAR, unlike the other member States has a climate characterised by wet, tropical conditions and average rainfall of between 300–250 mm/year and an average annual temperature range of 20–35°C.
- CAR has an extensive hydrological network, with the Congo basin in the south and the LCB in the north. This constitutes both the rivers Chari and Logone, the sources of which are found in CAR.
- Artisanal fishing is practised on the Chari and Logone rivers, their effluents, ponds and lagoons. A high biodiversity (195 identified species) supports the capture fishery which constitutes 60 percent of the national fishery production.
- Although the fishery sector is considered important for food security there is little strategy or planning for the sector or its future.
- Unexpected and inconsistent rainfall, either too heavy or not enough, are common problems that can result in: floods, silting of water systems and stress on water resources. These effects impact negatively on the lives of fishers leading to social conflict, lower fishery catches and thus decreased income and increased poverty and food insecurity.
- CAR is currently developing an environment policy and is party to a range of international agreements and conventions, such as the Kyoto protocol of the UNFCCC, the Algiers Convention, the UNCBD, The Convention on Wetlands of International Importance, and the National Plan of Action against Desertification Strategy and the United Nations Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD+). Furthermore, they are in the process of developing a plan for fisheries and aquaculture development.

On behalf of **Chad**, Messrs. Minde Ngakougnong, Mbainaissem Nadjitambaye and Awoto Yacoub gave the national presentation. They noted the following:

- The total fisheries production of Chad is estimated to be 61 000 tonnes annually, this fluctuates according to rainfall and pressure on the resource. Of about 70 species present in the Lake, 60 are of commercial value. Fisheries resources are important for food security, poverty reduction and sustainable development; overall, fisheries contribute 4.5 percent of the gross domestic product (GDP) of Chad.
- Since the period of droughts from 1972–1974, fishing communities have been heavily affected by the impacts of climate change, exacerbated by the arid environment of Chad.

- However, the presenters noted that there have been some positive effects on fishing resources as a result of these environmental changes for example: during floods, there are high levels of reproduction amongst fish species, contributing to increased catches and thus availability of food and improved income options.
- Adaptation measures implemented have included; reforestation and reduction of deforestation levels through community awareness projects; and protection of banks with hard defences in order to reduce soil erosion.
- Alternative options that may offer possible solutions included; to convert 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 practises for reducing inappropriate and damaging use of fishing gear.
- Chad has a National Adaptation Programme of Action (NAPA) that lists as priority actions related to fisheries; early warning systems on weather events; building preparedness to potential climate change impacts; and improvement of information, education and communications for adaptation to climate change. These priority activities aim to enhance quality of forecasting, improve the communications and information flows and strengthen the national strategy on risk management in relation to climate change.

On behalf of the **Niger**, Abdou Mahaman and Achirou Elhadj Abdou made the national presentation. They noted the following:

- Niger has high levels of poverty with 48.6 percent of the population under 15 years of age. The majority of the poor population reside in rural areas and this sector accounts for 41 percent of the GDP. However, the sector is threatened by various factors such as; desertification, degradation of natural resources, increase in population and the impacts of climate change. Niger has developed policies aimed at fighting these issues, these include the Poverty Reduction Strategy (PRS), Rural Development Strategy (RDS).
- National fish production is estimated at 55 860 tonnes in 2003, 43 700 of which come from the LCB. For fisheries, this sector has been historically marginalised in socio-economic policies and development plans, but a recent Development Strategy of Fishing and Aquaculture policy should assist in this area.
- Niger has developed a National Adaptation Programme of Action (NAPA) and two priorities activities cross the fisheries sector; one of them focusing on the water resources sector and one on the terrestrial ecosystem. The presenters noted that fisheries and aquaculture needs to be more fully integrated into the policies and strategies in the future.

On behalf of **Nigeria**, Mr Ahmed Muhammed made the national presentation. He noted that:

- Lake Chad supports the largest freshwater fishery in Nigeria with catches of around 50 000 tonnes annually, much of which, is absorbed for local consumption.
- The fishery also provides employment for over 2 million people, most of whom are engaged in fishing on a seasonal or part-time basis, using a variety of different types of gears including: active nets, static nets, traps, fish fences and hooks. The sector provides work for all generations within the population.
- The impacts of climate change and in particular the drying of the lake have offered considerable challenges to the fishers that now need to migrate further to access fisheries and to transport their catches to the market.
- Nigeria also produces 150 000 tonnes of fish products from aquaculture which is important for food and income generation. It provides an alternative opportunity for vulnerable members of fishing communities, requiring lower investment and

providing an opportunity to utilise the land around Lake Chad that has emerged from the drying of the lake for this purpose.

6. OVERVIEW OF CLIMATE CHANGE VULNERABILITY OF THE FISHERIES IN THE LAKE CHAD BASIN

A background report had been prepared for the Workshop (see Contributed Paper below), by Mr Ovie of the National Institute for Freshwater Fisheries Research (NIFFR), Nigeria, and Mr Belal of the Ministry of Livestock, fisheries and Animal Industries (MINEPIA), Cameroon. Mr Ovie presented on behalf of both authors.

He began by describing how, the LCB, although still productive, had experienced reductions from catches of 220 000 tonnes in 1974 to about 100 000 tonnes per annum today. This is extremely important for the residents of the Basin region as fish is amongst the most common and cheapest source of protein in the region and provides benefits and services for poverty alleviation, food security and contributions to national and regional economies. Annual fish production on the Lake is worth on average US$ 60 million, with over 200 000 people directly involved in fishing, and 10 million people supported by the sector. The Lake is extremely dynamic, constantly changing size, shape and depth in response to slight changes in annual precipitation and is linked to three main drainage systems; the Chari-Logone River subsystem (CAR); the Konadugu-Yobe river subsystem (Nigeria); and the Yedsaram/Ngadda River Subsystem (Cameroon).

Historically, three main cycles have characterised the hydrology of the Lake: the Mega Chad phase, the Normal Chad phase, and currently the Lesser Chad phase, which began after the drought of 1972 – 1973. This recent phase, the Lesser Chad phase, is one of water shortage due to decreased rainfall and fewer rainfall events in the Chad Basin. This change is considered due to climate change impacts. Water shortages in the Lake have been worsened by modification of river flows by dam construction in some of the major inflow rivers, a change from low water intensive crops (wheat) to high water intensive crops (rice), as well as an increase in population growth in the area. The region is also characterised by; slow economic growth, poor governance and political instability; insufficient infrastructure and lack of a dynamic private sector; high vulnerability to both domestic and external shocks; and a general exacerbation of poverty due to: HIV/AIDS, poor health care, low life expectancy, high maternal/infant mortality and high adult illiteracy.

Following the shrinkage of water volume, in this recent phase, and the emergence of swamp ecosystems, natural selection has favoured marshy species (*Clarias, Cichlids and Heterotis*) and there has been an associated decrease in species diversity over the past 40 years. Mr Ovie noted that overall the combined impacts on both the human and ecological system are; alteration of fish breeding and migration time, constrained access to preferred spawning grounds, increased migration and mobility of fishers southwards in search of more productive grounds and wetter ecosystems, and increased incidence of HIV/AIDS in the region. While reduced precipitation and water volume have caused; increased alkalinity, increased primary productivity of algal bloom, anoxic conditions, and concentrated effects of eutrophication. Water shortages also have an effect on land based activities such as agriculture, resulting in an increase in food prices.

Mr Ovie noted that in order to adapt, communities living in the LCB will need to consider a range of options, based around the changes occurring in the Lake, for example:

- Altering catching methods and gear to suit changing fish distribution, types and location of fishing grounds and changes in fish species distribution.
- Better methods for post harvest processing and storage could be considered to prevent loss of catches and maximising benefits from catches.

- Enforcing traditional fisheries management systems in the LCB to ensure that regulations are implemented, especially with growing populations and demand for fish.
- Positive changes in agricultural practises can result in a reduction in water usage, while alternative food sources, such as spirulina are widely available on the lake and offer a high protein alternative to fish production.
- Aquaculture is an important area of adaptation, and can be used to counter declining capture fisheries.
- Communities must consider more efficient water use, such as converting from gravity irrigation to drip or sprinkler methods to minimise water use.
- In respect to policy reform; consideration could be given to create a better national, regional and economic understanding of the production of the lake: to ensure food security and socio-economic stability. A policy to support co-management of the lake, in conjunction with existing management systems was also noted as important, as currently, excluding Cameroon, none are in place.
- Regional cooperation on actions for poverty reduction and alternative livelihoods were considered important as are policy support to address the lack of knowledge regarding exposure and impact of climate change on the fisheries communities.
- Rights of access should be agreed for water allocation, which guarantees minimum flow rates. Water use has been described as extremely inefficient within the lake, with a clear need to implement water conservation measures. This can be done through strengthening policies, institutions and processes (PIPs) across sectors in order to enhance implementation of existing and potential climate change adaptive measures.
- Finally, the need to establish or strengthen existing national disaster risk management agencies, not only to become better adapted, but to provide early warning signs in the event of a disaster.

Discussion

A discussion followed, focusing on the national presentations and the background report. Some of the questions and comments raised included:

- Several participants directed questions to Mr Ali, from AGHRYMET, on the predicted rise in temperature and possibility of compiling regional data from hydrological and meteorological sources. He explained that these predictions were based on various hypotheses, and there was a likelihood that the future reality may vary from the specific figures he mentioned, but there will be a rise in temperature. It was also noted that it will be vital to the future work on adaptation to have accurate figures on the minimum flow from all river sub-systems into the Lake, and that it is also important to set a timescale for this work. This information already exists in some countries, thus it should not be difficult to obtain in the LCB. It was proposed that the LCBC should facilitate this work.
- One participant commented on the Niger presentation, noting that a high level of coordination between the Government and other players in the fisheries and related sectors is recommended when dealing with issues at the community level. This is particularly relevant, as other sectors may also be trying to combat climate change impacts and activities could be coordinated.
- It was noted that there is still ample room for the development of aquaculture in the region, and this must be given significant weight when creating solutions for the issues of climate change.
- Several participants emphasised the importance of acknowledging that fishing is heavily integrated with agriculture in the region – people rely on both for their livelihood. However, fishing is often sidelined as an activity to support farming.

Therefore, documents and legal instruments on fisheries often do not exist. This view may be one reason why, in CAR, fisheries were not identified as a sector vulnerable to climate change in its NAPA although a large percentage of the Basin's population are involved in fisheries. It was suggested that a vulnerability study be undertaken to determine the contributions of the fisheries to the GDP and national economy of CAR, to food and livelihood security, etc (i.e. sensitivity of the sector to change) as well as the fisheries' adaptive capacity.

7. GROUP DISCUSSIONS ON NATIONAL AND REGIONAL IMPACTS OF CLIMATE CHANGE

Ms Davies reminded the participants of the aim of the Workshop, noting that much agreement had already been noted on the effects of climate change in LCBC member States with regard to fisheries and aquaculture systems and communities dependent on these. The next steps were described as the need to identify and prioritise actions to reduce vulnerability and improve resilience within both the human and aquatic systems. This would entail group discussions and presentations in relation to:

(1) identifying and prioritising impacts facing each country and categorising them as internal or external, and (2) recommendations of actions to address identified impacts. As a first step, the countries conducted group discussions to summarize climate change effects, impacts and maladaptions within the fishery systems on the wider fishery systems and to categorise them into four groups to reflect issues falling within the traditional fisheries management mandate at the national or regional level and those that would require cross-sectoral collaboration:

1) climate change related direct impacts on the national fisheries systems[1] within LCB (national inter-fisheries);
2) climate change related direct impacts on the LCB regional fisheries systems (regional intra-fisheries);
3) climate change related indirect impacts on the national fisheries system within LCB (national extra-fisheries); and
4) climate change related indirect impacts on the LCB regional fisheries system on the LCB region (regional extra-fisheries).

Largely, there was consensus on the following impacts which would have the largest effects both nationally and regionally:

National direct inter-fisheries impacts/effects:

- changes in precipitation and temperatures associated with reduced fish productivity and leading to maladaptation responses such as:
  - overexploitation of the increasingly limited fisheries resources;
  - habitat destruction;

destructive fishing techniques all of which having a negative effect of reducing fishing grounds leading to migration of fishers.

LCB regional direct inter-fisheries impacts/effects:

- flooding and drought and associated effects on fish productivity;
- increased conflict through greater human or fish migration;
- increased spread of human or fish disease; and
- it was felt that these impacts would be compounded by a lack of harmonised fisheries policies.

[1] Fisheries systems are to be interpreted in the broadest sense, including the aquatic systems and those communities and value chains dependent on these resources.

LCB indirect extra-fisheries impacts/effects were collated into overarching impacts that will have an effect on individual member States and/or the region, including the following:

- Climactic changes will become more frequent and periods of rainfall will be less predictable (primarily period between rainfall events causing flooding and drought) and increased temperatures.
- Higher levels of domestic and trans-boundary migration within the populations of the LCB. This is seen in pastoralists migrating to the Lake for water and fishers migrating to follow fish stocks. This change is presently causing increased levels of conflict amongst communities due to land use conflict and habitat destruction. It will also impact on families and communities as societal constructs are weakened. Increased migration can cause increased spread of disease such as HIV/AIDS (through breakdown of social cohesion) and meningitis (through disruption of vaccination programmes). Climatic changes may contribute to a rise in waterborne diseases such as cholera.
- Mismanagement of water resources generally as well as a lack of coordination of management nationally and regionally, compounded by lack of enforcement of existing regulations.
- Other impacts which would need to be dealt with nationally by all member states included: drought, flooding, deforestation, emergence and spread of human disease, rise in water temperature, reduced quality of water in the lake (through siltation and altered chemical composition), reduced quantity of water in the lake due to higher levels of irrigation and damming.

It was noted that these impacts would be severe given continued climactic variability and, overall, they would lead to reduced productivity of the fisheries, reduced income, livelihood insecurity, malnutrition and reduced food security, as well as the added difficulties due to an overall lack of coordination in managing resources.

8. RECOMMENDATIONS ON ADAPTATION ACTIONS

Ms De Young outlined the second part of the group discussions, namely to discuss and recommend actions for addressing the identified impacts, effects and maladaptations of climate change. The countries discussed in break-out groups as previously before reporting to plenary.

Cameroon participants noted the following: Nationally, impacts of climate change could be tackled with increased support by the Government for the fishers. They also noted that there was a need for better education and sensitisation of fishers, in order to create awareness of the damage caused by destructive fishing techniques, eutrophication and deforestation and the spread of vector-borne diseases. Suggested actions included; addressing the rapid growth and spread of invasive aquatic plants in the Basin; and measures to support fishing communities forced to migrate, including, for example, setting up mobile schools and enabling more cooperation within the region to manage those who are forced to migrate. At the Basin level, the Cameroon participants also recommended that more integrated policies could be developed, involving all relevant sectors, and that the LCBC could support the implementation of international agreements on climate change at a high political level. They noted the need for coordinated policy decisions by all member States on activities on the Lake.

Recommendations for national-level fisheries actions in **CAR** included: the creation of reserves within the Lake to protect spawning areas and creation of a national data base of fishery resources. They emphasised the need for a vulnerability study of the fisheries sector with regard to the effects of climate change. To support the fisheries' sector resilience to indirect (extra-fisheries) impacts, CAR suggested a strengthening of the institutional capacity of the fisheries industry; this could include support to development of aquaculture and lead to increased productivity and therefore wealth in the region. Furthermore, the potential outcomes of Lake Chad Sustainable

Development Programme (PRODEBALT) need to be fully realised put to use. Participants noted that the development and implementation of a fisheries-specific NAPA-type strategy would support adaptation actions in the sector. At the Basin level, CAR representatives suggested that there should be greater support to fishers from all member States and greater cooperation and harmonisation of policies across member States. This would strengthen human and institutional capacity regionally, in addressing climate change. The FAO CCRF and other instruments need to become fully promulgated in the region.

Participants from **Chad** stated that regarding national-level actions, there was a need for increased sensitisation of communities living close to the boarders of other member States in order to alleviate conflict raised by migrating communities. Additionally, LCB member State governments could support this by managing the movement of migrating populations at the regional level to avoid further conflict. They also noted that projects focusing on both raising awareness of the increased spread of disease and addressing the problem of overgrowth of invasive aquatic plants were important. Furthermore, they recommended that post-harvest facilities be developed to prevent loss of fisheries resources as a valuable food and economic commodity. At the Basin level, it was suggested that there was a strong need to increase the visibility and awareness of current projects being carried out in the LCB. Currently, these are not well known in the basin by the fishing communities. This would boost morale and trust within the LCBC and contribute towards it being an effective institution. Finally, they noted that there needs to be an ongoing dialogue between member States, and enhanced monitoring and data collection of information on climate change.

On the whole, the recommended actions by **Niger** largely mirrored those of the other countries. The participants emphasised the need for the co-administration of shared resources for the LCB, especially regarding reversing deforestation, tackling overgrowth of aquatic plants and the spread of disease (particularly HIV/AIDS). They called for more action to be taken to safeguard the water in the Lake, as this in turn contributes to maintaining: biological diversity, income, livelihoods and regional food security.

The **Nigerian** participants also made similar suggestions; however, they noted that there is a need for establishing an umbrella organisation for the region's fishers. This could support fishers and other stakeholders in adjusting to the impacts of climate change and strategise in order to adapt to such changes. It was also suggested that the Baga nodal market in the region be upgraded to connect with international markets. Strong recommendations were made to increase aquaculture capacity in the region. On regional extra-fisheries impacts, they noted that there needs to be a stronger move to create collaborative efforts in habitat restoration as well as on developing an incentives-based strategy to stimulate industrial utilisation of aquatic weeds. Finally, the Nigerian participants recommended stronger political unions and cooperation in dealing with climate change issues. This could be addressed through the formulation of legal frameworks and memoranda of understanding (MOU) regarding migration, fisheries management and micro-financing.

Discussion

Following the recommendations for adaptation, some points were raised, including:

- Many member States suggested aquaculture as a possible adaptation measure; however this was matched by concerns from some participants that aquaculture also requires a large amount of water and would face its own climate change issues. It was also queried about the appropriate scale for such projects and if there was enough available land in some of the countries to develop aquaculture projects. The local interest in such projects was questioned as in most member States, apart from in Nigeria, meat is favoured over fish. However, produce could be exported to Nigeria or outside the region.

- Conflict between migrating communities and local communities is a growing concern. It is clear that this issue needs to be addressed in order to avoid an escalation of conflict and damage to farmland and wildlife corridors.
- Modernisation and strengthening of monitoring techniques on the Lake needs to be a priority issue. Many fishers use destructive fishing methods and many participants voiced their concerns that this is not being addressed. Some suggested a cooperative effort in dealing with this through the LCBC. Often this issue is marginalised by national governments.
- It was also suggested that there needs to be better dissemination of knowledge of current projects in the region, especially regarding programmes on HIV/AIDS.
- Re-forestation of deforested areas could be incorporated into better post-harvest processing. For example, a programme could be created to ensure re-planting of trees, from which wood is used in drying and smoking fish. This would be a long term project of cyclical replanting.

9. RECOMMENDATIONS BASED ON COUNTRY GROUP DISCUSSIONS ON CLIMATE CHANGE IMPACTS AND ADAPTATIONS INFORMATION FROM THE COUNTRIES

Ms Davies summarized the recommendations by the member States (see Table 1). She noted that, at the forefront of these, was the suggestion to strengthen policy and legislation both nationally and regionally to deal with inter- and extra-fisheries effects, impacts and maladaptations of climate change and to build capacities for water resource management. The recommendations also included:

- strengthening of co-management to include more fisher associations and campaign to encourage participation in these;
- improving the production and value chain systems through the improvement of fish processing and preservation methods, strengthening and financing ("climate proofing") aquaculture initiatives and improving access to credit schemes;
- improving flood defensives and strengthening of banks from erosion;
- mobilization of resources to strengthen research on the impact of climate change on fisheries in the various member States of the LCBC;
- awareness-raising amongst and communication with fishing communities;
- improving post-harvest processes and value chain options; and
- improving cooperation between LCBC and international agencies to gain technical support and to implement various pan-African Declarations.

Discussion

Participants discussed the recommendations and noted the following:

- One participant suggested that a move toward improving the economic efficiency of the fisheries value chain needs to be cautious, so that other benefits of the system are maintained (e.g. ensure that such a move would not impoverish people by eliminating indirect and small jobs that are currently used for processing that contribute to local community employment).
- It was also suggested that setting up an umbrella organisation across the region to link fishers could be a very important body for information sharing.
- It was noted that an approach to deal with the entire ecosystem needs to be adopted. Many of the stakeholders and communities are involved in both agriculture and fisheries. They are vulnerable to climate change impacts on the whole ecosystem and any management strategy needs to reflect that.
- There was some discussion amongst participants on the definition and difference of climate change and climate vulnerability. It was concluded that is it important to consider both in adaptation strategies, as they are both having an effect on the ecosystems and human activities.

TABLE 1
Summary group discussion recommendations

	Inter-fisheries actions	Extra-fisheries actions
At the national level	**POLICY AND LEGISLATION** 1. Implementation and enforcement of national fishery policy and legislative frameworks to strengthen resilience to climate change impacts 2. Capitalising on and improving the existing fishing community level adaptation strategies 3. Coordinated efforts with relevant national policies, such as Rural Development Strategies and water use policies **MANAGEMENT** 4. Strengthen co-management including more fisher associations and also a campaign to encourage participation in these 5. The creation of a community level data collection and information system to monitor the fishery and climate change 6. An awareness and communication strategy to educate the fishing communities on climate change and possible mitigation measures (e.g. destructive fishing methods) 7. Strengthening technical capabilities of fisheries institutions **PRODUCTION AND VALUE CHAIN** 8. Strengthen and finance aquaculture initiatives as alternative option to capture fisheries including the creation of the necessary infrastructure/ facilities 9. Improvement of fish processing and preservation methods and facilitates including ice. Promote good hygiene practises. 10. Improvements to infrastructure for fisheries-including landing sites and post harvesting processing facilities 11. Access to credit in the fishing sector through micro-financing and revolving loans. 12. Creation of spatially and temporally flexible reserves or protected areas 13. Create value chain improvements, thereby increasing the profitability of fisheries resources 14. Support development and learning of suitable fishing techniques and other skills in local fishers **DEFENSIVES** 15. Infrastructure–construction of small dams and barriers for floods	**POLICY AND LEGISLATION** 1. Creation and implementation of legislation for management of integrated water resources that incorporates climate change considerations – including review of national programs and strategies related to climate change and the integration of fisheries sector into these (including local and municipal) 2. Lobby for fisheries players to play a larger part in government policy decisions **DIVERSIFICATION and AWARENESS** 3. Promote the diversification of sources of income for fishers e.g. agriculture, livestock, trade 4. Establish outreach programmes, information and training appropriate to climate change 5. Raising awareness amongst communities on HIV/ AIDS prevention and treatment MANAGEMENT 6. Create additional committees for the management and surveillance of water bodies 7. Clearing of waterways/construction of jetties to facilitate freer movement and to tackle invasive plants **MULTISECTOR IMPACTS** 8. To develop a soil defence and restoration project and also a reforestation project in the basin 9. The development and implementation of regulations to control livestock rearing and herd-based migration **GENERAL RESILIENCE** 10. Provision of suitable fishing and support infrastructure at various fishing communities such as schools, health centres and processing facilitates 11. Construct houses from local material/health centres and schools (mobile schools)
At the regional level	**STRATEGY and MANAGEMENT** 1. A sub-regional joint strategy to fight against the impacts of climate change 2. To develop and implement a policy supporting formalisation of co-management systems for fisheries 3. Support to extension programmes to enhance fish production with a regional strategy 4. LCBC to form a regional and permanent forum for artisanal fishers (processors/traders/aquaculture) of Lake Chad Basin from across the region to serve as platform for information sharing and lesson learning and to contribute a united voice to policy formulation 5. Harmonisation of national policies and regulations governing activities in the LCB 6. Increase visibility and awareness of climate change projects being carried out on the Lake for local communities 7. Fish trade in the LCB is poorly and informally managed, yet highly important, supporting policies (or integration into policies) is required to elevate the status of fishery trade, possibly to an international level.	**POLICY and WATER MANAGEMENT** 1. Support a better understanding of the contribution of the fisheries to local, national and regional economies, including its contributions to food/ nutrition and livelihood security 2. Regional level, integrated water management by LCBC including multi-sector ecosystem approach to the basin and to include wide ranging stakeholders 3. A policy at LCBC level on free trans-boundary movement may be required to address issues raised by migration such as land conflict and access to education. **AWARENESS** 4. To develop and implement regional actions on poverty reduction and alternative livelihoods especially in aquaculture and skill acquisition in non-fish enterprises 5. To scale up and scale out the work on HIV/ AIDS and other communicable diseases awareness building and prevention

TABLE 1 (CONTINUED)

	Inter-fisheries actions	Extra-fisheries actions
At the regional level	8. Inform, educate and communicate with the fisheries communities in the Lake Chad Basin about climate change and its impacts. **RESEARCH** 9. Mobilize resources to strengthen research on the impact of climate change on fisheries in the various member countries of the LCBC. 10. To support data collection of fishery and climate information to facilitate a regional data bank and collate information and data already existing in the region.	**RESEARCH AND ASSESSMENT** 6. Climate change risk assessments with costed adaptation plans with special consideration to the most vulnerable actors. 7. The status and strength of disaster risk management (DRM) and early warning systems in the region requires documenting 8. Integrate research into climate change effects on the system of the LCB 9. Research to prevent the further reduction of water in the Lake. **INTERNATIONAL COOPERATION** 10. LCBC to solicit cooperation with international agencies for technical support and to implement the various pan-African Declarations and to gain funds for implementation of the decisions NGOs, CBOs, adaptation planners and donor agencies must play complementary roles

10. DISCUSSIONS ON RELEVANT ONGOING PROJECTS WITHIN THE LCB PRODEBALT

Mr Tahir Brahim Adouma, regional coordinator of PRODEBALT, gave a presentation on the Lake Chad Sustainable Development Programme (PRODEBALT). He explained that the key objective of PRODEBALT is to reduce poverty for communities depending on the natural resources available in the LCB. Specifically, the programme is directed at restoring the productive capacity of the Lake Chad ecosystem. This will be achieved through four components:

- Protection of the lake and its watershed. This component aims to rehabilitate and maintain the long-term productive capacity of the Lake and its watershed ecosystems through protection and restoration of soil and water conservation, regeneration of pastoral ecosystems, prevention of proliferation of invasive aquatic plants, protection of endangered breeds and a study and plans for optimal management of water in the basin.
- Adaptation of production systems to climate change to reduce the socio-economic impacts of climate change and develop sustainable production systems through the extension of a monitoring network. This would include sustainable management of forest resources, pastoral areas and fisheries.
- Improving institutional support through skill building with stakeholders. This will require research and studies to carry out the development of a master plan to deal with erosion and siltation.
- Project management encompassing regional coordination in the LCBC and five national coordinators supported by the LCBC and technical services in member states.

He noted that in the region, fishing is not usually an isolated livelihood activity. Individuals usually integrate it with other sectors, especially agriculture. The aim of PRODEBALT is to harmonise activities regarding natural resources in all LCBC member countries to create a synergy of actions between all partners. The intended programme outcomes include: increasing water supply, reducing siltation in the lake, supporting agro-forestry and reforestation, preservation of threatened species and implementation of management plans for natural resources. PRODEBALT funds 200 micro-businesses supporting spirulina harvesting with 60 percent of the benefactors being women. In regard to fisheries, PROEBALT intends to create a master plan for fisheries management of the Lake Chad and an integrated management plan (IMP) of

the Chari, the Logone and Komadougou-Yobe river fisheries. They intend to develop co-management processes for the water resources, as well as developing a regional fisheries statistics programme that includes fisheries monitoring.

Discussion

After the PRODEBALT presentation, discussion evolved around;

- The need to inform players, including fishers about what is happening and by whom in PRODEBALT and what activities are taking place around the Lake, it was proposed to improve dissemination of information; and
- The need to coordinate the many overlapping elements within this programme and others already existing on the Lake.

Other existing projects in the LCB

Other ongoing projects were discussed in order to provide a better insight into activities being carried out on the lake. Mr Mahamat Sorto, consultant, FAO N'Djamena, provided an overview of some projects currently underway in Chad, as well as in the LCB, implemented jointly with the Ministry of Environment and FAO: focusing on aquaculture development in the region, and capacity building of local communities. He further noted that there are also projects focusing more on national food security in general and research into the uses and harvesting of spirulina, directed at developing quality and marketing options. Ms Katrien Holvoet, Consultant, FAO Cotonou, noted the possibility of collaborating in conjunction with the HIV/AIDS fisheries programme currently underway in Benin as it is also, as mentioned by several participants, an important issue in the LCBC region.

11. SUMMARY AND RECOMMENDATIONS

Summarizing the discussions, the Workshop recognized the following:

- the Lake Chad Basin, and the fisheries and aquaculture systems, communities and economies supported within the basin, are complex and facing multiple drivers of change (overfishing, land and aquatic resource management, water management, demographics, markets, natural variability, climate change, etc).
- Models have predicted and evidence suggests that variations and changes in precipitation, temperature and severe weather events (droughts and floods) are and will continue to be drivers of change (both positive and negative) in the basin's water levels and productivity of the aquatic system, as well as having impacts through land-based food production and livelihoods systems and human well-being, creating a sense of urgency to build on and improve the current resilience of the aquatic and human systems.
- The importance of fisheries as a source of food, income, employment (direct and indirect) and part of the culture is not fully documented ("anonymous") but significant both at the macro and micro levels. The Workshop shared the concern that the relative representation of the sector in the national climate change strategies may not reflect this importance and its particular sensitivity to climatic variability and change. In addition, impacts of adaptation actions in other sectors may impact the fisheries and aquaculture systems negatively as well as positively.
- Vulnerability to climatic variability and change are, in part, shared across other types of vulnerability; therefore, reducing vulnerability in general will assist in reducing vulnerability to climate change. For example, as communities of the LCB are mixed farmers/herders/fishers, actions across the food production systems (e.g. efficient water use, integrated rice/fish farming, drought resistant crops and animals) would assist in a portfolio approach to decreasing risk. In addition,

reducing vulnerability through general health and education improvement actions would benefit the LCB communities.

- There are many lessons to be learned from across the basin, from the climate change research perspective to the ground level adaptation examples. These need to be harnessed, capitalised on, up-scaled and shared among the LCB countries.
- The LCB region benefits from the multi-sectoral approach to aquatic resources management through the LCBC; however, regional management of share resources needs to be strengthened.

With this in mind, the Workshop recommended supporting national and regional actions toward a better understanding of the LCB human and aquatic systems' vulnerability to climate change. This would provide a strong footing for organising national and regional processes to support regional fisheries and aquaculture sector adaptations actions. Furthermore, the Workshop recommended that technical possibilities, best practises, governance systems and monitoring, control and surveillance (MCS) options be supported by investment in research and development to support resilience and adaptive capacity of the human and aquatic systems. The Workshop also a called for integrated cross-sectoral (forestry, agriculture, water, fisheries, etc.) support to decrease the system's vulnerability and support broader moves towards sustainable ecosystem-wide development. Also, existing political commitment must be strengthened for effective management of aquatic resource use through stronger regional collaboration, coordination of national and regional projects, advocacy and knowledge sharing among the LCB member states. The Workshop also recognized the need to identify and implement pilot projects to explore best practises and tools that can be used for implementing practical actions for adaptation to climate change. Lastly, it was suggested that these measures would require the identification of support and funding the recommendations at all levels (e.g. industry, fisher, community, NGO, government, and IGO/CSO).

12. CLOSING OF THE WORKSHOP

The Executive Secretary of the LCB, Mr Sanusi Imran Abdullahi, closed the meeting. He thanked all participants for attending and the Government of Japan, FAO, both the Rome and N'Djamena offices for their support. He noted that it was a great honour for the LCBC to have hosted the Workshop. Furthermore, he stated that the effects of climate change are visible to everyone, and that this is an opportunity that we must build on. Action should be taken to create awareness and capacity building to ensure sustainable livelihoods and wellbeing of communities living in the LCB and to place them in a better position to deal with the continuing detrimental effects of climate change. He further noted that the next steps would be to ensure that recommendations from the Workshop reaches the Heads of States so that there is a political discussion to move and act on the recommendations. Finally, he thanked everyone for attending and welcomed all present back to Chad in the future. The Chairman, Mr Ngakougnou, also thanked everyone and declared the Workshop closed.

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Annex 2 – **Agenda**

18 November 2011		
Registration		8:30-9:00
Opening of the meeting	LCBC, FAO	9:00-9:30
Presentation of the participants Election of chair and rapporteurs	All	9:30-9:45
Background and purpose of the meeting Adoption of the agenda	De Young All	9:45-10:00
Group photo Coffee break	All	10:00-10:30
Climate in the Lake Chad Basin and predictions for the future	OSS	10:30-11:15
Hydrology of the Lake Chad Basin	AGRHYMET	11:15-12:00
Lunch	All	12:00-13:00
National report Cameroon	Cameroon	13:00-13:30
National report Chad	Chad	13:30-14:00
National report CAR	CAR	14:00-14:30
Coffee	All	14:30-15:00
National report Niger	Niger	15:00-15:30
National report Nigeria	Nigeria	15:30-16:00
Presentation of background document	Ovie and Belal	16:00-17:00

19 November 2011		
Organization of group work	De Young	9:00-9:15
Group work	All	9:15-10:00
Coffee break	All	10:00-10:30
Presentation of outcomes and discussion	All	10:30-12:00
Lunch	All	12:00-13:00
Group work	All	13:00-14:30
Coffee break	All	14:30-15:00
Presentation of outcomes and discussion	All	15:00-16:30
Synthesis	All	16:30-17:00

20 November 2011		
Project development, partners and possibilities for funding	Davies	9:00-9:30
National climate change strategies	CC focal points	9:30-10:30
Prioritization of issues by country	De Young	10:30-12:00
Lunch	All	12:00-13:00
Regional and national components	De Young	13:00-13:30
Next steps, who does what (focal points)	De Young	13:30-14:00
Coffee	All	14:00-14:30
Wrap up	De Young	14:30-15:00

CONTRIBUTED PAPER

Identification and reduction of climate change vulnerabilty in the fisheries of the Lake Chad Basin

"If we do not do anything about global warming, we will end up with a catastrophic planet"
- Sachs (CNN, 15/08/2010)

"Global warming has been accelerated by man and it can be slowed by man too."
- President Barrack Obama

by

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Abbreviations and acronyms

AIDS	acquired immunodeficiency syndrome
CAR	Central African Republic
CO_2	carbon dioxide
DFID	Department for International Development
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross domestic product
GIWA	Global International Water Assessment
HIV	Human Immuno deficiency Virus
IDDRA	Institute for the Sustainable Management of Aquatic Resources
IPCC	Intergovernmental Panel on Climate Change
LCB	Lake Chad basin
LCBC	Lake Chad Basin Commission
LGA	local government authority
NASA	National Aeronautic Space Agency
SFLP	Sustainable Fisheries Livelihoods Programme

Abstract

This report, 'Identification and Reduction of Climate Change Vulnerability in the Fisheries of the Lake Chad Basin' is essentially a desk-based review and is structured in five main parts. The first part deals with a description of the basin focusing briefly on its geography, physical features, jurisdictional, social and economic boundaries. The second section gives a broad overview of climate change and its potential impact pathways on the fisheries of the basin and reviews the biological and ecological state of the system's natural resources. The socio-economic contribution of the fisheries to the livelihoods of the basin's communities and the wider society is described, including the governance and management of the basin's resources. This section concludes with identification and evaluation of current adaptive strategies to change and the major factors constraining such coping strategies, including an analysis of the system's vulnerability. Section 3 identifies a wide range of potential strategies for reducing vulnerability in the system in terms of decreased exposure, impacts and sensitivity and means of improving adaptive capacity and resilience of the system. A set of policy recommendations aiming at reducing the vulnerability and improving the resilience of the system is made in section 4. The report finishes with a short conclusion in section 5 that seeks the assistance of the international donor Agencies from developed countries to help address the impact of climate change on natural resources in Africa in general and the Lake Chad Basin in particular.

1. Introduction

The issue of climate change/global warming and the threat it poses to small-scale and commercial fisheries and aquaculture has been acknowledged (Daw *et al*., 2009). Environmental change, either due to anthropogenic green house induced gases or natural climatic variability is impacting fisheries and other natural resources, through environmental and biodiversity changes. In the Lake Chad basin (LCB), these changes which occur at both national and regional levels, have not only constrained livelihoods, but have also exacerbated community vulnerability in an environment that is already impoverished. UNEP (2004), acknowledged that the LCB, the lake itself and the natural resources and services they hold for the riparian communities are under threat from environmental, hydrological and biophysical changes due to anthropogenic climate change, natural climatic variability and anthropogenic stream flow modification. These factors have combined to account for the drastic reduction of water in the LCB and the lake itself leading to loss of fishing, agriculture and pastoral grounds; with severe implications for riparian livelihoods in terms of income generation, employment and food/nutrition security. Over the years, communities in the LCB have had to adopt different livelihoods strategies and portfolios in response to significant changes in hydrology and ecology manifested through reduced hydrologic cycle and surface runoff/underground water.

According to FAO (2004), the LCB is unique in the sense that "no where 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 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*., 2003b; 2003c; Neiland *et al*., 2005). This strategic importance, perhaps, informed its selection for this case study. In terms of fisheries, the Lake Chad and its floodplain/wetlands represents the single most important inland water fisheries ecosystem in both West and Central Africa (Neiland, 1998; Jolley *et al.,* 2002). Regionally (Nigeria, Niger, Cameroon and Chad combined), about 150 000 tonnes of fish, valued at about US$54million (whole sale value) are landed annually (Jolley *et al.,* 2002; Béné *et al*., 2003b; Neiland *et al*., 2003; Ovie *et al.*, 2007b). A nodal fish market, capturing processed fish products from the riparian countries, has been established and operational on a weekly basis in Doro Baga on the Nigerian shores of the lake. This market has informally acquired an international status.

Since 1972, the fisheries, agriculture and livestock resources of the LCB have been greatly influenced by the massive environmental changes that have occurred in the region. In particular, the huge reduction in lake area of over 25 000 km^2 in the 1960s to 2 500-6 000 km^2 in the 1980/1990s (Neiland *et al*., 2002), has greatly influenced the lives of the rural population of about 37 million that are dependent on the natural resources of the basin. The severe droughts of 1972-1974 and 1981-1982 that largely accounted for this scenario and believed to be due to climate change, manifested in significant socio-economic and ecological disruption (Béné *et al*., 2003a). Certainly, there is need to focus on this all-important sahelian water body because of the huge benefits it ia delivering to the riparian communities and the wider society.

In general, the report is essentially a desk-based review and is structured in five main parts: The first part deals with a description of the basin focusing briefly on its geography,

physical/climatic features, jurisdictional, social and economic boundaries. The second section gives a broad overview of the basin's biodiversity and the potential impact pathways of climate change on the basin's natural resources, including an analysis of socio economic and other implications of freshwater shortages in the basin. The socio-economic contribution of the fisheries to the livelihoods of the basin's communities and the wider society is described, including the governance and management of the basin's fisheries resources to evaluate how this impact on sustainable fisheries. This section also identified and evaluated current adaptive (resilience) strategies of both the aquatic resources and human population of the basin, including major factors constraining coping strategies. The section concludes with an analysis of the system's vulnerability. Section 3 identified a wide range of potential strategies for reducing vulnerability in the system in terms of decreased exposure, impacts and sensitivity and means of improving adaptive capacity and resilience of the system. A set of policy recommendations aimed at reducing the vulnerability and improving the resilience of the system is made in section 4. In general, the report focuses mainly on that part of the basin that includes the lake itself, the flood plains and the associated wetlands.

2. Definition of the boundaries of the Lake Chad Basin

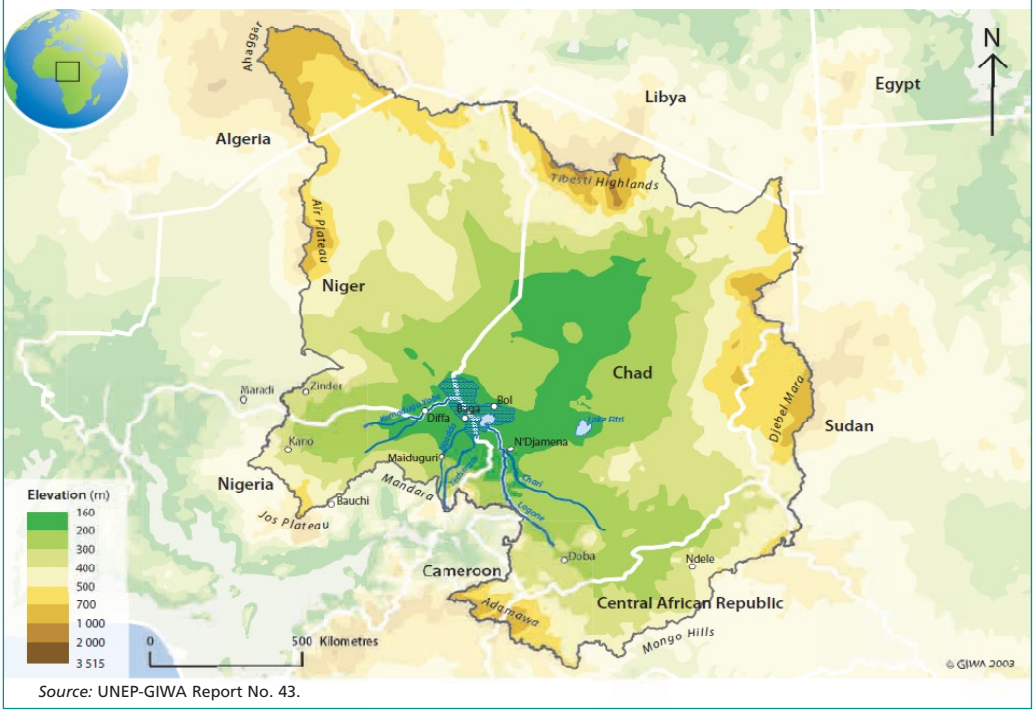
This section describes the location of the LCB, its general hydrology and climate including some aspects of its physical features. A brief description of the riparian countries and associated socio-economic profile is given. The Lake Chad Basin Commission (LCBC)- an intergovernmental agency set up to manage the land and water resources of the basin- is also briefly described. The section finishes with a short profile of the basin's ethnic and institutional characteristics.

2.1 LOCATION

2.1.1 The Basin

The Lake Chad basin 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 (Figure 1). It is said to be the remnant of the paleochad and at a time when the African tropical climate was more humid, the lake stretched far to the north of Africa. In its original form and state, the Lake Chad Basin (LCB) was about 2.5 million km^2 –about 8 percent of the surface area of Africa- and was shared between 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 ahnd 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 N and further west by the Mandaras in northern Cameroon at approximately 10 N. the Jos plateau marks the western boundary in the Nigerian sector of the basin (UNEP GIWA, 2004).

FIGURE 1
The Lake Chad Basin showing riparian countries



Source: UNEP-GIWA Report No. 43.

2.1.2 The Lake Chad

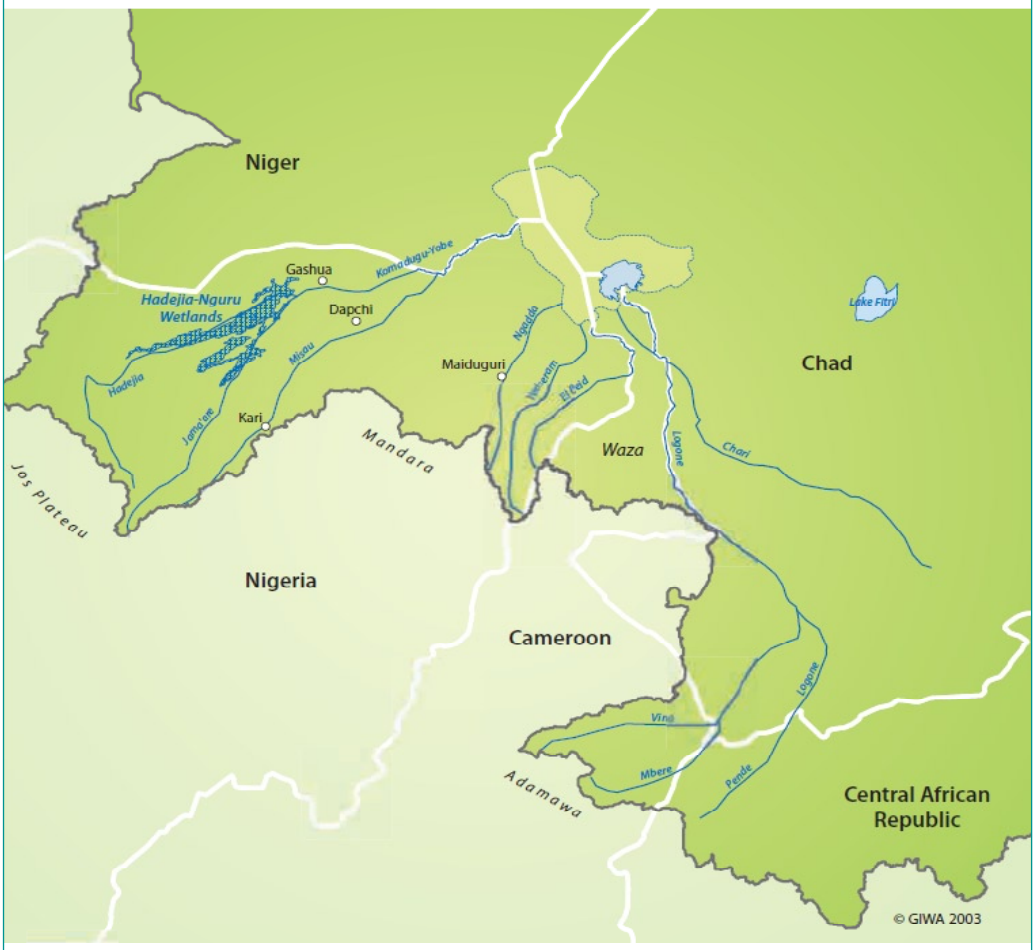
The lake Chad itself is a terminal depression with only four of the basin countries (Nigeria, Niger, Chad and Cameroon) in direct contact with it. The lake occupies less than 1 percent of the drainage basin (Coe and Foley, 2001). It is extremely shallow, with a mean depth of 4m (Carmouze and Lemoalle, 1983). Because of its shallow nature, any increase in lake volume resulting from precipitation and inflows result in a substantial increase in lake area and shoreline. The lake is extremely dynamic, constantly changing size, shape and depth and which occurs annually and over decades and centuries. Modern Lake Chad is said to be a a remnant of the mega or greater Chad phase (300 000-400 000 km^2) that occurred about 10 000-5 000 years ago (UNEP GIWA, 2004; FAO, 2004). Paleo-environmental evidence has shown that the lake dried out completely around year 1450, 1550,1750, 1850 and 1900 (Holz *et al.*, 1984).

2.2 HYDROLOGY OF THE LAKE CHAD BASIN

The lake Chad basin is drained by three main river subsystems-the Chari-Logone, the Komadugu-Yobe (KY) and the Yedseram/Ngadda (UNEP GIWA, 2004). These drainage systems are shown in Figure 2.

The Chari-Logone river subsystem, with a basin area of about 650 0000 km^2 and rising from the Cameroon mountains, contributes over 95 percent of the Lake Chad basin water. This river system which is about 1 400 in length, has a single annual flood regime occurring at the end of the rainy season, and lasting from August to September (Froese and Pauly, 2003). It feeds the extensive Waza-Logone floodplains (about 8 000 km^2) and the Yaeres in Cameroon. Flood water from the Chari-Logone flows

FIGURE 2
The main rivers in the Lake Chad Basin



Source: UNEP-GIWA Report No. 43.

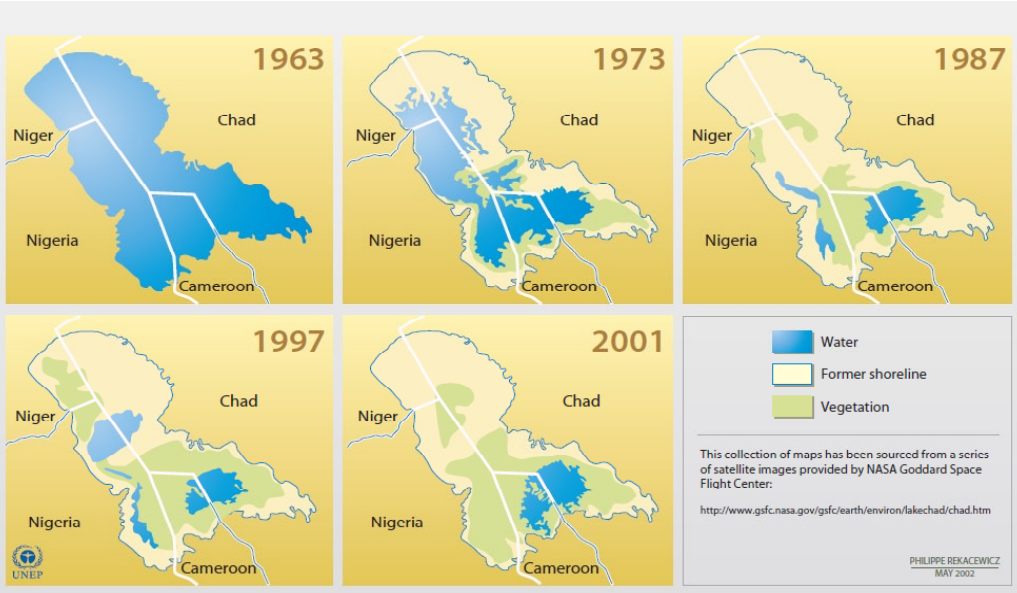
into the lake at its southern extreme and usually takes one or two months to reach the southwest shores. A number of minor tributaries such as the Pende, Vina, El-Beid and Mbere feed the Chari-Logone subsystem. The Maga dam is a major reservoir built on the Chari –Logone system.

The KY subsystem has a basin area of about 1 400 km^2 (World Bank, 2002a) 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. 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. The Hadejia River has three major dams built across it- Tiga (1 400 million m^3 reservoir; Challawa Gorge, 972 million m^3; and Hadejia, 1 200 million m^3). A major dam (Kafin zaki, 2 700 million m^3) has been planned for the Jama'are River but construction has nor commenced because of lack of funds.

The third major drainage system, the Yedseram/Ngadda river subsystem consist of the Yedseram and the Ngadda rivers- the former rising from the Mandara Hills in Cameroon and the former from Northern Nigeria. The Ngadda river contains the Alau lake located downstream of Maiduguri town in Nigeria.

Decadal variation in the hydrological status of the lake is shown in Figure 3. Clearly, there has been a significant reduction in lake area over the years, leading to what is now popularly known as the 'shrinking Lake Chad'. Water loss from the lake

FIGURE 3
Chronology of lake variability: 1960 to 2001



A chronology of change - natural and anthropogenic factors affecting Lake Chad.

Note: Images are taken in January each year. (Source: UNEP GRID Arendal 2003)

The figure above shows a time-lapse sequence of maps, sourced from satellite imagery, illustrating the evolution of the Lake 1963 to 2001 (Lemoalle 1991, USGS 2001).

1963: Open water is approximately 23 000 km^2 and each basin is connected by open water.

1973: The beginning of the effects of the 1972-1974 Sahelian droughts separated the northern pool from the southern by exposure of the Basin's inner ridge, the Great Barrier. During this period the northern pool suffered a general drying out period and a change from an open water lake environment to one of an unstable marshy appearance. The open water had totally dried out by 1975 and during the same period the open water areas of the southern pool reduced by 90% (FAO 1986 in Neiland & Béné 2003).

1987: The effect of both the 1972-1974 and 1982 Sahelian droughts has resulted in open water being restricted to the southern pool only.

1997: There was little variation over the previous decade with open water estimated to vary inter-annually in area between 1 500 to 2 000 km^2, plus a larger surrounding area of mixed permanent and temporary swampland of between 2 000 to 4 000 km^2.

2001: The state of open water flooding estimated to be 1 350 km^2 with around 4 000 km^2 of swampland (Neiland & Béné 2003). The expansion in the Lake is masked by the proliferation of floating vegetation.

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

is principally through evaporation and minor marginal leaks. Lake Chad, like Lakes Malawi and Tanganyika in East Africa, is endorheic-no outlet- (Beadle, 1981; Chouret and Lemoalle, 1975). In general, 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 argument of Coe and Foley (2001 cited on page 58, UNEP GIWA 2004), that overgrazing has a 'domino effect' on the shrinking of the lake is difficult to substantiate

Based on its historical hydrological stutus, the lake has been categorised by various workers into three main phases- Greater or Mega Chad (over 300 000-400 000 km^{2}); Normal Chad(18 000-25 000 km^{2}) and Small or Lesser Chad (2 000-9 000 km^{2}) (Tilho, 1928; Roche, 1973; Beadle, 1981). Not much is known of the Greater Chad, but it is believed that the lake had its largest hydrology at this period, about 10 000-5 000 years ago (UNEP GIWA, 2004) while the normal and lesser Chad occurred in the early 1960s and late 1970s, respectively (Servant and Servant, 1970; 1973). According to Neiland *et al.* (2005), the lake covered an area of 23 000 km^{2} in 1960 (the normal Chad) and by 1975 the lake had decreased by about 30 percent due to the Sahelian drought of 1972 and 1974.

During the 1970s and 80s, the hydrology of the lake was further stressed due to dam construction on major effluent rivers as described above. Important dams built for irrigation at this period included the Maga dam (SEMRY[1] project) on the Logone in Cameroon and the Hadejia-Jama'are River/Tiga/ Challawa dam construction in the Yobe Basin in Nigeria. In addition, the SODELAC[2] polder irrigation project on the eastern shores of the lake in Chad encroached on important wetlands that were drained and are no longer flooded (Ladu *et al*. 1999; Neiland *et al.* 2005). These human interventions led to the loss of an estimated 200 000 ha of floodplain areas along the lakeshores and rivers, areas that were critical for fish breeding and nursery. The Sahelian droughts in 1982-84 reduced the water flows even further and by 1990, the Lake Chad covered less than 2 000 km^{2} the smallest area this century (the so-called Lesser Chad). In addition to this open water area, a swampland covered an estimated 4 000 km^{2}.

A slight increase in the discharge of the effluent rivers in 1998 increased the floodplain areas and by 2000, it was reported that the northern basin had started to experience some flooding (Nigerien colleagues, personal communication). However, the lake continues, till date, to remain in the "lesser Chad" hydrological condition.

A typical annual seasonal variation in level of the lake and that of the River Chari (one of the main inflow rivers) is shown in Figure 4. In the river, water level rose very fast during the rainy season from July, peaked in September/October and thereafter decreased very rapidly also. Lake level peaked slightly later due to the time of arrival of the flood from the river to the lake, and because of its flat nature, lake level rise is not too apparent.

During the Greater Chad period, the 'great barrier' that divides the lake into the Northern and Southern basins was completely inundated making navigation possible on the entire lake. During the Normal and Lesser Chad phases, the barrier obstructs navigation between the two parts of the lake. The Lesser Chad was principally attributed to the drought of 1973, and by the end of 1975 the Northern basin was completely dry while the Southern basin was reduced to a remnant fed directly by the reduced annual flood from the Chari River. Highly reduced water level, followed by rapid emergence of vegetation caused a 'dam' of vegetation on the great barrier.

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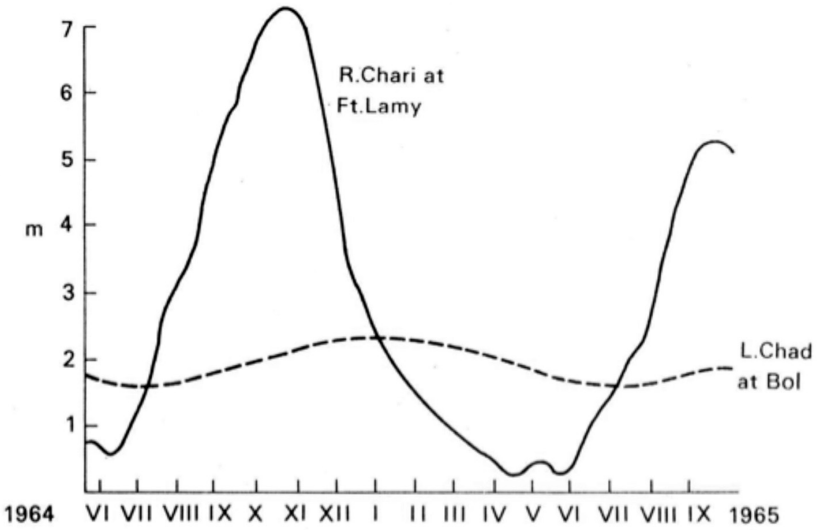
1 Société pour l'Expansion et la Modernisation de la Riziculture dans la région de Yagoua.

2 Societé de développement du lac.

FIGURE 4
Typical annual hydrological cycle of the Lake Chad Basin



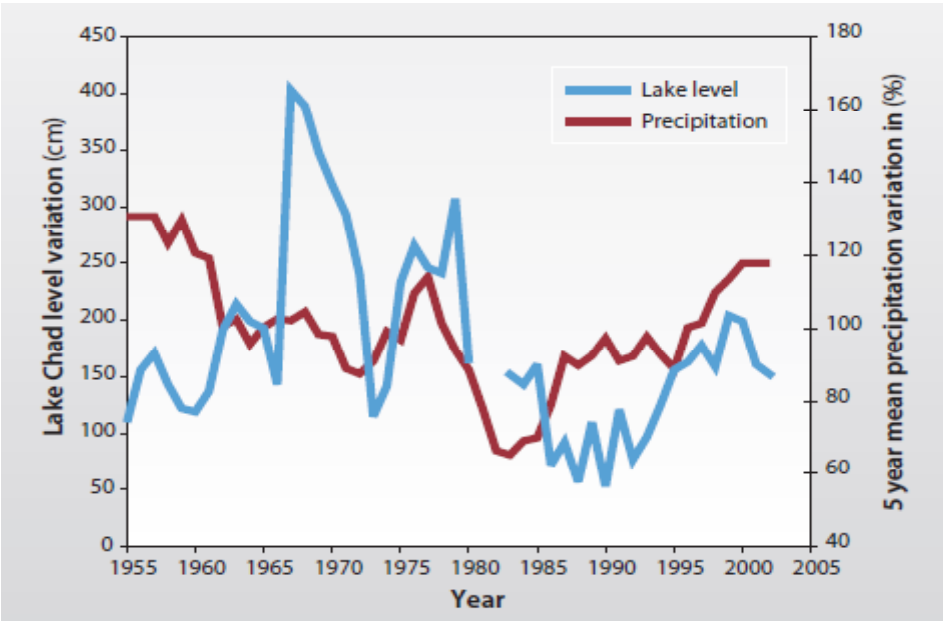
Source: Beadle, 1981.

2.3 CLIMATE OF THE LAKE CHAD BASIN: RAINFALL AND EVAPORATION

The Lake Chad Basin has a hot and dry climate. Rainfall varies from about 200 mm in the northern basin to about 300 mm in the southern basin (Chouret and Lemoalle, 1975). UNEP GIWA (2004) however, put rainfall at 1 500mm to less than 100mm in the southern and northern basin, respectively (Figure 5) 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.

Data on rainfall (Figure 5) show that total annual precipitation volumes vary considerably from year to year. In the 1980s, Cameroon faced a prolonged drought with rainfall as low as 487.4 mm/year, and shorter, less pronounced droughts in 1996-98 and 2004-06. In Nigeria, these drought episodes were more pronounced in 1972/73

FIGURE 5
Lake Chad level variation and yearly precipitation at Bol



Source: Tschierschke, 2002 In: UNEP-GIWA, 2004.

and 1982/84. Abrupt changes in rainfall are a general phenomenon for this area leading to high variation of outputs from agricultural production and fishing activities.

The basin is predominantly located in the transition zone between the Sahara desert and the Savanna grassland called the sahel. The climate and hydrology of the region is predominantly influenced by rainfall. The LCB is under the influence of the inter tropical convergence zone (ITCZ) which oscillates seasonally between 15° N and 15° S (Nieufwolf, 1977 in le Barbe& Lebel, 1997). High pressure originating from the sahara desert prevents rainfall in the north except during the boreal winter when occasionally cold air descends from the north. Rain, therefore, occurs in the region when the ITCZ has moved past this area towards the north (Le Barbe & Lebel, 1997). Rainfall occurs between April and October but is heaviest in August at a period when the ITCZ is at its maximum northern extent. About 90 percent of the rains fall between June and September.

The average annual temperature of the lake Chad water which is closely related to the annual, seasonal and diurnal variation in air temperature, varies between 25.5 °C 27.5 °C.

2.4 BRIEF PHYSICAL FEATURES OF THE LAKE CHAD BASIN

Built of basalt and at a summit of between 2 500 to 3 400 m above mean sea level (amsl), the Tibesti and Ahagger Highlands in Algeria form the highest elevation within the Lake Chad Basin. In western Sudan, there is the Djabel Mara volcanic mountains with an elevation of 3 088 m amsl but which decrease gradually to about 300m amsl towards the Lake Chad tectonic depression. Most of the interior of the region is a depression with heights not more than 500m amsl, the lowest point being about 160 m amsl (UNDP/FAO, 1972).

The Lake Chad basi was formed by extensional tectonic forces during the cretaceous period (Burke, 1976 in Isiorho & Nkereuwem, 1996) with the geological and geomorphological development by the rifting of the Central and west African Rift System. For fuller details of the geophysical and geological characteristics of the LCB, readers are referred to UNEP GIWA (2004 page 14-15).

Within the Lake Chad itself, several ecological zones, spanning from North to South, predominate due to fluctuating water levels. The following account is given by Beadle (1981): From the northern to the eastern shores are rows upon rows of partly submerged sand dunes forming elongated primontoria and islands, all oriented in a North-West –South-East direction, each partly fringed by papyrus and reed vegetation swamps. The dunes are thought to be accumulated by prevailing winds ie. North East harmattan (November-April) and the East and South West winds (May – October). Further into the Southern basin, the dunes are completely submerged under a belt of swamps composed mainly of papyrus (*Cyperus papyrus*), a reed (*Phragmites mauritianus*) and the grass (*Vossia cuspidatus*) (Beadle, 1981; Chouret and Lemoalle, 1975). In the Northern basin, the swamp islands are predominantly infested with *Phragmites australis,* while *Typha australis*, an obnoxious aquatic weed, dominate the shoreline.

In terms of depth, the Southern basin is shallower (2.5-4.5 m) than the Northern (4-7 m) principally due to discharge of sediments into the former by the Chari River, resulting in less water area and greater vegetation cover. The open waters of the lake are surrounded by permanent and/or seasonal marshes, oxbows, pools and swamplands. These distinct and varied ecological niches harbour a rich assemblage flora and fauna and account for the high biodiversity of the system.

2.5 THE BASIN'S COUNTRIES AND THEIR BRIEF SOCIO-ECONOMIC PROFILES

Cameroon, Chad, Niger, Nigeria, CAR, Algeria, Libya and the Sudan are the main countries in the LCB, although at the moment CAR Sudan and Libya are far away from the lake and therefore exploit very little of the basin's fisheries and other aquatic

resources. Presently, only the first four countries are in direct contact with the Lake Chad. A generalised profile of the countries is given in Table 1.

The LCB countries are among the poorest in the world as exemplified by the Human development index (HDI) and the percent of people living below the poverty line of less than 1 or 2 US$ a day. For example, Chad was ranked 155th out of 162 countries on the UN HDI with an annual per capita income of only 200 US$. The Gross National incomes (GNI) of the countries are extremely low except for Algeria and Libya. A GNI per capita ranking by the World Bank put Chad, CAR, Niger and Nigeria among the 23 poorest countries in the world (World Bank, 2002). Overall, the countries are characterised by slow economic growth with annual GDP growth ranging from about 1.4 percent in Chad for over 20 years (IMF, 2003) to 1.9 percent in Niger from 1990-2000 (Government of Niger).In CAR and Sudan, growth rates have declined steadily since 1997. In Nigeria, despite vast oil reserves, GDP growth averaged 1.6 percent between 1980 and 1990, 2.4 percent between 1990 and 1998, and just 1 percent in 1999 (Narayan and Petesch, 2002).

The economies of the countries are characterised by very low productivity, insufficient infrastructure, poor governance, a lack of a dynamic private sector and a vulnerability to domestic and external shocks. Most of the countries have also suffered or are suffering from political instability due to wars (Sudan and Chad) and democratic agitations as is currently happening in Libya. In each of the riparian countries, poverty is more intense within the sector of the country lying within the LCB boundaries (World Bank, 2002b).

The AIDS pandemic which is more prevalent on the active population (ages 15-46) has also impaired economic development in the region. Health and life expectancy are very poor, while infant mortality and adult illiteracy is high and very common (World Bank, 2002b).

The current population of the riparian communities in contact with the lake is about 39 million people made up of Nigeria (23), Chad (8), Sudan (3), Niger (2), Cameroon (2), CAR (1) and Algeria/Libya (0). Clearly Nigeria account for approximately 60 percent of the basins population. The annual population growth in the region has ranged between 2.5 and 3.0 percent (World Bank, 2002b) and has increased by about 11.7 million since 1990 (UNEP, 1999).

TABLE 1
A generalised socio-economic profile of the LCB riparian countries

Health and Education indicators		Chad	CAR	Cameroon	Nigeria	Niger	Sudan	Libya	Algeria	Sub-Saharan Africa
Life expectancy (2000)		48	43	50	47	46	56	71	71	41
Infant mortality per 1,000 live births (2000)		101	96	76	84	114	81	26	33	91
Prevalence of under nourishment, % of pop (1996-1998)		38	41	19	8	46	18	ND	5	33
Incidence of tuberculosis per 100,000 people		270	415	335	301	252	195	24	45	339
Physicians per 1000 people (1990-1999)		<0.05	<0.05	0.1	0.2	<0.05	0.1	1.3	1.0	0.1
Health care expenditure, % of GDP		2.9	3	5	2.8	2.6	3.3	ND	3.6	4.9
Adult illiteracy, % ages 15 and over (2000)	Male	48	40	18	28	76	31	9	24	30
	Female	66	65	31	44	92	54	32	43	47
Gross primary enrolment, % of school-age group (1998)		67	57	90	ND	31	56	153	109	78
Population		10 (8)*	4(1)	15(2)	150 (23)	16(2)	(3)	(0)	(0)	
% Living below 1 US$		64	67.4	40	34.1	63.0				
HDI		155	154	125	136	161				

Note: ND = No Data; * Values in brackets represent population within the basin.

Source: World Bank, 2002; Neiland et al., 2005; World Fact Book, Nov. 2010.

The basin's population is characterised by a young age structure, particularly in the southern riparian countries. In Niger for example, about 50 percent of the population is under 15 and only 2 percent is over 65. The reverse is the case with the northern riparian countries of Libya and Algeria where age structure is skewed in favour of the elderly (World Bank, 2002b).

The main economic activities in the basin fall into the following categories:

- Minining especially for Gold
- Oil exploration and exploitation
- Agriculture: cotton, groundnuts, millet, sorghum, cowpea, rice, onions, vegetables etc
- Fisheries in dams, rivers, floodplains and the lake Chad
- Manufacturing especially cotton ginning, leather work, milling and food industry.

In terms of production activities in the LCB, fishing is the most significant, accounting for about 45 percent of total income as shown in Table 2.

TABLE 2
The region's household sources of income

Activity	Million US$ (billion CFA*)
Fishing	45.1 (26.3)
Rain-fed and flood recession cropping	26.6 (15.5)
Animal husbandry	14.7 (8.6)
Small irrigated areas	10.8 (6.3)
Large irrigated areas	9.4 (5.5)

Note: (CFA= Franc de la communaute financiere africaine).
Source: UNEP-GIWA, 2004.

2.6 THE LAKE CHAD BASIN COMMISSION

The Lake Chad Basin Commission (LCBC) was created on 22nd May, 1964 based on the Convention and Statutes signed by the four lacustrine countries of Cameroon, Chad, Niger and Nigeria. A further agreement, signed in Lagos in 1968, covered the joint economic development of the area. The LCBC Headquarter was established in Fort Lamy (presently N'djamena, Chad) with about 70 staff, including administrators, scientists and technicians. The Central African Republic and Sudan joined the LCBC in respectively 1994 and 2002. The area included under the mandate of the LCBC (termed the 'Conventional Basin') increased from 427 300 km^2 (1964) to 969 955 km^2 with Central African Republic joining and has now enlarged, hugely, with the addition of Sudan.

The Commission headed by an Executive Secretary has the overarching policy objective of exploiting and improving the management of the LCB water resources for the welfare of the people concerned (Magomna and N'Garba Tchere, 1999). The specific aims of the LCBC are to: (i) regulate and control the use of water (for human population, irrigation, livestock and fisheries) and other natural resources in the Basin (ii) initiate, promote and coordinate natural resource development projects and research within the Basin and assist in its sound environmental development and management (iii) examine complaints and promote settlement of disputes, thereby promoting regional cooperation.

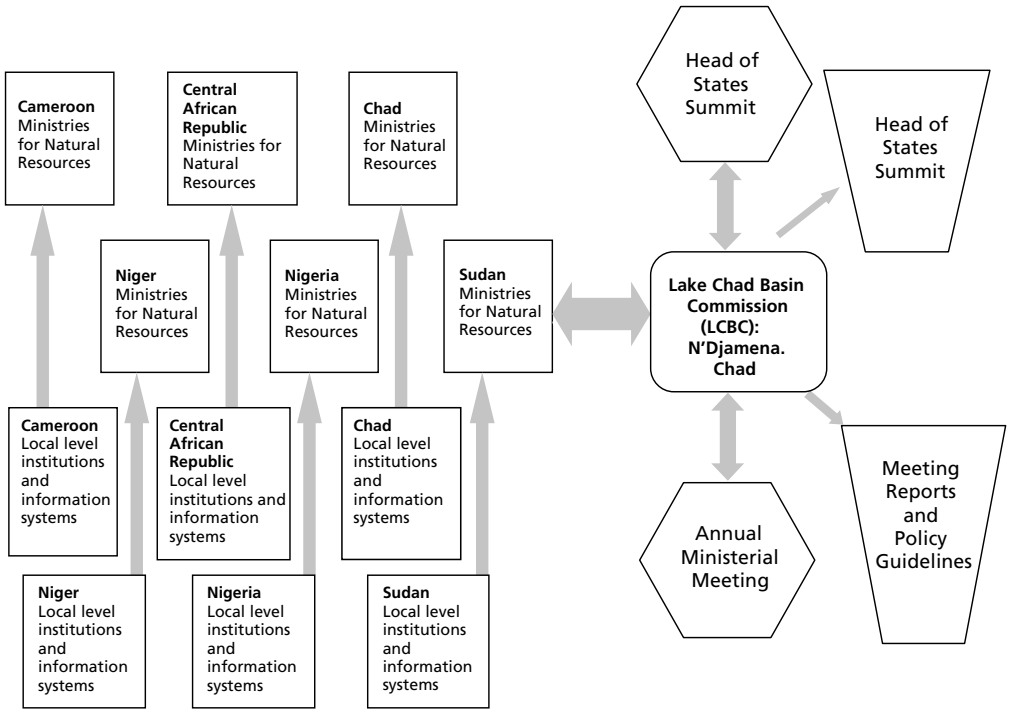
The Fort Lamy Convention that established the LCBC recognises the sovereign rights of member States over the water resources of the basin but forbids any unilateral exploitation of the lake water, especially when such use has a negative effect on the interests of the other States. The Convention also recognises the rights of member States to plan projects, provided they consult the Commission beforehand. Member States were also to refrain from any measure likely to alter the lakes water'balance, the quality of its water and the biological characteristics of the flora and fauna.

A periodic meeting, the 'Summit of Heads of States', is the highest policy-making body within the LCBC framework and provides a forum to discuss major issues affecting the Basin. This high level political meeting is underpinned by the 'Annual Ministerial Meeting or Session' responsible for articulating information from each country on key issues affecting the LCB. The output of the annual ministerial meeting, in the form of briefing reports and policy guidelines (if agreed by all countries), is discussed and ratified at the Heads of State Summit. A 'Final Communiqué' from the Heads of State Summit represents the overarching policy guideline for all the LCB countries (Neiland *et al.*, 2005). The organogram of the LCBC is shown in Figure 6.

Three Summit meetings took place in the 1970s (N'Djamena, 1972; Yaounde, 1973, Nguru, Nigeria, 1977). These meetings focused on institutional and financial organisation and workings of the LCBC, including the decision to create a LCB development Fund, which would rely on contributions from member countries rather than external sources for the implementation of development programmes. Agreed development programmes included livestock, agriculture, fisheries, roads/ communication network and free movement of fishermen on the open water of the lake. Three other summits in the 1980s (Lagos, 1983; Lagos, 1985 and N'Djamena, 1987) focused on regional development, food insecurity, the Sahel drought, climate change and desertification.

In 1992, the Commission adopted a Master Plan for the Basin, which included an "International Research Centre for Integrated Development and Management of Fisheries in the LCB (Project 19). The goals of this project included re-establishing the sustained yield of the fisheries by monitoring with reference to hydrological models, writing and adoption of international fishing regulations and provision of technical and financial support to fishing cooperatives. A budget of US$3 million, spanning four years, was made for this project but, at the time of this report, implementation had not started.

FIGURE 6
Organigram of the Lake Chad Basin Commission (LCBC)



Source: Neiland *et al.*, 2005.

In general, the Commission is known to be experiencing difficulties in the implementation of its mandates due both to financial constraints and sometimes to disputes over the interpretation of its mandate (Magomna and N'Gaba Tchere, 1999).

2.7 ETHNIC AND INSTITUTIONAL CHARACTERISTICS OF THE LCB

The LCB is occupied by several ethnic groups residing in various fishing villages for several decades such as the Hausa from Kebbi and Sokoto States of North-West Nigeria in addition to the Kanuris and Shuwas who are mainly herdsmen and have lived in the region for centuries (Madakan, 1998). Other ethnic groups include the Birgimis, the Lokotos, the Saras, Tubus, Bandas and Shuwas of Chad Republic, the Fulanis, Marghis, Mandaras, and Matakan of Cameroon and the Zabermas of Niger Republic. The Mobbers, Buduma, Kanembu, Kotoko, Haddad, Kouri and Manga tribes are also represented in the region (FAO, 2004).Trans border migration of these ethnic groups, facilitated by the ECOWAS Treaty and the Lake Chad Basin Commission statute, is predominant in the basin (Anene, 1970). Over the years, interactions between these tribes and their cultures, their religions and the mobility of herders have led to a mixing of races and a blurring of roles. Herders have become farmer-herders and farmer-fishermen. Farmers have added fish to their diet and, in turn, gone on to become traders (FAO, 2004)

In general, there are more than 70 ethnic groups in the LCB exploiting the natural environment by a range of activities. The majority of the people speak several local and an official language. The major local languages reflect pre-colonial administration or period. For example, kanuri is spoken mainly in Niger and Nigeria; Fulfude in Niger, Nigeria and and Cameroon and Arabic in Chad. Official languages (mainly English and French) is a reflection of colonialism. Of the four countries currently in direct contact with the lake -Nigeria, Chad, Niger, Cameroon- , Nigeria is the only country with English as official language.

Institutional arrangements in the region are typified by both formal (government) and informal (traditional Authority) mechanisMs While the basin overall is under the jurisdiction of the riparian national governments, the traditional authorities, represented by traditional institutions exercise strong control over natural resources. For example, the Nigerian shores of the LCB are located in the Borno State and the traditional management hierarchy resides with the Borno Emirate headed by the Shehu of Borno, assisted by numerous District, Village and Ward Heads as shown below:

Shehu of Borno (highest traditional authority in Borno State and second in hierarchy in Northern Nigeria)

District Head

▼

Village Head

▼

Ward Head

Similar traditional hierarchies are known to exist in the other basin countries, and their dominance over the control of the basin's natural resources is pervasive and accepted by both government and the rural communities (Neiland, 1998). Details of institutional governance and management of the fisheries is provided in subsection 3.6.

3. Evaluation of the system's vulnerability

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). Other major concerns enumerated by that report included habitat and community modification, unsustainable exploitation of fish and other living resources and pollution. These concerns and issues in the LCB have been linked to a number of causal factors that include anthropogenic causes ($C0_2$ induced climate change and human stream-flow modification) and natural climatic variability (UNEP GIWA, 2004). Severe water shortage has exacerbated community vulnerability and threatened the resilience of the socio-ecological system of the region. Here, socio-ecological system is defined as "a system that includes societal (human) and ecological (biophysical) sub-systems in mutual interactions (Gallopin *et al*., 1989; Allison *et al*., 2007).

In this section a brief review of models or theories underlying climate change effects is undertaken. This is followed by a description of the biological and ecological characteristics of the LCB in order to understand the various components of the basin upon which climate change acts. The economic, nutritional and social contributions of the basin's fisheries is discussed and this is followed by a prognosis of potential impact pathways of climate change on the biophysical and socio-ecological systems of the basin. The aquatic and human adaptive capacity of the system is analysed to enable an understanding of its robustnest and resilience. The penultimate section deals with an analysis and evaluation of governance and management of the fisheries, including property regimes, conflict resolution, sanction mechanisms and constraints to change in the management of the fisheries. The section ends with a brief discussion on disaster risk management (DRM) and an analysis of the basin's overall vulnerability to climate change in relation to exposure, sensitivity, potential impacts and adaptive capacity. These subsections are discussed below in the following sequence:

- Brief review of climate change models in the LCB
- Biological and ecological status of the region
- Economic, nutritional and social contributions of the LCB fisheries
- Identification of potential changes and impact pathways of climate change on the basin's resources
- Evaluation of current adaptive capacity and resilience of the aquatic and human system
- Governance and management of the fisheries including property regimes
- Conflict resolution and sanction mechanisms in the governance of the fisheries
- Climate change and disaster risk management (DRM)
- Constraints to change in the management of the fisheries
- Overall analysis of the systems vulnerability

3.1 BRIEF REVIEW OF EXISTING CLIMATE CHANGE MODELS IN THE LCB

To the best of our knowledge, there are no existing models predicting the impact of climate change on biophysical changes and impacts on the LCB ecosystem. Ficke *et al.*, (2005), acknowledged that 'predictions of climate change on the distribution of tropical fishes are few because although the topic is of interest, relatively little is known about tropical systems compared to temperate regions'. However, a number of theories that attempt to examine the impact of climate change on biophysical components of aquatic

ecosystems are available (eg. Xenopoulos *et al.*, 2005; Ficke *et al.,* 2005; Brander, 2006; Roessig *et al*., 2005; Daw *et al.*, 2009; Cochrane *et al.*, 2009; De Silva and Soto, 2009 and Doll and Xhang, 2010 among others). These reports are briefly reviewed and used under different sections of this report to reflect on the situation in the LCB.

Climate change effects causing increased evapo-transpiration and reduced precipitation will have serious impacts in river flows and dynamics as well as lake levels and temperatures. 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). As the survival of many aquatic organisms is tightly linked to temporal variation in flow (Poff *et al.*, 1997; Bunn and Arthington, 2002), small variations in discharge can have dramatic effects on the success of breeding migration and annual recruitment (Dudgeon, 2000). Aside from reduced precipitation, the huge evapo-transpiration in the LCB (2 000 mm/annum) compared to annual rainfall (200-300 mm) (Chouret and Lemoalle, 1975) is of major significance to the overall hydrology and fisheries/other natural resources of the basin. The declining *Alestes* fisheries of the Chari Logone (an important pelagic commercial fisheries of the LCB in the 1970s), is a case in point. The systematic reduction in rainfall and river flow the Chari-Logone and the Komadugu-Yobe river subsystems has almost wiped out this important source of income and food/nutrition security for the poor riparian communities of the basin.

Interactions between reduction in 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; Matthew, 1998; Ficke *et al.*, 2005) and aquatic communities and thus ecosystem structure and function (Schlosser *et al.*, 2000; Ficke *et al.*, 2005; FAO, 2004).

It is also expected that climate change will lead to increased toxic algal blooms and secondary infections of fishes (Steedman, 1991). Increased temperatures are known to exacerbate the bloom of certain blue green algae that have been implicated in mass fish kills in reservoirs, lakes and flood plains. Though of high human health benefits, the proliferation of the blue-green algae, *Spirulina,* in wadis (salt or brackish water pools) in the Chad Basin is noted for "excluding any other living organism" as it thrives in high temperature and high pH environment (FAO, 2004). It is a high value natural diet that has sustained local people in the basin for centuries not only as a vital food source but also as a means of income generation. The health importance is legion: lowering of cholesterol levels; enhancement of immune system; effective in the treatment of obesity and heart disease; prevention stress, arthritis and anaemia, osteoporosis and cancer (FAO, 2004 Chapter 9).

The incidence of parasite transmissions are also associated, not only with host condition and the presence of intermediate hosts necessary for the parasites life cycle, but also with water quality and temperature effects (Marcogliese, 2001). The immune function of fish is compromised by the presence of stressors, including crowding, high temperatures and osmotic stress associated with elevated salt concentration due to low water volume in the LCB. For example, rates of bacteria infections in aquaculture systems often peak at high temperatures (Wedemeyer, 1996). Climate change has been predicted to alter host parasite dynamics by changing transmission opportunities and host susceptibility (Roessig *et al.*, 2005).

Observed thermal effects on parasites, fishes, and water quality suggest that global warming may well increase the virulence of certain fish pathogens and the transmission of certain parasites (Ficke *et al.*, 2005). Parasitism and disease outbreaks can cause increased fish mortality, slower growth rates and lower marketability and economic returns of fish (Harvel *et al*., 2002).

Any impacts on fish biodiversity will also have serious consequences for livelihoods and well being of the fisheries dependent communities, and the implementation of effective conservation and policy measures to stem the expected impacts of climate change are urgently required.

3.2 BIOLOGICAL AND ECOLOGICAL STATE OF THE LCB RESOURCES

Dussart and Gras (1966) and Pouriot (1968) described the general biology, ecology and productivity of the Lake Chad Basin and the Chari-Logone river systeMs A general and more detailed accounts of the biology and ecology including detail flora and fauna of the region are also given in UNEP-GIWA (2004). The major biological components of the aquatic system are summarised below.

3.2.1 Aquatic vegetation

These include mainly the following species: *Potamogeton*, *Vallisneria spiralis*, *Ceratophyllum dimersum* and *Nymphea* sp.

3.2.2 Plankton composition

The phytoplankton community included mainly *Microcystis, Melosira, Aphanocapsa, Pistia, Utricularia, Scenedesmus*, *Synedra, Anacystis cyanoa, Anabaena* and *Coelosphaerium* sp. While over 120 species were reported between 1971-72, there are no recent inventories of the plankton community of the lake.

The zooplankton is dominated by *Thermocyclops neglectus*, *T. decipiens*, *Mesocyclops leukarti*, *Tropodiaptomus incognitus*, *Tropodiaptomus banforanus*, *Mesocyclops ogunnus*, *Ceriodaphnia cornuta*, *Bosmina longirostris*, *Moina dubia*, *Diaphanosoma excisum*, *Keratella cochlearis*, *K. vulga*, *Brachionus calyciflorus*, *B. falcatus* and *Asplanchna* sp.

3.2.3 Molluska

These included *Corbicula africana*, *Pisidium pirothi*, *Melania tuberculata*, *Cleopatra cyclosimoides* and *Byssannodonta parasitica.*

3.2.4 Chironomids

Tanytarsus sp., and *Clinotanypus clavipennis* were the major species.

3.2.5 Fish species

The past ichthyological fauna of the Lake Chad and its basin were listed by Blache (1964) to consist of 140 species. Lowe-McConnel (1987) cited by Sagua (1991) listed 176 species in the Chari-Logonne-Lake Chad System, while Hopson (1967), identified 84 fish species. Differences have been observed between the fish species composition of the north and south basin with a decreasing diversity towards the north. For example, the catfish *Synodontis mystus* and most of the *Synodontis* species have disappeared from the north (although also becoming scarce in the southern basin). Fewer and fewer species communities were reported towards the north east (Camouze *et al.,* 1983; Durand *et al.*, 1972).

A general overview of the ecology of the lake's fish community was given by De Merona *et al.*, (1979), and Leveque *et al.*, (1979). It has been observed that since the 1972/73 drought, there has been a considerable reduction in the number of species. The drastic environmental changes which have affected the region have also impacted on the composition of the fish resources and in turn on the catch composition recorded by fishers (Neiland *et al.*, 2005). During the drying period (1972-1978), natural selection operating on the fish communities favoured marshy species (eg. *Clarias* catfish, Tilapiine cichclids and *Heterotis* sp.) that physiologically and behaviourally are well adapted to survive this unstable hostile environment of low water, high temperatures and low dissolved oxygen that now dominate the ecosystem. The changes in relative

BOX 1

Changes in the Lake Chad fisheries- a tale of two fish – Alestes (freshwater sardine) and *Clarias* (catfish)

Before 1970, the small sardine-like fish called *Alestes baremose*, was an important component of the fisheries of the LCB. Feeding entirely on zooplankton throughout its life cycle, *Alestes* was abundant in the zones of the reed bed islands and the archipelago of the Lake and was also found in the open waters. During periods of rising river levels and flooding (October-December), huge numbers of *Alestes* would migrate into the Rivers Logone and Chari and invade the surrounding floodplain to breed in the shallow waters. With the subsequent decrease in water levels, a few months later, the adult and juveniles would retreat into the main channels and eventually into the lake. The annual cycle of migration of both adult and juveniles, which is adapted to the hydrological patterns, is crucial to the maintenance of the stock of *Alestes* in the LCB System. The setting of fishing nets along river channels and in the floodplain areas of northern Cameroon, in particular, was also timed to coincide with this pattern of migration, and as a result, this species made up a large part of the catch in these seasonal riverine fisheries.

Since 1970 and right up to the present day, the fisheries of the LCB have witnessed a significant decline in catches of *Alestes*. Instead, the fisheries are now dominated by *Clarias* catfish. One of the main reasons for this is the change in environmental conditions of the LCB. The recent Sahelian drought periods, decline of river flows, the reduction in the size of the lake and the emergence of a large area of swampland in the north and south basins have not favoured fish such as *Alestes*. The life cycle and migration of *Alestes* has been severely disrupted. Instead, highly resilient and fast breeding omnivorous fish, such as *Clarias* have taken their place. *Clarias* is well adapted to the new swampland conditions as it can even breathe air, through auxiliary gills under hypoxic conditions in the low water season. *Alestes* remain a minor component of the river fisheries in the region at present.

Source: Neiland *et al.* (2005).

abundance of the freshwater sardine (*Alestes*) and the catfish (*Clarias*), two dominant fish species in the lake basin, are described in Box 1.

Ecologically, typical lacustrine (open water) species such as *Lates, Gymnarchus, Distichodus* and *Hydrocynus* have either completely disappeared or are highly reduced/ restricted to the small portion of open water of the lake, larger river channels and flood plain lakes of the Logone and Chari. Major fish species are shown in Table 3, and as is evident, marshy species currently dominate the fisheries.

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. Most notably, as a consequence of the Sahelian drought of 1972-74 and 1982-84, which produced a lasting modification of the lacustrine hydrology, there has been marked changes in the taxonomic composition, distribution, diversity and production of the fisheries (Bénéch *et al*., 1979, 1983), Bénéch, 1975; Quensiere, 1976, 1979, 1981; Vidy, 1983; Sagua 1986; Lemoalle, 1991; Neiland *et al.*, 1996; Jolley *et al*., 2002). Despite these changes, the Lake Chad and its wetlands, unlike other continental fluvio systems, have displayed an exceptional performance in terms of productive capacity and resources available to fishermen (Sagua 1991; Jolley, 2002)

3.2.6 Other vertebrates of the Lake Chad Basin

Aside from fish, the LCB is an important sanctuary for many freshwater dependent vertebrates some of which depend on fish as the main source of food. Over 14 species of reptiles, seven species of mammals, 59 species of amphibians and 72 species of water

TABLE 3
Percentage composition of major fish species in the Lake Chad Basin (On the basis of market monitoring at Baga Kawa and Kinnassarum)

Genera	Baga-Kawa, Nigeria	Kinnassarum, Chad	Mean value
Alestes	0.43	3.27	1.85
Auchenoglanis	-	1.78	0.89
Bagrus	-	2.54	1.27
Clarias	50.05	23.02	36.54
Distichodus	-	0.01	0.01
Gymnarchus	0.01	17.0	8.51
Gnathonemus	-	-	-
Heterotis	18.89	25.17	22.03
Hydrocynus	-	3.25	1.63
Hyperopisus	-	0.42	0.21
Labeo	0.01	0.21	0.11
Lates	-	4.36	2.18
Mormyrus	2.07	0.35	1.21
Peterocephalus	-	0.53	0.27
Petersius	-	-	-
Polypterus	-	0.38	0.19
Protopterus	2,90	-	1.45
Schilbe	-	-	-
Synodontis	0.01	0.69	0.35
Tilapiine cichlids	25.37	16.95	21.16
Total	**100**	**100**	**100**

Source: Jolly *et al.*, 2002.

associated birds have been reported (Ita, 1994). Because of its location in the Sahelian region and its role as an important water resource, it has been described as a wintering ground for palearctic migratory birds (Ita, 1995; Ladu *et al*, 1999). Other important vertebrates found in the region include otters, crocodiles, hippopotamus, manatees, ostriches, cheetahs and , hyraxes (Okame, 1986; UNEP-GIWA, 2004).

3.2.7 Brief ecological description of the region

The LCB contains a variety of habitats that include deserts, shrub steppes, savannas, forests, lakes, wetlands and mountains (UNEP GIWA, 2004).

The main desert in the region, the Sahara, ranges from large areas of sand dunes to stone plateaus, gravel plains, dry riverbeds and salt flats. Vast underground aquifers that underlie most of the region are known to penetrate the surface to for oasis which are important transhumant sites in the basin. The annual rainfall is below 25 mm and mean annual temperatures are around 25 °C. In the hottest months, temperature can rise over 50 °C and temperature can fall below freezing in winter months. Generally, the flora and fauna of this area is poor.

The steppes are located south of the sahara desert withy rainfall and temperatures ranging from 100-200 mm and 26 to 30 °C. The steppes serve as a transition from the Sahara to the Sahel and is known to harbour a richer assemblage of flora and fauna than the Sahara desert.

The Savanna is known to be the largest ecoregion in the Basinand encompasses the lake Chad savanna floodplains. It is located in the south of the steppes and it represents the transition zone where the savanna meets the sahara desert. The topography is mainly flat and the climate is tropical, hot and strongly seasonal. The monthly mean maximum temperatures vary from 33 to 36 °C, while mean minimum temperature range from 18 to 21 °C. The annual rainfall range from 600 mm in the south to 200 mm

in the north. The soils are mainly sandy and highly permeable, making permanent surface water rare.

The forests, consisting mainly of woodlands and of volcanic origin, are located within the Sahara desert. The areas are cold and dry in the winter and hot and dry in the summer. Rainfall is variable but generally averages about 150 mm a year, with most falling at high elevations. The mean maximum temperatures reaches 30 °C at lower elevations and 18 to 20 °C at the highest elevations. Permanent water holes (gueltas) that are protected from direct sunlight in gorges, are common features of this ecoregion. Due to the presence of permanent pools, the flora and fauna are very rich and diverse. The lake and its associated wetlands has been described in section 2.

3.3 ECONOMIC, NUTRITIONAL AND SOCIAL CONTRIBUTIONS OF THE LCB FISHERIES

The fisheries of the LCB, comprising harvests from the lake itself, the rivers and floodplains, are among the largest and most productive in continental Africa (Neiland, 2005). These fisheries have played, and will continue to play crucial roles in the regional and national economies with current annual fisheries production of about 100 000 tonnes and an annual fish trade that is worth over US$54 million (Neiland *et al.*, 2005). In addition the fisheries contribute significantly to household income, food/nutrition security and employment, and provides an important safety-net for rural communities for whom the risks involved with relying exclusively on agricultural production are high (Ovie *et al.*, 2000; Béné *et al.*, 2003a; Neiland and Béné, 2004). In times of economic crises, such as crop failure, artisanal fisheries provide alternative and vital sources of livelihoods to rural households. The fisheries provide employment, income and food/nutritional security to over 10 million people in and around the fishing communities, while at the same time generating secondary employment for fish processors, fish sellers, transporters and numerous ancillary market–based actors (Béné *et al.*, 2003a; Ovie *et al.*, 2007a and 2007b).

Overall, the fisheries make an important contribution to underpinning the livelihoods of thousands of rural households in the LCB, where fishing and farming are the mainstay occupations. Throughout the year, local populations are alternately or simultaneously fishers, farmers and herders, and each part of land is potentially a fishing ground, a grazing area and a cultured field of arable crops, depending on the flood cycle (Béné *et al.*, 2005). Sagua (1991) estimated the number of rural households engaged in fishing activities in the LCB to be as high as 200 000 persons.

3.3.1 Fish markets and trade

Fish markets and fish trade are important and age long cultural component of the rural people of the LCB, contributing significantly to national and regional economies of the riparian countries and the wider society. Neiland *et al.* (2005) traced the history of fish trade in the LCB since the beginning of the nineteenth century (Box 2) and showed that this has contributed profoundly to subsistence livelihoods and poverty alleviation in the region.

There are two major components to the fish trade in the LCB. First, is a local trade within each country, with fishers and local merchants supplying both fresh and some processed fish to local markets within villages and towns. This trade does not involve long distance or cross border transportation and occurs in close proximity to fishing grounds and landing sites. The second component of the fish trade involves long distance cross border transportation of processed (smoked or sundried) fish to distant markets far from fishing grounds. For example, a large proportion of fish products from Cameroon, Niger and Chad are moved by their nationals into Doro Baga fish market in Nigeria (Box 3) on a weekly basis. From Doro Baga, the fish product is trucked to distant Southern Nigeria wholesale/retail fish markets (Figures 7 to 9) -

BOX 2

History of fish trade in the Lake Chad Basin

1000-1900: Pre-colonial periods (1 000 tonnes /year, wet wt.) Small fish trade during the pre- capitalist period; fisheries mainly part of the subsistence economy; fishing and farming to secure livelihoods and food security.

1900-1960: Colonial period (up to 10 000 tonnes /year): fish trade increased with growth of colonial economy, where commodity trade of surplus production was encouraged; increased demand for fish from urban areas; new roads and security for merchants facilitated this trade.

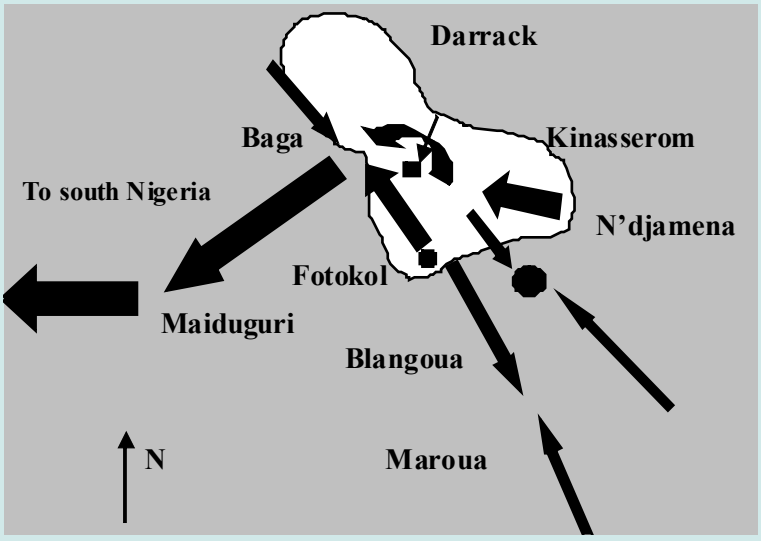
1960-1990: Post-colonial period (10-175 000 tonnes /year): following independence, all LCB countries implemented new economic policies: fisheries policies emphasized production increases; fishing effort, catches and trade increased; severe drought reduced Lake Chad and catch, and trade increased temporarily as fish stocks were concentrated; catch and trade then declined and stabilised-about 100 000t/yr; high demand for fish from urban south Nigeria.

1990-2004: Contemporary Period (60-120 000t/yr): Environmental conditions (slight increase in rainfall) have improved slightly, fish catches and trade have increased slightly; demand for fish remains high; urban Nigeria is the main market; policy for fish trade and livelihoods constrained by a regular flow of information and institutional capacity.

Source: Neiland *et al.,* 2005.

BOX 3

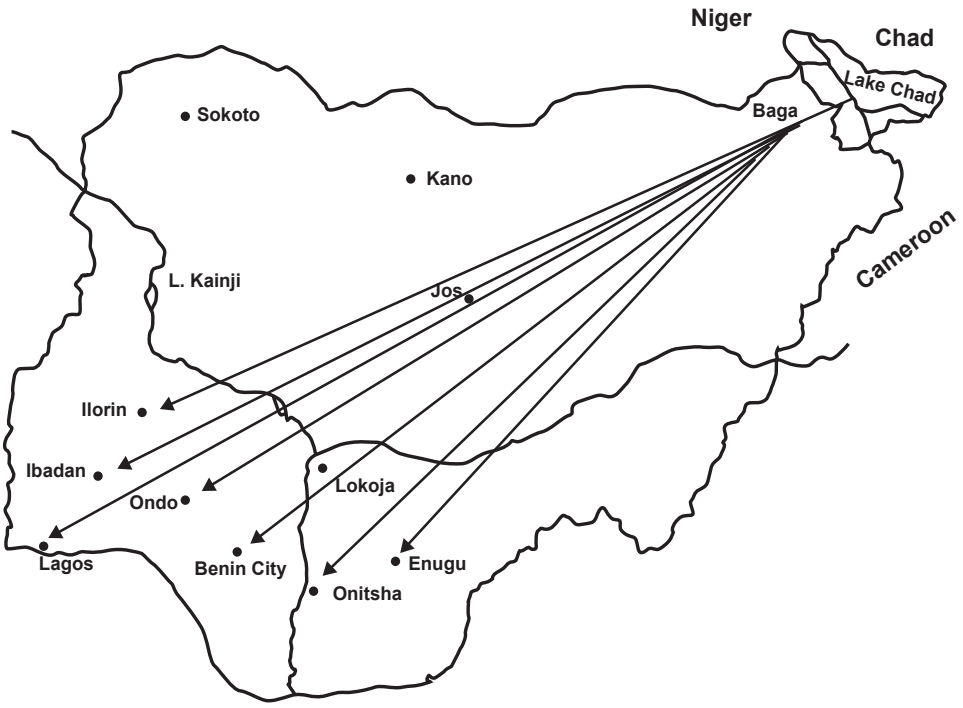
Sketch map of fish markets & trade routes in the Lake Chad Basin, centred on Lake Chad (2002-2003)



Source: Neiland *et al.,* 2005. Incorporating fish market and trade information into policy-making for sustainable livelihoods and poverty reduction.

a distance of over 1 000 km. Over 80-90 percent of the fish products from the basin end up in these southern Nigeria fish markets (Table 4). This long distance cross border fish product trade is a more recent development, which emerged in the past 50 years with the growth and expansion of urban cities and markets, better infrastructure (especially roads) and through the entrepreneurial activity of merchants.

FIGURE 7
Fish product movement from Doro-Baga in the LCB to Southern Nigeria markets



Source: Ovie, S. I., Ladu, B. M. and Sule, O. D. (2004).

FIGURE 8
A female fish processor (left) and fishermen (Right) offloading fresh fish from a canoe in the lake Chad Basin

Source: Ovie, 2000.

This map indicates how fish marketing pathways in the Lake Chad Basin fisheries (represented by arrows) link different countries and different parts of Nigeria. High mobility and migration of fisheries actors, difficult access to the production sites, and an international market attracting transporters and businessmen and women to Doro Baga are characteristics of the Lake Chad Basin fisheries.

FIGURE 9
Processed LCB fish products being transported to Southern Nigeria fish markets

Source: Ovie, 2000.

Starting from the end of the 1990s, a number of in-depth donor-driven fish market trade studies in the LCB was undertaken. Funded mainly by EU, DFID, FAO, DFID/ FAO- Sustainable Fisheries Livelihoods Programme SFLP, WorldFish etc., these studies which were multi-institutional and multi-disciplinary in design, involved all the riparian countries of Cameroon, Central African Republic, Chad, Niger and Nigeria working in parallel or simultaneously. Empirical data from the most recent studies on fish market trade with respect to fish volume and value and fish product destination are given in Table 4.

The total volume (weight) and value (money) of fish traded in the Chad Basin from September 2002-September 2003, under the DFID/FAO-SFLP study was 119 034 tonnes (wet weight) and approximately US$54m, respectively (Jolley *et al.*, 2002; Ovie *et al.*, 2007a and b). Assuming an auto-consumption of about 15-20 percent (Jolley *et al.*, 2002), the annual production and value would range from 136 889-142 841 tonnes and US$62 - US$64 million, respectively. Nigeria accounted for about 40 percent of the total annual basin production.

The combined Southern Nigeria urban markets of Onitsha, Enugu, Lagos, Ibadan, Ilorin, Benin and Ondo (Figure 7), take the bulk of the fish products. In these markets, (Figure 10) unlike in the Chad Basin, fish trade is predominantly women-driven, providing them with much needed income their empowerment in fulfilment of the third objective of the Millennium Development Goals (MDGs).

Overall, therefore, the fisheries and markets are huge, contributing enormously to the regional and local economies and, consequently, to food security and sustainable livelihoods.

TABLE 4
Overview of the fish trade in the Lake Chad Basin measured by FIMS* 2002-2003 (12 months)

Country	Volume of fish traded (tonnes, wet weight)[(a)]	Value of fish traded (US$000's) (% of total value)	Main markets
Cameroon	24 800	8 000 (15%)	Local, urban, Nigeria
CAR	530	254 (<1%)	Local, urban, Chad
Chad	10 873	6 400 (10%)	Local urban, Nigeria
Niger	37 840	14 800 (27%)	Local, Nigeria
Nigeria	45 864	26 000 (48%)	Local, urban, south Nigeria
Total	**119 034**	**53 854 (100%)**	

Source: modified from Neiland and Béné (eds) (2004).

Note: [(a)] measured dry weight converted to wet weight (x 4 conversion factor; no auto-consumption).

* FIMS = Fisheries Information Monitoring System.

FIGURE 10
Retail fish market for LCB fish products in southern markets

Source: Ovie, 2000.

3.4 IDENTIFICATION OF POTENTIAL BIOPHYSICAL CHANGES AND IMPACT PATHWAYS OF CLIMATE CHANGE ON THE BIOLOGICAL AND ECOLOGY OF THE REGION

This subsection consists of two parts: i. identification of general biophysical changes over different time scale and ii. Identification of potential impact pathways of climate change on the biology and ecology of the Basin

3.4.1 Identifying biophysical changes over different time scales

In identifying potential biophysical changes due to climate change or climate variability over different time scales for the Lake Chad Basin, the predictive models/theories of biophysical changes as discussed in section 3.1 were reviewed and used for this analysis as shown in (Table 5). Here, the framework of FAO (2006) was adopted.

3.4.2 Identification of potential impact pathways of climate change on the biology and ecology of the Basin

The awareness of the potential impacts of climate change on the fisheries and other natural resources, including fishery-dependent households and communities is increasing, although the exact nature and the scale of impacts are still not very clear. In general, climate change can be expected to impact fisheries through a diverse range of pathways – direct or indirect – which can be on fishing activities, fishers and their communities (Daw *et al.*, 2009).

For example, it has been predicted that climate change will affect individuals and populations of fish through physiological and behavioural responses to environmental changes (Boesch and Turner, 1984). Detailed predictions of temperature and rainfall variations are required to predict the impacts on river flow, water volume and fisheries production. Changes in environmental parameters such as water temperature, dissolved oxygen and pH can have deleterious effect on fishes (Moyle and Cech, 2004). Suboptimal environmental conditions induced by climate change or natural climate variability can decrease foraging, growth/ fecundity, alter metamorphosis, and affect endocrine homeostasis and migratory behaviour of fish (Barton and Barton, 1987; Donaldson, 1990; Portner *et al.*, 2001). In addition, changes in fisheries production may impact the fishers and fisheries-dependent communities through changes in employment, income, food/nutrition security and livelihoods diversification strategies.

This section provides an overview of existing climate change impact pathways relevant to the Lake Chad Basin.

TABLE 5
Identification of potential future biophysical changes and linked effects in the Lake Chad Basin due to climate change influences

Vulnerability contexts	Today	10 years from now	50+ years from now
Temperature	18-50 °C	Higher variations	May be more highly severe
Precipitation	200-300mm	Higher variations	Much higher variation
Fish catch	100-150,000 ton	Little more variation likely	More severe variation likely
Migration of fishers	fishers migration common	More severe	Greater migration likely
Water chemistry	Increased salinity	Slightly more severe	Greater severity likely
Seasonal health issues eg. Meningitis, measles	Several hundreds	Slightly more severe	Greater severity likely
Seasonal demand for fish	severe	Higher demand	Greater demand
Floods	Severe	Less severe due to declining rainfall	May be much less severe
Droughts	Slight	More severe	Greater severity
Sudden declines in fish catch	Slight	Greater decline as lake water area decreases	More severe decline in fish catch likely
Sudden outbreak of fish diseases due to higher temperature	Slight	More frequent	Greater frequency likely
River flows	Reduced flow	Much reduced flow	Highly reduced flow likely as drought and desertification intensifies
Evaporation	2000mm/anum	Increasing in magnitude	May be much more severe
Ground water	Less ground water	Much less ground water likely	A more severe reduction in ground water likely
Lake area	2000-2500 km^2	Decreasing low water level	Much more decreased water level likely
Species diversity	Diversity decreasing	More diversity reduction likely	Much more diversity reduction likely
Poverty	Increasing	More increases likely	Much more increases likely
Toxicity and bioaccumulation	Tolerable levels	Increasing levels	More severe levels
Parasites and diseases	Slight	Increasing severity and virulence	Much more severe

Effects of reduced river flows and basin levels on fisheries productivity due to higher temperatures and reduced rainfall

Higher temperatures and reduced rainfall would combine to reduce the extent of flood plain or wetland areas that are critical for fish breeding and nursery. Climate change has been predicted to impact freshwater fisheries through incremental changes in temperature, nutrient levels and lower dry season water volumes, leading to changes in sex ratios and altered time of spawning, migration and peak abundance (Daw *et al.*, 2009).

The level of river discharge has been described as an index of ecological space and habitat heterogeneity for fish survival, growth and reproduction (Xenopoulos, 2003). Oberdorff *et al.* (1995), Poff *et al.* (2001) and UNEP GIWA (2004) have indicated a positive correlation between enhanced river discharge, lake and floodplain areas and species diversity. While experimental tests linking the effects of river discharge on species diversity are difficult and currently lacking, several studies suggest that drought and reduced river flows have marked adverse effects on community composition, diversity, size structure of populations, spawning and recruitment of fish (Poff *et al.*, 2001; Lake, 2003).

The Chari-Logone river systems, including minor flows from the El Beid and the Komadugu-Yobe River are the major sources of water to Lake Chad and will be most affected if temperatures rise and rainfall decreases. Variations in river flow would lead to disturbances in flood pattern including extent, timing and duration.

BOX 4

Changes in fish species composition in the LCB over time

Denham (1826) in the early 19th century underscored the importance of the Lake Chad fisheries thus:

> "*The sweet and pleasant waters of the Lake Chad abounded in fish, which the women caught by wading in and then, having formed a line facing the shore, charging through the shallows, grabbing them as they try to swim away or leapt upon the shore*".

Low water has altered the physical environment leading to changes of fish species at both the individual (physiology) and population levels eg spawning, larval dispersal/retention and annual or decadal recruitment (Conwen *et al.*, 2000; Soto, 2002). The commercial *Alestes* fisheries in the Chari-Logone system river has declined drastically in addition to several highly valued and abundant commercial pelagic species such as *Lates* and *Hydrocynus* (Neiland *et al*., 2005). Over 90% reduction of fish in the Waza-Logone floodplain has been reported (IUCN, 2002b) in addition to massive destruction of nursery grounds especially in the Yaeres. Annual juvenile fish recruitment from this dominant floodplain into the Lake Chad is currently greatly compromised due to climate change variability and anthropogenic stream flow modification

Reduced flow from the Yaeres has also reduced the amount of nutrients carried as its water travels through the El-beid into the Lake proper, leading to reduced primary productivity and with implications for both herbivores and zooplanktivores.

Such a scenario is already occurring in the LCB based on time series trends of the transition from the 'mega' to the current 'lesser' Chad phase. Declines in rainfall due to climate change scenarios and human stream flow modification due principally to dams, have led to reduced river flows and shrinking wetlands, thus reducing the distribution and abundance of fish in the Lake basin. For example, the Yaere flood plain in Cameroon, undoubtedly the most significant breeding and nursery wetland in the LCB, and fed principally by the Logone River has experienced not only a significant reduction in river flow due to damming but also a remarkable decline in the annual recruitment of juvenile fish from this productive habitat and nursery refugia into the main bowl of the lake. Additionally, change in species from typical open water to marshy species is also occurring. The impact of environmental change on fish species is summarised in Box 4.

Spread of pathogens and pests

Climate change can also be mediated through mass mortality of aquatic species, including plants, fish, corals and mammals. 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 Chad were 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. These plants, especially, *Typha australis* is is currently devastating the Hadejia-Nguru wetlands and has not only derprived households of farm lands and hence livelihoods but are also clogging irrigation canals.

The typha stand is a preferred nesting ground for the avian pest *Quelea quelea*. The regular loss of rice and other grain crops to this bird has been a major concern in

terms of food security to the governments of Nigeria (UNEP GIWA, 2004). The bird is currently being controlled by massive aerial spraying of toxic chemicals.

Impact on fish and fishers migration

Low river flows have constrained seasonal fish migrations. Lake species that are often migratory and selective in spawning preferences suffered high mortality due to fewer accessible habitats. Constrained migration resulted in natural selection favouring marshy species such as *Clarias* that are adapted to freshwater shortage conditions (Benech *et al.*, 1983). Fisher have also to move, especially from the drier north to the south in search of better fishing sites.

Changes in water quality

Climate change impact through water chemistry changes have been reported for the Lake Chad. Beadle (1981) reported heavy precipitation of Calcium and Magnesium, increasing alkalinity, extremely low dissolved oxygen (DO) especially in the night and on cloudy days as a result of massive reduction in water volume. 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. For example, irrigation schemes in the basin that are dependent on intense use of fertilizers, herbicides and pesticides have had negative consequences for water quality leading to potential impacts on fish recruitment, survival, growth, income as well as human health.

Impacts on income, food/nutrition security, labour generation and poverty alleviation

According to Béné *et al.* (2003a) and Neiland and Béné (2004), fluctuations in fish stocks have had major economic consequences for human societies throughout history. 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. Impacts on food/nutrition security is of particular importance since over 80 percent of the rural poor in the region are dependent on fish as the commonest and cheapest source of animal protein. In the LCB, reduced water levels have not only led to decreased fish catch but also increased productive capital of fishers especially for hitherto near shore fishers. The LCB is exploited by both near shore and offshore artisanal fishers, although the former predominate. The near shore fishers, who lack sufficient resources or equipment (eg. bigger boats, engines, larger and more sophisticated gears etc) to fish offshore in response to shrinking water and ecosystem changes, are expected to be particularly vulnerable to changes in fish distributions and productivity. This has not only increased productive capital considerably, but also the cost of fish. In the same vein, LCB fishing communities have had to move in response to declining fishing ground caused by a gradual but steady decline in water area.

Impacts on agriculture

Another pathway of climate change impacts is through agriculture. Higher temperatures and evaporation and reduced precipitation have reduced water availability and adversely affected not only fisheries, but agricultural practices in the region.

Aside from fisheries, farming has become a very important component of the economy of the LCB as large reductions in lake area have led not only to increases in farming activities, but also the cropping of drought resistant crop species (Table 6) in response to increased drought (Neiland *et al.*, 1998).

TABLE 6
Common crops grown in the Lake Chad Basin

Crop categories	Crops
Cereals	Maize, millet, sorghum, rice, wheat
Grain legumes	Cowpeas, groundnut, babara nuts, sesame
Roots and tubers	Irish potatoes, sweet potatoes, yam and cassava
Vegetables	Tomatoes, cucumber, onions, peppers, carrot, pumpkins and okra
Fruits and tree crops	Mango, banana, guava, papaya, water melon
Non- food crops	Tobacco, sorrel, gourds, fodder crops

Source: Neiland *et al*. (1994).

To maximise benefits from agriculture and as a strategy to respond to increasing environmental change in the LCB, inter-cropping of cereals with grain legumes is often practiced, although cowpea and ground nut may be sole crops. Wheat is grown under irrigation, while large quantities of tomato, onions, pepper, carrots and other minor vegetables are grown as sole irrigated crops all year round or in draw-down floodplains of the lake basin. Fruit trees are grown either as companion crops or in homestead orchards (Shaib *et al.*, 1997).

Information on the total area of cultivated land and the area under irrigation in the LCB is not available at the time of writing this report but this could be extensive considering the volume of cereals and other crops from the region. For example, it was estimated that in 1993, the basin contributed, respectively, 57 and 27 percent of millet and sorghum to Nigeria's national annual production (Bakar, 1978). Similar production estimates are expected for the other basin countries. Small-scale irrigation for both subsistence and limited commercial cropping of pepper, onions, carrots, cucumber and other vegetables is common in the Lake Chad basin.

On the other hand, large scale irrigation projects such as the Maga Dam (SYMRY rice project) in Cameroon, the SODELAC polder rice project (LCBC, Chad) and the Southern Shore Ngala/Baga and the Hadejia-Jaamare dams for rice and wheat production were also initiated in the area but their real impact on food production is still sketchy. The decisions to construct these dams were unilaterally taken by the individual countries without recourse to the LCBC in contravention of the statute which states that:

"Member states should consult the LCBC before executing projects which could produce negative effects on the quantity and quality of surface and ground water resources in the LCB".

Impacts on human disease incidence

As climate change or climate variability leads to declining water environment with impacts resulting in reduced benefits from the fisheries, additional burden such as lack of savings/credits, and alternative livelihoods would drive people into risky behaviours that could manifest in increased vulnerability to HIV/AIDS and other sexually transmitted diseases. Migration and mobility to locate new fishing grounds (as near-shore fish stock and water environment deplete) are common features of the Lake Chad Basin fisheries that have exacerbated the incidence of HIV/AIDS in the region (NIFFR, 2008; Ovie and Holvoet, 2010). These recent studies revealed that women are highly vulnerable to the disease due to their inability to negotiate safe sex (unequal power relations), frequent divorces and remarriages, intergenerational marriages, transactional sex, prostitutionetc. The youths, driven by risky behaviours such as excessive alcohol consumption, drug use, multiple sex partners etc., were equally identified to belong to the high vulnerable group.

In addition, there have been studies linking human diseases (e.g. cholera and meningitis) to changing environmental temperature (Colwell, 1996; Pasual *et al*., 2000; Harvel *et al*., 2002) and other climate factors (Anderson, 1997; Hales *et al.*, 1999; Epstein, 2000). In

the North East of Nigeria and Far North region of Cameroon, that lie within the LCB, there have been increasing number of incidences of cholera and meningitis in recent times with a peak in 2010 resulting in the death of several hundred people. An estimated 100 000 deaths occurred in the sahel following the drought of 1973 (AEO, 2002). Dam construction in northern Nigeria has increased the vector of schistosomiasis in the area. In Kano, the incidence of the disease has increased from 0.8 percent before 1973 to 37.6 percent after 1973, following dam construction. A prevalence rate of 46.7 percent has been reported for the Tiga dam area (Imevhore *et al*., 1988.) In N'Djamena, Chad. 1 317 cases with 94 deaths were reported in an outbreak of cholera in 1996 (WHO, 1996).

In general, reduced river flow has been associated with a decrease in the assimilative capacity of ecosystems, exacerbation of sanitation problems and aggravation of diseases such as diarrhoea, cholera, typhoid, intestinal worms and hepatitis A and E (WHO, 1996).

Impact on animal husbandry

Animal production and export was the third largest source of income for households in the LCB before the advent of persistent droughts. Water shortage has not only reduced suitable grazing lands but has also reduced the quality and quantity of forage required to support a viable herd of animals.In the KYB (Nigeria) as well as the Yaeres (Cameroon) receding water during good hydrological years allowed fresh forage grass to grow using residual moisture. Prior to loss of floods, some 20 000 to 50 000 sheep and goats spent the dry season on the Yaeres floodplains (IUCN, 2003). Reduced quality grazing lands across the entire basin has following the droughts of the 1970s, encouraged herders to shift from grazing animals (cattle and carmels) to brousing animals (sheep and goats) resulting (USGS, 2001).

Impact on aquaculture

Although aquaculture is not a major enterprise in the LCB at the moment, its practice is slowly emerging in Niger, Nigeria and Cameroon (Authors personal field observation). In aquaculture, where production processes like choice of species, feeding and restocking are under greater human control, increasing seasonal and annual variability in precipitation resulting in drought extremes are likely to be the most significant drivers of change in inland water aquaculture (Allison *et al.*, 2007). Reduced annual and dry season rainfall and changes in the duration of the growing season are likely to have implications for aquaculture and create potential conflict with other water users in an already water scarce environment. Smaller holder fish farmers with ponds that retain less water and dry up faster are more likely to suffer shortened growing seasons, reduced harvest and a narrower choice of culture species and consequently less income and livelihoods from aquaculture (Handisyde *et al.*, 2006).

A summary of potential impact pathways of climate change on the ecosystem, fisheries and aquaculture in the LCB is shown in Table 7.

3.5 EVALUATION OF CURRENT ADAPTIVE CAPACITY AND RESILIENCE OF THE AQUATIC AND HUMAN SYSTEM

Ecological systems, including associated riparian communities, often have natural capacity to respond or adapt to externally and internally generated changes or perturbations. To reduce or forestall extreme vulnerability, ecosystems and communities are expected to exhibit a certain level of resilience which enables them deliver sustained benefits in the face of disturbances. In evaluating the current adaptive capacity of the LCB system, we start with some working definitions that we consider relevant to this section of the report. These include the following:

Vulnerability is defined as "a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity and its adaptive

capacity" (McCarthy *et al*., 2001) or as the "susceptibility of groups or individuals to harm as a result of climate changes" (Daw *et al*., 2009) or as "the extent to which climate change may damage or harm a system- this being a function of the system's sensitivity and its ability to adapt to new climatic conditions" (Allison *et al*., 2007). Central to vulnerability are the concepts of adaptive capacity and resilience.

Adaptive capacity is the ability of a system to evolve in order to accommodate climate changes or to expand the range of variability with which it can cope (Allison *et al.*, 2007).

Resilience has been thought of as the "ability to resist change" but a more current definition sees it as "the ability of a system to take disturbance, reorganise and renew itself" (Daw *et al*., 2009). According to Allison *et al.*, 2007, resilience in small

TABLE 7
Potential pathways of climate change impacts on fisheries of the LCB

CLIMATE VARIABLE	PHYSICAL CHANGE	PROCESSES	POTENTIAL IMPACTS FOR FISHERIES/ OTHER SECTORS
Physical environment	Changes in morphology of lake and size of the floodplains/wetlands	Reduced lake size and wetlands necessary for breeding, nursery and annual recruitment	Potential decline in annual recruitment of juvenile fish into the lake leading to reduced fish production overall
	Changes in water chemistry due to reduced water volume	Heavy precipitation of nutrients especially Calcium and Magnesium leading to increased alkalinity salinity and extremely low DO especially at night and cloudy days.	Increased primary productivity and dense algal bloom leading to intense respiration and mass fish kill due to extreme anoxia and clogging of fish gills by algal and other particles
	Change in water volume and lake depth	Numerous exposed bottom sand dunes that became heavily vegetated with aquatic macrophytes	Reduction in fishing areas, increased predation and impediment to navigation and fishing. Massive reduction in papyrus –floating aquatic vegetation for canoe construction
Fish stocks	Low water depth and high water temperatures Frequent up-welling caused by winds	Potential changes in sex ratios Altered time of spawning Altered time of migration Altered time of abundance Effect on fish recruitment success Effect on aquaculture	Potential changes in biodiversity;- difficulty in predicting peak abundance of target species for exploitation Adverse effect on abundance and production of juvenile fish in the system; Swamp species (eg *Clarias* and *Heterobranchus*) replace pelagic species such as *Lates* and *Hydrocynus* Migration and mobility of households due to declining stock exacerbates HIV/AIDS and other infections Reduced aquaculture production
Ecosytems	Reduced water flows and increased droughts	Changes in lake water levels Changes in dry season water flows in rivers Habitat modification and destruction	Reduced lake and river productivity Reduced and increased pelagic and swamp fisheries, respectively Reduced biodiversity Reduced grazing lands
Inland fishing operations and livelihoods	Changing levels of rainfall Less predictable rain/dry seasons Markets and fish trade	Decreased rainfall leads to reduced opportunities for fishing, farming and aquaculture as part of rural livelihoods portfolios Decreased ability to plan livelihood activities e.g. farming and fishing seasonality Constricting fish markets and trade	Reduced diversity of rural livelihoods; greater risks in agriculture; greater reliance on non-farm income Reduced safety nets for rural communities Increased vulnerability of riparian floodplain households and communities Reduced income and benefits of market- based fisheries stakeholders

Source: Adopted from Daw *et al*. (2009).

scale fisheries in the developing world is one that "absorb shocks and reorganises itself following stresses and disturbances while still delivering benefits for poverty alleviation".

The fisheries in the LCB, as elsewhere in Africa (eg. Lakes Victoria, Tanganyika, Malawi and Volta, the Niger Inland Delta and the Niger and Congo Rivers) are known to be already experiencing a high level of climatic variations leading to fluctuations in primary productivity, fish production/distribution and livelihoods (FAO, 2007 and 2010).

The discussion on the current adaptive capacity of the system focuses on indicators of resilience of the aquatic system, the human social-economic system, and the institutional system.

3.5.1 Indicators of resilience of the aquatic system

Certain intrinsic characteristics of the LCB confer upon it certain degree of resilience and adaptive capacity. One special characteristic of the LCB system is its shallowness (2.5-4.5 m in the South basin and 4-7 m in the North basin) and a highly diverse micro habitats and niches.

The characteristic shallow nature of the lake and its flat and undefined shorelines make the lake extremely sensitive to slight variation in water level - a characteristic that confers both positive (easy reflooding) and negative (rapid lake withdrawal) advantages. The relative transition from the Mega Chad (300 000 -400 000 km^2) to the Normal Chad (18 000-25 000 km^2) and to its present status of a lesser Chad (2 000-9 000 km^2) has been ascribed to medium to slight changes in rainfall (Tilho, 1928; Roche, 1975; Beadle, 1981; Servant and Servant, 1970; Neiland *et al.*, 2005). Currently, the lake is said to have an area of about 2 500 km^2 (LCBC, personal communication). While restoration to the Mega Chad phase is not likely, it is hoped that a return to the Normal Chad phase is a possibility due to the shallowness and the lake's capacity to adjust very rapidly to inter-annual or decadal rainfall and flow regimes. It is known that all the irrigation schemes of the LCB utilise water extremely inefficiently (UNEP, GIWA, 2004) and major losses have been associated with high evapotranspiration, infiltration, poor open drainage canals, cropping pattern and irrigation method. Clearing of clogged drainage canals, lining of irrigation canals replacement of open canals with underground pipes, change from gravity irrigation to drip and sprinkler method are some management methods that could relate the hydrology of the lake and its wetlands.

Another adaptive and resilience capacity of the LCB system is its high complex ecological system and huge biodiversity of fish stock and other aquatic resources. The Basin is endowed with several ecological zones comprising flood plains (eg the Yaeres and the Waza-logone in Cameroon, the Hadejia-Nguru wetlands in Nigeria), oxbows, permanent and temporary pools, reeds, submerged, emergent vegetation and numerous islands that span from North to South due to fluctuating water levels (FAO, 2004). Open water species like *Lates* and *Hydrocynus* have given way to hardier and more resilient species like Clarias. The extent of biodiversity is captured vividly by the accounts of Beadle (1981), Hepper, (1970) and Blake (1964).

> "*From the North to the East shores are rows upon rows of partly submerged sand dunes forming elongated primontoria and islands, all oriented in a North West –South East direction, each partly fringed by papyrus and reed vegetation swamps. The dunes were thought to be accumulated by prevailing winds –North East harmattan (November-April) and the East and South West winds (May –October). Further into the Southern basin, the dunes are completely submerged under a belt of swamps composed mainly of papyrus (Cyperus papyrus), a reed Phragmatites mauritianus, and the grass Vossia cuspidatus. In the Northern basin, the swamp islands are dominated by Phragmites australis and Typha australis along the shoreline".*

The papyrus in particular, is of historical significance to the LCB, being the raw material for the construction of the famous canoe called *kadey* in Buduma language. Before and around the 1920s, the *kadey* was the only means of navigation on the lake (there being no plank canoes) and a major source of income and livelihoods to the people of the LCB (FAO, 2004). It is reported that the famous Norwegian sailor, Thor Heyadahl crossed the Atlantic Ocean in 1970, with a 12 m long papyrus boat he contracted the Buduma fishermen in the LCB to build in an attempt to prove that ancient African sailors could have reached the coast of the Americas long before Christopher Columbus.

These habitats and associated resources have provided livelihood benefits and other services to the local communities but are currently under serious threat from climate change induced changes. Massive reduction in lake volume has gravely compromised these aquatic products and the benefits derivable from them by the riparian communities. The famous papyrus boats are more as these have been replaced by plank boats (FAO, 2004).

The LCB can still be described as an environment which is relatively undisturbed by man and, hence, still largely maintaining its integrity. Aside from climate change effect, other drivers of change, such as agriculture and oil pollution would impact this environmental integrity. Oil pollution could potentially become a problem if oil is found in commercial quantities in the Basin. Some exploitation apparently is currently going on far away from the lake shore in the Chad Republic and both Cameroon and Nigeria have just initiated seismic investigations in the Yaere floodplains and in the Baga –Kawa, respectively.

3.5.2 Indicators of resilience of the human system

Historical shifts in species composition and habitat modification have had implications for artisanal fishers who have had to adapt to the changing hydrology, habitat and species composition to remain in the fisheries and secure their livelihoods. Reduction in lake area and habitat variability had a number of socio economic challenges. Fishers have had to switch from small-scale open water fishery (eg. *Alestes*) to swamp species (such as *Clarias*). This switch, for the small scale fishers, was particularly difficult as this required also a change in fishing gears. For example, it is known that the use of cast nets, one of the most active and ubiquitous open water gear on the lake in the 1960s, has been largely replaced by specialised passive gears like cane traps, gill nets and hooks that are adapted to floodplain or swamp fisheries. Furthermore, reduced water and fishing areas meant that fishers had to pull longer distances to open waters of the lake to fish higher valued species such as *Lates, Gymnarchus* and *Hydrocynus*. This also meant heavy investment on bigger and safer boats in addition to bigger outboard engines to power the boats. As revealed in a study on rural livelihoods and wealth ranking in the Chad Basin (Ovie *et al*., 2000), only the well-off households were able to make the initial investment and adjustment as this required substantial investment in cash.

About eight different types of fishing grounds are exploited across the basin, the most common being seasonal ponds and receding channels, followed by Chari and Logone rivers, the open waters of the Lake and the permanent ponds and oxbows. The heterogeneity of the exploitable areas has provided the rural communities the opportunity to switch among local ecological niches for fish exploitation in the course of an annual cycle. However, the freedom to fish is not without some operational rules such as access/gear restrictions and payment of fees. In the LCB, very few *de facto* open access exist as the majority of the fishing communities operate under some form of control and access/gear restriction. For example migrants are not allowed to use the very efficient fishing trap and technique called *dumba* and even permanent residents have to pay a fee before using it. These restrictions can be seasonal or permanent and are controlled by the traditional authorities and/or the State. According to Béné *et al*.

(2005), the operation of access/gear restriction and access fee payment in the Chad Basin were a direct response to the shrinking ecosystem as these arrangements were less prevalent during the normal Chad period. These constraints have to some extent, reduced the capacity of the households in the basin, especially the migrants, to adapt and adjust to the impact of climate change in the region. Overall, however, it is an attempt at resource conservation and resilience.

Governance and Management of the fisheries

A number of institutions participate in the management of the fisheries of the LCB. Three typologies, (i) traditional systems [informal], (ii) modern or centralized systems [formal] and (iii) mixed systems (Table 8) of fisheries management systems have been distinguished (Neiland *et al.*, 2000; Béné *et al.*, 2005). The traditional systems are classified as those operated by traditional authorities (District or Village Heads and Chief fishermen) which enforce regulations to control fishing activities. The modern systems are by the administrations of the central governments where fisheries re gulations are enforced by officers of the state, usually located in the Departments of Fisheries. In the absence of formal co-management arrangements, the mixed systems involve the participation (intentionally or inadvertently) of both the traditional and modern government administrations.

As shown in Table 8, management systems operated under the traditional administrations (Type i) are very frequent in Cameroon (70 percent of the villages) and relatively frequent in Chad and Nigeria (38 percent and 33 percent, respectively). The mixed system (type ii) is most common in Chad and Nigeria (45 percent and 56 percent, respectively) and relatively frequent in Cameroon (30 percent). The type iii, mixed system occurs sporadically in Chad and Nigeria (17 and 11 percent, respectively) and does not occur in Cameroon. In general, traditional (Type i), overlapping with modern authorities (mixed type ii) is present in 100 percent of the Cameroonian villages, in 83 percent of Nigerian and 89 percent of Chadian villages.

TABLE 8
Classification of fisheries management systems in the LCB

Management System	Description	No. of villages operating under each management system (% of total in each country)		
		Cameroon	Chad	Nigeria
Type i: Traditional	Operated by the traditional authorities (district or village head, chief fisherman)	14 (70%)	11(38%)	3(33%)
Type ii: Mixed	Participation (either intentionally of inadvertently) of both traditional and modern government	6 (30%)	13 (45%)	5 (56%)
Type iii: Modern	Operated by central government's administrations with regulations enforced by officers of the state	–	5 (17%)	1 (11%)
Total		**20 (100%)**	**29 (100%)**	**9 (100%)**

Source: Neiland *et al.*, 2000; Béné *et al.*, 2005.

The preponderance or predominance of the mixed management system in the basin is note worthy and could be a veritable platform to anchor adaptive strategies for mitigating the impact of climate change in the region if their authorities are not threatened by government who see fisheries management as their *de facto* responsibility. But how effective are these traditional authorities in the management of those resources? Are their authorities recognised or are they being eroded or threatened? Béné *et al.* (2005), showed that the authority of the local traditional leaders is still considered accepted and respected by community members as shown in Table 9.

However, the above studies also revealed a gradual and steady erosion of traditional authorities especially in Nigeria and Cameroon. The full extent of this gradual

diminution of traditional authorities and the impact on the sustainable management of the basin's resources cannot be ascertained, but it is reasonable to infer that such a scenario could lead to negative outcomes for the sustainable exploitation of the fisheries, on the long-run, if the trend continues. A recent study of the fisheries of the Komadugu Yobe Basin (southern section of the LCB in Nigeria), however, revealed no diminution of the powers of the traditional authorities. In an evaluation of fisheries governance in the area, a State Director of fisheries in the area confessed to a survey team *"I cannot send my field staff to any water body for field data collection without first writing to the village head of the community where the water body is located"* - DoF, Jigawa State (Ovie and Raji, 2009). The traditional authorities and communities, over the years, have acquired a sound knowledge of the fisheries and other natural resources of the basin in terms of their management and sustainable exploitation.

TABLE 9
Classification of fisheries management systems in the LCB

Indicators		No. of villages (% total)		
		Cameroon	Chad	Nigeria
Recognition of leaders' authority	Yes	15 (75%)	24 (83%)	15 (100%)
	No	3 (15%)	5 (17%)	–
	Uncertain	2 (10%)	–	–
Changes in traditional authority	Erosion	14 (70%)	4 (18%)	10 (67%)
	No changes	6 (30%)	13 (59%)	4 (27%)
	Improvement	–	5 (23%)	1 (7%)

Source: Béné *et al.*, 2005.

Fisheries and Property Regimes in the Lake Chad Basin

While all the water bodies in the basin are *de jure* State properties, the majority of them fall into common property regimes with well defined, albeit informal, access rights (Berkes, 1989; Béné *et al.*, 2005). The authorised users are the villagers or the members of the local community. Clear operational rules exist which define, within the communities, the way the authorised users can extract the resource. These rules which are generally not written (informal) are known and respected by the villagers and enforced by the local authorities, usually the village chief and/or the head fisherman. In addition, well-defined institutional mechanisms (collective action rules) have been established within the communities to facilitate conflict resolution and punishment of resource users that breach extant rules. In general, while the traditional authorities may be facing increasing pressure and erosion of their authority, traditional management systems based on common property regimes is still the predominant system operating in the Lake Chad Basin especially, in Cameroon, Chad and Nigeria.

Conflict resolution and sanction mechanisms in the governance of the LCB fisheries

Given the competitive nature underlying access and uses under a portfolio of common property regimes (CPR) such as in the Lake Chad Basin, conflicts over natural resources (fisheries, land, water, forest etc.) are almost inevitable and likely to increase in a climate change scenario, making conflict resolution mechanisms (CRM) an important component of the administration of the basin's resources. Conflict resolution mechanisms have been identified to be crucial to the viability of CPR and their associated management systems (Ostrom, 1990). Such conflict resolution mechanisms can range from being totally informal (ie. open discussion between the disputants - and eventually a spontaneous mediator) to completely structured and institutionalised procedures (ie. a well developed court with legal authority) as described by Maas and Anderson (1986).

In the case of the LCB, informal mechanisms of resolving conflicts between resource users predominate in the region (Béné *et al.*, 2003a). A feature of the existing CRM in

the Basin is its 'incremental' nature, which allows higher level traditional institutions to intervene in the event of failure of lower level authorities or mediators (Béné *et al.*, 2003).

A major pillar of any CRM is the associated sanctions that are brought to bear on violators of standing operational rules governing the use of natural resources. Two types of sanctions have often been associated with common property regimes. According to Ostrom (1990) and Ostrom *et al.* (1994), in order to achieve long-term and enduring resource management, sanctions should be made of a 'subtle balance between two constraints'. Firstly, the arrangement should ensure that the sanctions are gradual and secondly the eventual final sanction should be sufficiently deterring. In the case of the latter, the social and financial costs of the sanction should be higher than the expected gain to the violator.

In the Lake Chad Basin, the sanction portfolios set up by the local traditional Institutions embody above two typologies (Béné *et al.*, 2003a). First, the sanction (cost) at each level is gradually increased. In the majority of villages in the Chad Basin, the system starts with a verbal warning (no social or financial cost) by the local leader which allows the rule breaker to repent and act responsibly. If the violator continues with the unacceptable behaviour, the next sanction level usually involves fines that may be combined with temporary ban from the village or gear confiscation. This continuum of gradual but increasing sanction costs, coupled with the potential involvement of higher traditional authority, was judged to be sufficiently dissuasive in the lake Chad Basin (Béné *et al.*, 2003a).

Disaster risk management

Disaster risk management seeks to address vulnerability through early warning systems, timely weather forecasts, market information systems and disaster recovery program (Allison *et al.*, 2007). Information on disaster risk management in the LCB is generally lacking, although each riparian country has Agencies responsible for national emergencies and disaster management. Such agency draws membership from a wide range of stakeholders and interest groups that include the military/paramilitary, civil society organisations, the civil service, traditional institutions, non-governmental institutions etc. Although the Lake Chad Basin Commission (LCBC) has the overall mandate of managing the natural resources of the basin, including disaster risk management, it has had limited engagement due to financial, technical and administrative constraints.

Current constraints to change management

It is generally thought that the constraints to change would lie in the policy domain. However, Neiland (2003), in a draft proposal for the formation of a "Lake Chad Basin Fisheries Development Program (LCB_FDP)" highlighted a number of factors that constrain the ability to achieve sustainable livelihoods.

Firstly, it is thought that, from a government and policy perspective, the fisheries and their characteristics are not well understood. More specifically, the 'value' of the fisheries to all basin countries is not fully recognized. For example, the extent to which fisheries contribute to economic development, food security and poverty alleviation. This lack of both general and specific understanding of the contribution of the fisheries has constrained the development of appropriate fisheries policies to improve fisher livelihoods. A better understanding of the operation of the existing fishery system, which is characterised by a high level of productivity, but also a high level of poverty, is needed by all stakeholders involved to minimise current constraints to change.

Secondly, from the perspective of the fishing communities, the political and social constraints which they face in their life are tangible. The Lake Chad Basin is a difficult terrain with communities that are isolated both geographically and socially, and lack access to a wide range of information to inform their livelihoods decisions. A greater

sharing and dissemination of information by all stakeholders is required in order to identify key issues and constraints to change and development.

Thirdly, the communities lack an appropriate level of organisation and the capacity to participate in policy or decision making by government or to exchange information with other stakeholders on a regular basis. The deficiency in information availability and the difficulties of disseminating same to the rural communities at national and regional levels in the basin has been highlighted by UNEP GIWA (2004). The creation of opportunities for wider and greater stakeholder participation in decision-making leading to the formulation of appropriate policies and institutions (within fisheries and among sectors) would result in improved resource management and utilization.

Fourthly, fishing communities in the Lake Chad Basin are vulnerable to external pressures from stronger individuals or groups, including local political leaders, market traders and even members of the security forces that operate in the area. Access control, for example, is virtually the prerogative of some powerful individuals or families backed by an equally powerful group of local leaders. Some local leaders and security forces are known to extort illegal taxes from operators of the fisheries and have constituted a constraint to adaptive capacity.

Fifthly, despite the huge monetary value of the fisheries, over 70 percent of the fishing communities in the Chad Basin are still categorised as poor (Béné *et al*, 2003a). This prevailing or pervading poverty is a potential constraint to the ability of communities to evolve viable adaptive strategies. Lack of productive capital to procure better and improved fishing gears and invest in alternative sources of livelihoods is a potential constraint to adaptive capacity and strategies.

Other potential constraints to adaptive capacities have also been highlighted by Daw *et al.* (2009). It is argued that responses to direct impacts of climate change events on fisheries are more effective if they are anticipatory as part of a long term integrated disaster risk management planning. The lack or weak structure of the DRM agencies in the LCB is a major constraint to potential adaptive strategies in the region.

The lack of diversified fish products and markets, including lack of or poor information base on the fisheries is considered another constraint to achieving adaptive strategies to climate change impact. Diversified fish products would make fisheries less prone to economic shocks while adequate information would help fishers and fish traders navigate both national and international markets and achieve fair prices for their fish (FAO, 2007). Decreasing the marginalisation and vulnerability of small-scale fishers is thought to be an anticipatory adaptation to a range of threats, as well as facilitating sustainable management and viable adaptive strategy to change.

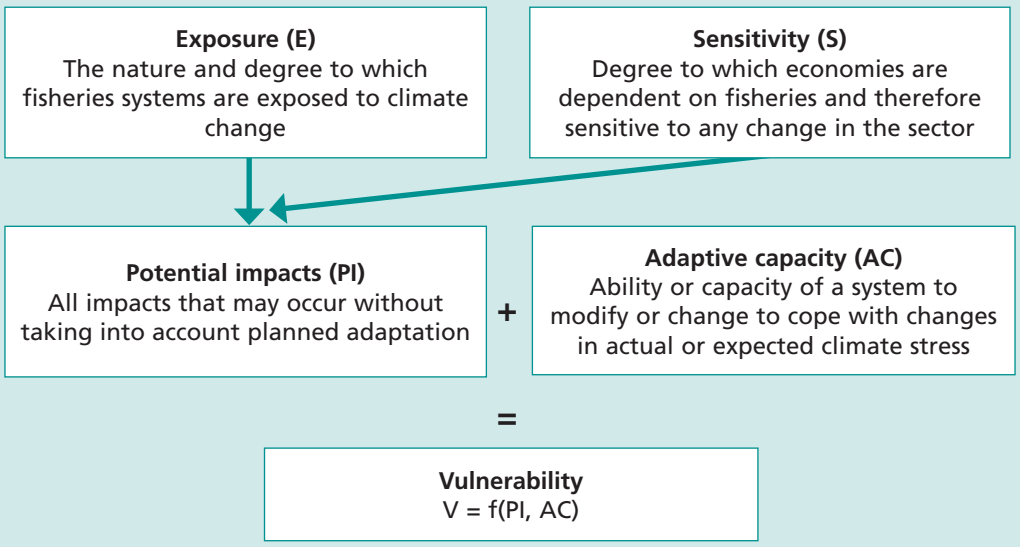
In the Lake Chad Basin, women constitute a good percentage of the population and work force, but lack traditional hereditary access rights to land or fishing grounds and, therefore, tend to be poorer. The subordinate economic position of women in the region has constrained them from engaging in meaningful, viable and sustainable adaptive strategies as compared to male stakeholders. There is need, therefore, to empower women to enable them construct viable livelihoods for themselves in fulfilment of the third objective of the Millennium Development Goal.

3.6 ANALYSIS OF THE LCB SYSTEM'S VULNERABILITY

In section 3.5, vulnerability is defined, within the context of this analysis, as the susceptibility of individuals or groups to harm as a result of climate change. The Intergovernmental Panel on Climate Change (IPCC) defined vulnerability as "…a function of the character, magnitude and rate of climatic variation to which a system is exposed, its sensitivity and its adaptive capacity" (McCarthy *et al*., 2001). This element or relationship is illustrated in Box 5. Vulnerability, either at the individual, group or ecosystem level, has been recognised to be compounded by external stressors such

BOX 5

Conceptual model of vulnerability



Source: FAO (2006).

as environmental threats, internal factors that determine the effect or impact of such threats and how responses to such changes manifest (Daw *et al.*, 2009).

Vulnerability is exacerbated if a system is unable to develop coping strategies to deal with the negative impacts brought about by the change. If, however, the opposite is the case, vulnerability, either of the system or of the natural resource-dependent communities is minimised. Under this latter scenario, the system is considered to be resilient- resilience here defined as the ability of a system to absorb shock or disturbance, reorganise and renew itself in order to remain in a desirable state and continues to deliver benefits for poverty reduction (Allison *et al.*, 2007; Folke, 2006).

Given the above analysis and conceptual framework, a number of vulnerability factors can be discerned for the Lake Chad Basin system. The systems' vulnerability or risk exposure (risk exposure being the degree to which the basin will face a change in climate) would include outcomes of climate change-induced factors such as higher temperatures, reduced precipitation/drought, reduced river flow leading to habitat modification or outright habitat loss and reduced fish catch/distribution among other potential consequences. All these have adverse potential knock-on effect on fish trade and income and, consequently on poverty and the contribution of the fisheries to household, national and regional economy.

Boesch and Turner (1984) argued that physiological and behavioural responses of fish to temperature and rainfall variations will occur at both the individual and population levels. Elevated water temperature, low dissolved oxygen, changes in pH and indeed any suboptimal physico-chemical conditions induced by climate change can decrease foraging, growth/ fecundity, alter metamorphosis, and affect endocrine homeostasis and migratory behaviour of fish (Barton and Barton, 1987; Donaldson, 1990; Portner *et al.*, 2001). Fish biodiversity, their distribution and abundance are highly vulnerable to suboptimal water chemistry.

Fish spawning, larval dispersal/retention and recruitment of fish stocks are highly sensitive to reduced precipitation, reduced river flow and habitat loss (Conwen *et al.*, 2000; Soto, 2002; Xenopulous *et al.*, 2005). While Lake Chad is still a productive ecosystem, there has been a steady decrease in fish production over the years due to drought and shrinking of the lake area. Over the years, the water area of the lake has

reduced from about 25 000 km^2 in the 1960s to about 2 500 km^2 at present (Jolley *et al.*, 2002; Béné *et al*., 2005).

Fish stocks are vulnerable to these changes as decreased or fluctuating fish production is expected to exacerbate the vulnerability of rural households and communities that are dependent on the fisheries and other aquatic resources of the lake for their income, food/nutrition security, labour generation and poverty alleviation. Worldwide, fluctuations in fish stocks have had major economic consequences for human societies throughout history (Béné *et al.* 2003a; Neiland and Béné, 2004) and this is true for the Lake Chad Basin in which fish production has been decreasing over the years (Jolley *et al.*, 2002; Ovie *et al*., 2004; Béné *et al.*, 2005). Vulnerability due to food/nutrition insecurity is considered most critical since over 80 percent of the rural poor in the region are dependent on fish as the most common and cheapest source of animal protein.

Lake Chad Basin fishing households have been vulnerable to increased productive capital in recent times in terms of higher cost of fishing and other livelihood inputs. In a region where credit and soft loans are largely unavailable, the operations of fishers have been severely constrained in terms of their ability to secure financial capital to procure better and improved gears and crafts to enable them fish distant waters as the lake recedes. The LCB is exploited typically by both near shore and offshore artisanal fishers, although the former predominate. For the near shore fishers who lack sufficient resources or equipment (eg. bigger boats, engines, larger and more sophisticated gears etc) to fish offshore in response to declining water and ecosystem change, climate change related risks become important in their quest for fish and livelihood. This has not only increased productive capital considerably, but also the cost of fish.

Reduced lake area/fishing grounds and declining fish catches and income have made fisheries-dependent communities, especially fishers, vulnerable. The fishers have been forced to migrate[3] or temporarily move away from their homes in search of more productive fishing grounds as near-shore fish stocks get depleted due to climate change effects. In the LCB, seasonal migration and mobility of fishers, fish processors, traders, transporters and even farmers are highly prevalent. There is a regular massive movement of pastoralists from the dry north of the basin to the wetter south in search of grazing lands (UNEP GIWA, 2004; FAO, 2004). This common feature of the basin has been found to exacerbate the incidence of HIV/AIDS in the Lake Chad Basin as migrants get engaged with multiple sex partners and indulge in other risky behaviours such as excess alcohol consumption and drug use in their new places of abode (NIFFR, 2008; Ovie and Holvoet, 2010).

Aside from fisheries, general agriculture such as arable farming and animal husbandry has also become vulnerable to climate change effects (Bdliya *et al.*, 1999; FAO, 2004). Reduced precipitation and river flow, coupled with dam construction on river inflows to the lake have depressed water availability for irrigated agriculture and grazing lands, thus limiting the productive capacity and the economic benefits that this sector provides for the rural households and the wider society. The reduced benefits from this sector due to climate change impacts have potentials to plunge households or communities into further poverty in a region that is already experiencing impoverishment.

The vulnerability of the Lake Chad Basin to climate change in relation to the spread of diseases has been documented. In the North East of Nigeria (Ministry of Health, Borno State) and the Far North region of Cameroon that is situated within the LCB, there have been heightened incidences of cholera and meningitis in recent times with a peak in 2010 that resulted in the death of several hundred people. There have been

[3] According to the International Organisation for Migration (IOM), migration and mobility is defined as individuals or groups who stay away from their families for more than 3 and less than 3 months, respectively.

studies linking human diseases (e.g. cholera and meningitis) to changing environmental temperature (Colwell, 1996; Pasual *et al.*, 2000; Harvel *et al.*, 2002) and other climate factors (Anderson, 1997; Hales *et al.*, 1999; Epstein, 2000).

In general, climate change has been implicated in mass mortality of many aquatic species, including plants, fish, and mammals (Harvel *et al.*, 1999**).** Warmer waters are known to increase the vulnerability and susceptibility of fish to pathogens as the former deal with thermal stress (Harvell *et al.*, 2002).

4. Identification of strategies to reduce vulnerability of the system

This section aims to identify a range of existing and potential mitigating factors to reduce vulnerability caused by climate change effects in the LCB. Various strategies (current and potential) are identified that would minimise exposure and impacts, decrease sensitivity and improve adaptive capacity and socio-ecological resilience of the system.

In an ever changing world, effective and robust adaptive strategies in the face of environmental, social- economic fluctuations and oscillations are vital elements of survival and resilience. Adaptation to climate change can be defined as "an adjustment in ecological, social or economic systems, in relation to observed or expected changes in climatic stimuli and their effects and impacts in order to alleviate adverse impacts of change, or take advantage of new opportunities" (Daw *et al*., 2009). Adaptation is considered an active set of strategies and actions taken by people in reaction to, or in anticipation of change, in order to enhance or maintain their well-being. Building capacities to increase the ability of individuals, groups or organisations to predict or adapt to changes as well as implementing adaptation strategies are major pillars of adaptation in the face of climate change and increased climate variability.

Climate change is known to impact on the environment in ways that threaten the overall sustainability of the ecosystem and the benefits derived from it. Consequently and in order to ensure sustainable livelihoods, it is crucial to develop appropriate coping or adaptive strategies as responses to extreme ecosystem or natural resource variation/change. Over the years, fishery communities and indeed other sectors of agriculture are known to have developed adaptations and coping strategies for dealing with fluctuating environmental conditions and failing/falling livelihoods accruing from the exploitation of available natural resources. In the LCB, a number of in-depth livelihoods studies had been undertaken for the riparian countries under an EU and DFID/FAO-Sustainable Fisheries Livelihoods Programme between 1998 and 2004 (eg. Zakara and Dara, 2000; Ovie *et al*., 2000; Ovie *et al*., 2001; Njock and Mindjimba, 2000; Neiland *et al.,* 2002; Béné *et al*., 2003a; Béné *et al*., 2003b; Béné *et al*., 2003c; Béné and Neiland, 2003; Béné *et al*., 2000; Ovie *et al.,* 2007a and b). These studies examined not only existing livelihoods portfolios but also gave insights into potential strategies for overcoming livelihoods stress in a changing environment. A number of these adaptive strategies are discussed below and summarised in Table 10 in response to the impacts identified in Table 7. In general, these adaptations are either reactive or anticipatory in nature (Table 10).

4.1 EXAMPLES OF CURRENT ADAPTATION STRATEGIES IN LCB

4.1.1 Alternative sources of income

Diversified, adaptable, flexible and mobile rural livelihoods have been identified to be common features of unstable productive ecosystems like the LCB (Allison *et al.*, 2007). Fisheries communities in the Lake Chad Basin have anchored their livelihoods on fisheries, farming, livestock rearing, petty trading and transportation of both fish and agricultural products, and most times switching between these activities in the course of a seasonal annual cycle. Fishing and farming are particularly inextricably linked as every household in the basin integrates fishing with farming (Ovie *et al.*, 2000; Béné *et al.*, 2005). In addition to rainfed, dry season (November-June) recession

TABLE 10
Adaptations to climate change impacts on fisheries of the LCB

Impact on fisheries	Potential adaptation measures	Responsibility (public/ private)	Reactive/ Anticipatory
Reduced fisheries productivity and yields (indirect ecological)	Increase effort or fishing power; migration and mobility	Private	Either
Increased variability of yield (indirect ecological)	Diversify livelihood portfolio- farming, animal husbandry, small scale aquaculture	Private	Either
	Precautionary management for resilient ecosystems	Public/private	Anticipatory
	Implementation of integrated and adaptive management	Public	Anticipatory
Reduced profitability (indirect ecological and socio economic)	Diversify livelihoods	Private	Either
	Exit the fisheries for other livelihoods/investments	Private	Reactive
Trade and market shocks (indirect socio- economic)	Diversification of market and products	Private/public	Either
	Information services for anticipation of price and market shocks	Public	Anticipatory
Displacement of population leading to influx of new fishers (indirect socio-economic)	Support for existing local management institutions	Public	Either

Source: Daw *et al.* (2009).

farming is practiced as flood water recedes, planting diversified crops such as cowpea, maize, guinea corn and varieties of vegetables. The residual moisture left when the floodplains dry up is sufficient for growing vegetables and crops. In dryer areas where recession farming is not possible, community members engage in small-scale irrigation farming using various ranges of water pumps. The Lake Chad Basin is, therefore, unique in the sense that unlike other ecological zones outside the lake basin, farming is practiced almost all-year round. Allison and Ellis (2001) indicated that "fishing, farming and livestock herding have become inextricably linked over many generations in the overall objectives of achieving household nutritional security - and in a typical year, oscillations occur between the components of this tri-economy". In general, the contribution from each of these livelihoods components varies considerably between seasons and may also differ significantly between years.

4.1.2 Storage management

Over the years and due to dwindling agricultural production, households in the basin have developed and acquired expertise in mass storage and local preservation of agricultural products as a safety net for lean periods. The practice involves buying grains at periods of harvest when prices are low and storing for consumption and sale at periods of scarcity and higher prices. Many households have used this strategy to subsist during difficult periods of the year. With regards to processed fish products (mainly smoked and sundried), very high ambient basin temperatures cause fish products to spoil and lead to economic losses to fish traders especially at the retail level. To mitigate the problem of spoilage, local fish traders in the LCB have adopted the use of some preservatives such as a mixture of vegetable oil (mainly groundnut oil) and a local tree extract (*otapiapia*) to prolong the shelf-life of processed fish products, both for local sales and during transportation to markets within and outside the basin. Aside from the preserving properties, the mixture also imparts a delectable lustre to the surface of the fish to the delight of consumers (Ovie *et al.*, 2007b).

4.1.3 Migration and mobility

Migration and mobility is another adaptive strategy employed by fishing communities to overcome climate change impacts in the Lake Chad Basin. In response to annual and inter-annual variation in lake water area, fish distribution and catch, fishers and some other fishery dependent individuals or households engage in seasonal migration (away from home for more than three months) or mobility (away from home for less than three months) in search of better income and livelihoods from the fisheries. Migration and mobility have provided households in the region access to new and better fishing grounds and other economic opportunities that have enabled them construct new and enhanced livelihoods portfolios for themselves and their households. Whole community movement with the establishment of new settlements have also been reported (Sarch and Birkett, 2000).

4.1.4 Diverse pattern of fishing

In response to changing water ennvironments and general ecology, fisheries communities in the Lake Chad Basin have adopted different pattern of fishing strategies to overcome or cope with the impacts of climate change and lake variability. Such seasonal adaptations often concern species exploited, location of fishing grounds and types of gears used. At high water, open water species (tilapias, *Hydrocynus, Alestes, Heterotis* etc.) are exploited, while fishers switch to swamp species such as *Clarias* at low water. In each case, special fishing gears (eg. gill net, cast nets, cane trap, Malian trap, hooks, etc.), capable of responding to prevailing ecosystem changes on a seasonal cycle are used for fish exploitation. In general, fishers are known to deploy active gears eg. cast net, drift nets, and seine nets at high water, while passive gears such as gill nets, cane/ Malian traps, hooks etc are used at low water. There is no evidence of differential use of gears by the different ethnic groups in the LCB.

4.1.5 Fisheries management

Fisheries management is a vital tool for controlling and preserving fish stock for sustainable harvest. As discussed in section 2.2.3, Fisheries management in Nigeria is, *de jure,* the responsibility of government at all levels. However, fisheries management, especially in the LCB, has often been strongly controlled by traditional institutions although in conjunction with formal institutions. This informal co-management approach has profited the local communities as the traditional institutions have tended to be flexible to accommodate the impact of seasonality due to climate variability. Neiland *et al.* (2005) reported that "*The Nguru-Gashua Wetlands (within the LCB) in Northern Nigeria are an important source of fisheries resources for surrounding villages. During the flood season, there is an open access regime to the river fisheries. When flood recedes, the deep sections of the rivers are managed by village water management councils. Fishers either pay for the right to use the deep sections or give up part of their catch to the council; outsiders must seek permission. River sectors are fished one at a time in rotation. Flood pools are owned by individuals or families, who must also give up part of their catch to the village which uses the proceeds for community development projects*".

Overall, there has been limited involvement of the Governments in regulating access to fishing in the LCB. The informal fisheries co-management arrangement with informal declarations of closed seasons to allow the fish to breed, gear regulations, and ban on obnoxious fishing methods such as use of chemicals, etc has been successful in sustaining the fisheries of the Lake Chad Basin (Sagua, 1991; Neiland *et al*,. 2005).

4.2 POTENTIAL ADAPTATION STRATEGIES FOR THE LCB

In addition to the current adaptive strategies mentioned above, additional strategies warrant attention and investment. The following areas are identified.

4.2.1 Small scale aquaculture as a strategy

Small and medium-scale aquaculture are considered important adaptive strategies to counter and supplement declining fish harvest from the lake basin. Aquaculture in small ponds is widely seen as a potential option for increasing fish production, consumption, income and creating jobs in the Lake Chad Basin. Mr. Nandi Tahir, the Director of Fisheries, Niger Republic (now fisheries desk officer, LCBC), in a meeting on the fisheries of the LCB, described a simple but strategic method used by rural households in Niger to ensure some level of annual fish recruitment in response to acute water depletion on the Niger side of the lake in the 80s/90s. According to him, rural households usually harvest juvenile fish from shallow drying ponds, keep such harvest in earthen pots in the vicinity of their homes and release same to surrounding pools once they get flooded in the next rainy season.

Aquaculture production in the region is increasing and the expertise and experience is also available with regional aquaculture experts to transfer knowledge to interested stakeholders. In Nigeria, for example, production has risen from about 26 000 tonnes in 2000 to 56 000 tonnes in 2005 and 85 000 tonnes in 2007 and annual production currently stands at over 120 000 tonnes. Small-scale aquaculture in the region appears to be a viable adaptive strategy to climate change impacts and the shrinking of the lake and associated wetlands.

4.2.2 Efficient water use and conservation

As previously stated, water use for irrigation in the LCB has been described as "extremely inefficient" and there is yet no incentive for farmers to reverse this trend (UNEP- GIWA, 2004). By implementing water conservation measures, less water will be needed to produce, say, a unit of rice. Switching from water intensive crops like rice to less water demanding ones like sorghum, millet, cowpea etc would help conserve water for other uses. Gravity irrigation commonly practiced in the LCB is known to be a water wasting technology and a switch to drip or sprinkler method of irrigation would be a viable option and adaptive strategy in the basin. More efficient water use in the inflowing river systems would allow more water to reach the various wetlands (especially the Yaeres, the Waza-Logone and the Hadejia- Nguru) and would rejuvenate fishing, flood and recession farming, grazing and other wetlands goods and services (UNEP-GIWA, 2004; FAO. 2004). As a matter of policy, education programs and incentives may be necessary ro promote and encourage water conservation.

4.2.3 Inter-basin water transfer

Inter-basin water transfer has been proposed by the LCBC as one option for reversing the decreasing freshwater shortage in the LCB and restore the lake. The plan, contained in the LCBC Master Plan and Strategic Action Plan (LCBC, 1998) is based on the argument that there cannot be enough water savings through efficient water management as the largest amount of water loss is attributed to evaporation. Consequently, proponents of the plan submit that "the conditions in the lake call for measures beyond the management of the available water resources in the Basin". Inter-basin water transfer, it is argued "would improve base flow and channel storage, arrest groundwater recession and falling water table and restore the lake" (LCBC, 1998). The plan involves moving 900 m^3/s of water, by gravity, from the the Oubangui River (the major tributary of the Congo River) in a navigable canal to the Lake Chad. The canal is expected to be channelled into the Chari-Logone and from there into the southern portion of Lake Chad. Part of the channel was also proposed to flow into the Benue Rivers onward to Port-Harcourt and the Atlantic in the Niger Delta. Proponents suggest that by restoring lake Chad, it will also allow for reinstatement of the activities such as recession farming, fishing and animal husbandry for the benefit of the local people and the wider society. It is also intended that it would facilitate communication among

countries by allowing year round navigation. The water transfer project is envisaged to deter environmental degradation, enhance environmental and ecosystem equilibrium and reduce migration of people and conflict among settlers and environmental refugees (UNECA unpublished in UNEP-GIWA, 2004).

4.2.4 Additional potential adaptive strategies

In response to dwindling water availability, sectors outside the fisheries have embarked on small-scale dam construction to store water for irrigation and water supply for both domestic use and livestock. While these dams (eg. the Hadejia-Jaamare in Nigeria and the Maga dam in Cameroon) have caused the loss of habitat, biodiversity and fisheries production, the reservoirs that have been created also provide new habitat for lacustrine fish species such as *Lates, Hydrocynus* and *Gymnarchus* that have either disappeared or declined remarkably in response to open water shrinkage. If fully rehabilitated, these species, considered to be iconic in terms of value and acceptance, would once again restore their economic importance. The reservoirs also have great potential for cage-culture, which is considered a cheap means of fish production as cost of power and pumps are eliminated and fish is grown in near perfect natural conditions. A cage of 30 m^2 can produce 9 tonnes of catfish annually (Fasina-Bombata, 2010).

5. Policy recommendations

This section deals with policy recommendations that target the mitigation of key constraints identified in the course of the review and which are thought to preclude the system from delivering its expected benefits, both in the short and long term. It is hoped that these set of recommendations will minimise future impacts on the trans-boundary aquatic environment with respect to the socio- ecological characteristics of the basin.

While various climate change impact pathways and adaptive strategies have been identified and discussed above, it is doubtful if these strategies are robust and resilient enough to cope with existing and potential impacts of climate change on the fisheries and other natural resources of the region without adequate national and regional (LCBC) policy support. Consequently, it is thought that adaptations in the policy domain are required to strengthen and sustain adaptive strategies of the rural fisheries communities. The following policy recommendations are therefore made:

1. Adoption and implementation of formal co-management approaches that would formally bring the management and use of the basin's natural resources closer to the local people and make them part of the decision-making process
2. Implementation of national and regional actions on poverty reduction and alternative livelihoods portfolios (eg. aquaculture, irrigated gardening, livestock herding, petty trading and skill acquisition in non-fish enterprises.)
3. Engagement in a sustained and directed sensitisation/awareness campaign on the impact of climate change on fisheries and the contribution of fisheries to household livelihoods, poverty reduction and national/regional economies. There is a general lack of understanding on the contribution of the basin's fisheries to economic development, food security and poverty alleviation.
4. In general, government must strive to provide policy support to reduce the exposure of fishery people to climate related risks, including reducing the dependence of people's livelihoods on climate-sensitive resources and supporting people's capacity to anticipate and cope with climate related changes. Government can do this in a number of ways:
   - Conduct climate change risk assessments and allow for the cost of adaptation and the potential changes in economic contribution from the fisheries sector.
   - Sustained support for control of gear and effort regulation. Lightly fished stocks with standard recommended gears are known to be potentially more resilient in the face of climate induced environmental changes.
   - In the LCB, formal and informal institutions for fisheries management exist but lack logistics for effective operation. There is need to strengthen and empower existing or new institutions that can respond to climate change threats along with other pressures such as over-fishing, pollution and changing hydrological conditions. Institutions need to be flexible with respect to rules, customs and taboos in order to accommodate the impact of climate variability. For example there is need to remove barriers to access common property resources by the poor in times of crises or scarcity and the maintenance of a reciprocal access arrangement as a social insurance mechanism (Allison and Ellis, 2001).
   - At the regional level, water management by the Lake Chad Basin Commission (LCBC) has largely been ineffective as national governments have engaged in series of dam constructions on effluent rivers without any imprimatur from the apex organisation. The LCBC needs to be strengthened with an appropriate department to cope with issues of water and disaster risk management.

- While a water allocation agreement has been proposed by LCBC with the help of FAO, this has not become operational as it is yet to be ratified by member States . There is need to ratify and operationalise a water allocation agreement (backed by a legal framework) between the member States to ensure an integrated river basin management. The agreement is expected to set minimum flow rates for points along the KYB and the Chari-Logone subsysteMs By such agreement, water users will not be able to abstract water at a level that would cause flows to drop below set levels.
- There is need to strengthen Policies, Institutions and Processes (PIPs) in the region to give effective policy support and implementation to existing and potential climate change adaptive measures.
- At the regional level, LCBC can formulate a protocol on free trans-boundary movement for member states to allow for easy migration and mobility to respond to changes in the distribution of fish and other natural resources of the region. The Economic Community of West Africa States (ECOWAS) protocol on free movement would have been sufficient but Cameroon and Chad are not member countries.
- Strengthening of disaster and risk reduction management agencies in the riparian countries to cope with potential adverse effect of climate change on fishery reduction and drought whenever they occur. This is critical to preventing further descent into poverty and food/nutrition insecurity in an already impoverished region.
- Support for new or existing resilience community based interventions to enhance livelihoods in the fishery communities. An ongoing FAO project in the Chad Basin ”Fisheries and HIV/AIDS in Africa” is currently mitigating the impact of HIV/AIDS in the region by providing revolving loans and other assistance to communities in the area for livelihoods diversification. Government and other international organisations can key or buy into this scheme to scale it up as there are interesting emerging results.
- Fish trade in the LCB is a major component of the local and regional economy, but these markets are not properly structured. The Doro-Baga fish market on the Nigerian western shores of the lake is the single most important fish market in the LCB, capturing over 80 percent of the fish products from the Basin on a weekly basis. This market is informally managed by market based organisations but can be supported through relevant policy by the LCBC to elevate its status to that of a regional international market that would continue to provide adequate livelihoods support to riparian communities
- In mitigating impacts and devising appropriate adaptive strategies for climate change, other bodies such as NGOs, community-based organisations, adaptation planners and donor agencies should play complementary roles as suggested by FAO (2006).

6. Conclusions and next steps

The Lake Chad Basin, shared by the republics of Cameroon, Chad, Central Africa, Niger and Nigeria, represents a huge reservoir of natural resources. The estimated 200 million population of the region are heavily dependent and inextricably linked to the natural resources of the basin for their livelihoods (Neiland *et al.* 2005, Béné *et al.*, 2003). Aside from the very recent efforts at oil exploration and exploitation, fisheries, agriculture and livestock rearing have constituted major socio-economic livelihoods portfolios, generating income, food/nutrition security, employment and labour for the riparian rural households and the wider society. In this context, these natural resources have made and are making significant contributions to both national and regional economies of the area (Béné *et al.*, 2003b; 2003c).

In particular, the fisheries of the lake and its adjoining floodplains and inflowing rivers have been of historical and socio economic significance, contributing both income (through capture and post-harvest activities) and food/nutrition security (Béné *et al.*, 2007). The fisheries production of the basin is currently about 100 000 tonnes with a monetary value of over US50 million dollars (Neiland and Béné, 2004). Over the years, however, there has been a gradual and significant reduction from the peak production in the 1970s.

In general, the fisheries, agriculture, livestock production and other goods and services provided by the basin, have been undergoing a steady decline since 1970s due largely to the massive environmental changes that have occurred in the region as a result of climate change and human strean-flow modification UNEP-GIWA, 2004). In particular, the reduction in lake water from an area of over 25 000 km^2 in the 1960s to 2 500-6 000 km^2 in the 1980/1990s (Neiland *et al.*, 2002) has impacted adversely on the natural resources and the livelihoods of the rural population that are dependent on them.

The location of the Lake Chad Basin in the Sahel means that it is highly vulnerable to the climatic perturbations in the region and climatic events have greatly influenced ecology and natural resources (Beadle 1981; Lemoalle, 1991), and thus also human livelihoods.

Reduced lake volume has led to habitat loss or habitat modification, further leading to changes in species composition/distribution and a decline in available natural resource. The adverse socio-economic implications on riparian communities who are dependent on the basin's natural resources for their livelihoods and well-being are obvious.

Several impact pathways of climate change (sections 3 subsections 3.4 and 3.5) on the fisheries of the LCB, including existing and potential adaptive/coping strategies to mitigate climate change impacts (section 4.0) have been proposed. These need to be followed up and strengthened through appropriate policy support framework at both national and regional levels.

The countries of the LCB have been described as 'weak States' characterised by weak political and economic stability, poor institutional capacity, limited information base and knowledge, incomplete development narratives/strategies, limitation of national policy-making and implementation process etc, (Neiland *et al*, 2005). The region will require international assistance to adapt to climate change and implement necessary mitigation measures. This, it is suggested, should include assistance to undertake more detailed climate change research that would lead to a greater understanding of patterns of vulnerability in in the system in order to develop and prioritise adaptation interventions in the Lake Chad Basin.

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).

Climate change and its impacts are already on the international agenda, but there is a need to mainstream fisheries, especially small-scale inland fisheries into existing or future programmes of the United Nations and other international organisations.

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FAO FISHERIES AND AQUACULTURE PROCEEDINGS 25

Climate change implications for fishing communities in the Lake Chad Basin

What have we learned and what can we do better?

FAO/Lake Chad Basin Commission Workshop
18–20 November 2011
N'Djamena, Chad

These are the proceedings from the workshop on "Climate change implications for fishing communities in the Lake Chad Basin: What have we learned and what can we do better?" held in N'Djamena, Chad from 18 to 20 November, 2011, organized by the Lake Chad Basin Commission in collaboration with the FAO Fisheries and Aquaculture Department.
The meeting included participants representing climate change and fisheries issues from Cameroon, Central African Republic, Chad, Niger and Nigeria who discussed the hydrology and climatic trends of the Lake Chad region as well as the national contexts and implications of climate change for fisheries in the basin. The meeting identified vulnerabilities specific to the fisheries and recommendations for actions to increase adaptability and resilience of the fisheries systems. The meeting recommended improved coordinated action and information sharing for effective aquatic resource use management to ensure sustainable development of land and aquatic based activities in the basin.

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