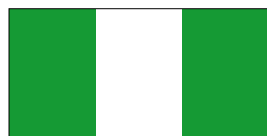
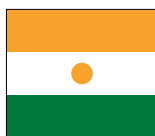




# Report on the State of the Lake Chad Basin Ecosystem







# Report on the State of the Lake Chad Basin Ecosystem



## FOREWORD

I am pleased to have the opportunity to welcome you to this, the first ever report on the state of the Lake Chad basin ecosystem. This report, which summarises our present knowledge about the basin ecosystem, is a flagship publication of the Lake Chad Basin Commission (LCBC) and has been developed on the initiative of the Lake Chad Basin Observatory. The aim is to update and republish this report every two years.

Lake Chad is a large, shallow lake in Africa composed of freshwater, which is rare for an endorheic lake. It plays an important economic role in the region, supplying water to more than 30 million people living in the four countries bordering the lake – Cameroon, Chad, Niger and Nigeria. Commonly considered to be an inland sea, Lake Chad is an important crossroads for regional trade. It is an important part of the sub-region's economy.

The Lake Chad basin is home to millions of people whose lives are dependent upon it. The integrated development of the lake's water resources and biodiversity constitute a cornerstone of the sub-region's socioeconomic development and stability.

In general, environmental issues are managed sectorially by each LCBC member state, although they are determined by a number of sociocultural, technological, political and economic parameters.

This report on the state of the Lake Chad basin's ecosystem addresses the above challenges and serves to support strategic planning and assist decision-making. The report brings together the core data assessing the condition of the basin's water and other environmental resources and also its socioeconomic activities. Furthermore, it takes stock of previous actions, current challenges and future possibilities for improving the management of the basin as a whole, using a list of indicators produced by the LCBC for monitoring the health of the basin. Finally, the report highlights cooperation between LCBC member states and the projects and programmes funded by a range of donors which seek to reverse land and water degradation trends in the basin, while taking into account the area's socioeconomic and demographic issues.

I hope this report will serve as an informative and richly abundant source of information for policymakers, development agencies, the media, teachers and researchers, as well as for the basin's inhabitants more broadly.

My greatest wish is that the publication of this report will serve to galvanise the basin community to take coordinated action at the national and regional levels for the protection and preservation of the Lake Chad basin ecosystem, which represents our common heritage and legacy of environmental resources for the welfare of present and future generations

I would like to thank the LCBC Executive Secretary for the preparation of this report and also the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) for its consistent support with the production of this publication.

I hope you enjoy the read!

Kind regards,



His Excellency Mr Wassalké Boukari

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## ABBREVIATIONS

ACAPEE	Association of Environmental Assessment Practitioners of the Central African Republic	GWA	General Water Authority
ACEEN	Cameroonian Association for Education and the Environnement	GWP	Global Water Partnership
AFD	French Development Agency	HALCIA	High Authority for the Fight against Corruption and Related Offences
AfDB	African Development Bank	HC/I/NTIC	High Commission for Computing and New Information Communication Technologies
AHT	AHT GROUP AG	HCME	High Commission for State Modernisation
ASECNA	Agency for Aerial Navigation Safety in Africa and Madagascar	HDI	Human Development Index
AU	African Union	HIMO	Manual Labour Intensive Activities
AWF	African Water Facility	IDB	Islamic Development Bank
BDT	Les Brasseries du Tchad	IEC	Independent Electoral Commission
BET	Borkou-Ennedi-Tibesti region	IRD	Institut de Recherche pour le Développement (French Research Institute for Development)
BGR	Bundesanstalt für Geowissenschaften und Rohstoffe (Federal Institute for Geosciences and Natural Resources)	ITCZ	Intertropical Convergence Zone
BPP	Baga Polder Project	ITF	Intertropical front
CAME	African Ministers' Council on Water	ITRAD	Chadian Institute for Agricultural Research for Development
CBD	Convention on Biological Diversity	IUCN	International Union for Conservation of Nature
CEDAW	Convention on the Elimination of All Forms of Discrimination against Women	IWRM	Integrated Water Resource Management
CESC	Economic, Social and Cultural Council	KRIP	Kano River Irrigation Project
CILSS	Permanent Interstate Committee for Drought Control in the Sahel	LACBO	Lake Chad Basin Observatory
CIPA	Chinese Investment Promotion Agency	LCBC	Lake Chad Basin Commission
CLD	Community-led development	MDG	Millennium Development Goal
CNDH/LF	National Commission on Human Rights and Fundamental Liberties	MERIS	Medium-resolution imaging spectrometer
CNDP	National Council for Political Dialogue	NAPA	National Adaptation Programme of Action
CNDS	National Commission for Social Dialogue	NCF	Nigerian Conservation Foundation
CNEA	National Commission for Water and Sanitation	NDVI	Normalised difference vegetation index
CONAC	National Anti-Corruption Commission	NEPA	Nigeria's National Electric Power Authority
CREA	Regional Commissions for Water and Sanitation	NEPAD	New Partnership for Africa's Development
DGRHA	Directorate of Rural Engineering and Water Management for Agriculture	NGO	Non-governmental organisation
DWS	Drinking water supply	NPFS	National Programme for Food Security
ECCAS	Economic Community of Central African States	ONASA	National Office for Food Security
ECOWAS	Economic Community of West African States	ONDR	National Office for Rural Development
EDF	European Development Fund	OPEC	Organization of Petroleum Exporting Countries
EFCC	Economic and Financial Crimes Commission	PACRC	Community Action Project for Climate Resilience
ESMP	Environment and social management plan	PADL/GRN	Support Programme for Local Development and Natural Resources Management
EU	European Union	PAIBLT	Project in support of the Lake Chad Basin initiative to reduce STI/HIV/AIDS vulnerability and risks
FAO	United Nations Food and Agriculture Organization	PAN-GIRE	National Action Programme – Integrated Water Resources Management
FYIP	Five-year investment plan	PARGIRE-AC	Regional Action Plan for Integrated Water Resources Management in Central Africa
GCM	Global circulation models	PDRI-CL	Integrated Rural Development Programme – Chari Logone
GEF	Global Environment Fund	PMCT	Prevention of mother-to-child transmission
GHI	Global Hunger Index	PET	Potential evapotranspiration
GIWA	Global International Waters Assessment	PRODEBALT	Lake Chad Basin Sustainable Development Programme
GIZ/GTZ	Deutsche Gesellschaft für Internationale Zusammenarbeit	PTEIB	Inter-Basin Water Transfer Project
GDP	Gross domestic product	Ramsar	The Convention on Wetlands of International Importance
		RDB	Regional database



RNNTT	Termit and Tin Toumma National Nature Reserve
SAP	Strategic action programme
SCIP	South Chad Irrigation Project
SODELAC	Lake Development Society
STEE	Chadian Water and Electricity Society
TBA	Transboundary diagnostic analysis
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
WHO	World Health Organization
WMO	World Meteorological Organization



# Introduction

This Report on the State of the Ecosystem of the Lake Chad Basin is the first in a series, with updates planned to be published every two years. Given the importance of this first report the LCBC has chosen to concentrate on a establishing a baseline year to enable ongoing monitoring of the ecosystem, with attention also being paid to a longer period from 1950 to 2012, wherever the data permits

This reports aims at providing precise, reliable and up-to-date information on the terrestrial and aquatic ecosystems and socioeconomic aspects of the Lake Chad basin. It is addressed to political decision makers, parliamentarians and senior civil servants in the member states of the LCBC, to development partner organisations, to the international community and to the general public.

## The Lake Chad Basin Commission



1: M. Sanusi Imran Abdullahi, Executive Secretary of the Lake Chad Basin Commission

The Lake Chad Basin Commission (LCBC) was founded on the 22nd May, 1964 by the four riparian states of the lake: Cameroon, Chad, Niger and Nigeria. The hydrographic basin covers an area of 2 397 420 km<sup>2</sup> and reaching Algeria in the north and Sudan to the east. The 'conventional basin'



2: The LCBC in N'Djamena, Chad

covers an area of 967,000 km<sup>2</sup>, which is around 40% of the hydrographic basin.

There are now six countries in the LCBC, with the Central African Republic joining in 1996 and Libya in 2008. The Sudan, Egypt, the Republic of Congo and the Democratic Republic of the Congo have observer status. The Commission has its headquarters in N'Djamena in the Republic of Chad. More information on the LCBC can be found on its web-site ([www.cblt.org](http://www.cblt.org)).

The LCBC's mandate is:

**To manage the waters of Lake Chad and the other trans-boundary water resources in the Lake Chad basin in a sustainable and equitable way;**

**To conserve the ecosystems of the conventional basin;**

**To promote regional integration and safeguard peace and security in the conventional basin.**

Its mission is:

1. To gather, examine and disseminate information about the projects drawn up by member states and recommend a common work plan and joint research programmes in the basin;
2. To maintain the link between the High Contracting Parties in order to ensure the most effective use of the water resources;
3. To monitor the implementation of the studies and work in the basin and informing member states informed in this regard;
4. To draw up a common set of rules to regulate navigation;

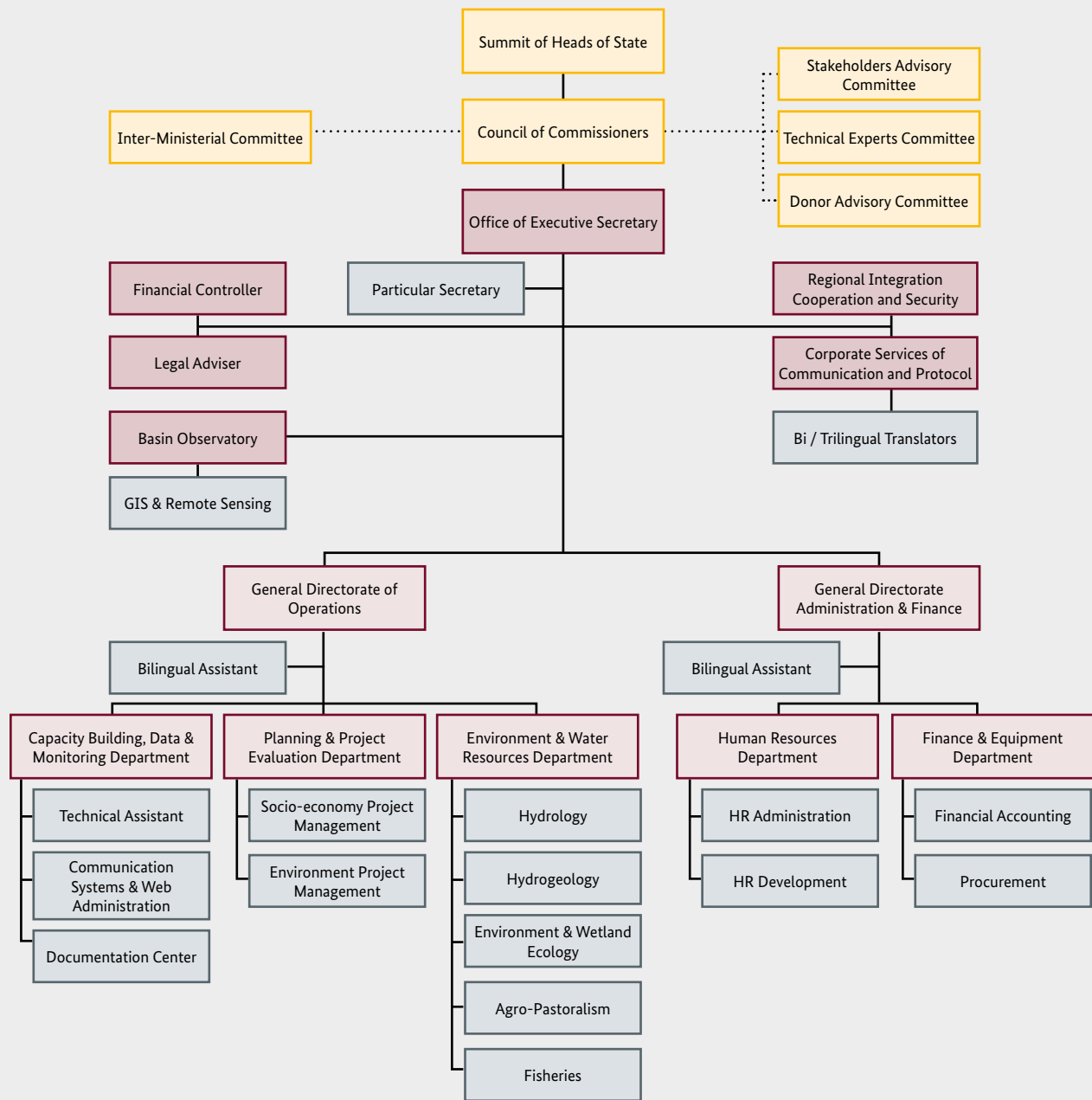
5. To establish regulations that cover LCBC staffing, and ensure that these are applied;
6. To review complaints, encourage the settlement of disputes and reinforce regional cooperation.

The LCBC's institutional structure mainly comprises the Summit of Heads of State and Government, the Council of Ministers and the Executive Secretariat. The subsidiary bodies are the Technical Committee; the Regional Parliamentary Committee; the Committee of Water Resource Experts; the Committee for the Environment, Sciences and Planning; the national agencies of the Lake Chad Basin Commission; and the Forum of Partners.



3: Extraordinary session of the Council of Ministers of the LCBC in Cameroon

Figure 1: Organigram of the LCBC in 2012



Source: LCBC

## Objective of the report

The Report on the State of the Ecosystem of the Lake Chad Basin aims to inform decision-making, through factual content and expert analyses. It informs, educates and empowers stakeholders and thus contributes to a better management of water and other natural resources in the basin.

Through an analysis of the major trends in the basin, the report helps provide an understanding of a number of issues of varying complexity. In particular, it focuses attention on emerging issues within the basin and the necessity to be more proactive in resolving these problems. Similar to other reports of this nature, it provides information on:

- the use and importance of the water resources in the basin in securing the livelihoods and wellbeing of the population;
- the current state of water resources and the surrounding environment, which constitutes a motor of change for other natural resources and how they impact on health;
- the challenges facing Member States terms of human development and access to natural resources; and
- the interdependence of the countries of the Lake Chad basin and the critical role that cooperation can play in optimising the benefits and equitable use of the basin's water and other environmental resources.

The experiences in other transboundary river basins around the world show that the use of monitoring instruments for shared basins can contribute to consolidating mutual trust and improve joint decision-making between countries.

This report seeks to trigger debate on the major issues affecting the basin, such as the natural and anthropogenic causes for the shrinking of Lake Chad, and, in so doing, instigate coordinated political interventions to address the challenges at hand – in particular, those related to governance, resource use, population growth, climate change and, above all, regional and international cooperation.

## Methodological approach used for the Report on the State of the Ecosystem of the Lake Chad Basin

The report on the state of the ecosystem has been assembled using data and information from the LCBC member states, and has been prepared in its entirety by the Lake Chad Basin Observatory, with the support of academics from the region. The collaboration took place within the framework of the Committee of Water Resource Experts (CERE) and the Committee for the Environment, Sciences and Planning (CESP), two subsidiary bodies of the LCBC, and with the support of German technical cooperation (GIZ), and the AHT GROUP AG, a consultancy office recruited by GIZ.

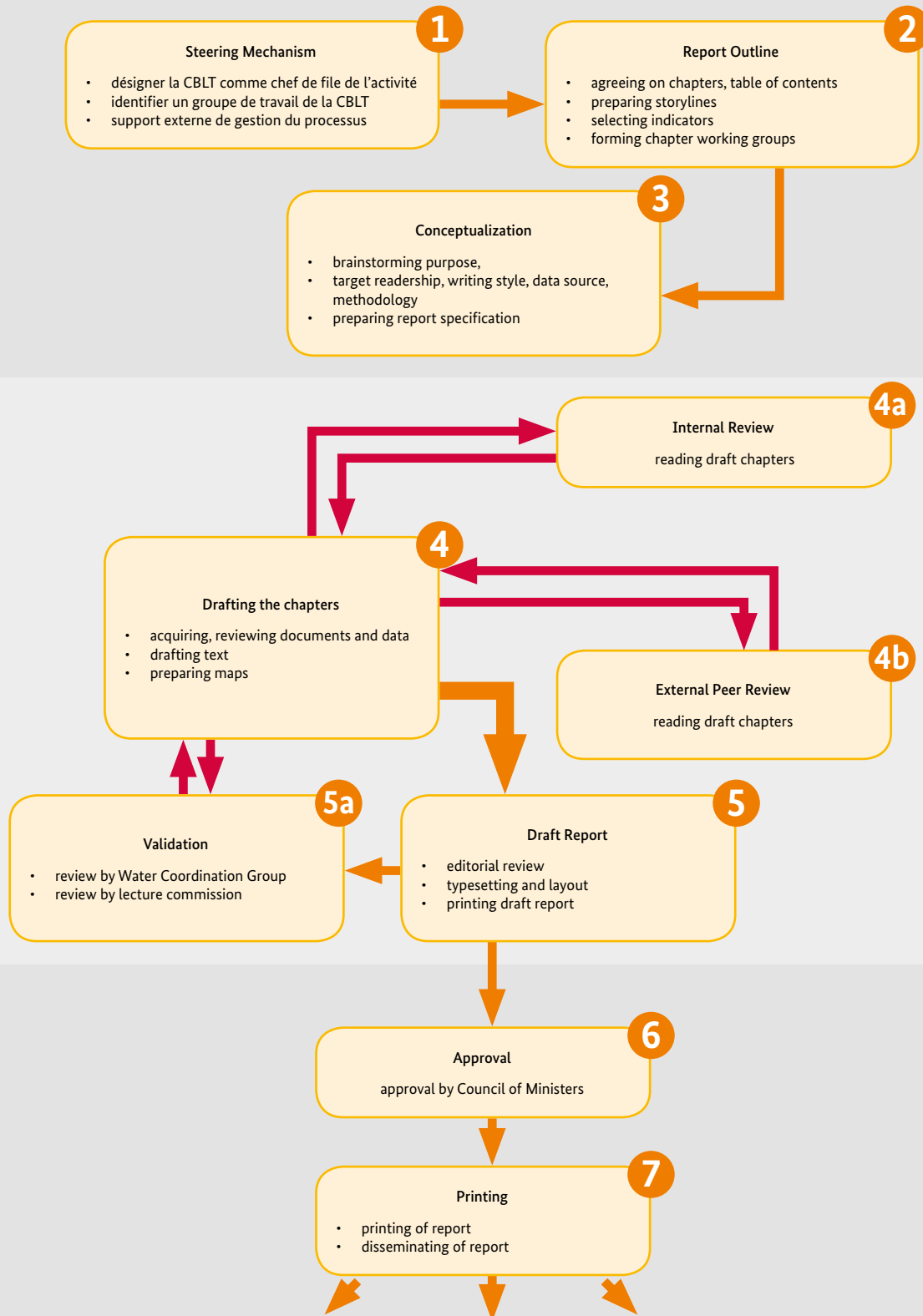
The participation of other resource persons from the Executive Secretariat of the LCBC was vital, enabling the integration of transdisciplinary experiences into the report. During the drafting process, the draft report was submitted for the approval of all the basin stakeholders whose inputs were essential.

The preparation of the report required substantial effort, focus and perseverance, particularly with regard to organising the drafting and, above all, in gathering the data, which were often disparate or lacking. A high degree of flexibility and creativity was required to ensure a consensual validation of the report. Final drafting required the input of professional formatting specialists, to guarantee that the report conforms to international scientific standards.



4: Validation Workshop for the Report on the State of the Ecosystem of the Lake Chad Basin in N'Djamena, Chad

Figure 2: The development and validation process of the report on the state of the ecosystem of the Lake Chad basin



**Analytical framework**

The process also called for the identification of key indicators which could be used to illustrate the state of biophysical and ecological resources and the state of human development in the basin.

The environmental indicators are a tool used to assess the state of the ecosystem, the pressures upon it and the responses that are envisaged for restoring the balance between the different factors governing it. The report on the state of the ecosystem of the Lake Chad basin is based primarily Transboundary Diagnostic Analysis (TDA) carried out by the LCBC in 2008, which also formed the basis of the Strategic Action Plan.

The TDA developed a report on the environmental indicators for the basin ecosystems which were subject to anthropogenic and natural pressures such as hydrological variability, water pollution, sedimentation, or the presence of invasive plant species. The degradation of the environment (biodiversity, water quality, soil quality etc.) has a direct impact on the health of the population and the ecosystem and requires social and environmental responses through political action and development programmes. The general tendencies observed in the basin ecosystem are improving for some indicators and deteriorating for others. To enrich this reflection, the report on the state of the ecosystem of the Lake Chad basin uses the Driving Force-Pressure-State-Impact-Response (DPSIR) analytical framework. The DPSIR framework promotes an analysis centred on the satisfaction of human needs, and the impacts and mitigating measures this requires, and thus aims to ensure that the report is of relevance to all concerned actors and decision makers. The framework has proven its worth in a variety of contexts including water resources and catchment management, analysing climate change impacts and in the

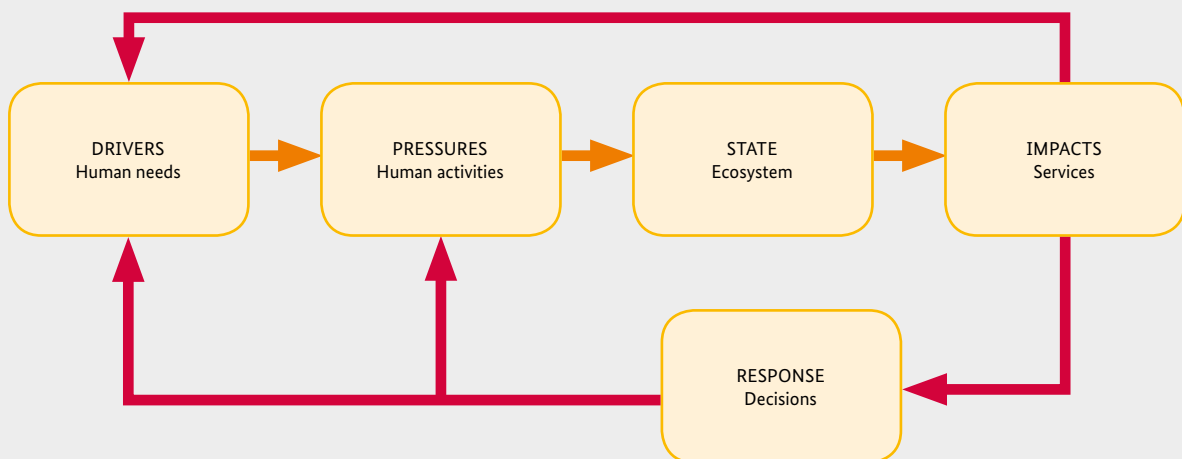
context of managing invasive species. It was also used in the development of the State of the Nile River basin Report from 2012. The framework illustrates the links and interactions between particular aspects of the basin ecosystem whilst retaining relevance to the overall system.

The basic premise of the DPSIR framework is that the driving forces to satisfy human needs (the need for food, water, shelter, security etc.) lead to human activities that create pressures on the environment (changing land and resource use, increased water demand, water pollution etc.), which in turn impact upon the state of the environment (impacting upon the quality and quantity of the physical, chemical or biological environment). This change of state in the environment has an impact on ecosystem and human health and leads to direct or indirect responses from national government, regional organisations or at international level, which can then effect the drivers, the pressures or the state of the ecosystem (see Figure 1).

The report is based on the information and data of projects and programmes which have followed the TDA, in order to determine the state of the ecosystem in 2012 and the tendencies for 2014. These form the indicators which will orient any subsequent data collection, either to augment the LCBC’s regional data base or to monitor the state of the entire ecosystem of the Lake Chad basin.

Chapter 1 of the report presents the general context of the basin, defining to a large extent the boundary conditions of the ecosystem. Chapters 2 and 3 present the driving forces and pressures and the changing state of the basin from a socio-economic and a water resources perspective. Chapter 4 presents the impacts these changes are currently having on the ecosystem in the basin, whilst Chapter 5 presents a variety of responses from regional and national organisations across the basin

Figure 3: The DPSIR analytical framework used for the report on the state of the ecosystem of the Lake Chad basin





## Report structure

The report on the state of the ecosystem of the Lake Chad basin comprises five chapters. It starts with a section that highlights the purpose and rationale of the report and also the way in which it has been organised. This is followed by a presentation of the state of the biophysical and ecological resources of the basin. Finally, the report closes with a presentation of some of the programmes and projects run by the LCBC or by the member states to address the issues raised in previous chapters.

**Chapter 1** describes the physical environment of the basin, especially its geology, geomorphology, the relief of the catchment and major soil types. The basin's hydrography is extensively covered, which is essential in gaining a better understanding of those living in the region and of the socio-economic activities on which they depend. The climate, the vegetation and the fauna are further key elements to understanding the ecosystem of the basin. The chapter closes with a description of human settlement in the basin.

**Chapter 2** looks at the basin population, which constitutes a significant challenge, but also a major asset for economic growth in the sub-region. This chapter also treats questions of water related illnesses, food security, governance and gender issues.

**Chapter 3** deals with the opportunities presented by the water resources in the basin and their qualitative and quantitative characteristics. The chapter also focuses on the different water uses around which the socio-economic activities are organised. It concludes with an overview of the current state of water resources and distinguishes the major trends going forward.

**Chapter 4** discusses the transboundary environmental problems that are the source of the ecological and socio-economic changes occurring in the basin. It examines the deep-rooted causes of these problems as well as how they are developing over time.

**Chapter 5** charts the projects and programmes undertaken both at national level by member states and at regional level by the LCBC to reverse land and water degradation trends in the basin. Indeed, since 2008 the LCBC has had at its disposal two strategies designed to preserve and develop the basin: (1) the National Action Plan (NAP) and (2) the Strategic Action Plan (SAP), which is regional in scope.



from top to bottom:

5: Children of Lake Chad on the banks of the Chari, Chad

6: A woman drawing water from a borehole

7: Transporting fuel wood, Moundou, Chad

8: A PRODEBALT production of plants

## Facts and figures on the LCBC member states

Cameroon						
	Total area (km <sup>2</sup> )	475,650	Population (% urban pop.)	20.62 m (53%)	GDP broken down by sector (2007–2012)	• I = 20% • II = 31% • III = 49%
	Types of climate (from north to south)	Tropical and equatorial	GDP per cap. (2012)	USD 1,180	Cultivated area (as % of total territory, 2012)	7,750,000 ha (16.3%)
	Average rainfall	1,604 mm per year	HDI (2012)	0.495	Irrigated area (as % of cultivated area, 2000)	25,650 ha (0.3%)
Libya						
	Total area (km <sup>2</sup> )	1,759,540	Population (% urban pop.)	6.04 m (78%)	GDP broken down by sector (2007–2012)	• I = 2% • II = 76% • III = 22%
	Types of climate (from north to south)	Mediterranean and desert	GDP per cap. (2012)	USD 11,497	Cultivated area (as % of total territory, 2012)	2,055,000 ha (1.2%)
	Average rainfall	56 mm per year	HDI (2012)	0.769	Irrigated area (as % of cultivated area, 2000)	470,000 ha (22.9%)
Niger						
	Total area (km <sup>2</sup> )	1,267,000	Population (% urban pop.)	15.89 m (18%)	GDP broken down by sector (2007–2012)	• I = 38% • II = 20% • III = 41%
	Types of climate (from north to south)	Desert	GDP per cap. (2011)	USD 374	Cultivated area (as % of total territory, 2012)	16,000,000 ha (12.6%)
	Average rainfall	151 mm per year	HDI (2012)	0.304	Irrigated area (as % of cultivated area, 2011)	99,890 ha (0.6%)
Nigeria						
	Total area (km <sup>2</sup> )	923,768	Population (% urban pop.)	159.71 m (50%)	GDP broken down by sector (2007–2012)	• I = 22% • II = 27% • III = 51%
	Types of climate (from north to south)	Desert and tropical	GDP per cap. (2011)	USD 1,280	Cultivated area (as % of total territory, 2012)	41,700,000 ha (45%)
	Average rainfall	1–150 mm per year	HDI (2012)	0.471	Irrigated area (as % of cultivated area, 2004)	293,200 ha (0.7%)
Central African Republic						
	Total area (km <sup>2</sup> )	623,000	Population (% urban pop.)	4.35 m (39%)	GDP broken down by sector (2007–2012)	• I = 54% • II = 14% • III = 32%
	Types of climate (from north to south)	Tropical and equatorial	GDP per cap. (2012)	USD 738	Cultivated area (as % of total territory, 2012)	1,880,000 ha (3%)
	Average rainfall	1,343 mm per year	HDI (2012)	0.352	Irrigated area (as % of cultivated area, 1987)	135 ha (0.007%)
Chad						
	Total area (km <sup>2</sup> )	1,284,000	Population (% urban population)	11.72 m (22%)	GDP broken down by sector (2007–2012)	• I = 56 % • II = 13 % • III = 31%
	Types of climate (from north to south)	Desert and tropical	GDP per cap. (2011)	USD 876	Cultivated area (as % of total territory, 2012)	4,932,000 ha (3.8%)
	Average rainfall	322 mm per year	HDI (2012)	0.340	Irrigated area (as % of cultivated area, 2002)	30,270 ha (0.6%)

## Lake Chad Basin facts and figures

Area of the basin	2,434,000 km <sup>2</sup> (≈8% of the total area of the African continent)
The percentage of the basin area pertaining to each country	Algeria (3.8%), Cameroon (2.1%), Central African Republic (9.3%), Chad excluding the country's Far North region (43.9%), Libya (0.1%), the Niger (29%), Nigeria (7.6%) and Darfur in Sudan (4.2%)
Location of the basin	Lying between latitudes 6° and 24° north and longitudes 8° and 24° east
Countries directly bordering Lake Chad	Cameroon, Chad, the Niger and Nigeria
Countries falling within the basin	Algeria, Cameroon, Central African Republic, Chad, Libya, Niger, Nigeria and the Sudan
LCBC member countries	Cameroon, Central African Republic, Chad, Libya, the Niger and Nigeria
Main tributaries and sub-basins	Chari-Logone basin, 690,000 km <sup>2</sup> Komadugu-Yobe basin, 148,000 km <sup>2</sup>
Flow rate of the Chari (average for period 2000–2009)	21.2 km <sup>3</sup> per year, 672 m <sup>3</sup> per second
Run-off coefficient of the tributaries and sub-basins	Between 5% and 40%
Surface area of the lake (2012)	12,177 km <sup>2</sup> , of which 4,516 km <sup>2</sup> is open water
Average depth (Medium Lake Chad)	Between 1.5 and 4 metres
Altitude of the lake	From 275 to 284 metres above sea level
Climate	Arid in the north of the basin and semi-arid in the south
Rainfall	<ul style="list-style-type: none"> <li>• Saharan climate (less than 100 mm per year)</li> <li>• Sahelo-Saharan climate (100–400 mm per year)</li> <li>• Sahelo-Sudanian climate (400–600 mm per year)</li> <li>• Sudano-Guinean climate (600–1,500 mm per year)</li> </ul>
Combined population of LCBC member states	228.7 millions
Population in the basin	45 million inhabitants
Most important cities in the basin	N'Djamena (Chad), Kano (Nigeria) and Maiduguri (Nigeria)
Economic activities in the basin	Agriculture, extractive industries (mining, oil), fishing, industries and crafts
Activities that consume the highest quantities of basin water	Primary sector (crop and livestock farming and fishing), domestic use
Main dams	Tiga Dam, Nigeria (1971–74, 1992) Maga Dam, Cameroon (1979) Challawa Gorge Dam, Nigeria (1990–92)

Source: Data Compilation of the LCBC, FAO, World Bank



## 1

# General characteristics of the Lake Chad basin

## Key messages

Lake Chad is intriguing, on one hand due to its highly variable water level, implying major ecological and demographic changes and on the other, due to the relative softness of its water, which is surprisingly low in dissolved solids, unlike in most other endorheic basins (closed catchment basins with no outflow to external rivers or oceans). The softness of the water is a clear asset in this semi-arid region.

History tells us that the Lake Chad region contained Mediterranean-type woody vegetation. Having passed through several different states, the situation around the lake has particularly deteriorated in the last 50 years as a result of the decreasing pluviometry and a high population growth rate (averaging 3% per year).

The pluviometry now varies between 100 mm in the north to 1,400 mm in the south of the basin, reflecting the presence of four main climate zones: Saharan, Sahelian, Sudanian and Sudano-Guinean.

The large part of the basin's geology comprises sedimentary formations from the Tertiary and Quaternary periods. The entire basin is encircled by sizeable uplands that hem it in and make Lake Chad, located in the centre of the basin, an endorheic feature, with no outflow to external water bodies.

Beyond the soils that are autochthonous to the different highland areas, those found in the Lake Chad basin were developed during the Quaternary period. Also, crusted soils, halomorphic soils and hydromorphic soils have formed in the channels of the watercourses.

The hydrography of the Lake Chad basin is dominated by the Chari-Logone and the Komadugu-Yobe river systems and, in addition to direct rainfall runoff, the inflows of these watercourses are vital for Lake Chad. The hydrography also comprises floodplains, small lakes and ponds, which provide local communities with important socio-economic and ecological services including the recharge of aquifers.

The Lake Chad basin has a wealth of flora and fauna, particularly with regard to species of fish and migratory birds that are mostly to be found in and on Lake Chad. Protected areas of international importance have been created to make it possible to protect these species, but they are often poorly managed by state-run services that lack sufficient means.

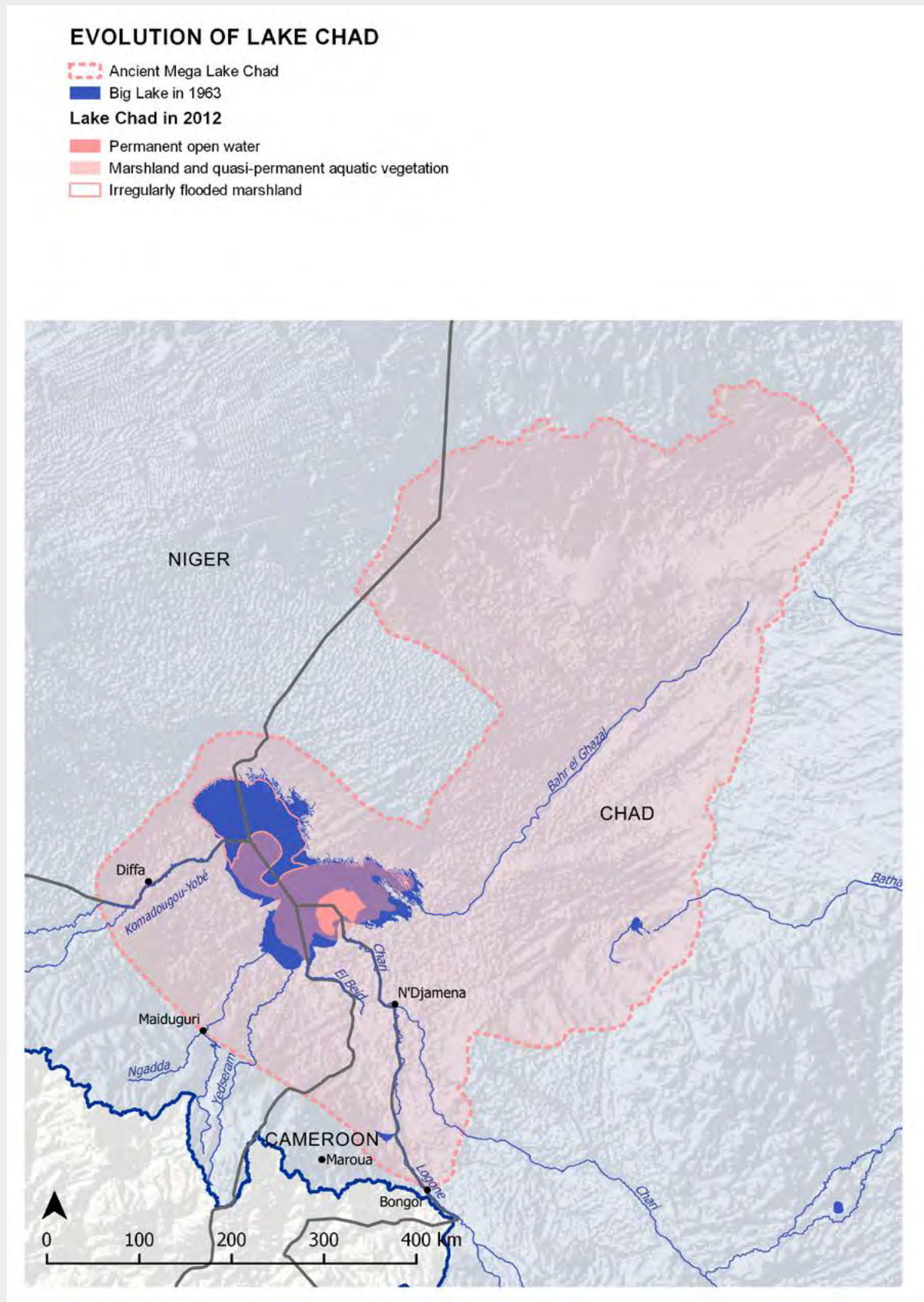
Ethnic diversity and a transboundary ethnic distribution are key features of the human settlement of the Lake Chad basin.



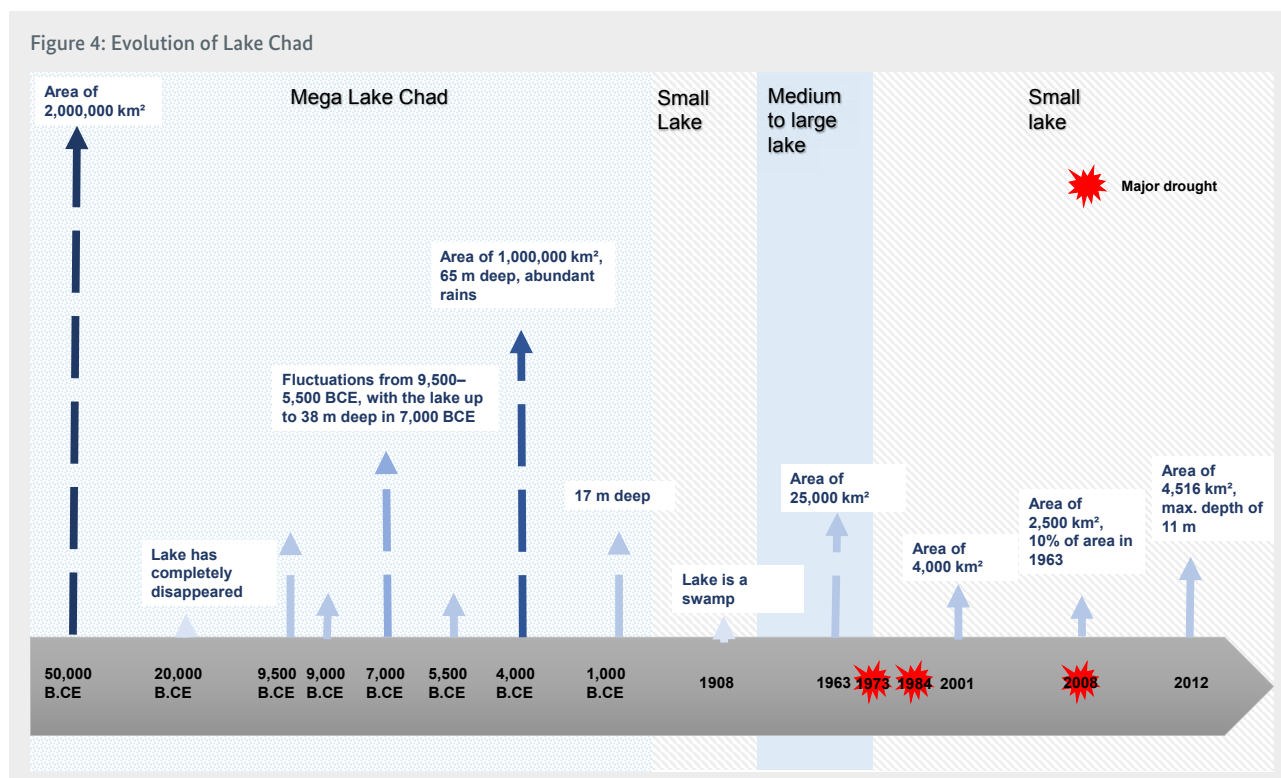
9: Manda national park, Chad

### History of the Lake Chad basin

Map 1: Evolution of Lake Chad



Source: Atlas de l'Afrique - Tchad, 2012



Located in central Africa, Lake Chad is in constant evolution from season to season, from year to year, from decade to decade and even from era to era. During the post-glacial period, the climatic conditions of the Sahara were much milder than they are nowadays and the desert covered a much smaller area than at present.

According to historians, much of what is now the Sahara was mostly covered with Mediterranean-type woody vegetation, particularly in the central mountainous areas, which were surrounded by numerous lakes and dry grasslands. These conditions were more favourable for sustaining large numbers of wildlife, and game species of all kinds would have been abundant.

Lake Chad would grow or shrink in accordance with wet and dry periods, but from around 4,000 BCE to the present day, the level of the lake has receded dramatically, corresponding with the advancing aridity and the advance of the desert.

Such variances in Lake Chad are evidence that a number of changes have occurred since 50,000 BCE. This situation has been magnified over the last 50 years due to decreasing rain, severe droughts (particularly those in 1973, 1984 and 2008) and human activity affecting the availability of water resources.

The different states of the lake were classified into three phases by Tilho in 1928, with the IRD (French Research Institute for Development) adding a fourth category in 2012. These different states are determined in the following way.

Table 1: The state of Lake Chad in different periods

State of Lake Chad	Small and dry	Small	Medium	Large
Categorisation by	IRD	Tilho	Tilho	Tilho
Flow rate of the Chari–Logone River (km <sup>3</sup> per year)	< 15	15–34	35–43	> 43
Water level (m)	Northern pool dry	Different levels	280–282	> 282.3
Number of water bodies	Several	Several	One	One
Area of the lake under water (km <sup>2</sup> )	2,000–6,000	2,000–14,000	15,000–19,000	20,000–25,000
Area of the lake under water in its northern pool (km <sup>2</sup> )	0	0–8,000	9,000	10,000
Main land typologies	Swamp and savannah	Swamp	Dune archipelago	Open water
Aquatic vegetation	++	+++	++	+

Source: IRD, 2014

During the periods when it was at its maximum extension, 'Mega Lake Chad' covered an area of around 350,000 km<sup>2</sup>, with its deepest point at the Bodele depression (approx. 210 m) and linked to modern-day Lake Chad through the Bahr el Ghazal.

From the 20th century onwards, it has been possible to determine much more precisely the periods when the lake has receded or, conversely, grown.

Over the first half of the 20<sup>th</sup> Century and up until the start of the 1970s, two major phases of the lake can be distinguished: the Large Lake Chad with an area between 20.000 and 25.000 km<sup>2</sup>, and a transition period known as the Medium Lake Chad, covering an area between 15.000 and 19.000 km<sup>2</sup>

In 1968 Lake Chad was a single flooded water body in an entirely arid environment. The form of the lake was considerably narrowed at the level shallows, connecting the northern and southern basins.

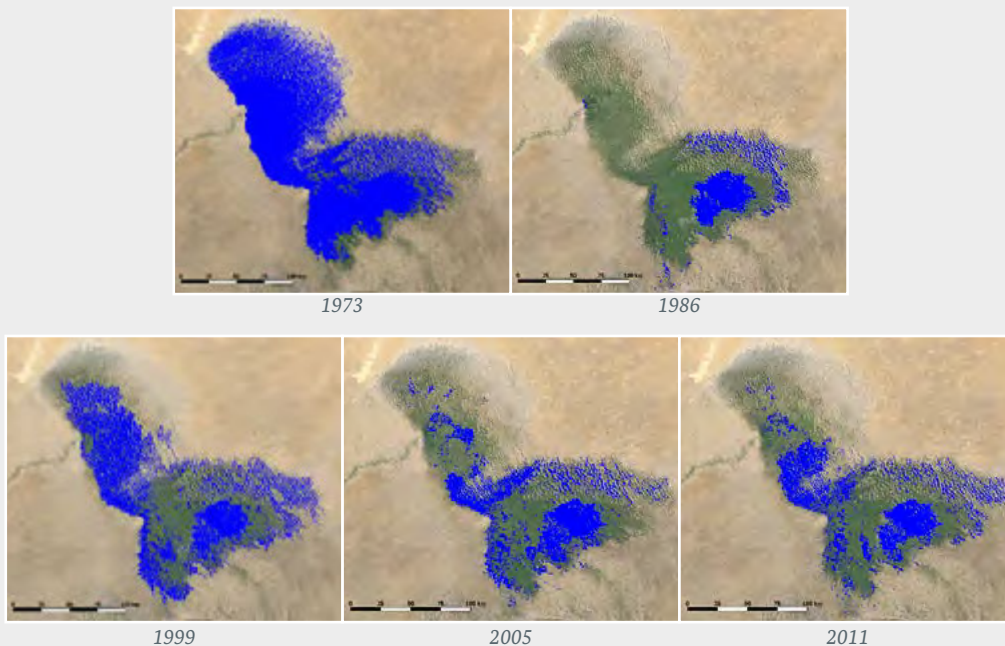
Since 1973 the basin has been experiencing a small lake phase (i.e. where the lake covers an area of between 2,000 and 14,000 km<sup>2</sup>), much as it did at the beginning of the 20<sup>th</sup> century. The years of major drought were followed by the northern pool remaining dry all year round (1985, 1987, 1988 and 1991), corresponding with the IRD categorisation of a Small Lake Chad. Since the end of the 1990s rainfall has increased, resulting in once again in the expansion of the area of Lake Chad's open waters and swamps.

In 2007, the northern basin had completely dried out. The lake had retreated to the southern basin which was made up of open water and swamps dominated by aquatic plants.



10: Envisat image of Lake Chad taken in 2007 by MERIS

Figure 5: Cartography of the different states of Lake Chad between 1973 and 2011





### Boundaries of the Lake Chad basin

The Lake Chad basin is located in central Africa between 5 and 25 degrees of northern latitude and 5 and 25 degrees of eastern longitude. The geographical of topographical basin in its entirety covers an area of 2 397 424 km<sup>2</sup>, or 8% of the African continent. The basin is surrounded by transboundary basins such as the Nile basin to the east, the Congo basin to the south, the Niger basin to the west and the Nubian basin to the north.

The hydrographically active part of the basin, occupying the area below the 15<sup>th</sup> southern parallel, can be divided into two principle basins: the Chari-Logone basin, which covers an area of 690.000 km<sup>2</sup>, and the Komadougou-Yobé basin, with an area of approximately 148.000 km<sup>2</sup>. There are

a further three, less important basins (with an average area of less than 15.000 km<sup>2</sup>). These are the basin of Yedseram, Ngadda and El Beid.

The conventional basin is the intervention zone of the LCBC, or the territory defined in 1964) by the Convention of Fort Lamy (now N'Djamena), between Cameroon, Chad, Niger and Nigeria. In 2012, it covered an area of 967.000 km<sup>2</sup> and included three regions of Cameroon, two regions of Niger, six federal states in Nigeria, three regions of the Central African Republic (CAR) and a large part of Chad. The CAR joined the LCBC in 1994 and Libya was admitted as a member in 2008. The Commission has four observer states: Sudan, Congo-Brazzaville, the Democratic Republic of Congo and Egypt.

Table 2: Country areas and shares in the basin

Country	Total area (km <sup>2</sup> )	Area of the Lake Chad basin (km <sup>2</sup> )	Area of the conventional basin section (km <sup>2</sup> )	Proportion of territory in the topographical basin (%)	Share of the area of the topographical basin (%)
Chad	1,284,000	1,109 201	361,980	86.4	46.3
Niger	1,267,000	671,868	162,375	53.0	28.0
CAR	622,980	217,340	197,800	34.9	9.1
Nigeria	923,770	180,364	188,000	19.5	7.5
Algeria	2,381,740	89,694	-	3.8	3.7
Sudan	2,505,810	81,360	-	3.2	3.4
Cameroon	475,440	46,049	56,800	9.7	1.9
Libya	1,759,540	1,548	-	0.1	0.1
<b>Total</b>	<b>11,220,280</b>	<b>2 397,424</b>	<b>967,000</b>	<b>-</b>	<b>100.0</b>

Source: LCBC

Map 2: Delimitations in the Lake Chad basin



Source: LCBC

## Abiotic environment

### Geology

With a clear understanding of the geology of the Lake Chad basin, one can better understand both the ecosystem and the social and ecological transformations the basin has experienced over recent decades. Two large geological units underlie the Lake Chad basin.

**Sedimentary formations:** Describing from the bottom up, this series comprises the Continental Intercalaire that is visible in Nigeria and the Niger and consists of sandstone (directly above the crystalline basement). Then come the Cretaceous deposits (the Continental Hamadien) formed of marl-sandstone, shale and conglomerates. Next are volcanic formations (basalt, andesite, etc.) which are exposed in Adamawa (Cameroon), and then 150-metre-thick sandstone sediments (ferruginous sandstone, sand, argillite, kaolinite, bauxite and ferruginous crust in the uppermost part) from the Tertiary period making up the Continental Terminal, which appears in Chad and the Central African Republic.

This formation is covered with a layer of sand around 30 metres thick from the Lower Pliocene, which is topped with a formation from the Upper Pliocene (280 m), above which comes the Quaternary. The Quaternary is mainly visible in the downstream basin of the Chari River with its fluvial or fluvio-lacustrine deposits both old (quartz pebbles, hardened debris, coarse-grained sand, topped with clay and sandy series) and recent (sandy-clayey deposits intercalated with sandy series) appearing in Bongor (Chad), the Yaere plains (Cameroon) and Massenya (Chad).

**Crystalline basement formations:** These are composed of a varied sub-basement lithology that comprises granitic, quartzitic and migmatitic crystalline rocks in Niger (Hoggar Mountains, Air Mountains), Nigeria (Jos Plateau), Cameroon (Adamawa Plateau and the Mandara Mountains), and Chad and Libya (Tibesti Mountains).

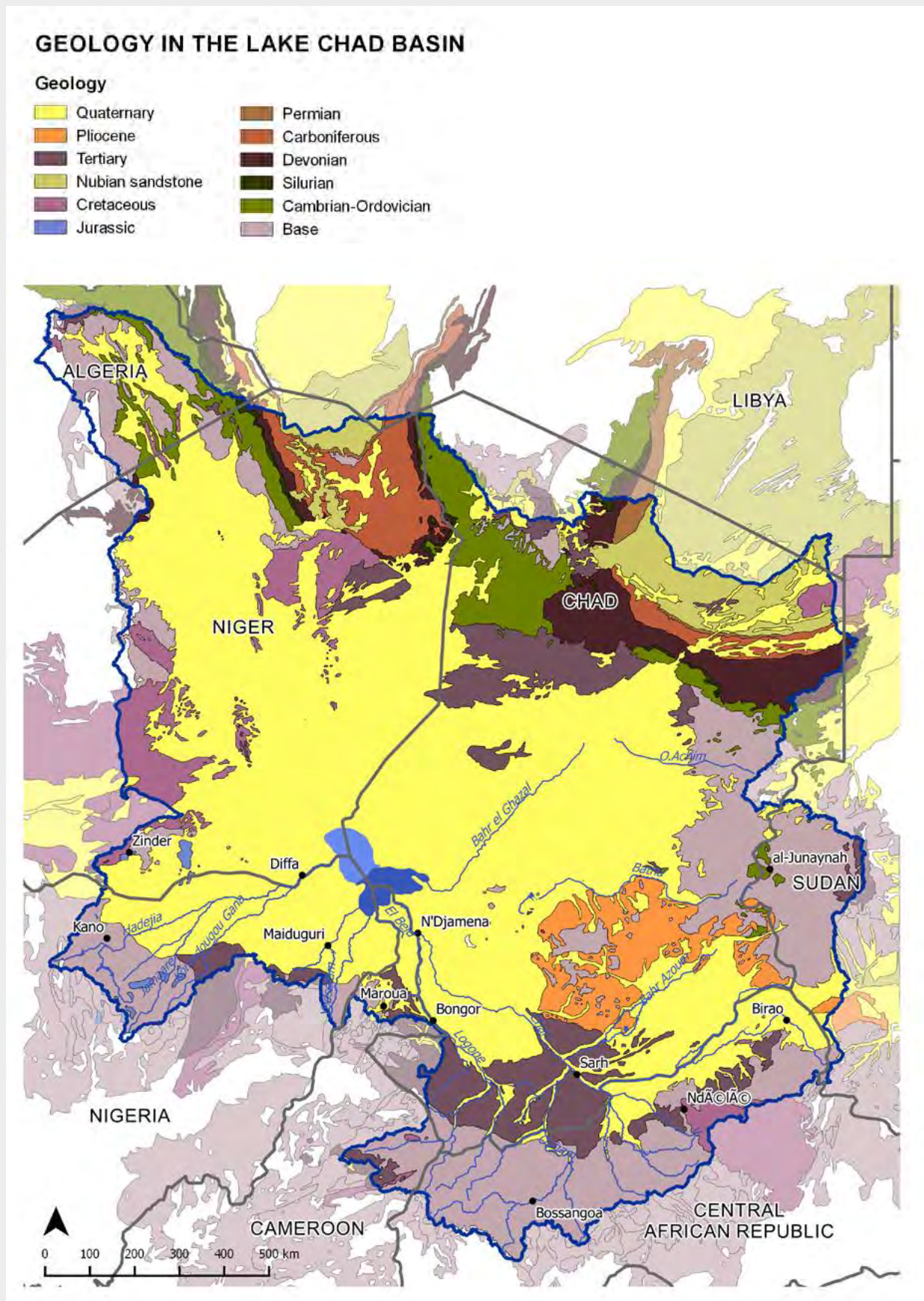


11: Granite rock, Cameroon



12: Elephant rock, Chad

Map 3: Geology in the Lake Chad basin



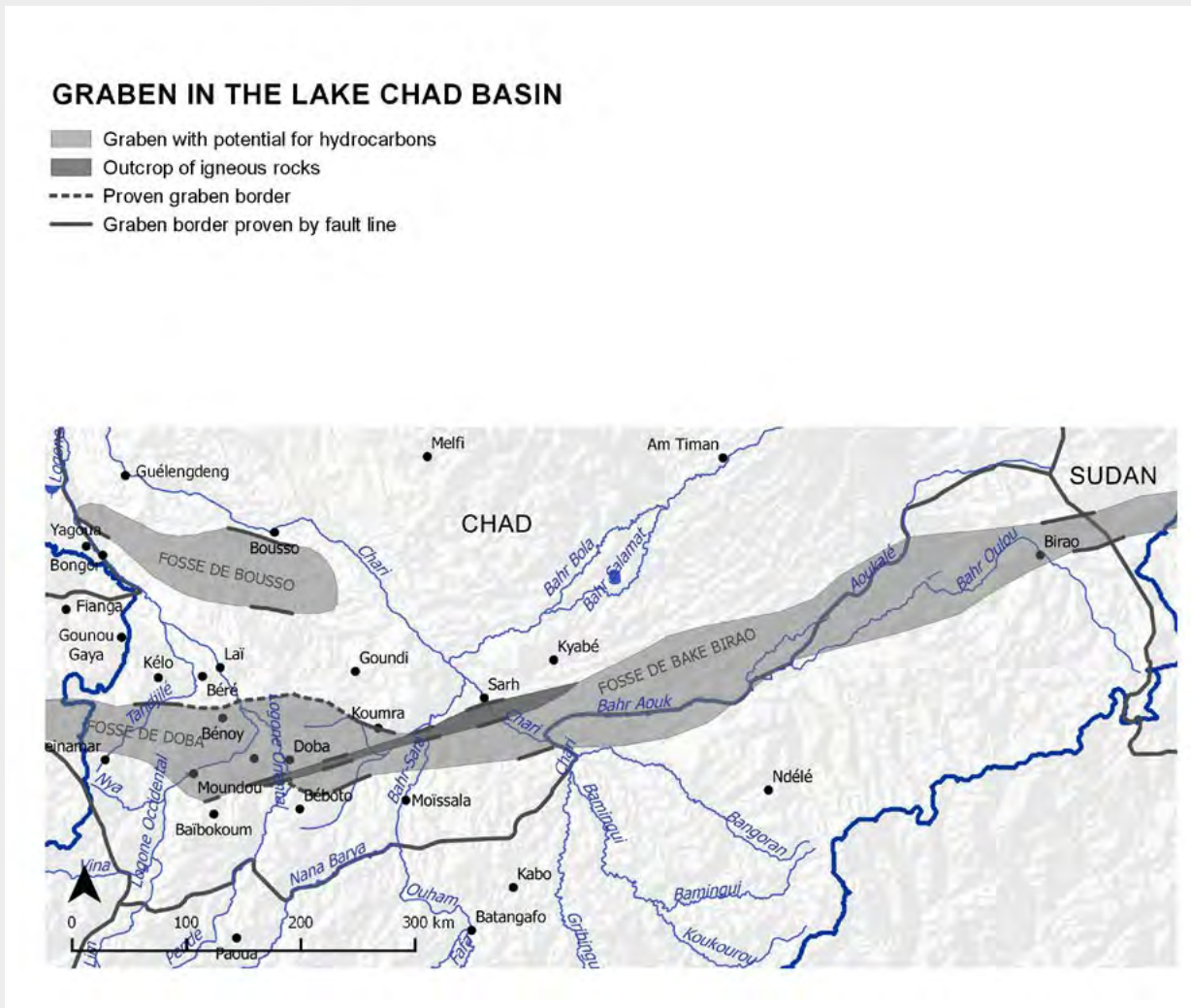
Source: Digital map digitized from "Study of Water Resources in the Lake Chad Basin" (REG 71), UNDP (Special Fund) – UNESCO, 1966 – 1968, original scale 1:5 Million

**Geological particularities of the Lake Chad basin**

Many deep sedimentary basins exist in the Lake Chad basin, some of which have real economic value due to the presence of marine Cretaceous formations, and thus potentially contain oil or gas. These include the depression east of Air in Niger, the Bilma basin, the Djado basin (Termit), the Bousso trough, the Bake-Birao trough, the Doba trough,

the Doseo-Salamat trough and a host of others. The Doba trough stretches from Moundou to Bahr Aouk and to Birao in the Central African Republic (Bake-Birao trough), being separated from Bebo by a tectonic event. The thickness of the sediment varies from 3,500 to 7,000 metres, and it is 15 kilometres long and 80 kilometres wide. The Doba trough oilfield, operational since 2003, is where oil is currently being extracted in Chad.

Map 4: Graben in the Lake Chad basin



Source: ORSTOM/ P. Louis, 1966

## Geomorphology

Lake Chad's topographical basin lies between 5° and 25° north and 5° and 25° east. Covering an area of around 2.397.500km<sup>2</sup>, it is an enclosed basin, hemmed in by highland formations: the Djado Plateau and the Tibesti Mountains to the north; the Ennedi Plateau to the north-east; the Ouaddai highlands and the Jebel Marra in Darfur to the east; the Guera Massif and the Bongos Massif to the southeast; the Adamawa Plateau to the south; the Jos Plateau and the Mandara Mountains to the southwest; and the Hoggar Mountains and Air Mountains to the northwest.

The basin relief is largely flat, composed of a peneplain with altitudes varying between 300 m and 500 m. It is surround-

ed by highlands: In the by the Hoggar Mountains (2.908 m), the Djado Plateau (2.158 m), the Tibesti Massif (3.415 m) and the Ennedi Plateau (1.450 m); to the east by the Guéra Massif (1.508 m), the Ouaddai Massif (1.320 m), the the Darfur Massif (3.042 m); to the south by the Jos Plateau (1.829 m), the Mandara Mountains (1.494 m). the Adamaoua Plateau (1.410 m) and the Bongo Massif (1.330 m); to the west by the Air Massif (2.022 m).

Different water courses have their sources in these highlands flowing down to Lake Chad (280 m). Due to the relatively flat terrain in and around the lake, a change in water level of only a few centimeters can result in the flooding of considerable areas.



13: Waza Logone plain, Cameroon

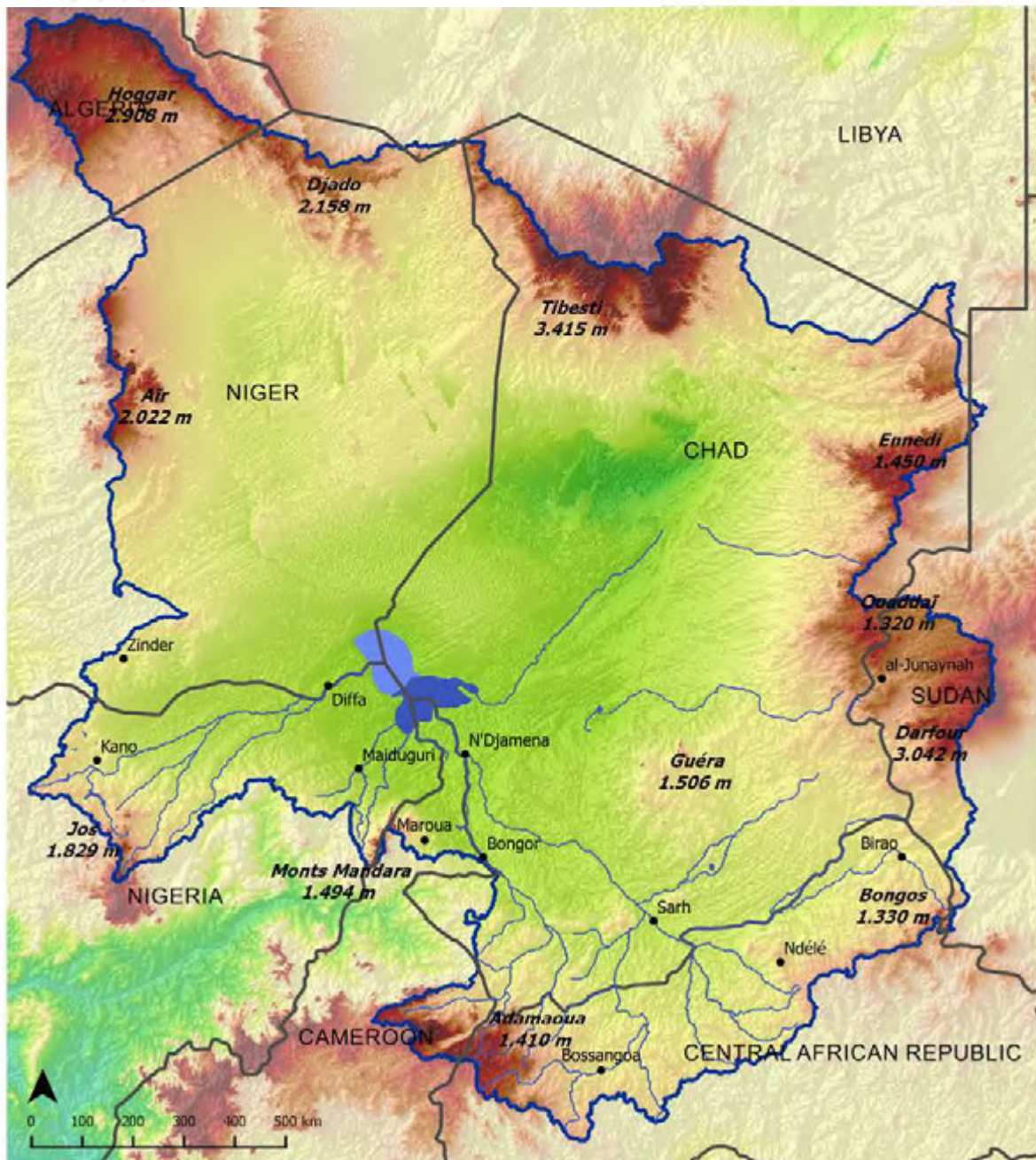


14: Landscape around the southern basin, Lake Chad

Map 5: Relief in the Lake Chad basin

### RELIEF IN THE LAKE CHAD BASIN

Altitude in m



Source: SRTM 90 x 90 Digital Elevation Database with hillshade, NASA

## Pedology

The major soil types found in the Lake Chad basin are constituted of: ferralitic and wind-derived underdeveloped raw mineral soils; isohumic (or subarid) soils; ferruginous tropical soils; hydromorphic soils; halomorphic (or salsodic) soils; and vertisols.

With the exception of the soils that are autochthonous to the mountainous areas, the basin's soils were formed during the Tertiary and Quaternary periods. In the lower reaches of the Chari River, between Sarh and N'Djamena and into Lake Chad, the soils derive from earlier deltas, from the lake bottom of the Mega Lake Chad (an earlier manifestation of the lake) and also from ancient wind-formed sand dunes from the north. Some of the soils are brown or reddish and tend to be ferruginous and slightly leached.

The soils in the Logone floodplains mainly comprise vertisols and also calcic hydromorphic soils which are erosion resistant. These clayey hydromorphic soils, when fed by the rains that fill the depressions, are highly conducive to the growth of grasses.

The region of Bahr el Ghazal is characterised by vast stretches of shifting sands, made up of deposits from Mega Lake Chad in the Quaternary period.

In the Borno region, all the soils are 'juvenile' as they are made up of hydromorphic soils, brown and halomorphic soils, and aeolian sands. In the topographic depressions there are vertisols or mixtures of vertisols and brown soils.

In the Kanem region, the wadi floors are not sandy, and the aquifers are located between 3 and 10 metres from the surface. The floors of the isolated wadis are composed of loamy or silty-sandy soils.



15: Vertisol near Bongor, Chad



Table 3: Description of the soils, their origins and location

Soil type	Origin	Location
Vertisols	Ancient deltas, lake bottoms, ancient sand dunes, southern mountains	Yaere, Mayo-Kebbi region, and Borno
Ferruginous crust	Lateritic or ferruginous soils	Pala (Chad)
Hydromorphic	Formed from sediments	Borno, the riverbeds of the Chari, the ancient delta, and the Massenya basin
Halomorphic and silty-sandy	Clays and pseudogley	Borno, Yaere, Lake Fitri, Massenya, and the whole of the lower Chari River
Aeolian sands	Formed from disintegrating rocks (sandstone) or from dunes	Borno, Diffa and Bol
Ferruginous sands	Sandstone	Mao, Bol, Ngouri and Moussoro in Chad, and also Diffa, N'Guigmi and Maine Soroa

### Soil quality

The soils of the Lake Chad basin are generally low in organic matter. They have deteriorated over time, and to farming practices overusing chemical fertilisers have resulted in high levels of salinity. However, it is primarily water erosion and hardening processes that have changed the physical quality of the soils left after slash-and-burn farming and deforestation.

In 2012 the Chadian government, with the support of the FAO, drew up a strategy to combat bushfires and reduce the area affected in the country. In other basin countries, laws and strategies in this regard also exist. However, the application of these laws often collides with a failure by authorities to monitor the situation and, above all, by the resistance of local people who often have no alternative but to continue these practices.



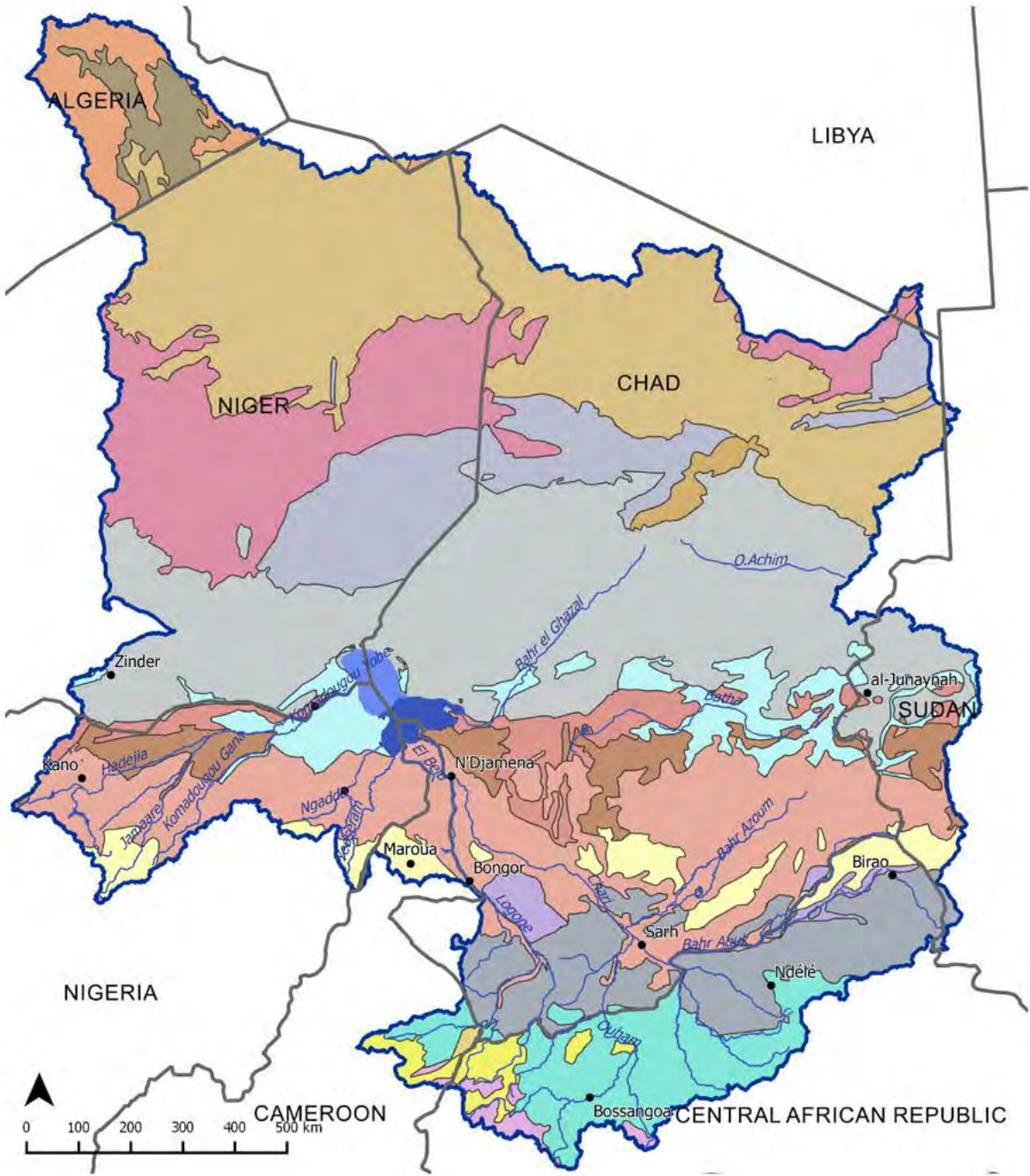
16: Runoff erosion effects soils low in organic material

Map 6: Soils in the Lake Chad basin

### SOILS IN THE LAKE CHAD BASIN

**Soil units**

- |  |   |  |
|--|---|--|
|  Acrisols   |  Lithosols     |  Regosols   |
|  Arenosols  |  Luvisols      |  Solonchaks |
|  Cambisols  |  Nitosols      |  Solonetz   |
|  Ferralsols |  Phaeozems     |  Vertisols  |
|  Fluvisols  |  Planosols     |  Xerosols   |
|  Gleysols   |  Podzoluvisols |  Yermosols  |



Source: FAO data

## Hydrography

Lake Chad basin is endorheic – a closed basin with no out-flow to external water bodies. The lake is fed by a series of rivers:

- The Chari River, which flows from the Bongos mountain chain in the Central African Republic and Darfur. Its main water catchment point is the Bahr-Sarh river, located near to the town of Sarh.
- The Logone, with its sources on the Adamawa Plateau in Cameroon and in the Karre Mountains of the Central African Republic (CAR).
- The Komadougou-Yobe River, which forms a section of the border between Nigeria and the Niger, flows into the northern pool of Lake Chad. It originates on the Jos Plateau in Nigeria.
- The remaining hydrography comprises intermittent watercourses: the Serbewel, a distributary flowing out of the Chari River, downstream of N'Djamena; the El Beid River, flowing in from the Yaere plain and running along the border of Cameroon's Far North region; the Ngadda River that rises in northern Nigeria; and the Yedseram River that rises in the Mandara Mountains of Cameroon.

Table 4: Areas of sub-catchments

Main sub-catchments	Area
Chari-Logone	330,000 km <sup>2</sup>
Komadugu-Yobe	120,000 km <sup>2</sup>
Yedseram	16,320 km <sup>2</sup>
Ngadda	14,400 km <sup>2</sup>
El Beid	22,640 km <sup>2</sup>

Source: LCBC

Lake Chad is divided into a southern basin, which is fed by the Chari, and a northern basin, which is filled only in wet years. The lake is shallow (3–4 m), and in the past under normal conditions it was 250 kilometres at its longest and 70 kilometres wide at its narrowest point. It has no outlet, but loses water uniquely through infiltration into underlying aquifers and, more commonly, evaporation (around 49.95 km<sup>3</sup> per year). Between 85 and 90% of the water in Lake Chad is supplied by the Chari-Logone system. The other water courses contribute only a very small volume to the Lake.



17: The Bahr Sara, one of the principal tributaries to the Chari, Chad



18: The Logone, border between Chad and Cameroon

The level, volume and surface area of the lake fluctuates as a function of climatic variation. During the humid years in the first half of the 20th Century, around 70% of the lake's area comprised open water. The remainder was a marshy archipelago. During the prolonged dry periods, and in the dry season (particularly from March to April), there is almost no vegetation in the lake. With the arrival of the rainy season in June-July, the seeds in the soil germinate and the plants grow back, notably in the southern basin of the lake. Since becoming the Small Lake Chad, the lake has a very limited area of open water and resembles a swamp dominated by grasses, papyrus, common reeds and bulrushes. New small islands have appeared which have been quickly settled and exploited by the population.

The hydrography of the Lake Chad basin plays an important role in the region's economy and in maintaining the balance of its environment. The population of the basin mainly live in rural areas and make a living from livestock, agriculture and from fishing. The region has a subsistence

economy and is highly vulnerable to variations in water availability. The four countries directly bordering the lake are particularly vulnerable in this regard. The watercourses shape people's way of life in the riparian communities, where diverse ethnic groups live side by side, distributed sparsely across the region. The Kanembu and Haddad groups mainly inhabit the eastern and northern shores of the lake, the island-dwelling Bu and Duma live in the archipelago, the Sugurti and the Kanembu inhabit the western shores, and the Arabs and the Kuri are mainly found on the southern side.

Lake Chad, with its wetland ecosystem and rich and varied biophysical environment, acts as a buffer against the advancing desert. All sections of the lake under national control have been designated as Ramsar sites by member states and recognised as wetlands of international importance. The Nigerian and Chadian sections of Lake Chad were recognised as Ramsar sites in 2001, with the Nigerian and Cameroonian sections following suit in 2008.

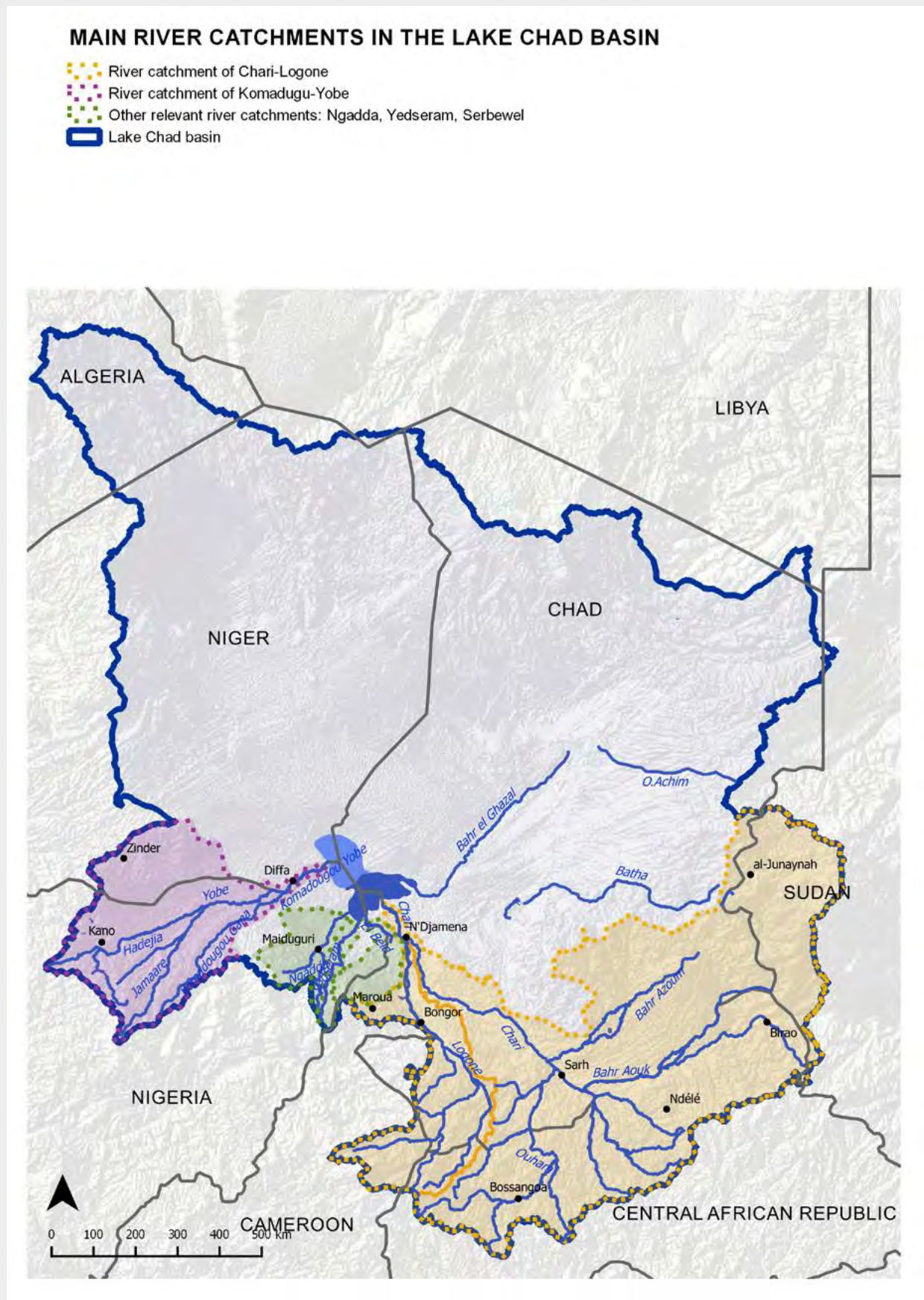


19: Lake Chad vegetation in the humid zone



20: View of Lake Chad

Map 7: Main river catchments in the Lake Chad basin



Source: SRTM 90 x 90 Digital Elevation Database with hillshade, NASA

## Climate

The overall climate of the Lake Chad basin can be classified as tropical hyper-arid, with four distinct climate zones of different rainfall levels. The annual rainfall decreases as one moves from the south of the basin, with 1,500 mm per year, to the north, with 100 mm per year, with an annual rainfall of 320 mm per year around the lake. Moving from the north to the south of the basin, the following climatic zones can be identified:

- The Saharan climate, which is characterised by less than 100 mm of rain per year in Libya.
- The Sahelo-Saharan or Sahelian climate, with an average annual rainfall of between 100 mm and 400 mm to the north of Diffa (Niger). This zone includes Lake Chad.
- The Sahelo-Sudanian climate, which is wetter with an average annual rainfall of between 400 mm and 600 mm (in the far northern region of Cameroon, northern parts of Nigeria and N'Djamena in Chad).

- The Sudano-Guinean climate, with an average annual rainfall of between 600 mm and 1,500 mm (in the north of the Central African Republic, south of Chad and a part of Cameroon and of Nigeria).

The climate of the Lake Chad area is Sahelian, which is characterised by a very short rainy season from June to October and a long dry season for the rest of the year.

The average annual temperature in the basin varies from 35°C and 40°C; it is hot and dry from March to June, and dry and cooler from November to February. The area has low relative air humidity, and thus high atmospheric evaporation.

The annual evaporation from the surface of Lake Chad's open waters has been estimated at 2,150 mm and higher, while the annual rate of evapotranspiration in the city of Bol, calculated using the Penman formula, has been determined as 2,079 mm.

The hot and dry winds come from the north-east of the basin in the dry season, but in the rainy season the winds blow from a south-westerly direction.



21: A storm in Bongor, Chad

Map 8: Climate zones in the Lake Chad basin

### CLIMATE ZONES IN THE LAKE CHAD BASIN

**Climate classification**

- Saharan climate
- Sahelian-Saharan climate
- Sahelian-Sudanese climate
- Sudanese-Guinean climate
- Isohyetes



Source: Generated by AHT from Isohyetes

The rainfall regime displays major interannual irregularities. The distribution of the rains over the course of a year varies from region to region depending on local atmospheric conditions. Moving from south to north, the duration of the rainy season and the quantity of rainfall rapidly diminishes. The isohyets change from an average of 1,200 mm to less than 100 mm. The ongoing reductions in rainfall recorded in these regions have changed the conditions of areas that were previously considered as wetlands into those typical of a desert environment.

The annual temperature cycles display a typical north-south gradient, influenced by the position of the sun and by cloud cover. An increase in cloud cover during the course of the wet season inhibits solar radiation and therefore causes temperatures to drop. This is evident in the arid and semi-arid areas where the seasonal contrast between periods with and without cloud cover is starker. Towards the south, where clouds and rain feature throughout almost

the entire year, the temperature cycles vary less compared with those of the north, where spikes in temperature can be very sharp.

Table 5: The influence of the climate on crops

Influence of the climate on crop growing (FAO 2004)	
Saharan climate	No crop growing, no rangeland for grazing
Sahelo-Saharan climate	No crop growing, negligible rangeland for grazing
Sahelo-Sudanian climate	Millet, sorghum, sesame
Sudano-Guinean climate	Maize, beans, peanut, peas, barley, wheat

Source: FAO, 2004



22: Watermelon fields, Cameroon



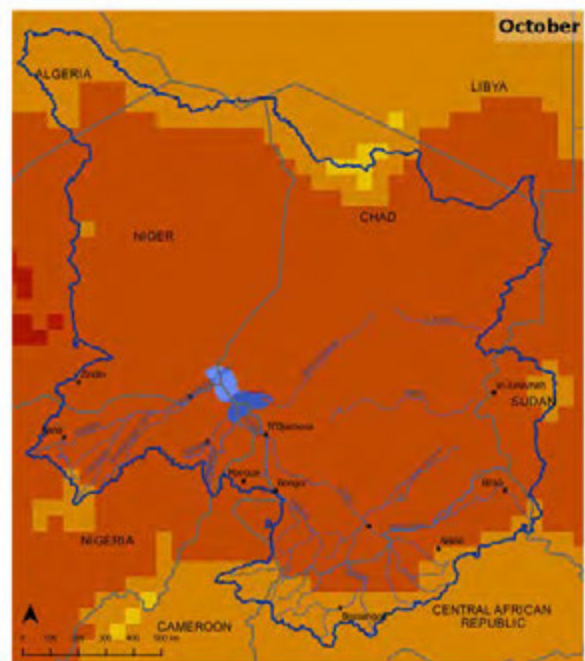
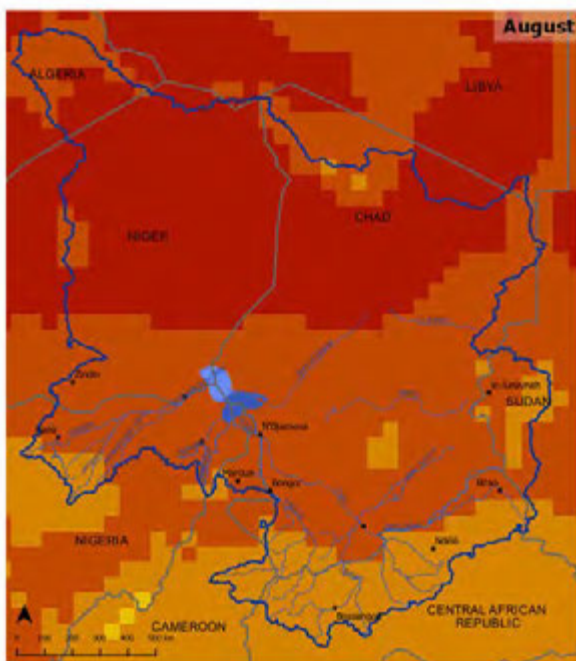
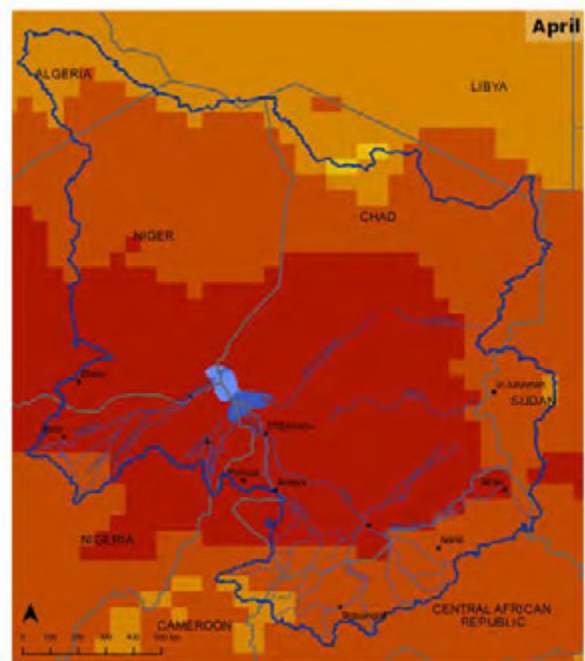
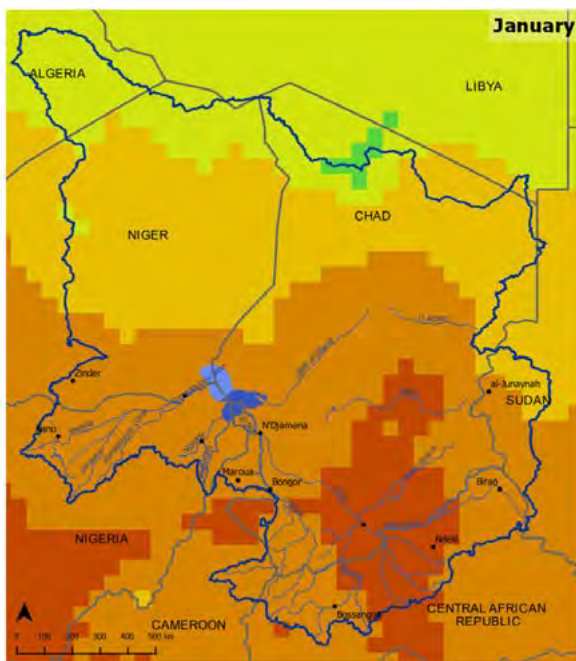
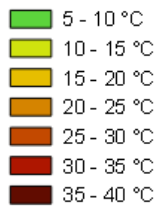
23: Growing sorghum, Cameroon



Map 9: Mean monthly temperature in the Lake Chad basin

### MEAN MONTHLY TEMPERATURE IN THE LAKE CHAD BASIN

Mean temperature



Source: <ftp://ftp.ncdc.noaa.gov/pub/data/ghcn/daily/all/>

## Biotic environment

### Vegetation and flora

The Lake Chad basin contains a great diversity of habitats, including desert landscapes, shrub-steppe zones, areas of savannah, forest and wetlands as well as mountainous areas. Its extensive lowlands, where Doum palms grow, are mainly used for farming.

The northern half of the basin comprises the deserts of Tenere, the Erg (sea of dunes) of Bilma, and the Erg of Djourab. In this region vegetation is practically non-existent. However, in the south, in the Sahelian climate belt, vegetation comprises dry savannah and savannah interspersed with prickly shrubs.

There are flood plains along the Chari and Logone Rivers, the most well-known being the Grand Yaere plain along the border between Cameroon and Chad, the Massenya floodplains, the Sategui plain, and the Hadejia-Nguru wetlands in Nigeria and Chad. The floodplains contain very few trees, and the shrublands and grasslands only change in the marshy depressions.

The Komadugu-Yobe basin is located in the Sahelian climate zone, but a decrease in rainfall over recent decades has seen the vegetation change to that of a Sahelo-Saharan climate. Here, tamarind and baobab trees are particularly evident, and sometimes dense vegetation grows alongside the Komadugu-Yobe River.

The Borno basin is also located in the Sahelian zone, but the influence of the Sahelo-Sudanian climate is clearly evident. The northern section of the basin comprises shrub-steppe that gradually transforms into wooded savannah in the south.

In the upstream section of the Chari and in the section of the Logone running through the Central African Republic, the flora can be divided into two zones: the mid-Sudanian (in the Ouham-Pende prefecture) and Sudano-Guinean (in Baboua and Bocaranga). Rainfall in this zone varies between 900 mm and 1,110 mm. The vegetation comprises mosaics of open forest and perhaps some dense dry forest interspersed with woodland and shrubland savannahs and cut through with gallery forests.



from top to bottom:

24: Wooded savannah, Central African Republic

25: Ziziphus fruits, Chad

26: Dom palm fruits, Niger

In the downstream section of the Chari, which has a Sudano-Sahelian climate zone that terminates in the Mas-sensya region, shrub-steppe, shrub savannah and wooded savannah predominate.

In the Lake Chad region, the vegetation mainly comprises woody species: *Acacia raddiana* spp., *Maerua crassifolia*, *Balanites aegyptiaca*, *Leptadenia pyrotechnica*, *Capparis decidua*, *Ziziphus mauritiana*, *Combretum glutinosum*, and *Scerocarpa birrea*. Likewise, the herbaceous stratum is dominated by the following species: *Cymbopogon proximus*, *Aristida funiculata*, *Aristida palluda*, *Panicum laetum*, *Panicum turgidum*, *Eragrostis tremula* and *Shoenefeldia gracilis*. It features several types of landscape, which vary according to the water level of the lake. The islands of the archipelago in the east of the basin are formed by the dunes of a partially submerged erg. Islets of vegetation (free-floating or rooted) are composed of marshy or dry grassy plains (nutsedges and reeds) and of trees (acacia, mango tree, etc.). Around these islets, marshes determine the vegetation. The open waters are choked here and there by invasive plants.

The lakeside areas contain fields, orchards, crops and acacia plantations. Certain areas are heavily degraded as a result of increasing agricultural activities and demographic pressures on vegetation. The *Calotropis* is a particularly prevalent species in roadside areas and in areas exposed as the lake recedes.

The northern catchment area, which features grassland and shrub-steppe, takes in certain areas of the lake, but also the regions of Kanem and Hadjar Lamis in Chad and a part of Niger.

Niger's section of this watershed (Zinder and Diffa) contains dense mesquite forests (140,000 ha). The management of these forests contributes, on the one hand, to reducing their detrimental effects (invasion of fertile lands, degradation of rangelands and harm to animals) and, on the other, to providing fuel wood.

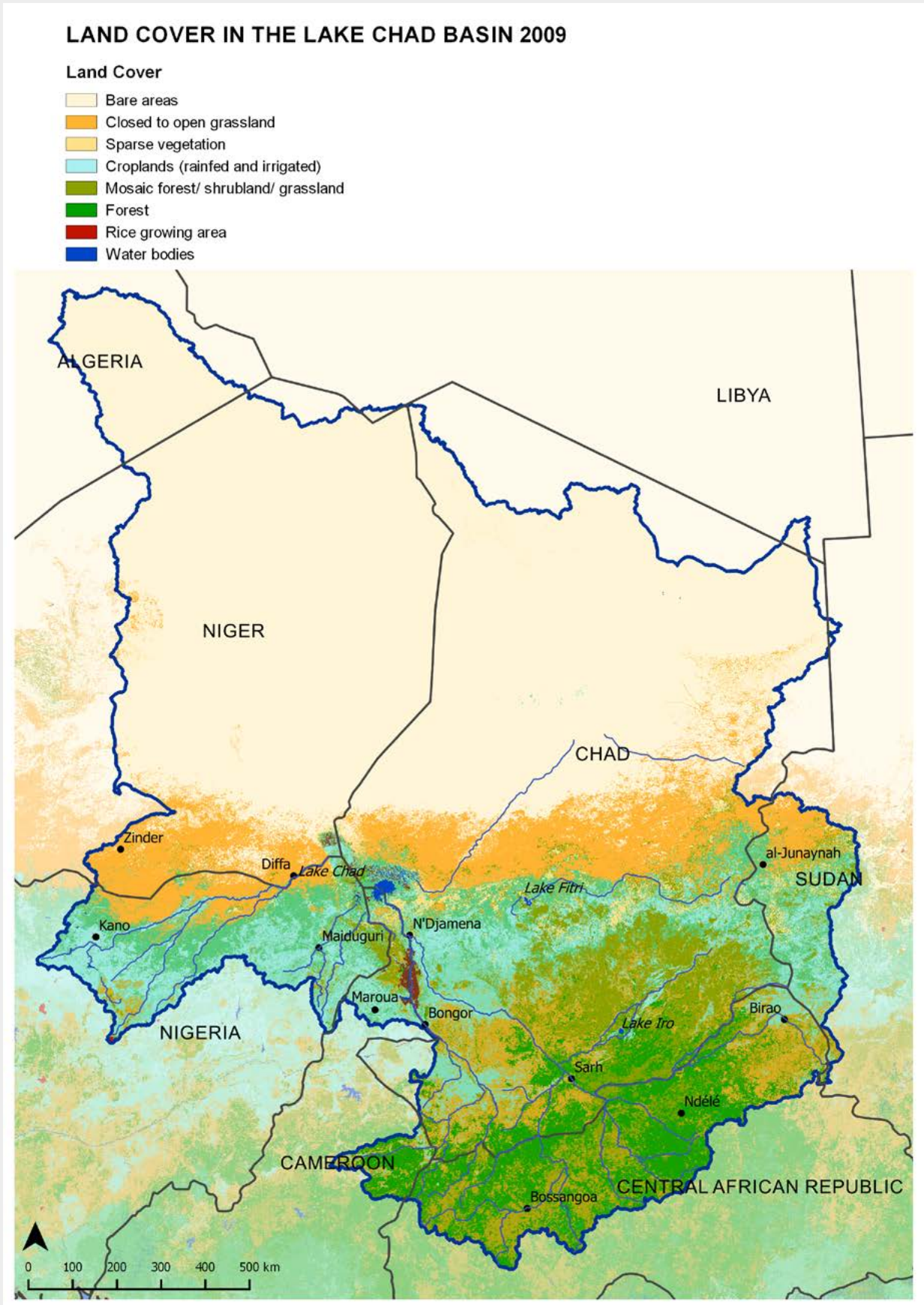


27: View of the humid zone of the Hadejia-Nguru, Nigeria



28: Humid zone of the Hadejia-Nguru, Nigeria

Map 10: Land cover in the Lake Chad basin in 2009



Source: LCBC

Besides the typical vegetation of the Sahel, other areas around the basin, such as the mountains, agroforestry systems, gallery forests, transition zones and oases, each harbour their own distinctive collections of flora and fauna.

The most widespread plant species in the basin are the *Acacia* and the *Tamarindus indica* of the Central African gallery forests. The *Prosopis* spp. are invasive plants that are

only found in the wooded savannahs around Lake Chad in the regions of Bol (Chad) and Diffa (Niger).

*Cyperus papyrus* plants are more likely to be found in the lake itself than elsewhere in the basin. *Ziziphus* spp., *Calotropis procera*, *Aristida* spp. and *Ipomoea* spp. are found at the edge of the lake between Nigeria and Chad. Being steppe species, they typically mark the beginning of the Sahelian belt of the Lake Chad basin.

Table 6: Main forest species in the basin

Vegetation	Some species
Mountain vegetation	<i>Boswellia</i> , <i>Combretum</i> , <i>Acacia albida</i>
Wooded savannah	<i>Acacia senegal</i> , <i>Prosopis</i> spp., <i>Balanites aegyptiaca</i>
Shrub-steppe	<i>Ziziphus</i> spp., <i>Calotropis procera</i> , <i>Aristida</i> spp.
Grassland	<i>Echinochloa pyramidalis</i> , <i>Hyparrhenia rufa</i>
Desert	<i>Acacia raddiana</i> , <i>Ziziphus mauritiana</i>
Agroforestry system	<i>Parkia biglobosa</i> , <i>Prosopis africana</i> , <i>Tamarindus indica</i>
Gallery forest	<i>Tamarindus indica</i> , <i>Disopyros mespiliformis</i> , <i>Hyphaene thebaica</i>
Aquatic vegetation	<i>Aeschynomene elaphroxylon</i> , <i>Cyperus papyrus</i>
Transition zone vegetation	<i>Vertiveria nigritana</i>
Riparian forest	<i>Khaya senegalensis</i> , <i>Acacia nilotica</i> , <i>Hyphaene thebaica</i>
Oasis	<i>Daniella oliveri</i> , <i>Vitex doniana</i> , <i>Burkea africana</i>



29: Rhumsiki landscape, Mandara mountains, Cameroon

## Fauna

Reliable information on the fauna present in the Lake Chad basin is fragmented, and national datasets are not comparable.

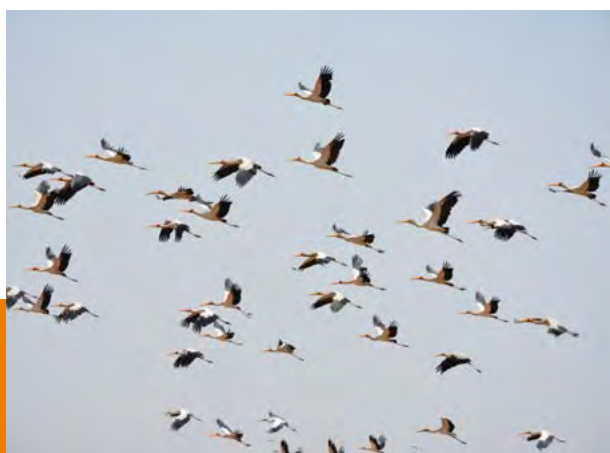
What is known is that the basin's wildlife resources are many and varied. Depending on the country, between 130 and 209 mammal species and more than 500 bird species have been counted. Much of the wildlife seeks haven in or around the wetlands, such as the elephants, lions and Derby elands that are found in the north of Cameroon and in the Central African Republic.

The basin hosts numerous bird species such as the crowned crane, white-bellied bustard, black-bellied bustard, Denham's bustard, peregrine falcon and diverse duck species. More than 350 species have been estimated in the basin with hundreds of thousands of migratory birds. Lake Chad, offering a first stop, is a special place for migratory birds.

The lake is also home to hippos, otters, and water bush-buck, an antelope that lives in marshlands. Herds of elephant also enter the lake area, depending on the season and it provides a good habitat for "Kouri" cattle, a species endemic to the lake, with good potential for dairy and meat production. But what most characterizes the lake most of all for the population is its important fishing potential.

Table 7: Some species founded in the Lake Chad basin

Taxonomic group	Some species
Mammals	Elephant, lion, giraffe, Derby eland, hippopotamus, addax, gazelle, cheetah, buffalo, greater kudu, damaliscus, panther, serval, manatee, patas monkey, Senegal bushbaby, warthog
Reptiles	Python, cobra, Nile monitor, Nile crocodile
Birds	Ostrich, bustard, duck, guinea fowl, numerous migratory birds
Fish	Nile perch, mudfish, tilapia, Nile tilapia, Heterotis niloticus (also known as the African arawona)
Prawns	Nile prawn, giant freshwater prawn
Amphibians	Nile frog



30: Soaring birds, Cameroon



31: Hippopotamus in Lake Chad

### Fishery resources

Between 120 and 140 species of fish have been counted in Lake Chad and its tributaries. The open waters of the northern pool contain fewer fish than those of the southern pool and the archipelago as these waters are shallow. Lake species, such as the Lates perches or even the *Gymnarchus*, have practically disappeared. Only the marsh-dwelling species (*Clarias*, *Heterotis* and *tilapia*) are still to be found. Two types of migratory fish are found in the ponds and floodplains: marsh and pond-dwelling species (*Alestes*, *Labeo* and *Distichodus*) and species that come in from rivers and lakes. The El Beid constitutes the second largest fishery in the basin, along with Logomatya, a natural drain from the Grand Yaere floodplain. In Lake Maga, situated in the Waza-Logone floodplain, 56 species of fish have been counted, including *tilapia*, mudfish, tigerfish, catfish, etc.

Due to a lack of monitoring, recent quantitative data on fish in the Lake Chad basin are limited and those that exist are based on market studies undertaken in the early 2000s.

- *Clariids (catfish)*  
Catfish mainly live in stagnant water and can tolerate extreme environmental conditions (particularly low or high temperatures and low levels of dissolved oxygen). They dwell in the muddy substrates of the lake, and can breathe in the atmosphere using respiratory organs. The fish will sometimes exit the waters around the islands, moving along shallow routes using their pectoral fins and lamellae in search of food or breeding grounds.
- *Heterotis niloticus*  
This species reaches around one metre in length and can weigh more than six kilograms. The young fish are found in marshy areas among the aquatic vegetation, whereas the adults live in the open waters of the lake in the limnetic zone and the littoral zone.
- *Cichlids (tilapias)*  
Most of the *tilapia* in Lake Chad reach maturity within three to four months, weighing between 100 to 200 g and measuring 10 to 12 cm. They spawn three or four times a year. Males define and defend their territories, which are located on the bottom of shallow marshy areas.



Table 8: Fish catches by species (as a %), based on monitoring of the stocks of the two main fish markets in Chad and in Nigeria

Genus or common name	Average value (%)
<i>Clarias</i>	36.54
<i>Heterotis</i>	22.03
<i>Tilapia</i>	21.16
<i>Gymnarchus</i>	8.51
<i>Lates</i>	2.18
<i>Alestes</i>	1.85
<i>Hyperopisus bebe bebe</i>	1.63
<i>Protopterus</i>	1.45
<i>Bagrus</i>	1.27
<i>Mormyropps</i>	1.21
<i>Auchenoglanis</i>	0.89
<i>Synodontis</i>	0.35
<i>Peterocephalus</i>	0.26
<i>Hyperopisus bebe occidentalis</i>	0.21
<i>Polypterus</i>	0.19
<i>Mormyrus</i>	0.18
<i>Labeo</i>	0.11
<i>Distichodus</i>	0.01
<i>Schilbe</i>	0

Source: Jolley et al., 2002



to the left 32: Selling fish in Diffa, Niger  
from top to bottom:  
33: *Heterotis Niloticus*  
34: *Catfish*

## Conservation of natural resources

Wildlife remains extremely threatened in the basin, although some species have received protected status. To preserve the basin's wildlife and forest resources, states have defined and recognised areas of value, which are managed through legal or other arrangements. For example, the mountainous area of Termit, which straddles the regions of Zinder, Diffa and Agadez, are full of Addax oryx and Damagazelles. Termit is one of the few sites in the world with a viable population of Addax in nature.

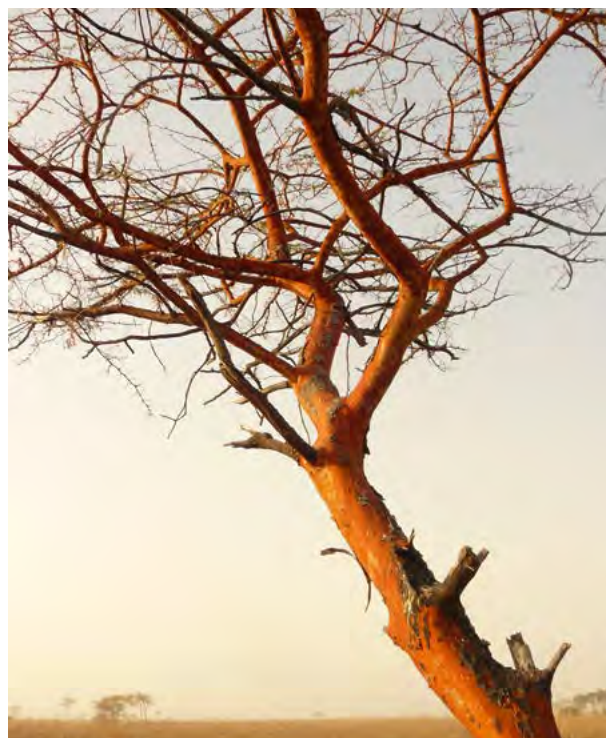
The protected areas are a tool for conserving the basin's biodiversity and fall within the framework of the Convention on Biological Diversity, adopted at the Rio Earth Summit in 1992. In the Lake Chad basin 30 geographical areas have been designated as protected areas and validated by the International Union for Conservation of Nature (IUCN). Together they comprise an area of around 352,721 km<sup>2</sup>. Alongside these wildlife reserves, there are forest reserves, which are either managed by local communities or by devolved or decentralised government services.

Table 9: Number and area of protected areas (IUCN) in the Lake Chad basin

Protected areas	No.	km <sup>2</sup>	IUCN category
<b>Cameroon</b>			
National park	3	1,759	II
<b>Niger</b>			
Strict nature reserve	1	12,800	Ia
Nature reserve	2	161,560	IV
<b>Nigeria</b>			
Wildlife reserve	3	3,275	IV
<b>Central African Republic</b>			
Wildlife reserve	6	23,856	IV
National park	3	31,052	II
Private reserve	1	2,636	IV
Strict nature reserve	1	843	Ia
<b>Chad</b>			
Wildlife reserve	7	110,800	IV
National park	3	4,140	II
<b>Total</b>	<b>30</b>	<b>352,721</b>	

Source: [protectedareas.net](http://protectedareas.net)

The IUCN categorisation for protected areas is set according to the way the park is managed. Category Ia, for example, refers to protected areas that are mainly managed for scientific purposes or the protection of wilderness resources. Category II aims to protect ecosystems by permitting recreational uses of the park. Category IV protected areas mainly focus on conservation, with interventions at the management level.



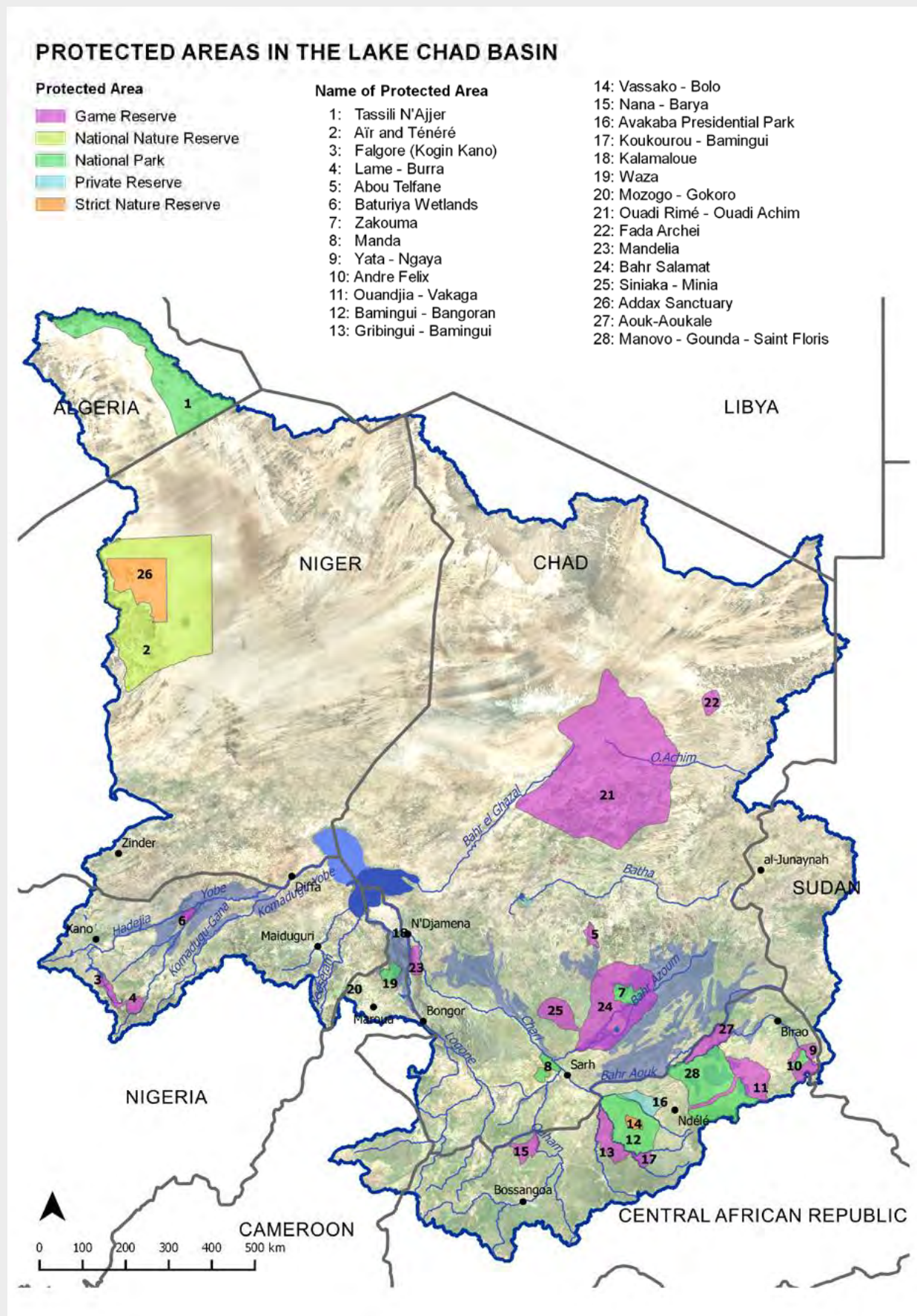
from top to bottom:

35: Acacia Seyal in the Waza national park, Cameroon

36: Entrance to the Waza national park, Cameroon



Map 11: Protected areas in the Lake Chad basin



Source: <http://www.protectedplanet.net>

### Manovo-Gounda St Floris Park in the Central African Republic

Covering an area of 1,869,800 ha, Manovo-Gounda St Floris (MGSF) Park is Central Africa's largest savannah park. Straddling two ecological zones, one Sudano-Sahelian and the other Sudano-Guinean, MGSF Park owes its importance to its wealth of flora and fauna. The park is adjacent to the Zakouma Park, which lies on the other side of the border in Chad, and both parks would benefit from being designated as a single transboundary park.

MGSF Park is home to a great number of endangered species, particularly the black rhinoceros, elephant, hippopotamus, red-fronted gazelle, lion, leopard, cheetah and wild dog. There are also large number of herbivores, especially buffalo, kob, waterbuck, and hartebeest. Some 320 bird species were recorded in MGSF Park, and at least 25 of these were birds of prey. The floodplains to the north of the park are also important for waterfowl and the shoebill.

The park's wildlife reflects its transitional position between eastern and western Africa, and between the Sahel and the rainforests. In line with the prevailing trend, the park's situation is extremely critical, threatened by incessant human activities (poaching, grazing, farming, fires, diamond extraction, general insecurity), which have had a major impact on its flora and fauna. From the aerial surveys undertaken in 2010, one can conclude that the park has lost its outstanding universal value.

### Zakouma Park in Chad

Created in 1963, Zakouma was the first national park in Chad. It is entirely surrounded by the Wildlife Area Bahr Salamat. The park was neglected during the long period of civil war in Chad, but since 1989 it has been undergoing a restoration program, supported by the European Union



from top to bottom:  
37: Elephant with its baby  
38: A roller  
39: A buffalo



### Waza National Park in Cameroon

First established in 1934, Waza Park officially became a national park at the end of the 1960s. With its 170.000 ha, this large park is the most famous wildlife reserve in Cameroon. The park is home to a large number of species, such as elephants, lions, giraffes, kobs, gazelles and hippopotamuses, and also numerous birds, including ostriches, pelicans, herons and marabou storks.

A number of surveys have been carried out in Waza National Park which show that it holds more than 30 mammal species. Added to this, are more than 370 bird species, of which 71 are water bird species. Around 20 of the species have been internationally recognised.



### Termit Reserve in Niger

The Termit Massif is a range of low mountains in Niger, situated half-way between the Air Mountains and Lake Chad. The region contains a large variety of animal and plant life in its desert and steppe landscapes. The Termit and Tin Toumma National Nature Reserve (TTNRR), which stretches over 97.000 km<sup>2</sup>, was officially established on 6 March 2012. The reserve provides habitats for numerous endangered species. The most significant species is the addax antelope, which is included on the IUCN's Red List of Threatened Species as one of the rarest and most endangered species on the planet today. Around 300 addaxes have been recorded in the reserve.



from top to bottom:

40: Roan antelope

41: African grey hornbill

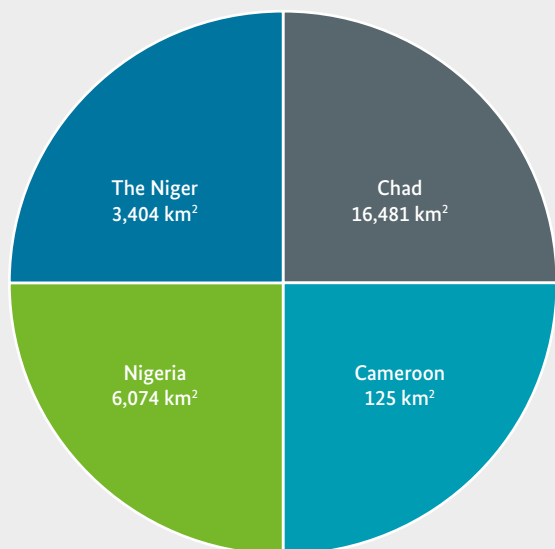
42: Sunrise and giraffes at the Waza national park

43: The addax, a species on the verge of extinction

### Wetlands preservation

Basin states have also recognised areas as protected under the international Ramsar Convention. This instrument, adopted on 2 February 1971, is a United Nations treaty for the conservation and sustainable use of internationally important wetlands. Lake Chad is without question the most important Ramsar site in the region.

Figure 6: Sections of Lake Chad in each country, according to the RAMSAR convention



Source: World Commission on Protected Areas, 2012

Table 10: Number and areas of RAMSAR sites in the Lake Chad basin

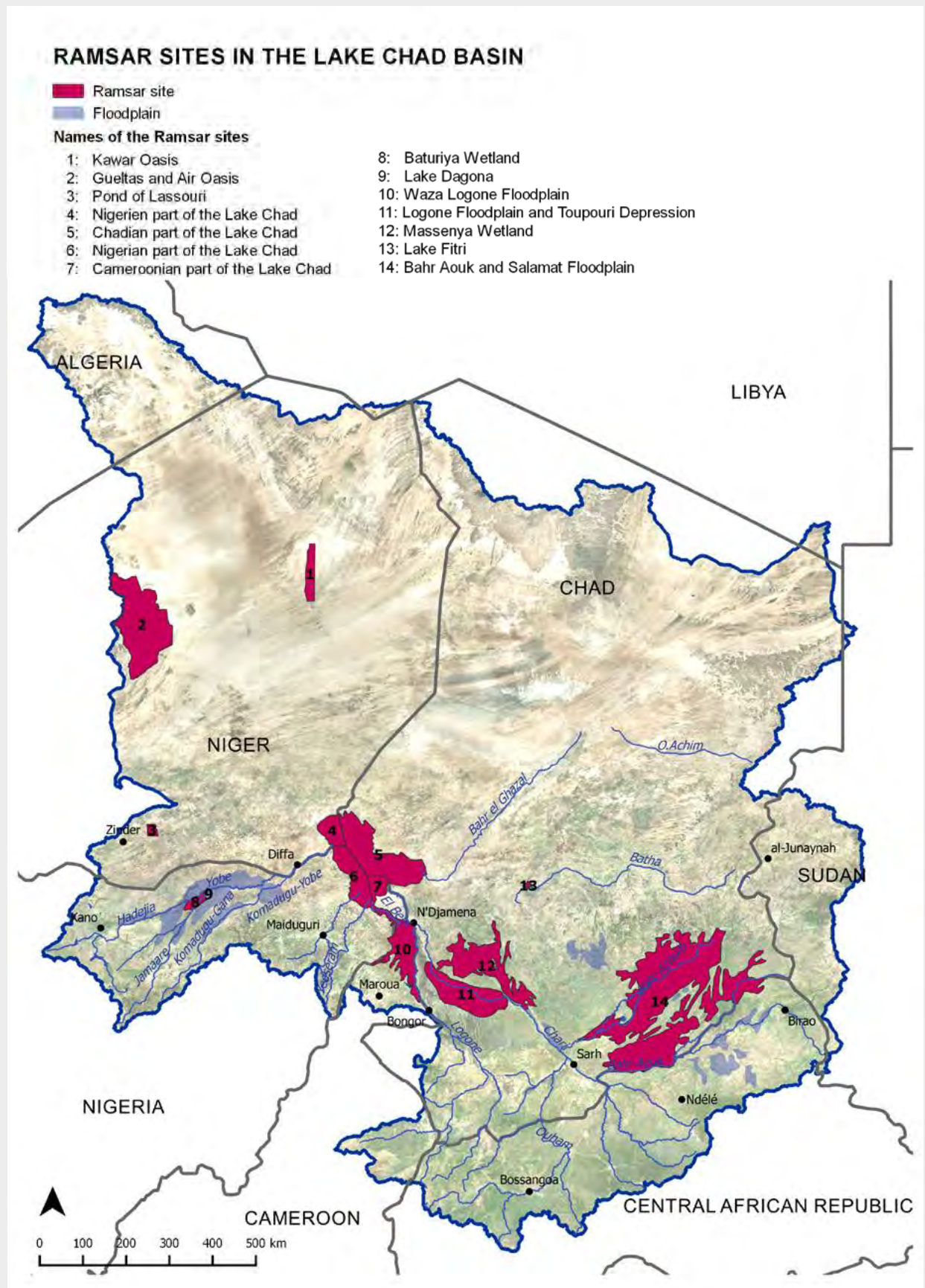
Country	Number	Area (km <sup>2</sup> )
Cameroon	2	6,125
Niger	4	31,489
Nigeria	3	7,088
Chad	6	124,051
<b>Total</b>	<b>15</b>	<b>168,753</b>

Source: IUCN World Commission on Protected Areas, 2012



44: A fisherman on lake Maga, Cameroon

Map 12: Ramsar sites in the Lake Chad basin



Source: <http://www.ramsar.org>

## Constraints and challenges

The parks are commonly affected by non-authorized livestock grazing, poaching, bushfires and charcoal production, particularly in the north of Cameroon where stray domestic animals and devastating bushfires threaten their integrity. The main species under threat in the area include the African wild dog (*Lycaon pictus*), the hippopotamus and the panther, all with globally declining populations (less than 5,000 individuals), as well as the elephant.

The issue facing authorities remains how to ensure the conservation and sustainable use of the basin's biodiversity and of its immediate environment, while promoting the use of wildlife and livestock corridors as a way of rehabilitating and maintaining the biological and genetic diversity of protected areas. In Chad for example, using corridors as a park management technique has led to visible increases in wildlife numbers.

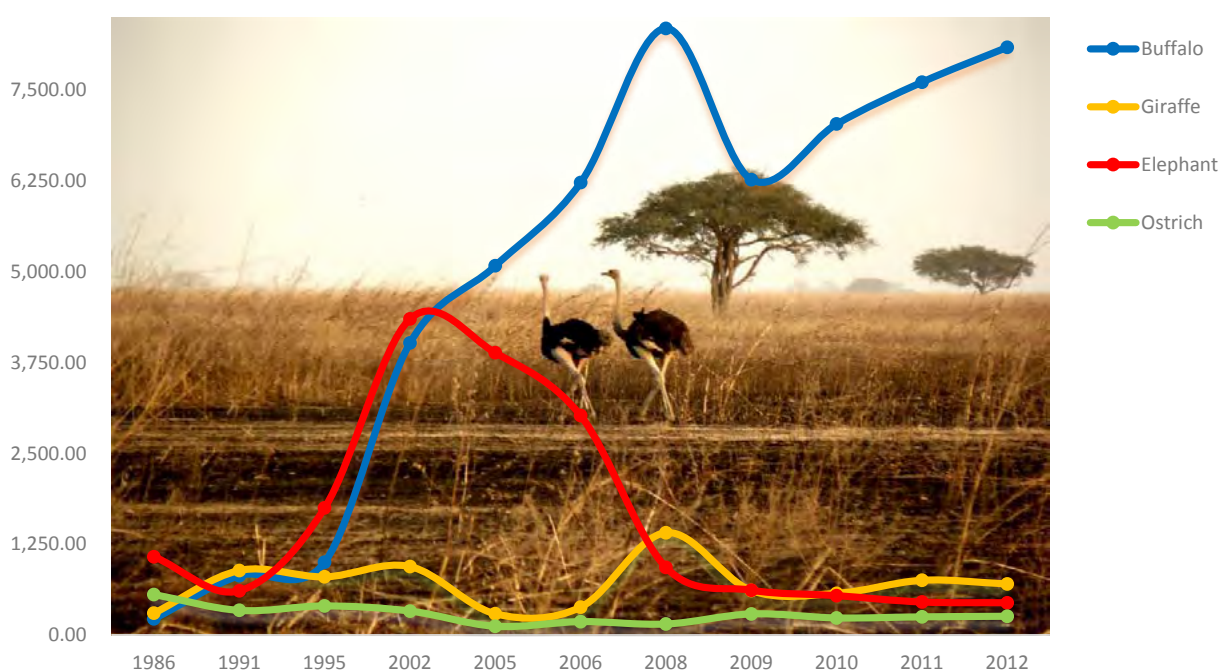
## Biodiversity in Chad

Chad's flora and fauna, at one time rich and varied, suffers daily from the effects of human activities and of climate change. The development projects undertaken by the Lake Development Company (SODELAC), sedimentation of the lake bed with deposits of sand blowing in from the desert, the proliferation of invasive plants, the use of pesticides and illegal fishing gear, poaching, deforestation, etc. are all responsible for the degradation of the basin's natural resources and thus its flora and fauna. Chad is doing what it can to preserve its natural resources, and its policies in this regard are now bearing modest fruit.

Both the Mandéla Wildlife Reserve and the whole right bank of the Logone River were refuge areas for large mam-

mals, such as the elephant, buffalo, wild dog, kob, defassa waterbuck, giraffe and hippopotamus. These areas were severely affected by the political and military turmoil that took hold in the country in the 1970s and 80s, causing elephants to disappear from the region. A certain number have sporadically returned to the Mandéla Wildlife Reserve, coming in from neighbouring Cameroon, but the major human incursions and impacts in this area mean that they do not stay very long. The populations of certain species, such as giraffes and ostriches, have, however, been seen to be stabilising, while others, such as the buffalo, are even on the increase. When it comes to aquatic fauna, the Logone River, the ponds and particularly the lakes contain all the species of fish found in the Lake Chad basin. Conversely, crocodiles and turtles are among the species considered rare and threatened with extinction.

Figure 7: Changes in the population of certain species in Chad since 1986



Source: Chad statistical data

## Human settlement

The Lake Chad basin is ethnically highly diverse, with around 70 ethnic groups who are by faith Christian, Muslim or Animist. Each group has its own specific economic activity, culture and language. Ethnic groups often straddle the region's international borders.

Chad's population is composed of 12 ethnic groups, the largest of which are the Sara, mostly dwelling in the south and engaged in farming activities; the Buduma (fishers), the Arabs (herders), the Masa and the Moundang (sedentary livestock farmers).

In Libya, the Tubu form the ethnic majority in the south of the country along the border with Chad. They are both sedentary and nomadic herders, inhabiting the Tibesti Mountains. As such, they reside across a huge 1,300,000-km<sup>2</sup> region and speak a Nilo-Saharan language close to the Kanuri language of Chad.

The south of Niger and the north of Nigeria contain largely the same mix of ethnic groups, namely the Hausas and the Fula (Fulbe or Fulani), who are predominantly Muslim. Comprising around 30 million individuals, they form the majority throughout the entire pastoral area. However, the Kanuri are a dominant ethnic group in the Nigerian state of Borno.

Table 11: Numbers of religious adherents by faith in the countries of the Lake Chad basin

Country	Christians	Muslims	Other faiths	Total population in millions
Cameroon	8,248,000	4,124,000	8,248,000	20,620,000
Libya	163,080	5,834,640	42,280	6,040,000
Niger	158,900	14,301,000	1,430,100	15,890,000
Nigeria	63,884,000	79,855,000	15,971,000	159,710,000
Central African Republic	2,175,000	652,500	1,522,500	4,350,000
Chad	4,102,000	6,446,000	1,172,000	11,720,000
<b>Total</b>	<b>78,730,980</b>	<b>111,213,140</b>	<b>28,385,880</b>	<b>212,894,000</b>

Source: *The World Factbook CIA, 2012*



45: Massa women on the banks of the Logone, Cameroon



In the north of Cameroon, a large variety of different ethnic groups and religions live alongside each other (Muslims, Christians and Animists). These communities grow millet and sorghum and rear goats, sheep and zebu. The largest ethnic group in the region remains the Fula. The northern tip of Cameroon also shares with Chad populations of Arabs, Kotoko, Masa and Sara, as well as other ethnic groups.

There are more than 20 ethnic groups in the Central African Republic, the main ones being the Gbaya, who live in the centre and west of the country and across into eastern Cameroon, and the Banda living in the north-eastern Aouk region. These groups are mainly Christian by faith. The Sara (Ngama, Mbaye and Kaba) are northern peoples who dwell along the northern border with Chad and are linguistically distinct from the two previously mentioned groups. The Wodaabe (Fula), who are mainly Muslim by faith, are found in the rangelands in the north and centre of the country.



from top to bottom:

46: Traditional chiefs on the road to Maroua, Cameroon

47: Mbororo women, Central African Republic



## Conclusion

The topographical basin of Lake Chad is a closed endorheic basin characterised by high hills and mountains, the highest of which are the Darfur and Tibesti Mountains. The basin is characterised by two large geological units of sedimentary formations and crystalline basement which determine the major soil types. These soils are generally low in organic matter, and thus require the use of chemical when growing crops, such as rice, cotton or sugar cane.

The basin's hydrographic network is weak, comprising only the lake and its main tributaries, namely the Chari-Logone basin spread across Cameroon, Chad and the Central African Republic, and the Komadugu-Yobe basin in the borderlands between Niger and Nigeria. Added to these are the floodplains located between the highlands and Lake Chad, such as the Waza-Logone floodplain, which play an internationally important environmental role. Two-thirds of the hydrographic basin are, however, located in the arid zone and thus contribute little towards feeding Lake Chad.

The climate of the Lake Chad basin can be divided into four zones which reflect the pattern of isohyets that decrease as one moves northwards across the basin. Average rainfall can range between 1,400 mm in Bossangoa and an average of 200 mm over Lake Chad. Temperatures and evapotranspiration in the basin are generally very high and, in a pattern opposite to that of rainfall rates, increase as one moves northwards across the basin.

One of the key features of the Lake Chad basin is its great diversity of habitats, comprising desert, shrub-steppe,

savannah, forest, wetland and mountains. The landscape in the immediate vicinity of Lake Chad varies depending on the water levels of the lake.

All these areas of vegetation support a distinct collection of flora and fauna. Between 130 and 209 mammal species have been recorded, as well as more than 500 bird species. Indeed, hundreds of thousands of birds migrate to the lake and stay for part of the year. However, what sets Lake Chad apart from other African lakes is its potential fish stocks, comprising between 120 to 140 species. Lake Maga (Cameroon) and the Waza-Logone floodplain alone contain 56 species of fish including tilapia, mudfish, tigerfish and catfish.

Conservation is a challenge that all states must address, given the considerable scale of natural resources in the Lake Chad basin. More than 30 sites have been designated as protected areas. Basin countries have also protected other areas within the framework of the international Ramsar Convention. Lake Chad is without question the most important site in the region holding this status.

The peoples of the Lake Chad basin are highly diverse ethnically and linguistically, with Hausa and Arabic being the most widely spoken languages. A single ethnic group can find itself straddling international borders.

In spite of the reduction in its size caused by recurrent drought, Lake Chad itself is still large enough to provide a viable habitat for animals, plant life and the numerous peoples who use its resources. However, it still faces many threats that jeopardise its integrity.



## 2

## Socio-economics

**Key messages**

In 2012 the total population of the Lake Chad basin was estimated at 45 million inhabitants (from 37 million in 2002, according to the UNDP), with the majority living in cities. The population growth rate is high, standing at between 1.5% and 3.7% per year, depending on the country. Population densities are higher in Nigeria and in lakeside areas, but fall away in the northern, more arid areas of the basin.

Population pressure is most evident in rapidly growing urban areas such as Kano and Maiduguri in Nigeria and N'Djamena in Chad. There are around 70 ethnic groups in the basin, each with their own culture and language. Some of these groups are to be found living across international borders.

Some groups are leaving or have left their home regions, which have become difficult to live in for a variety of reasons and are settling in new areas. Causes for this increasingly common phenomena include armed conflicts, the vagaries of the climate and socio-economic drivers. The droughts of the 1970s and '80s and during the period from 2008 to 2010 led to the large-scale migration of northern livestock farmers to the south, particularly into the neighbouring Ubangi basin, which has raised social tensions and led to (food and military) security issues.

The principal economic activities in the Lake Chad region include crop and livestock farming and fishing. Trade is important, with significant cross-border trade flows between

the lakeside states. With a view to developing the region economically, these countries have identified opportunities for agrifood processing.

The development of markets in urban areas and the high level of demand for local produce have led to a boom in rurally produced tradable foodstuffs. This flow of goods reinforces food security in the sub-region. However, natural disasters and social and military turmoil have ruptured the momentum of economic progress in certain regions of the basin (such as Maiduguri in Nigeria or Ouham in the CAR).

The development of socio-economic activities such as fishing in Lake Chad is not without public health consequences. The increase in the prevalence rate of infections linked to HIV/AIDS is particularly pronounced. Moreover, endemic water related disease including malaria, cholera, bilharzia, guinea worm and onchocerciasis are common. These are present across the region, increasing the vulnerability of the population.

With respect to governance, the basin states have undertaken important initiatives designed to consolidate democracy. Extensive institutional, administrative and economic reform projects are underway with the overriding objective of improving the planning and management of development, and the effectiveness of public services, particularly with regard to the integrated management of water resources. These changes can have an effect on reducing gender disparities, with women increasingly participating in development processes.

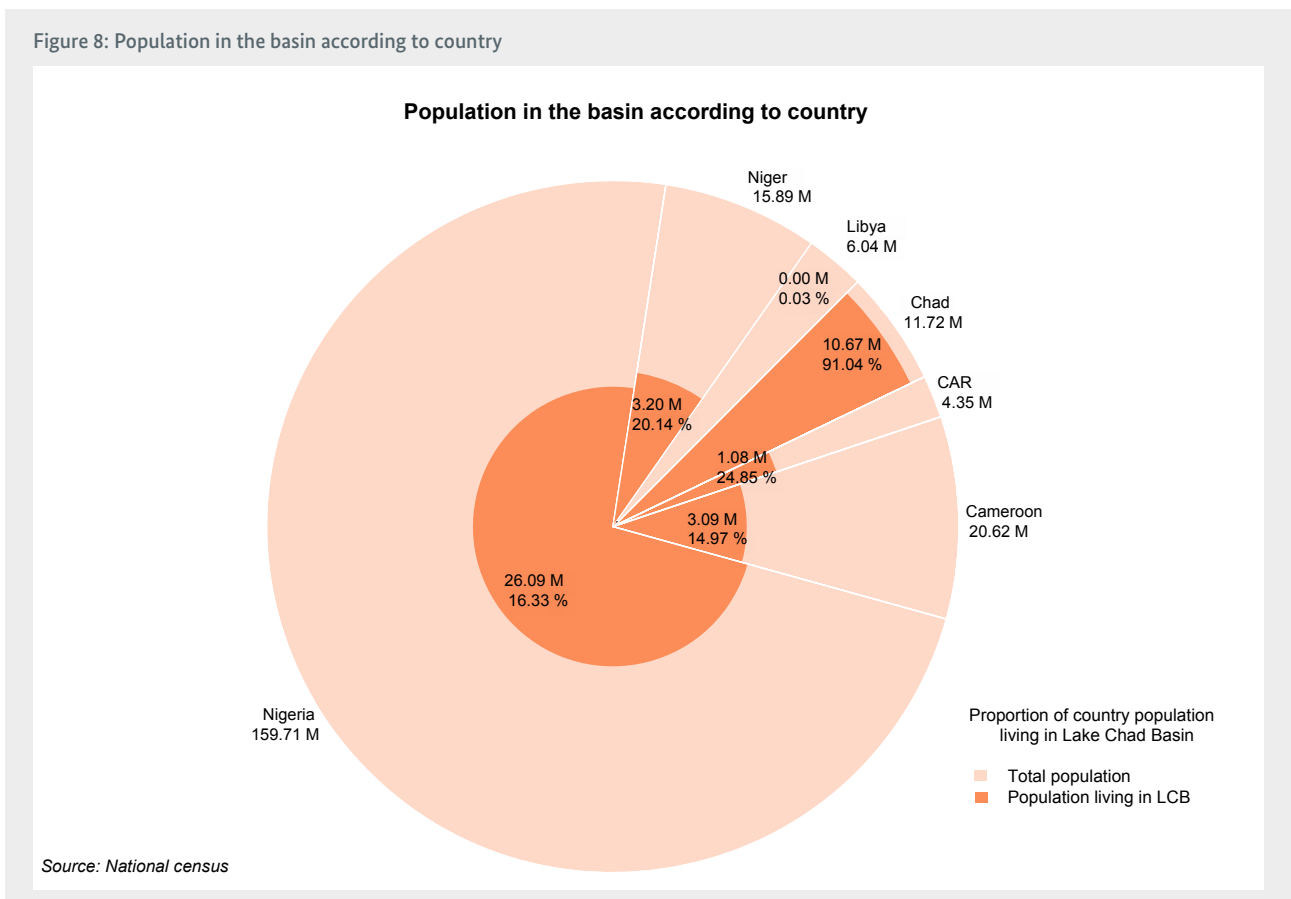
### Population and population pressure

#### Population structure

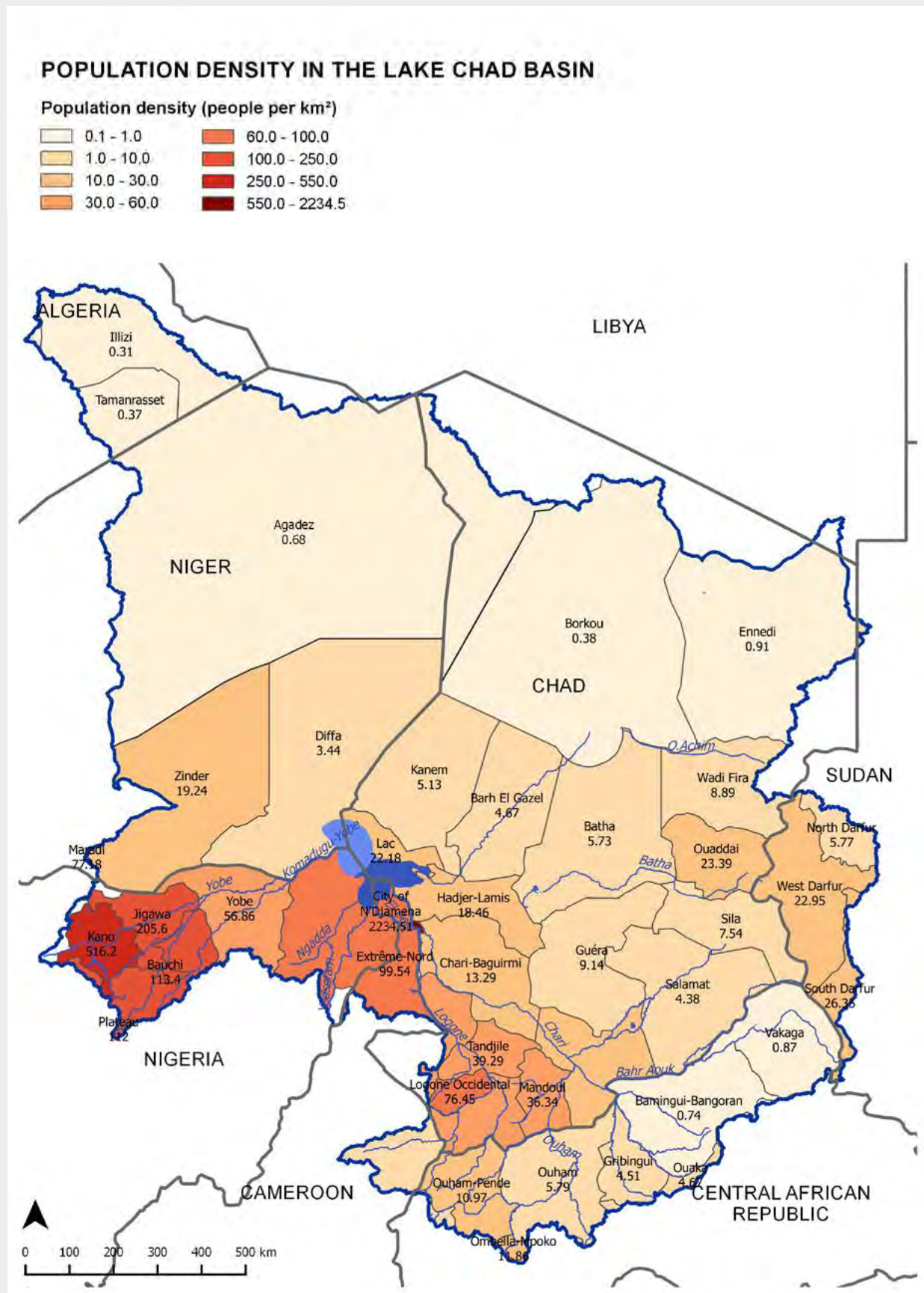
In 2012, the population of the Lake Chad basin was estimated to be around 45 million inhabitants, representing almost 20% of the total population of the six basin countries. Chad is the most economically dependent on the basin's resources with than 91% of the Chadian population living in the basin. However, Nigerians represent the largest national population group in basin, with over 26 million people. Cameroon and Niger have equally high population densities living in the lakeside region, and have an average of 20% of their respective national populations living within the basin. Conversely, the Libyan territories that fall within the basin are sparsely populated, holding less than 1% of that country's total population.

The population is heterogeneously spread across the geographical area of the basin. Population growth is much more pronounced in the urban areas within the basin area and the highest population densities are found around three economic hubs in the north of Nigeria (Kano, Zaria and Jos with over 500 inhabitants per km<sup>2</sup> in Kano) and in Chad. The densities become lower in the arid regions in the north of Chad (0.1 to 1 inhabitant per km<sup>2</sup>), where insufficient rainfall has forced agropastoralist to migrate southwards.

Figure 8: Population in the basin according to country



Map 13: Population density in the Lake Chad basin



Source: <http://www.citypopulation.de>

The population pyramids of Cameroon, Niger, Nigeria, Chad and the Central African Republic (CAR) have a large base, a concave middle section and a narrow top. These pyramids reflect a young and growing population. Although Niger's pyramid has a large base, the pattern for men aged over 25 displays a number of singularities. These

can be put down to emigration or to a larger number of deaths due to crises and war. Libya's pyramid differs from the other countries, as the country has entered a demographic transition phase, with a population growth rate of 1.5 in 2000. However, the widening of the base shows that the birth rate has increased over the last 10 years.

Figure 9: Population pyramids in 2010

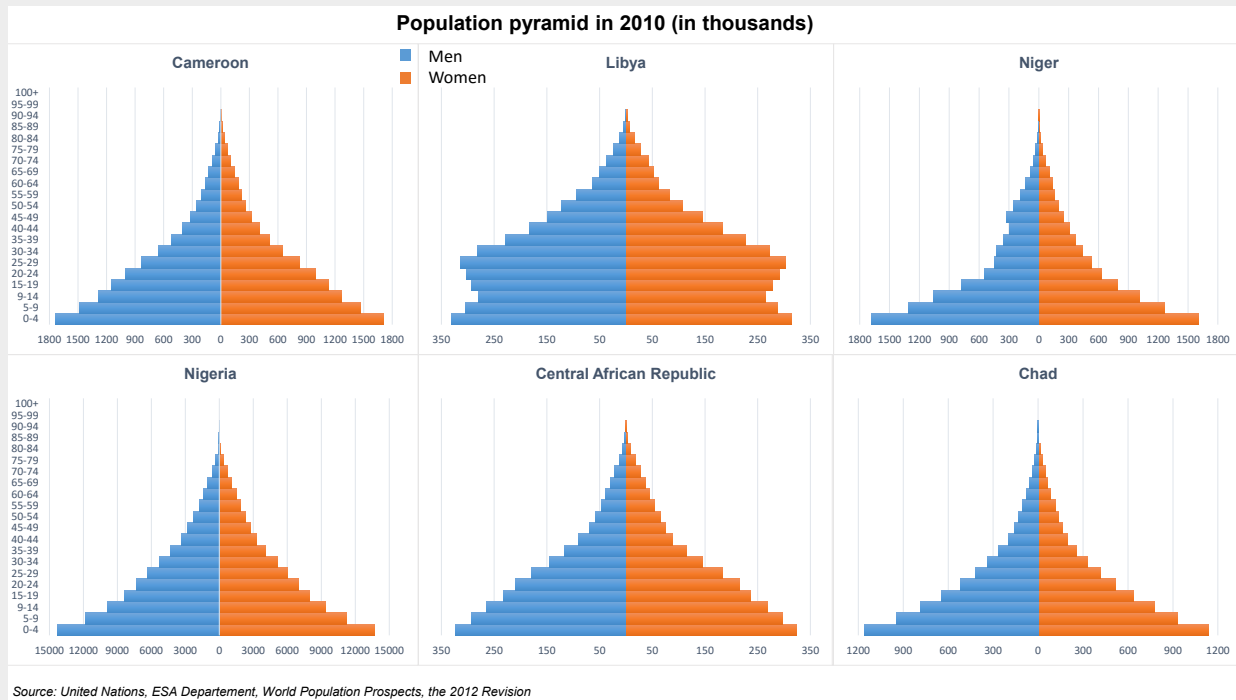
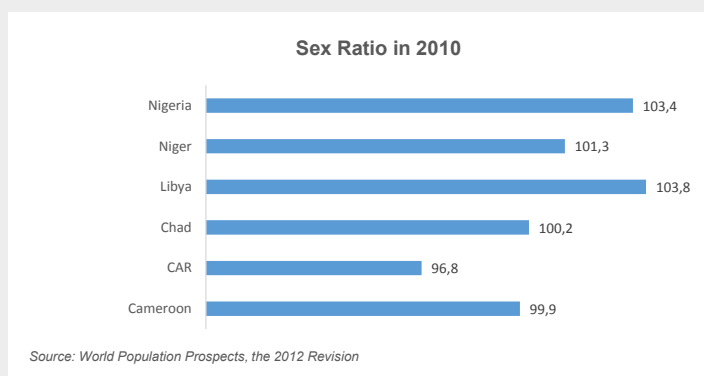


Figure 10: Sex ratios in 2010



The sex ratio describes the ratio of men to women. In countries such as Nigeria, Niger, Libya and Chad, there are slightly more men than women, whereas the ratios of Cameroon and the CAR indicate that these countries have slightly more women than men.



48: A mother with her twins in Maroua, Cameroon

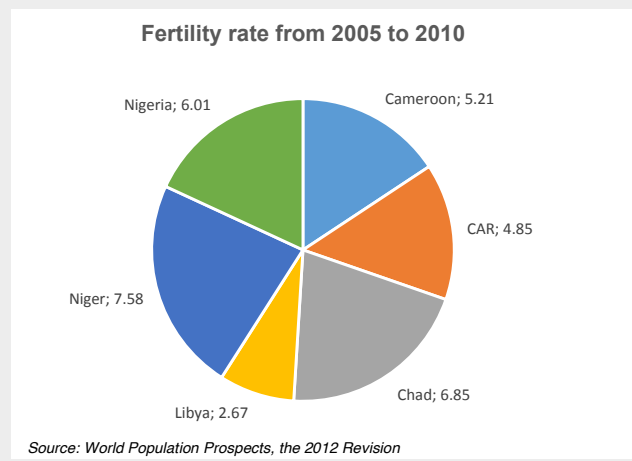
Given that an average of 45% of women are of child-bearing age (15–45 years), the fertility rate is high in all the basin countries, with the exception of Libya. The highest fertility index is in Niger, averaging almost eight children per woman.

Lake Chad basin countries also suffer from high infant mortality rates due to poor public health conditions. The CAR for example has an alarming rate of nearly 100 infant deaths per 1,000 live births, followed closely by Chad and Nigeria.

Libya has a markedly lower infant mortality rate, at 15.4 infant deaths per 1,000 live births, a fertility index of only 2.67 children per woman and a life expectancy of 74.

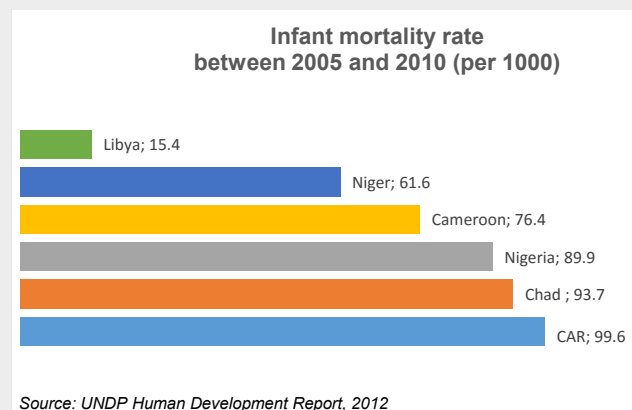
The life expectancy at birth in other countries is low (for example 48.5 years in the CAR and around 58 years in Niger). These countries have registered a clear increase in life expectancy since the 1960s, however, there have been setbacks caused by drought, famine and war that have affected some countries. Despite ongoing national development efforts, the living conditions of the populations have only been marginally improved. Cameroon is a resource-rich country, but life expectancy in 2012 was the same as it was in 1990. This is evidence of the country's worsening living conditions due, in particular, to the economic crisis that has driven up the cost of living.

Figure 11: Fertility rate from 2005 to 2010



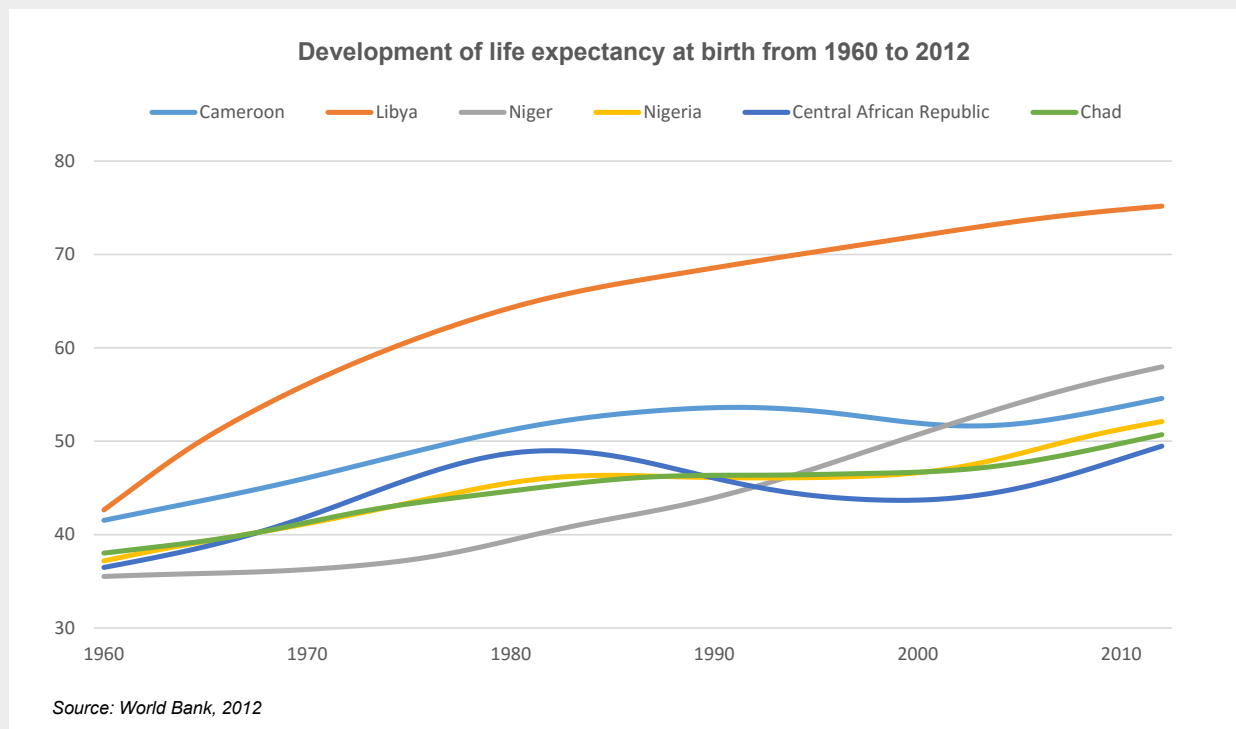
Source: World Population Prospects, the 2012 Revision

Figure 12: Infant mortality rate between 2005 and 2010 (per 1000)



Source: UNDP Human Development Report, 2012

Figure 13: Development of life expectancy at birth from 1960 to 2012



Source: World Bank, 2012

### Issues concerning education and employment policies

Across the basin poverty-reduction objectives are written into national development strategies and into the countries' financial legislation. In those states earning oil revenue, the increase in income has made it possible to improve the level of investment and of social expenditure. However, states lack the infrastructure required to cope with the current demographic context. Chad has experienced a sharp increase or around 13% per year in the number of pupils attending secondary school. The net enrollment rate in primary schools across the basin is, for example, higher than the adult literacy, which is without doubt the result of national education policies. For example, Cameroon introduced free primary education for all in 2000 and the net enrollment rate in primary school for the 2008-2012 period was 98.2%, while in Nigeria, it was only 57.6%. Niger shows a large gap between the adult literacy rate between 2008 and 2011 (28.7%) and the net enrollment rate (63.7%). These policies have contributed to an increased enrollment of students, such as in Chad, where the number of students in secondary increases on average by 13% per year.

However, because of this, and due to the increase in population, particularly in big cities, states face other challenges such as providing the necessary infrastructure and employment opportunities. On completing school, many young people face unemployment due to the lack of jobs. The public sector is the principal employer in the formal sector work and despite a number of private sector companies, the recruitment of young people remains a challenge. However, the informal sector absorbs a substantial number of these young people and offers alternative opportunities in small-scale itinerant trade or in other income-generating activities. An example of this is the rapid development



49: School is out, Cameroon

of motorcycle-taxi services in most towns and cities in the basin, and in particular in Maroua, Maiduguri, Kano and N'Djamena, although these services are currently illegal.

In Chad and the Central African Republic nearly 10% of the young people with no steady employment work making clay bricks. This informal activity supports the development of the low-cost construction sector using local materials. However, trees need to be felled to fire the brick kilns, leading to deforestation of the surrounding areas.

Around three-quarters of the non-farming population work in the informal sector. The formal sector absorbs less than 10% of the available work force, with nearly half employed directly in the civil service, with the remainder holding jobs in industry, security, the construction sector, etc.

Figure 14: Adult literacy rates between 2008 and 2012 and net rate of primary school education between 2008 and 2011

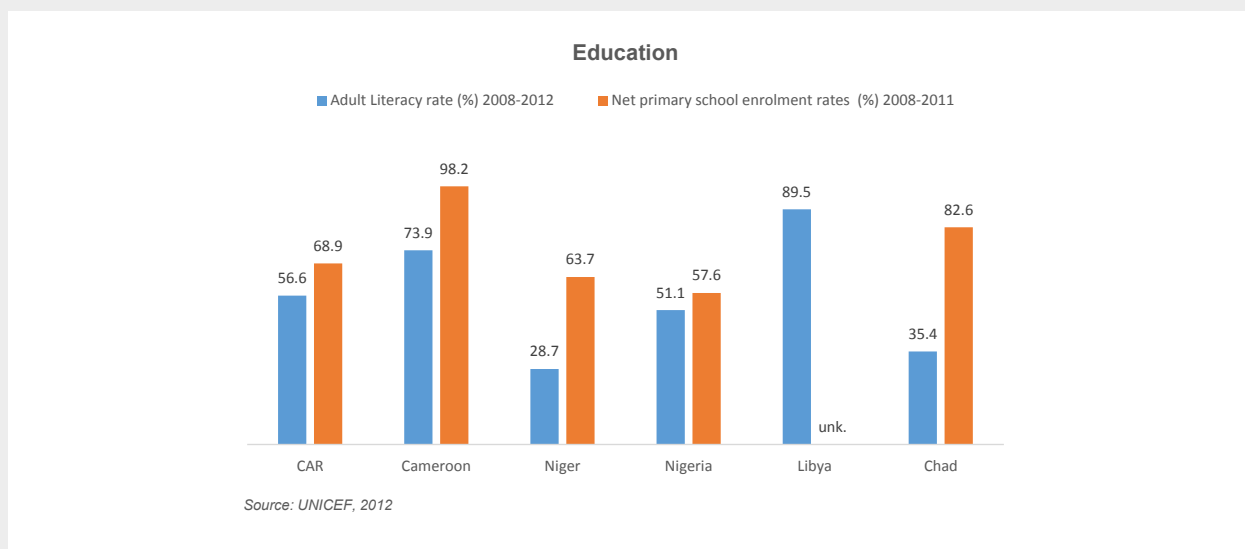
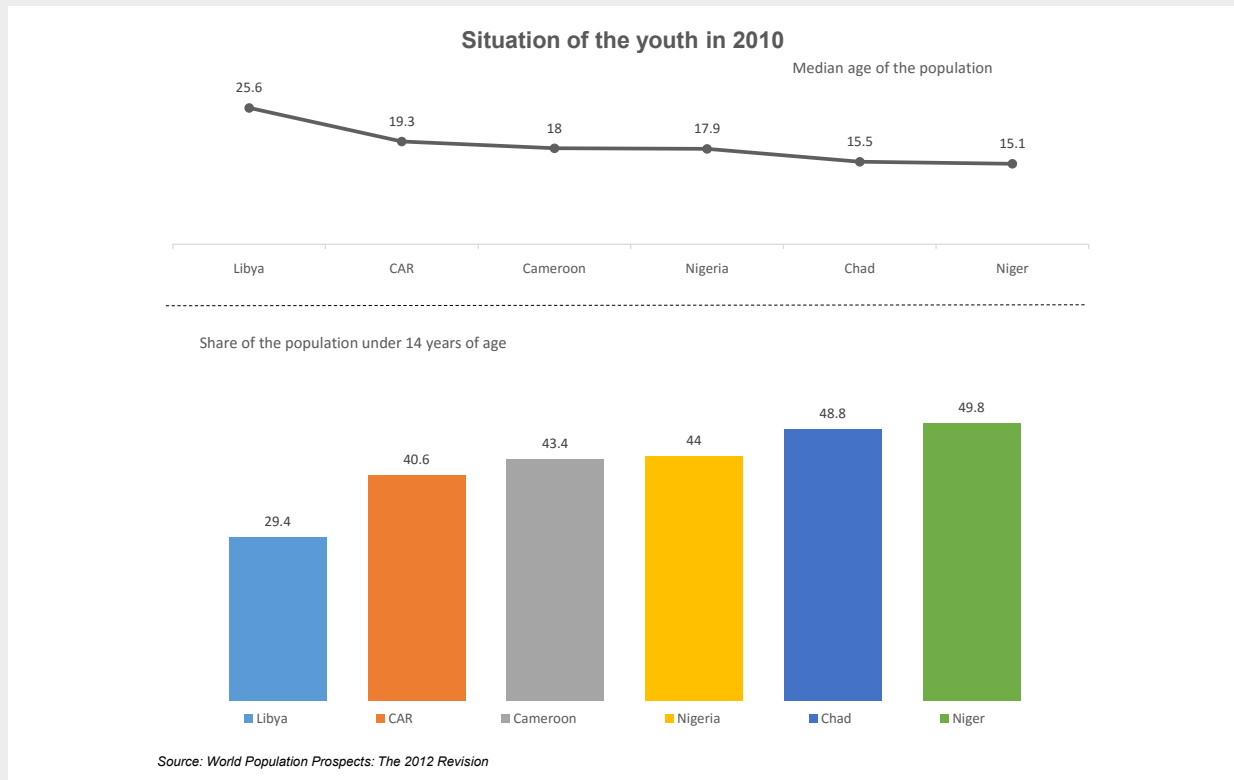




Figure 15: Situation of the youth in 2010



50 + 51: The informal sector is an important source of employment and revenue for young people

## Migration dynamics

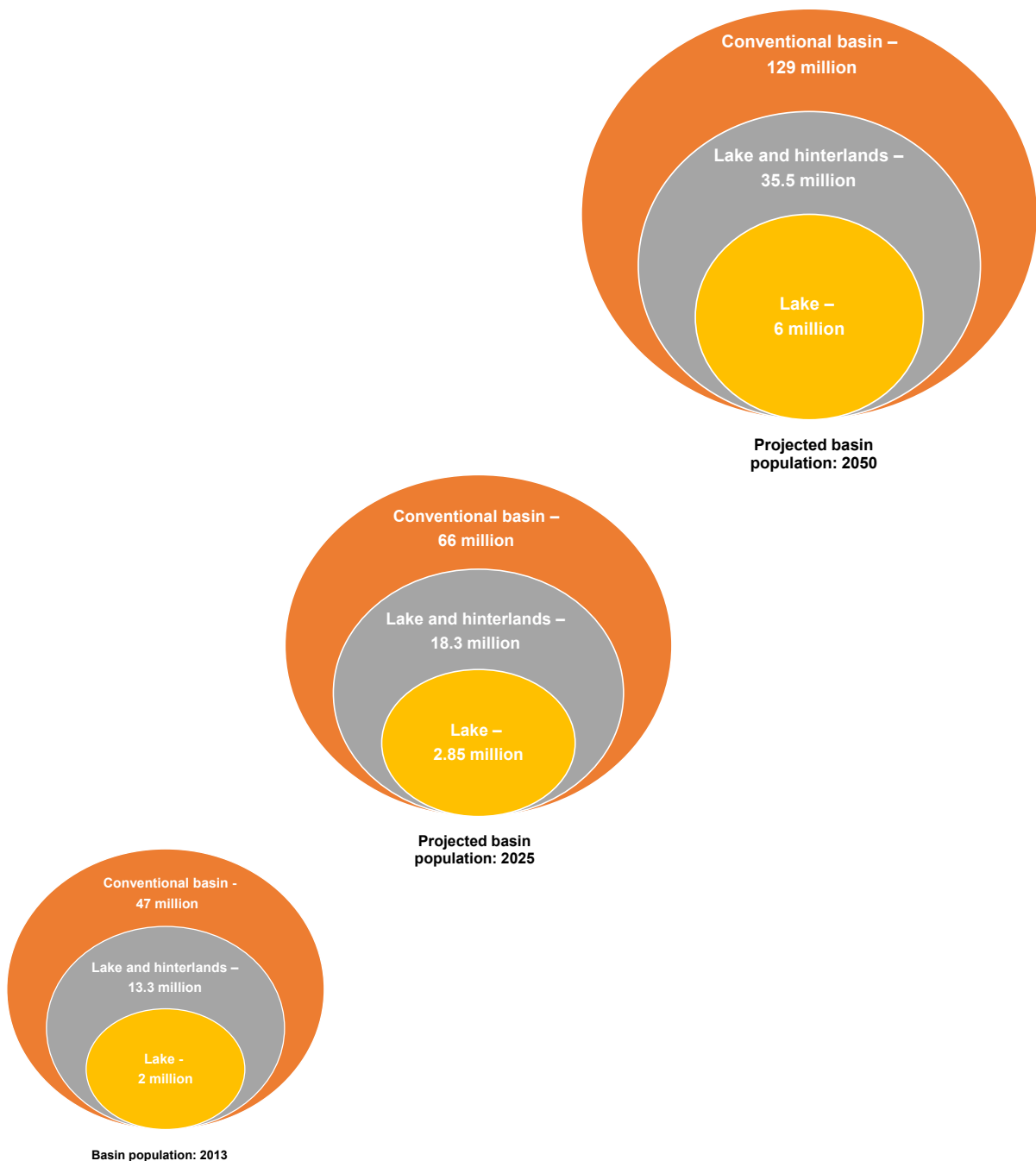
### 1. A growing population

Lake Chad's lakeside areas, that means around 30-40 km away from the lake shore, very often hold populations that are highly diverse with regards to nationality. Alongside the indigenous peoples of the Lake Chad basin states live Malians, Senegalese, Ghanaians and Liberians who, for the most part, are attracted by fishing opportunities.

It is estimated that the lakeside population living within a radius of 300 km will grow from 13 million inhabitants in 2012 to at least 35 million by 2050. The population of the conventional basin is also expected to increase dramatically from 45 million inhabitants in 2012 to 129 million in 2050.

The current average annual growth rate is just over 3.2% per year. This growth rate exceeds 4% in the most attractive southern shore areas, but is lower along the northern shore. The flow of migration to lakeside areas is substantial, attracting migrants from beyond the regional rural areas.

Figure 16: Forecasted demographic growth of the basin population between 2013 and 2050



2. A high rate of urbanisation

The population of the Lake Chad basin was estimated at around 45 million inhabitants in 2012, with a population growth rate ranging from 1.5% to 3.7% per year. The population is heterogeneously spread across the the basin, with high concentrations in the main urban areas. The most

populous cities are Kano in Nigeria with more than three million inhabitants, Maiduguri in Borno State, Nigeria, with around 830,000 inhabitants, and N'Djamena in Chad with more than one million inhabitants in 2010.

The growth of the population directly around the lake is mainly due to the development of the fishing sector, which is the principal economic resource in the region. It is also due to the lack family planning policies and standards with respect to marriage and limiting the number of births. The major cities are mainly developing at such a high pace due to the forced migration of populations in response to droughts and conflicts, amplifying natural growth. Despite the limited infrastructure and equipment, they represent commercial centres with the main resources coming from Lake Chad.

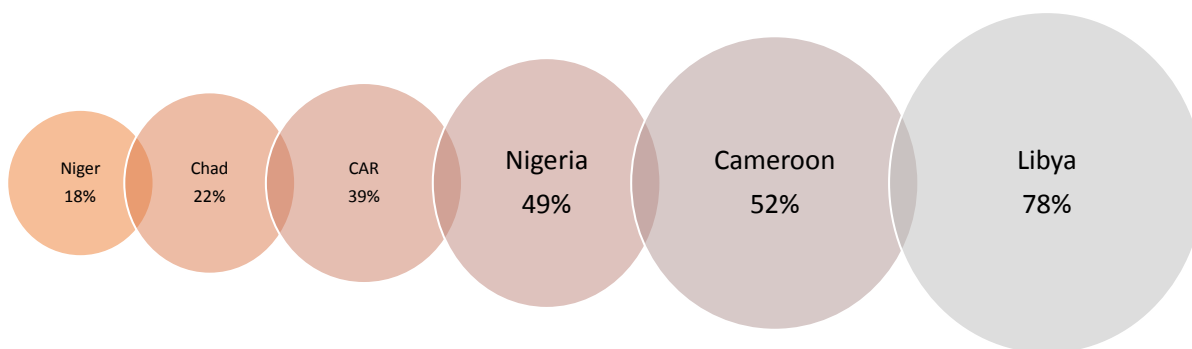
Table 12: Cities with more than 750,000 inhabitants

Country	City	Population (thousands)	% of total population
Chad	N'Djamena	1,038	9.2
Nigeria	Maiduguri	827	0.9
	Kano	3,271	2.2

Source: World Urbanization Prospects, the 2011 revision

Figure 17: Income and poverty in 2012

Percentage of the population living in urban environments in 2010



Source: UNDP Human Development Report, 2012

Map 14: Urban population in the Lake Chad Basin



Source: <http://www.citypopulation.de/>

### 3. Highly attractive economic hubs

The rapidly growing population of the Lake Chad basin can in part be attributed to the facilities offered by improved commerce and trade, which are a consequence of the region's economic expansion.

Maiduguri, capital of Borno state in Nigeria, hosts high numbers of merchants and migrants from Cameroon, Chad, the Central African Republic and Diffa in Niger. The city is mostly known for its trade in manufactured goods, such as motorcycles, radios and spare parts for vehicles, which are brought up from Nigeria's ports. Despite the precarious road network, the development of some transport links between cities, towns and rural areas has boosted rural migration, which is accentuated by an improved supply of foodstuffs and other products to local markets. Ongoing urbanisation has increased energy demands, intensified natural resource use and led to the uncontrolled occupation of space in urban centres.

The spike in migration into the lakeside region is due to the productivity of Lake Chad and the scale of fishing and polder farming activities. All this means that pressure on the water resources required for domestic and agricultural activities is growing.



52: Local market of Bongor, Chad

### 4. Harsh weather conditions drive migration

The droughts of the 1973 and 1984 and again in 2008 prompted a large-scale migration of herders and their cattle towards the wetlands around Lake Chad and sometimes further south. These climatic impacts on the population increased pressures on the resources of the lake and led to conflicts over water sources. The variability of the water level of the lake has prompted fishermen from the northern pool to move to the southern pool and has also seen the development of new villages in lakeside areas, both along its shore and on the drained land revealed as the waters retreat.

Furthermore, a large number of pastoralists have headed south, moving particularly into the neighbouring Ubangi River basin in search of pasture and water. However, social tensions and (military/political and water) security problems very soon arose between the newcomers and the indigenous communities.

### 5. Conflicts causing people to flee

Up to 2012 several armed conflicts have displaced communities. Armed rebellions in the border area between Chad and the CAR in the 1990s prompted local people to flee to other, safer regions in the centre of Chad or to the south of the CAR. The wars in Darfur and South Sudan in the 2000s also prompted mass movements of people into Chad and the CAR. These movements impact directly on the availability and use of resources in host regions and heighten



53: Island transport on Lake Chad

tensions with the local population, possibly leading to security issues.

**Socio-economic and financial information**

**Income and poverty**

Wealth is unevenly distributed within the countries of the Lake Chad basin. Some of these countries do indeed have high revenues but fail to effectively combat poverty, retarding their development. Due to its oil reserves, Nigeria is Africa’s leading economic power, and yet nearly 70% of its population lives on less than USD 1.25 per day, whilst the gross annual national revenue per person is 5 270 USD. Whilst the development policies implemented in the Lake Chad basin countries to meet the Millennium Development Goals (MDGs) have yielded some positive results, they are not enough to effectively combat poverty. Delays exist in the development of the health and education sectors, levels of corruption are high and religious, social and political conflicts hinder the successful implementation of sectoral policies in across the region.

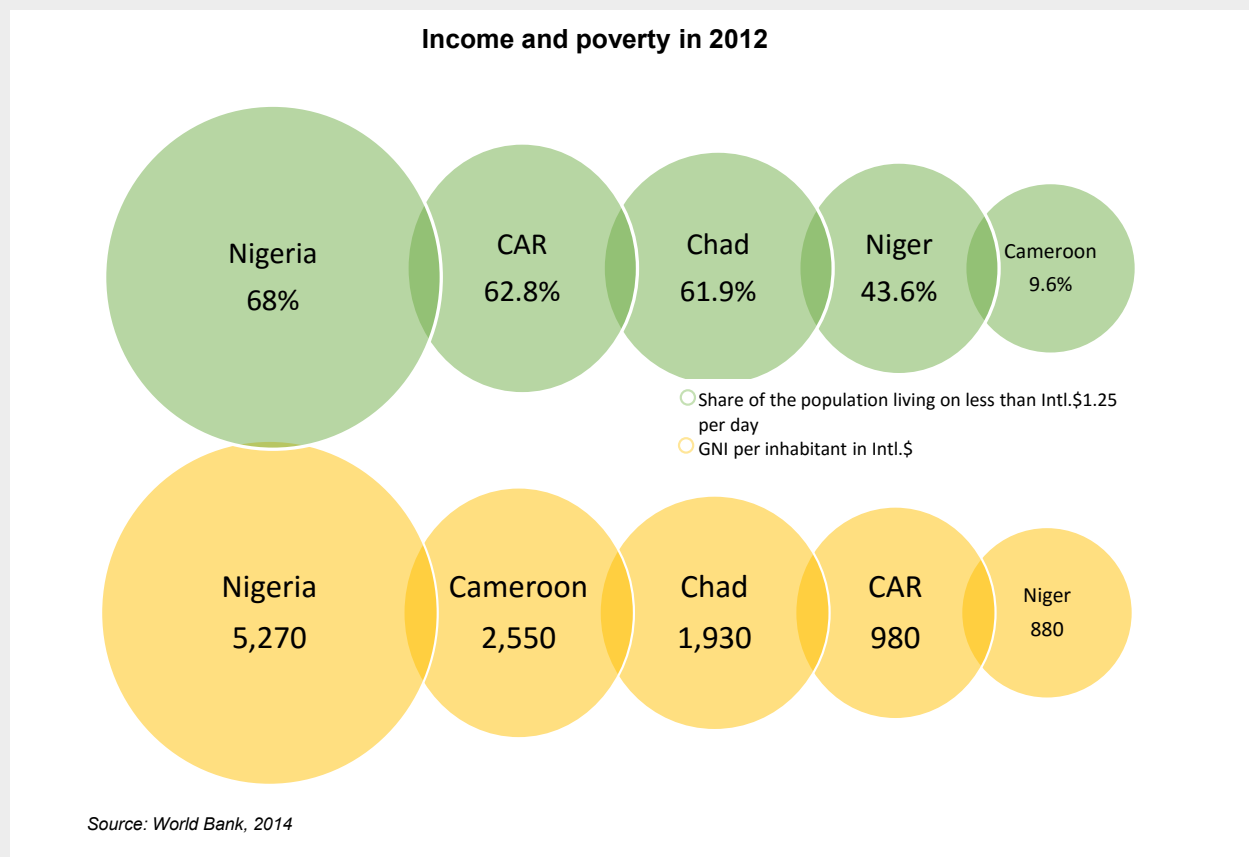
The Human Development Index (HDI) is based on three main criteria: life expectancy at birth, education levels and standard of living. All of the LCBC member states, with the exception of Libya, are ranked in the group of the least-developed countries on the index, with Niger, Chad and the CAR in the bottom ten worldwide. This highlights



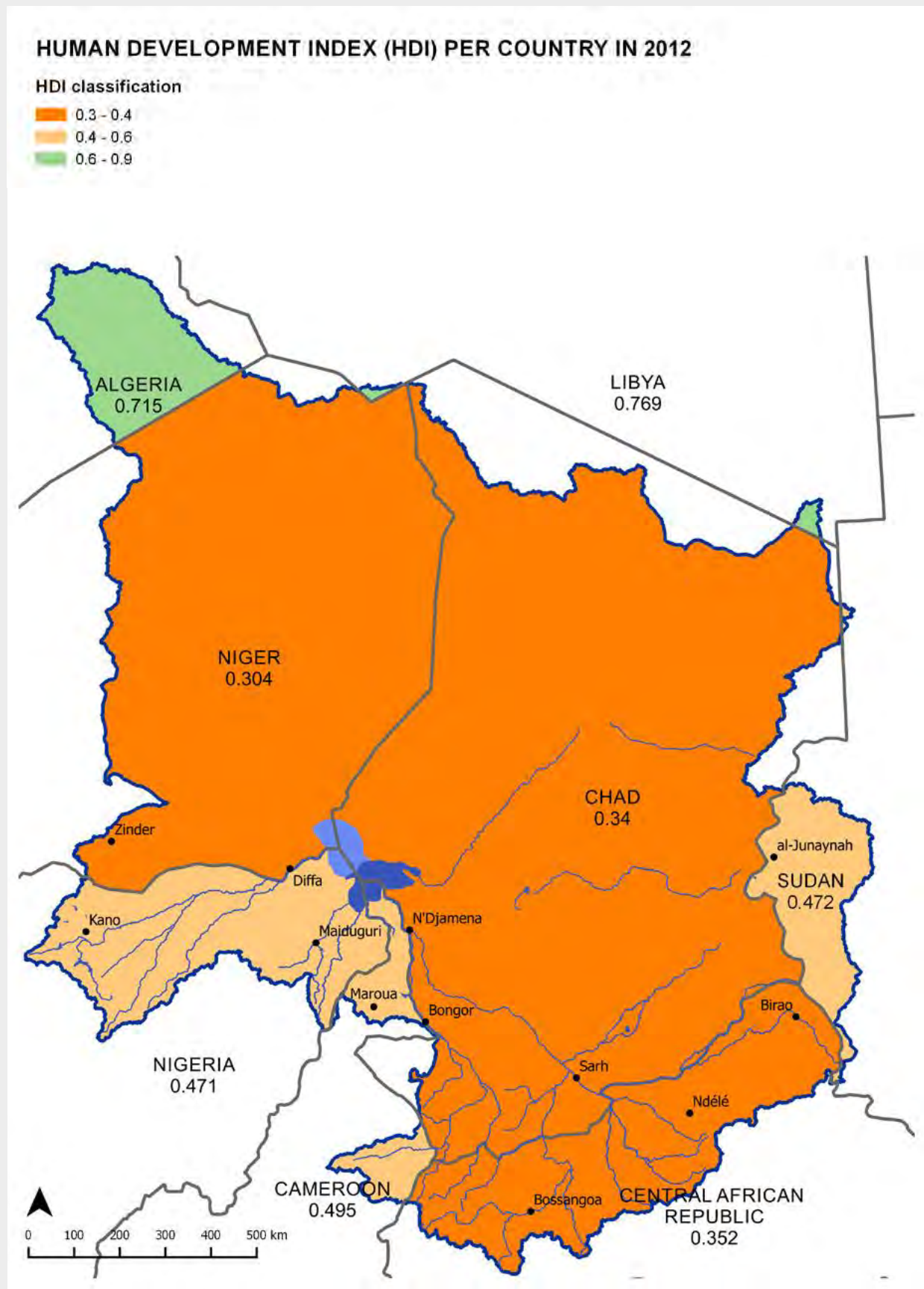
54: A street vendor in Moundou, Chad

the needs and challenges the countries are facing in their efforts to achieve economic, social and environmental development in the region. These needs will only increase with the increasing population.

Figure 18: Revenu et pauvreté par pays en 2012



Map 15: Human Development Index (HDI) per country in 2012



Source: Human Development Index Report, UNDP, 2012

## National production

Despite the decline in agricultural production from the 1970s onwards, due in part climate variance and increasing levels of insecurity in some zones and in spite of the growth of other sectors (particularly the oil industry), agriculture remains a major contributor to the GDPs of the Lake Chad basin states, with Libya being the only exception. Cameroon, despite its abundant resources, has started to lag, with the contribution of the agricultural sector to GDP shrinking over the last 10 years due to a lack of investment. However, the country remains an exporter of agroforestry products.

The agricultural sector remains a major provider of employment in almost all basin countries. It employs between 26% and 84% of the working population, of which between 36% to 56% are women, depending on the nation. Only in Libya is the agricultural sector of no particular importance for the employment market (employing only 3% of the working population, 69% of whom are women).

The rural populations of all the LCBC-member states have decreased since 2000. In 2010 Libya had the lowest proportion of rural inhabitants (22% in 2010 against 24% in 2000), while Niger has the highest proportion (82% in 2010 against 84% in 2000).

Figure 19: Sectoral contribution to GDP (top) and employment share in agriculture (bottom)

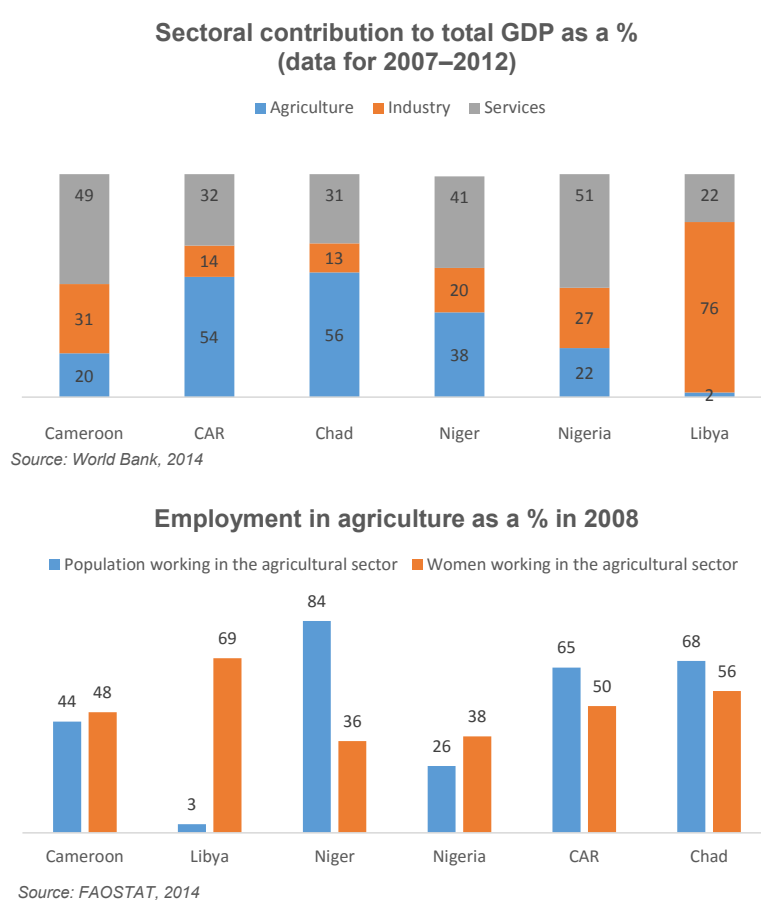
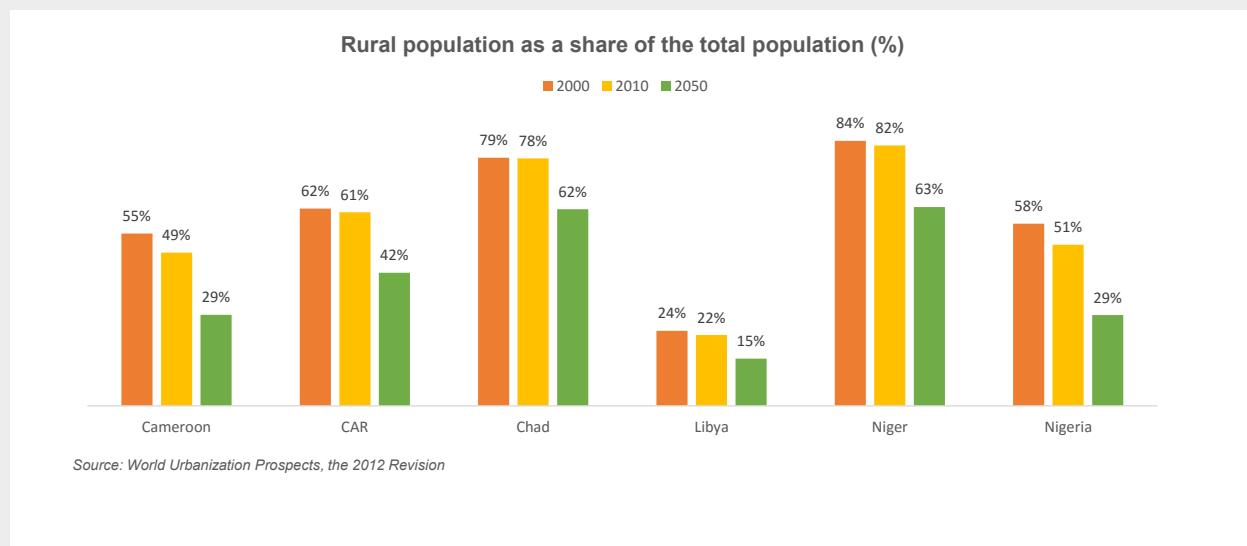




Figure 20: Rural population as a share of the total population (%)



In 2012 Libya was a country that earned its revenue solely from the oil sector, and oil made up almost all the country’s exports and GDP. The industrial sector in other countries is characterised principally by the cement production industry and sheet metal production, agrifood processing (brewing, oil pressing, sugar refining, etc.), meat production, and leatherworks.

Generally speaking, the service sector is driven by telecommunications and the transport and logistics sectors, along with the booming sectors of health, education, administration, and trade.

Niger is largely dependent on revenues derived from uranium mining and, very recently, from oil. While oil production is underway in most of the LCBC member states, this sector has begun to slow in recent years.



55 + 56: Transport and construction are two sectors creating employment in the Lake Chad basin

### Economic activities and marketing circuits in the Lake Chad basin

Economic activities around the lake include metal ore extraction, oil exploration and exploitation and the production of cotton, rice, millet, peanut and onions. Prominent basin industries are cotton ginning, brewing, tanning and agrifood activities.

The core occupations of local people working around the lake are agriculture, livestock rearing and fishing. Around two million people living within a 100 km of the lake earn their incomes from the lake's natural resources. These resources have developed over time in tandem with the lake itself and its cycles of floods and droughts. They are often endogenous, which places the lake at the heart of a network of urban, rural and regional markets.

The droughts of recent decades have exposed fertile land favoring the development of the agricultural sector, which has been boosted by strong demand linked to population growth in the area. Agriculture is practiced mainly at the lake side, while the livestock and fishing are practiced in the lake and on the islands. In addition to the agricultural and pastoral production, there is also a considerable exploitation of certain wild foods which generates additional revenue for households. These might be, on the one hand, vegetable matter such as algae, spirulina, fruit (from African locust bean trees, *Balanites*, *Ziziphus*, tamarinds, doum palms, date palms, acacias, etc.), seeds (shea, cashew, *Balanites*, etc.), leaves, roots, and woody or other parts of vegetables (gum arabic), and, on the other, honey, fish and other animal-based products (derived from hunting). These products have a role to play in services, in feeding people and animals, in pharmacopoeia and in soil improvement.

Spaces are generally multifunctional and ethnic groups have learned to diversify their activities to accommodate



57: Leatherworker, Cameroon

flooding and climate variability, allowing different resources to be exploited on the same space. This combination of activities by the same social group has the advantage of limiting resource use conflicts. Although some ethnic specialties are old (such as the fish trade by the Hausa and Kanuri in Nigeria), monopolies of activities related to a social group are limited.



58: Trade is intense between Cameroon and Chad, particularly on the Logone, the border between the two countries

Map 16: Economic activities around the Lake Chad

### ECONOMIC ACTIVITIES AROUND THE LAKE CHAD

**Fishing predominant**

- Fishing main activity from January to June
- Landlocked, scarcely visited area
- Temporary fishing stations and seasonal concentration of herds

**Flood recession agriculture**

- Dense agriculture, fishing secondary
- Isolated traditional land use, high seasonal migration

**Transhumant stock**

- Considerable fishing and flood recession agriculture
- Unpredictable rainfed agriculture, Wadi and flood recession agriculture, logging
- Rainfed agriculture, local logging

**Others**

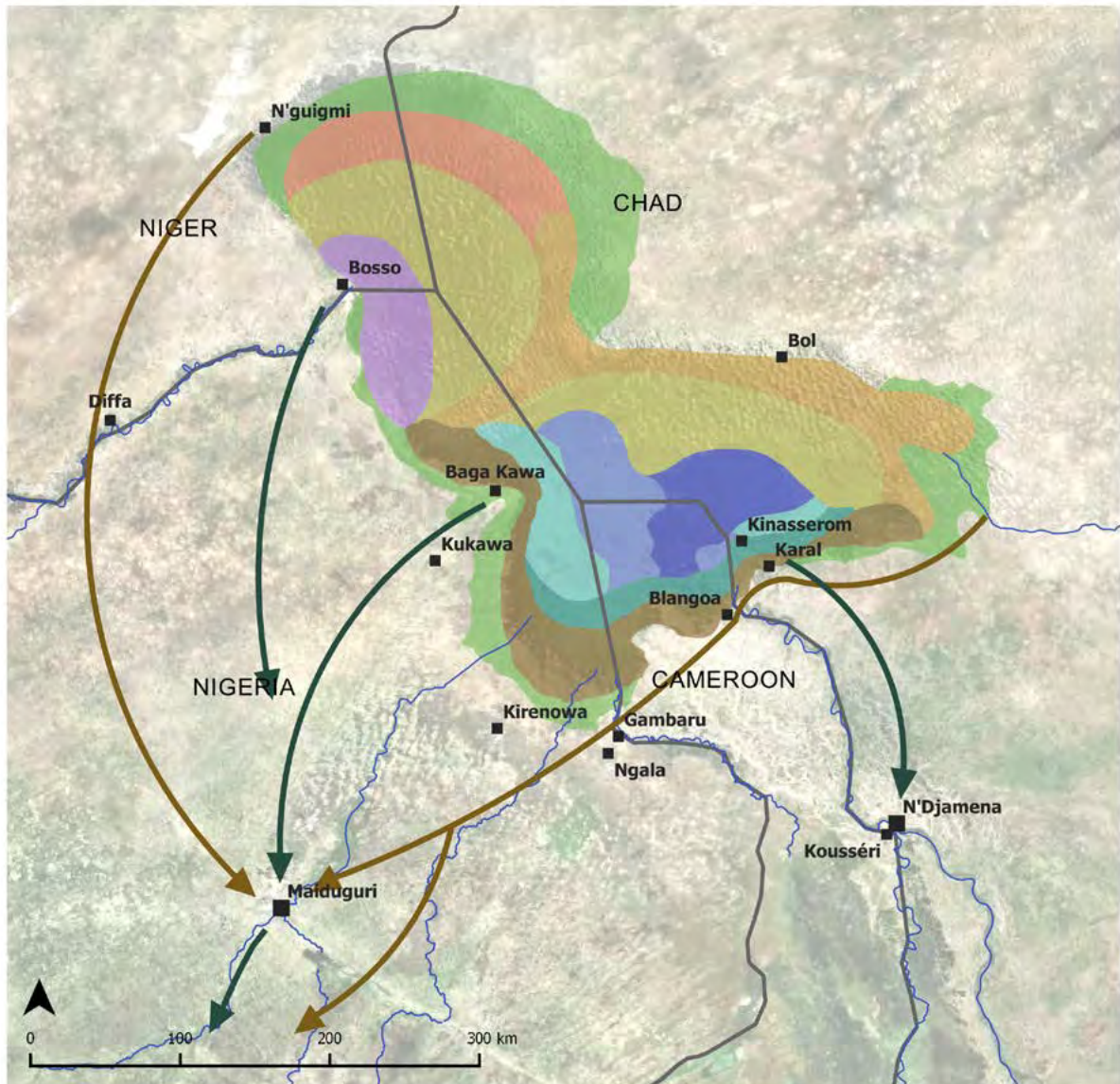
- Agriculture or fishing, depending on flooding, considerable temporary migration, transhumant stock breeding
- Buduma multy activity and transhumant stock breeding, logging

**Principal flows**

- Live animals
- Fish and agricultural products

**Principal markets**

- Regional market
- Local market



Source: IRD, 2012

The construction of a road network, notably in Nigeria, has opened up previously isolated areas and has been an engine for economic development in the region. Markets around the lake, which are relatively well structured and more or less specialized, allow the grouping of products which are then transported to large urban markets in cities such as Maiduguri and N'Djamena.

When it comes to trade, Nigeria is the major player, with a large Nigerian population within and outside the lakeside area, particularly in centres such as Baga Kawa, Wulgo, Monguno, Gambarou and Maiduguri.

The lake is the main source of food required to ensure the food security of local communities in places such as Bol, Kinasserom, Karal, Gredaya, Massaguet, Massakory and Rig-Rig, the major cities in the basin (N'Djamena, Maiduguri, Diffa, etc.) and areas beyond the basin.

### The agricultural sector

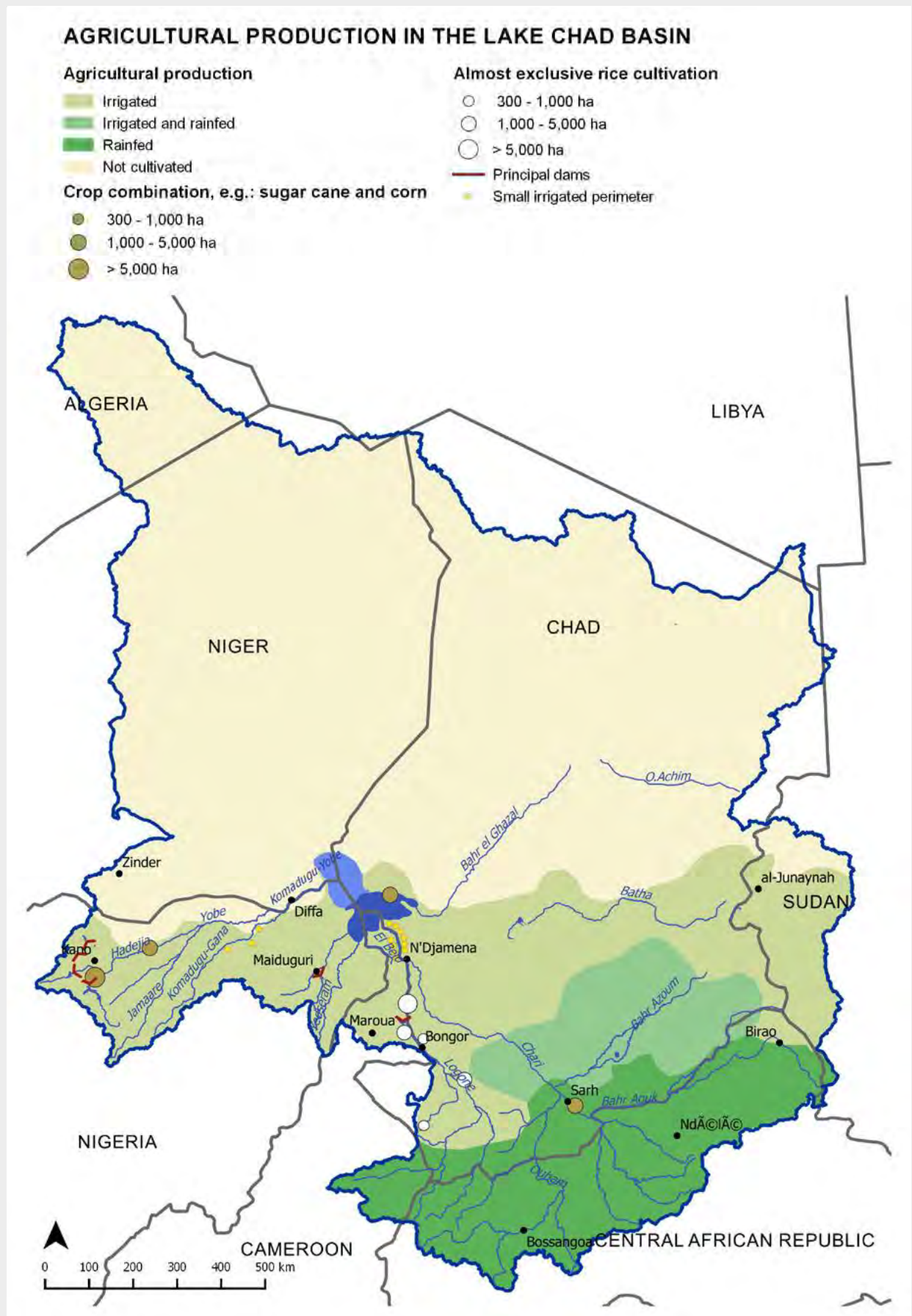
In the Lake Chad basin, food crops and cash crops are the key components of agriculture. Depending on the country, the main food crops include millet, sorghum, wheat, cocoyam, taro, maize, cassava, sweet potato, yam, onion, bell pepper and okra.

Cash crops include cotton, rice and dates, which are generally produced in extensive farming systems. These systems do not maximize soil productivity in the short term through the use of chemical inputs, irrigation or drainage, but instead use the naturally occurring resources in the soil. The categorisation of farming is based on the partial or full control of the water used. In the Sudanian zone, production systems are diversified and rely on manual, animal-powered or mechanised crop-growing techniques. The Sudano-Sahelian and Sahelian zones feature production systems structured according to rainfall patterns and the available water sources.



59: Transporting rice in the Bongor irrigation perimeter, Chad

Map 17: Agricultural production systems in the Lake Chad Basin



Source: IRD, 2012

### *Agricultural production systems*

1. *Rainfed farming* takes place in the rainy season without irrigation, and is fully reliant on rainfall. It is mainly practiced around Lake Chad and in the upstream areas of the Chari-Logone and Komadugu-Yobe river basins. This system produces mainly red sorghum, pearl millet, maize, peanut, cowpea, cotton, sweet potato, etc.

The floodplains of the Chari-Logone, situated in the border area between Chad and Cameroon (Yaere-Naga), have an important role in the basin's agricultural systems. This elevated area is used for rain-fed farming and market gardening.

In Diffa in Niger and Bol in Chad, dunes are used for rain-fed farming, particularly for millet, with some 5,000,000 ha dedicated to the crop. A mechanical and biological control strategy is being implemented in Niger in order to stabilise and improve the quality of cultivable land.

Production systems in the Sudanian zone (in the south) are highly diversified and rely on manual, animal-powered and mechanised techniques.

2. *Flood-recession farming* is a technique used along the length of watercourses, in lowlands and in floodplains, such as the Salamat in Chad or the Waza-Logone in Cameroon. It is actually a natural irrigation system provided by the flooding, which naturally saturates soils in floodplains. Flood recession crops thus depend on the level of flooding, the soil type and market demand. Cereals (maize, rice and transplanted sorghum) are grown everywhere. Legumes, tubers or market vegetables are also produced in large quantities, such as peppers in Niger for the Nigerian market. Flood recession farming is practiced by a large majority of the population around the lake and remains mainly a household practice, although some mechanical interventions are undertaken to develop cash crops.



from top to bottom:

60: Motorised farming technique in Bongor, Chad

61: Rainfed rice in Doba, Chad

62: Flood recession sorghum crop in Yagoua, Cameroon

In Cameroon's North Region, very large areas of land are given over to growing flood-recession sorghum (about 120,000 ha per year). Flood-recession sorghum (locally known as mouskouari) is grown on the vertisols. These heavy clay soils, locally known as karal, have a high water retention capacity and are found in the basin's depressions. Flood-recession sorghum is transplanted at the end of the rainy season and completes its development cycle by drawing on the retained moisture in the soil.

3. *Irrigated agriculture* is practised broadly in the southern half of the basin, in major developed areas and small areas

along rivers and around lakes. They are either irrigated using pumped groundwater, by pumping surface water or a using mixed system. Irrigation was introduced is becoming increasingly widespread to meet the growing demand of the population and the vulnerability of rainfed agriculture to climate stress. Endogenous or exogenous, these agricultural practices that require either partial or total water control, were appropriated and adapted by farmers to suit local conditions. Generally, the irrigated areas are specialized for the production of rice. The use of inputs (such as seeds, fertilizers, insecticides) and sometimes organic manure is widespread in this system. Irrigated agriculture is also suitable for products of market gardening or legumes, which serve as food supplement for people in the region.



63: A motor pump used in farming

- **The system of dams:**

*The Kano River Irrigation Project in Nigeria:* The Kano River Irrigation Project (KRIP) is gravity fed from the Tiga Dam (Komadugu-Yobe) and was completed in 1974. The water it impounds supplies the city of Kano and also supports agriculture. Today, around 9,400 ha are cultivated during the rainy season and 4,950 ha during the off-season (or 60% of the project's lands according to an IUCN estimate). During the rainy season irrigation is used to complement rainfall, and is absolutely essential for agriculture in the dry season.

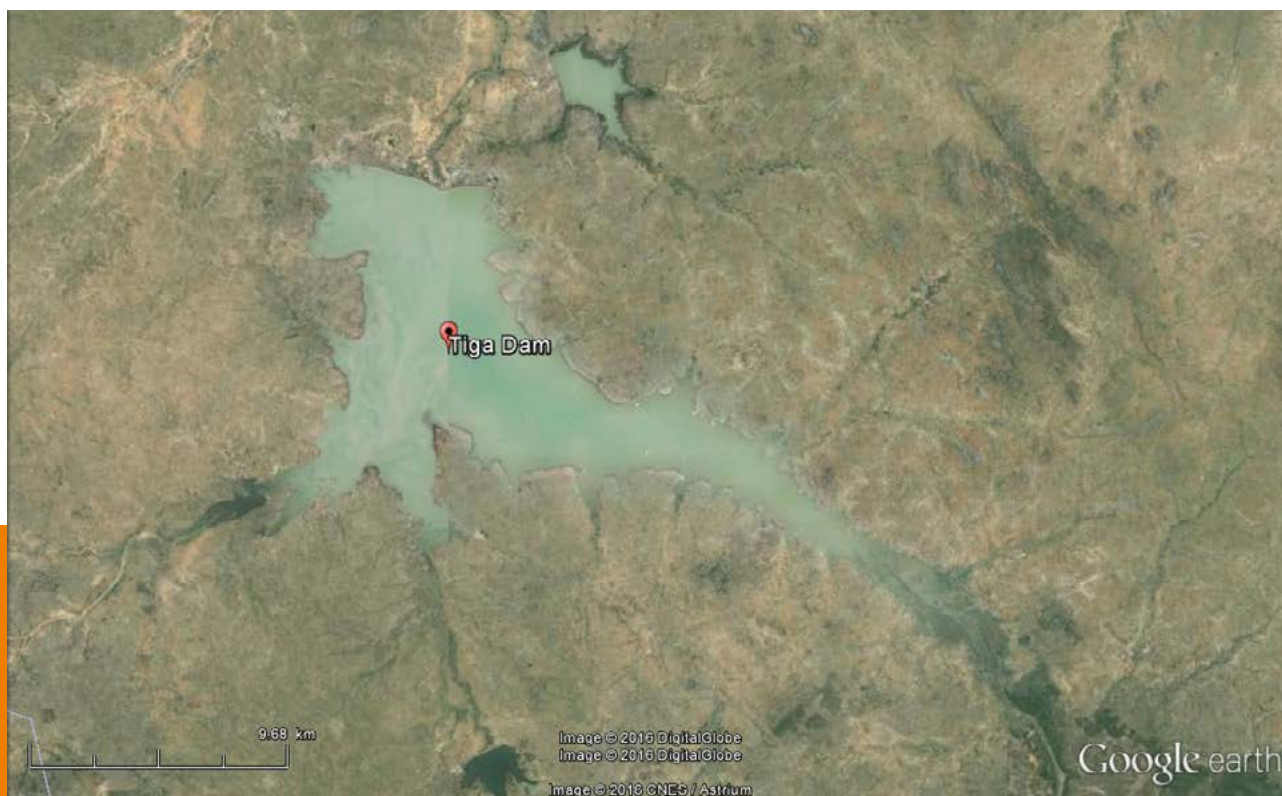
The KRIP scheme was initially intended for the cultivation of wheat and sugar cane (with 20,230 ha gravity fed and 1,620 ha under sprinklers) although rice growing using a gravity-fed distribution system is now the predominant activity. Double cropping is possible, with rice grown in the rainy season (or maize in areas where water is in shorter supply) and a range of crops (maize, cowpea, wheat, bell peppers, tomatoes, onions, diverse vegetables) grown in the dry season.

*SEMRY in Cameroon:* In 1951, under the aegis of a mechanised farming trial in Cameroon, a 24-hectare rice growing scheme was developed in Pouss. The aim of the

trial was to train up the growers and to process and market the rice. An extensive flooded rice growing scheme connected to basic hydraulic installations was established up under the title of SEMRY-I – Yagoua. A 40-kilometre-long levee constructed along a raised bank between Yagoua and Djafga protected an area of 1,500 ha (which was extended to 2,700 ha in 1965) against flooding. In high-flow periods, water intakes under the levee supplied channels that gravity-fed water to the rice paddies. Difficulties relating to deficient high-flow periods led to the hydraulic installations being modernised in the 1970s.

The positive results achieved through irrigation and intensive practices prompted the development of rice growing in the Yaere floodplains to the north of the Danay stream (SEMRY-II). These developments resulted in a substantial transformation of the ecology (the functioning of the Yaere) and society (traditional social practices) in the area:

- A 27 km long levee between Pouss and Guirvidig was built, creating the Maga reservoir with a capacity of 500 million m<sup>3</sup> (of which 340 million m<sup>3</sup> are usable) and a surface area that varies between 120 km<sup>2</sup> and 360 km<sup>2</sup>.



64: Satellite image of the Tiga dam, Nigeria

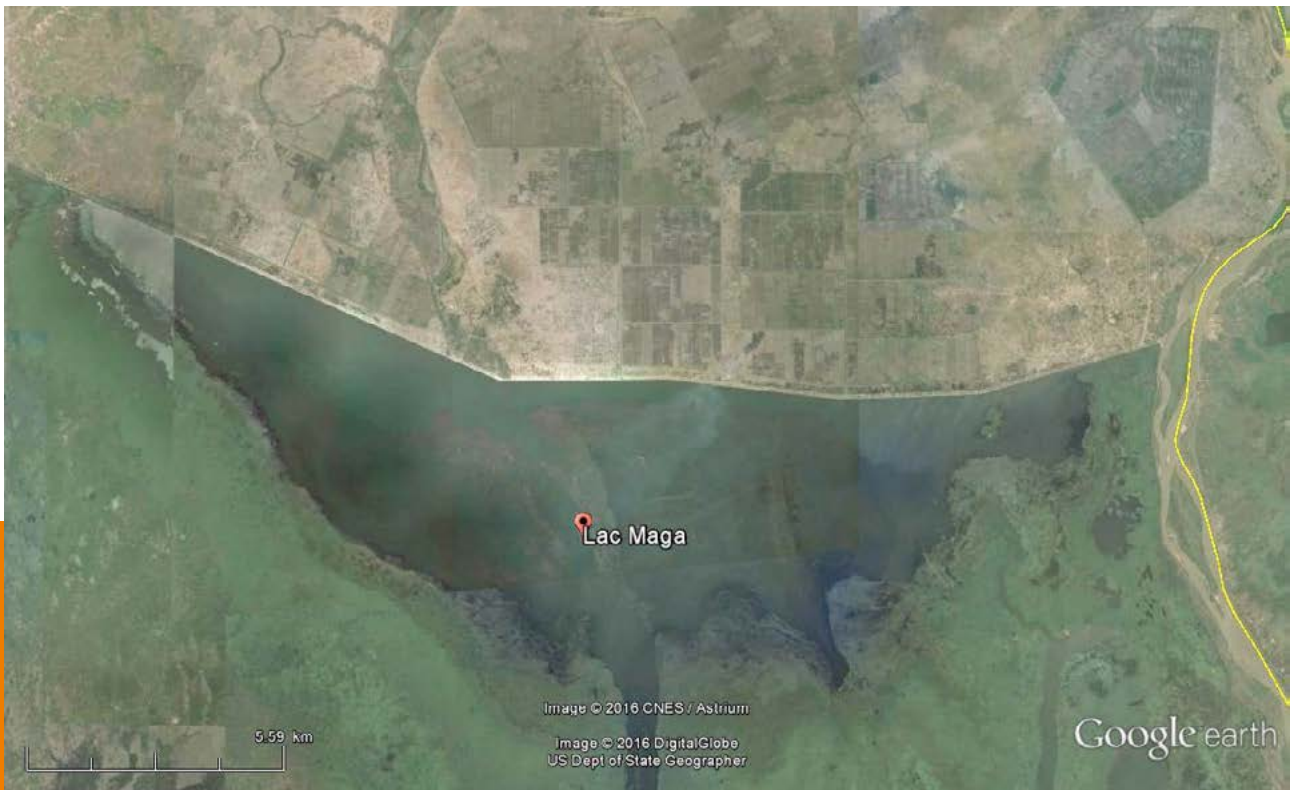




- Four large irrigation systems were installed (1978–86) drawing water from the reservoir. The schemes cover an area of 6,200 ha (5,500 ha of which is cultivable rice paddy) and are farmed by 11,000 farming families.
- The Musgum territories have undergone socio-economic changes.



Maga's fields produce an average of 35,000 tonnes of rice per year. The overall production of the SEMRY-II Company is estimated at 60,000 tonnes per year. Scheme lands are no longer solely given over to pasture or used for rain-fed farming. The flow rate of the Guerleo stream, a distributary of the Logone River that has been affected by declining water flow, no longer exceeds 30m<sup>3</sup>/s, which therefore limits how the riverside areas of this intermittent water-course can be used. However, Lake Maga continues to be important for fishing (producing an estimated 2,000 tonnes of fish per year) and for other activities, such as market gardening and fruit production.



from top to bottom:

65: Rice being sold at market in Maga, Cameroon

66: A rice field in Maga, Cameroon

67: Satellite image of Lake Maga, Cameroon

- **Polder systems**

Polders are areas of the lake (mainly in Chad and to a lesser extent in Nigeria) that are protected from flooding through the installation of temporary or permanent dams made of local materials or reinforced concrete. Polders can be used for growing wheat, rice, maize, flood-recession sorghum, sugar cane, date palms and fruit trees. It is also possible to grow vegetable and fodder crops on these sites.

Several kinds of polder exist:

- *Traditional polders* are operated seasonally. They are enclosed with sand dykes and their water is provided in season by infiltration through the dyke and by rises in the water table. Over the years the surface soils can become saline and the area of cultivable land diminishes as the water table gradually declines.
- *Controlled polders* are filled with water as the level of the lake rises. The installation of a dyke means that incoming water can be controlled and then stopped after submersion.
- *Modern polders* are fed by pumping water directly from the lake and are therefore less dependent on water levels (as long as the pump inflow remains underwater).



from top to bottom:

68: Aerial view of a polder, Chad

69 + 70: Pumping station supplying the polders

### Polders – an opportunity for farming in Lake Chad

The north-eastern side of Lake Chad is made up of deposits of mud that are rich in organic matter overlying clay. Polder soils develop on this formation which corresponds to a lacustrine series, the deposits of which were first laid down more than 9,000 years ago. The groundwater in polders is close to the surface (0.5–2.5 m). Currently, only the Chadian polders, which have been installed in the fertile oxbows of Lake Chad, are operational. However, the waters of the 2010 and 2012 floods have not yet receded sufficiently, particularly around the Bol oxbow, and it has not been possible to free up the cultivable lands in these polders for farming. The improved traditional polder at Kindjiria operates a system of three harvests over two years, growing wheat on 300 ha and maize on 600 ha over two years. Other polders also now in place are at Doum-Doum (2,400 ha), the Lake Prefecture Rural Development Project – PDRPL (6,900 ha), Ngouri (1,000 ha), Bol (20,000 ha) and Liwa (27,000 ha). Three modern polders managed by the lake development company SODELAC and located near to Bol are the Guini, Berim (approximately 11,000 ha) and Mamdi (2,500 ha) polders.



71: An arm of Lake Chad in near Boll, Mamdi polder, Chad

#### • Other examples of total / partial water control:

*The Banda sugar cane plantation in Chad:* The Banda sugar facility is managed by the Compagnie Sucrière du Tchad (Chad Sugar Company), a private firm that is involved in all operations relevant to the sector, from the production of sugar cane to the marketing of the end-product.

The Banda sugar cane plantation is situated near the town of Sarh and covers a gross total area of 3,700 ha and a net total area varying between 3,300 ha and 3,500 ha. Its water supplies are fed in from six in-stream pumping stations installed along the banks of the Chari, which have a total capacity of 3,000 m<sup>3</sup>/h (830 l/s). A temporary sandbag weir is installed during the low-flow period (between February and June) to increase the water level and ensure extraction is maintained. Irrigation water is delivered by 33 pivot sprinkler arms and each one is deployed over a 106-hectare plot.



from top to bottom:

72: Satellite image of the sugar growing fields in Banda, Chad

73 + 74: The irrigation system in place in Banda, Chad

*Casier B in Bongor, Chad:* Casier B is a rice-growing site located to the north of Bongor. Operating since 1965, it maintains one section under full water control (500 ha), which can be double cropped, and another section under partial water control (2,000 ha), where only one crop can be grown annually.

The 2,000 ha under partial water control are supplied using a conventional gravity-fed system, which makes irrigation wholly dependent on the high-flow periods of the Logone River. In 2001, growing was limited to around 150 ha planted with rice and was managed by a consortium of farmers with the support of the National Office for Rural Development (ONDR). Since 2003 the whole 2,000-hectare site has been worked. The 520 net hectares under full water control are fed by two in-stream pumping stations on the Logone River, which are managed by the growers' consortium set up for the relaunch of Casier B, following the withdrawal of the state.

#### 4. The wadi system in Chad

The agropastoralists in the Barh el Gazal and Kanem regions of Chad are farmers who practise crop and live-stock farming. Besides rain-fed crop growing, they practise market gardening in the off-season in the wadis located near their villages.

Wadis are low-lying lands or depressions occurring between dunes that are found throughout the sandy plateau of the Bahr el Ghazal. The wadis determine the location of villages, and they are used in manifold ways, such as to water livestock, to grow trees and shrubs, and to practise market gardening. These depressions mean that the water table is closer to the surface, so that wells do not have to be dug very deep.

#### *Cereals cultivated and eating habits*

Across the whole of the Lake Chad basin, mealie meal, made from flour from locally grown cereals is the staple food. This is accompanied with a sauce made often made from okra, cowpea or Guinea sorrel leaves. Peanuts are also commonly added to the sauces. These sauces are generally served with a few pieces of meat or dried fish.

In basin countries, cereals, roots and tubers make up over 50% of the overall dietary energy intake. As such, they are key to ensuring local people's food security and to securing income.



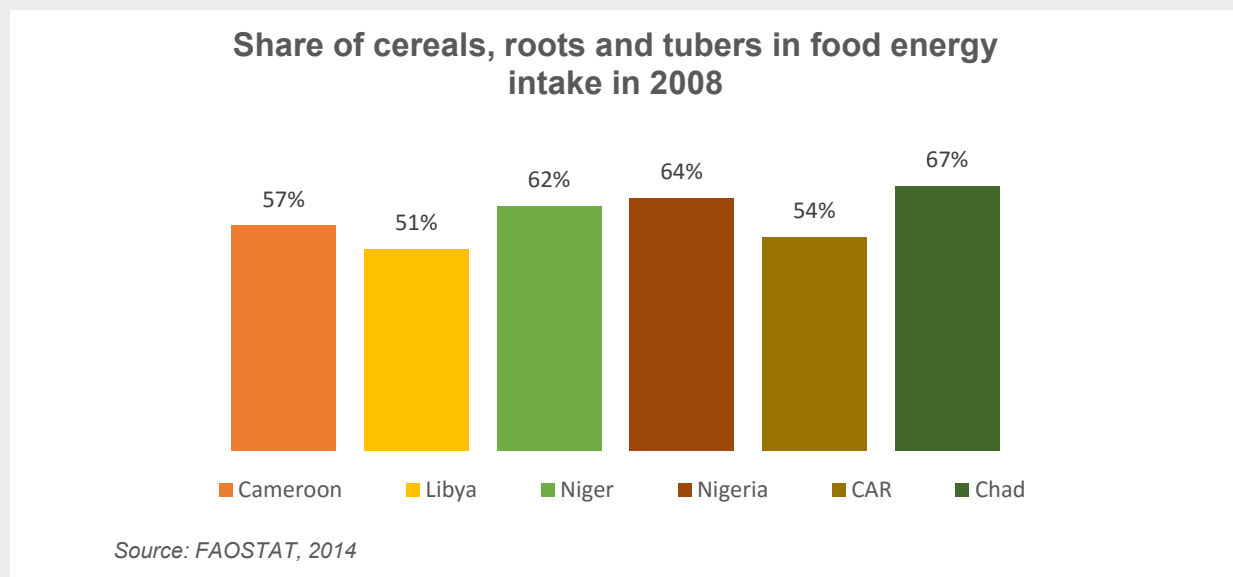
from top to bottom:

75: Casier B near Bongor, Chad

76: Preparing the rice harvest for sale, Chad

77: Cereal being sold at market, Nigeria

Figure 21: Share of cereals, roots and tubers in food energy intake in 2008



Maize is a key cereal in the countries of the Lake Chad basin. It is farmed on the southern shores of the lake, in the Bol archipelago, on the polders and on the Nigerian side of the northern pool. Other foods essential to the local diet include millet, rice and sorghum. Sorghum, called great millet in West Africa, is a tall grass that is heat and drought resistant. It is generally grown on flood-recession sites. Small-grain millet is the staple foodstuff. It is used to make mealie meal, bili-bili (fermented millet beer), fritters, etc. Rice, which was once only a food for special occasions, is becoming increasingly popular. There are many varieties, but the SEMRY rice from Cameroon is particularly popular.



78: Sorghum cob

Table 13: Cereal production levels by country in tonnes, in 2012

Cereal production in tonnes in 2012	Wheat	Maize	Millet	Paddy rice	Sorghum	Total
Cameroon	800	1,622,000	98,000	139,000	1,102,000	2,961,800
Libya	200,000	2,900	8,500	~	~	211,400
Niger	5,666	18,955	3,862,155	50,254	1,375,697	5,312,727
Nigeria	100,000	9,410,000	5,000,000	4,833,000	6,900,000	26,243,000
Central African Republic	~	161,500	11,500	42,000	45,600	260,600
Chad	7,500	200,000	924,000	180,000	1,200,000	2,511,500
<b>Total</b>	<b>313,966</b>	<b>11,415,355</b>	<b>9,904,155</b>	<b>5,244,254</b>	<b>10,623,297</b>	<b>37,501,027</b>

Source: FAOSTAT, 2012

### 1. Focus on cash crops

In the Lake Chad basin, the two key cash crops are cotton and peanut.

Table 14: Quantities of peanuts produced in tonnes in 2012

Quantities produced (t)	2012
Cameroon	633,799
Niger	291,763
Nigeria	3,071,000
Central African Republic	149,264
Chad	371,000
Tchad	7 500

Source: FAOSTAT, 2012

Due to long periods of drought, the peanut market may have shrunk during certain periods. However, over a 25-year period, the quantity produced in each country has continued to grow – on average, production has quadrupled, and from 1987 to 2012 the Niger experienced a sevenfold increase in production.

These figures reflect (a) the increasing dietary needs of a growing population, (b) the economic value of the peanut and (c) the fact that the peanut is a key staple food of basin inhabitants. Ground down, peanuts are used to enrich almost all the sauces used in meals. They are eaten raw, boiled or grilled as an accompaniment to tea or as a simple snack. Peanuts have a high nutritional value and provide essential vitamins and minerals.

Cotton, which is grown in the Sudanian zone, was introduced to Africa by the Arabs and Portuguese, and the Fulbe people from the foot of the Mandara Mountains were spinning and weaving the fibre well before the arrival of the European colonisers. It is only after the latter's arrival that the international trade in cotton got underway.

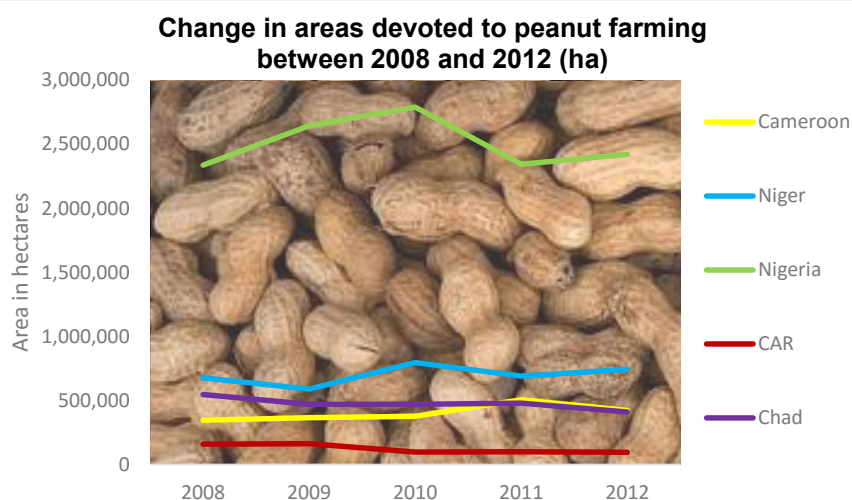
Cotton, also known as 'white gold', is a source of income for thousands of families in the north of Cameroon, the south of Chad, Nigeria and, to a lesser extent, in Niger.

Cameroon, which produces USD 130 million of cotton, and Chad, which produces USD 41 million, are among the world's top 30 cotton-exporting countries. The destinations for these two countries' exports are mainly European Union countries, particularly France, Germany, Belgium, Portugal and Spain.



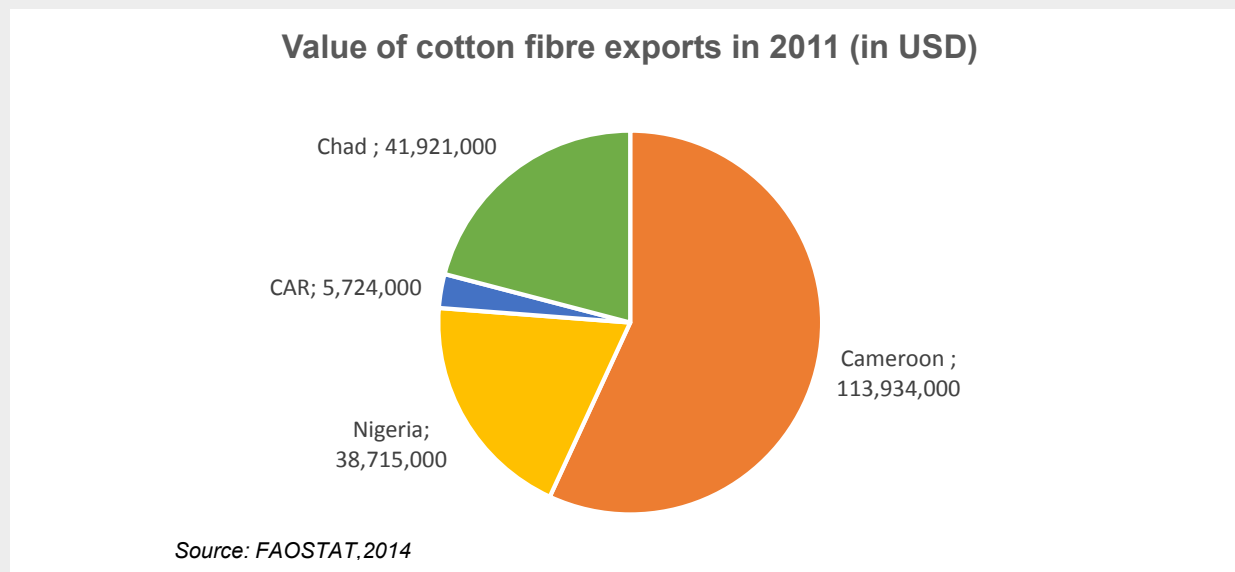
79: Cotton swab

Figure 22: Change in areas devoted to peanut farming in 2012 (in ha)



Source: FAOSTAT, 2014

Figure 23: Value of cotton fibre exports in 2011 (in USD)

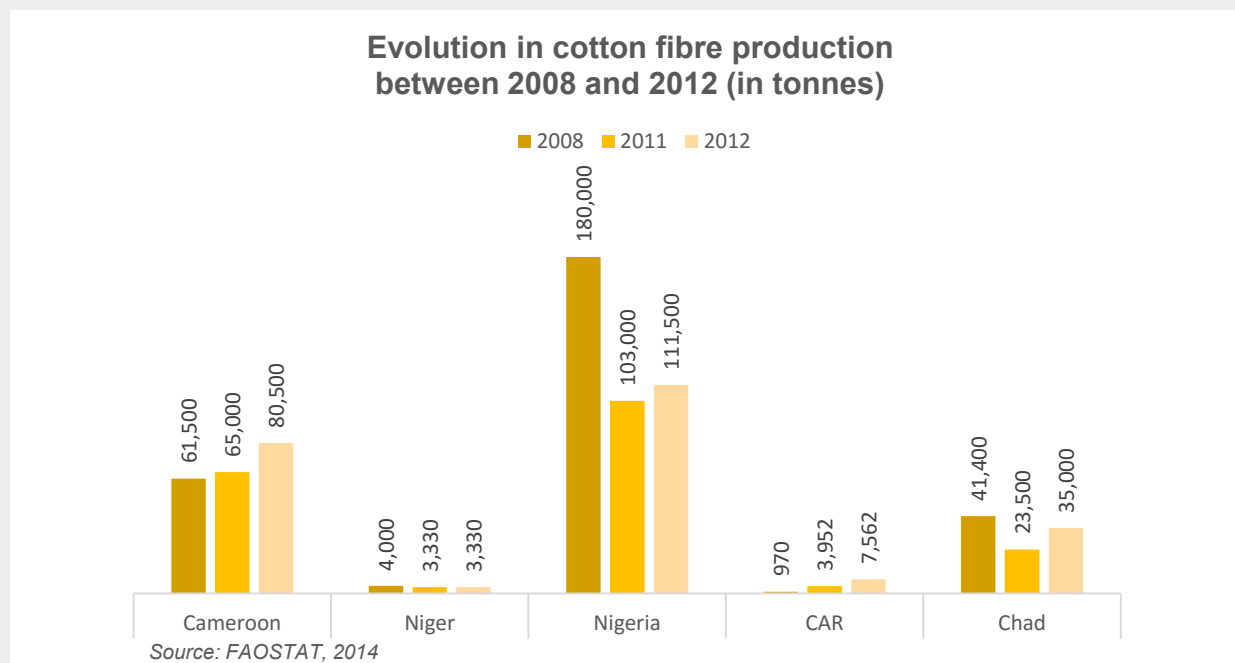


In both Cameroon and Chad cotton production is managed by a parastatal company which is part state and part privately owned. These companies, called Sodecoton in Cameroon and Cotontchad in Chad, organise the production and sale of cotton fibre. In other words, they deal directly with private cotton growers and buy up all of their output. These growers benefit in return by receiving loans that enable them to sow and treat their cotton fields. The parastatal companies collect the cotton and process it in one of the many ginning factories that exist in each country, and the resulting cotton is then sent for export.

This situation can be good for cotton growers as they can be sure they will sell all of their production. However, the purchase prices are low because of the monopolies in place. In spite of the quasi-contractual relationship that ties them to their national cotton company, some Cameroonian cotton growers have gone and sold their production in Nigeria, where they receive a higher prices

Cotton production has furthermore suffered from the lower purchase price of cottonseed paid to growers (which is the result of the fall in CFA franc cotton prices) and from the increasing cost of fertilisers.

Figure 24: Evolution in cotton fibre production between 2008 and 2012 (in tonnes)



### The development of cotton production in the Central African Republic

The development of cotton production in the Central African Republic (CAR) has been sporadic, reflecting the evolution of production and support structures (research and development, extension services, marketing, etc.), variations in world cotton fibre prices, the different policies in place for the sector and the country's sociopolitical context. In economic terms, cotton growing employs a large number of people such as cotton farmers, haulage professionals, processing staff, exporters and public-sector employees. Cotton growing in the savannahs of the north-west, centre-north and centre-east of the country constitutes an important source of employment for young people, promotes monetarisation and stimulates the local economy. Although production and yields remain low (at around 550 kg/ha on average) and the average size of plots is small (0.5 ha per grower), cotton is the number one cash

crop in the CAR. The Chinese Investment Promotion Agency (CIPA) has invested 15.9 billion CFA francs in the sector worth, aiming to result in an increased production from 15,000 t for the 2010/2011 season to 22,000 t in 2011/2012 through an extension of cultivated areas and an expected increase in yields.



80: Cotton waiting to be collected by SODECOTON, Cameroon

Table 15: Planned evolution of cotton production in CAR

		2009-2010	2010-2011	2011-2012
Cultivated area	Ha	19,550	25,760	38,407
Production of cotton grain	T	11,500	15,000	22,000
Cotton grain transported to CIPA works	T	10,456	10,061	18,763
Production of cotton fibre by CIPA	T	3,307	3,952	7,445

Source: *Les évolutions récentes des productions agricoles en République centrafricaine, 2012*<sup>1</sup>

<sup>1</sup> Data on the cotton grain production for the 2011 - 2012 agricultural campaign have not been fully taken into account as part of the harvest remains stored in farmers/ warehouses due to the crisis which prevented the transport of the grain to factories.

#### 2. Products for local consumption and other cash crops

Along with these two major cash crops, a number of regions have specialised in growing produce aimed at local consumers and at export markets in particular. In both

the Chadian and Cameroonian parts of the Chari delta, a wide range of vegetables and fruits are grown for sale in the markets of N'Djamena, such as tomatoes, salad leaves, carrots, watermelon, sugar cane, okra, sweet potato, onion and cassava.



81: Locally produced tomatoes being sold at market



82: Sweet potatoes being sold at market



### *Gum arabic in Chad*

Chad is the world's second largest producer of gum arabic, and it is the country's third largest export, excluding oil. Gum trees grow naturally across the southern half of the country (in the Sahelian and Sudanian zones). The gum harvest provides an extra source of income for more than 500,000 households of crop farmers and sedentary and nomadic livestock farmers (source: AFD – French Development Agency).

### *Bell peppers in Niger*

More than 125,000 tonnes of bell peppers are harvested and sold fresh or dried each year to the Nigerian market. Bell peppers are grown along the length of the Komadugu-Yobe River on both Nigerien and Nigerian sides of the river. For the Diffa region in the east of Niger, the bell pepper has become the main cash crop. The development of pepper growing has positively impacted on the living standards of the region's inhabitants who now refer to the bell pepper as the red gold of the Manga people. According to statistics from the Ministry of Agricultural Development, two-thirds of the 30,000 hectares of cultivable land alongside the Komadugu-Yobe River are used for bell pepper growing (source: IRD).

### *Onion*

The onion is the 'third most important cash crop after cotton and peanuts in the north of Cameroon. In 2007, studies indicated that more than 3,400 ha were used for onion growing, which is practised by 13,600 farmers in the northern regions, 10,000 of whom operate in the Far North region. Annually 70,000 tonnes of onions are produced.'

In Cameroon, onions are mainly grown for export to the south of the country (Yaounde, Douala and Bafoussam) and to neighbouring countries. Originally grown using traditional methods, more modern techniques have been promoted by farmer cooperatives. These techniques reduce the working time required and thus increase profits.

'The plots are divided into squares of varying dimensions, depending on the production areas. Irrigation is carried out using motor pumps or, for those less well-off, by shadoof. The wells, which are generally seasonal, are built with local materials and need to be repaired annually' (source: HAL Archives Ouvertes).



from top to bottom:

83: Onions produced in Cameroon

84: A shadoof is a swinging device that serves to draw water from a well

### *Constraints on agriculture around the lake*

The harsh climate and its variability remain the main constraints on the sector. The retreat of the lake resulting from a series of relatively dry years has created new areas of cultivable land, which has proven beneficial to local farmers. However, these farmers are particularly affected by seasonal variability, as the receding water levels affect their harvests.

Conversely, early floods have destroyed hectares of sweet potato, cassava and maize, sometimes leaving sites submerged. The increasing pluviometrie which is now being witnessed has returned previously farmed lakeside areas to marshland.

While this has reduced the amount of cultivable land for market gardening it has also facilitated water extraction for irrigation schemes, as pump intakes are now constantly submerged. Additional constraints include questions of land ownership, conflicts between socio-economic groups, lack of leadership, and strategic failures particularly regarding the large irrigated areas, which were on the basis of the characteristics of lake in the past without anticipating its decline.

### **Livestock sector**

#### *Groups of pastoralists and pastoral systems*

In the basin, pastoralism is based primarily on mobility with transhumant farming and pastoral nomadism dominating. The nomads are mostly camel Toubou and

Arabs from the north of Niger and Chad who travel as far south as Nigeria and Cameroon. The Toubou are herders, who live almost exclusively from livestock as no other activity is suitable for the areas in which they live. The Choa Arabs, originally from Chad, but found in all countries in the south of the basin, practice both sedentary agriculture and nomadism. The Fulani, present throughout the basin are mostly transhumant cattle farmers, travelling throughout the year. True nomadism, however, is disappearing in some areas, as is the case of M'Bororo in Cameroon, originally from CAR, who settled in the 1920s and now practice sedentary agriculture. In the CAR, livestock rearing is fairly new, and some Fulani Mbororo have stayed there due to the quality of the pasture. Lake Chad, with its forage and water availability throughout the year, has become an almost obligatory passage for this and other groups following the droughts of the 70s.

One of the remarkable features in recent years is the development of livestock raising by groups of farmers and / or fishermen and in the other direction, the development of agriculture and fisheries for people living on the islands of Lake Chad or a slightly further away. This is particularly the case for the Boudouma and Kouri people who have increased their herd sizes as a result of successful farming and fishing activities, whereas many sedentary farmers and fishermen, particularly the Kanembu and Borno of the Diffa region and of Borno State have invested in cattle rearing and entrust their livestock to local herders operating around the lake. The Hausa, on the other hand, are renowned for cattle fattening



85: Transhumant pastoralist in Cameroon

The rangelands of the Lake Chad basin typically hold large and small livestock – i.e. breeds of cattle, horse, camel, donkey, goat, sheep, poultry and pig. Of particular note is the Kuri cow, rare cattle breed that, although not native to Lake Chad alone, is a specific feature of the rangelands of the area and one that is dying out. The Kuri cow is important as it not only promotes the development of cross-border trade, but is also a highly productive milker. While other

species produce an average of one to two litres of milk per day on average, the Kuri cow can give between four to six litres daily. The table below displays the headcounts for the species reared in the basin.

*Marketing livestock products*

Pastoralism in the Lake Chad basin is characterized by the presence of large and small livestock. The herds consist of breeds of cattle, horses, camels, donkeys, goats, sheep, poultry, pigs. Particular attention should be given to the “Kouri” cow, which is endangered and indigenous to the Lake Chad. In addition to meat, the Kouris can produce 4 to 6 litres of milk per day, compared to 1 to 2 litres per day for other breeds (Aminou Tassiou 1998). Despite the importance of his presence in the basin, “Kouri” cow is endangered.

Table 16: Species and breeds farmed

Species	Breed
Cattle	Bororo, Fulani, Arab, Kilara, Wadara, Toupouri, Massa, Kuri
Sheep	Arabs, Fulani, Uda, Peul, Waila, Kababish, Poulfouli or Massa, Kirdimi
Goat	Arab, Moussoro, Baguirmi, Kirdimi
Camel	Gorane, Kanem, Mahamid or Manga, Arab or Zebedi
Horse	Dongola, Arab Berber, Logone pony



from top to bottom:

86: Herd of camels in the north of the basin

87: Aquatic pasture

Table 17: Head of livestock per country in 2012

Head of livestock in 2012	Cameroon	Libya	Niger	Nigeria	Central African Republic	Chad	Total
Cattle	5,001,000	198,000	10,125,768	19,200,000	4,250,000	7,800,000	46,574,768
Goat	4,600,000	2,550,000	13,760,687	57,600,000	5,800,000	6,780,000	91,090,687
Sheep	4,000,000	7,150,000	10,369,517	38,500,000	400,000	3,150,000	63,569,517
Camel	0	57,000	1,676,567	20,000	0	1,450,000	3,203,567
<b>Total</b>	<b>13,601,000</b>	<b>9,955,000</b>	<b>35,932,539</b>	<b>115,320,000</b>	<b>10,450,000</b>	<b>19,180,000</b>	<b>204,438,539</b>

Source: FAOSTAT, 2012

Livestock is as productive a sector as crop growing in the basin and is a cornerstone of the economy, second only to oil and the exploitation of other mineral resources. The herds constitute an important form of capital, producing meat, milk, leather, etc. Dromedaries, donkeys and horses also serve as modes of transport.

The estimated number of livestock in Chad in 2012 was around 19 million head, 40% of which were cattle. Between 30% and 40% of rural people are involved in commercial livestock activities, although these figures do not take do not account for the animals held at household level for the family's own use.

In Niger, which has a total of 35 million head of livestock, animal husbandry is the second most important activity after crop growing. Sales of livestock farming produce are second only to those of uranium.

There are estimated to be around five million head of cattle in Cameroon, mainly concentrated in the Benue basin (Adamawa) and around Lake Chad (the North and Far North regions), whilst stocks of small ruminants are estimated at around eight million animals. Other species are generally much more difficult to quantify. When it comes to the livestock and meat trade, Cameroon exports livestock to Nigeria, Gabon and Equatorial Guinea and imports livestock from Chad and the Central African Republic, as well as frozen meat from the European Union.

The city of Kano is the main centre for cattle trading in the Nigerian part of the basin. Most herds are cattle (with a total of 20 million head), with sheep and goat herds featuring in the north.

Chad and Niger are the two main camel-rearing countries, with camels raised mainly for their meat, but also for their milk.



88: Sheep being sold at Diffa market, Niger



89: Transporting wood on a donkey's back

### The Kouri cow, a unique species in the Lake Chad basin

Kouri cattle are productive and well adapted to its environs around the Lake Chad basin – traditionally the eastern archipelagos and the valleys of the Yobe River. The breed is reared in a unique way, as part of a system of traditional production that includes flood-recession farming, crop growing, fishing, livestock grazing and also crop residues.

The breed is renowned for its superior capacity for milk and meat production. Special features of the breed are its horns, which are very wide at the base and bulbous in shape, and the lack of a hump on its back.

The fact that the Kouri cannot thrive outside of its current ecological niche means that it is in a state of increasing decline. This is exacerbated by the receding water levels of Lake Chad, which leave fewer of the aquatic fresh grasses that the breed particularly prefers. Crossbreeding with the Zebu is also threatening the species.

Immediate action is therefore needed to halt and ultimately reverse the Kouri's decline. An approach that has long been proposed is the establishment of a core breeding stock on the islands in Lake Chad. This will not only improve the breed, but also protect it from the threat of



90: Kouri cattle are distinguishable by their colour and their horns

extinction. Over recent years the LCBC has worked through the PRODEBALT programme to rehabilitate the breeding centre on Sayam island in Lake Chad for the benefit of all the region's countries. This activity adds to those undertaken by Chad and Nigeria in this regard.

#### Constraints in the livestock sector

The livestock sector receives little support. While technical supervision and the organisation of rangeland grazing is weak and the persistence of a number of infectious and parasitic diseases, and lack of research programmes continues to plague the sector it is the challenge of feeding livestock that remains the major challenge in the basin. Additionally, knowledge of transhumant livestock production is relatively poor and there is a lack of control over livestock populations and movements.

Tensions are rising due not only to population growth and ongoing exploitation of forests for fuel wood, but also to the fact that nomadic communities are increasingly moving southwards as their previously verdant grazing lands become depleted.

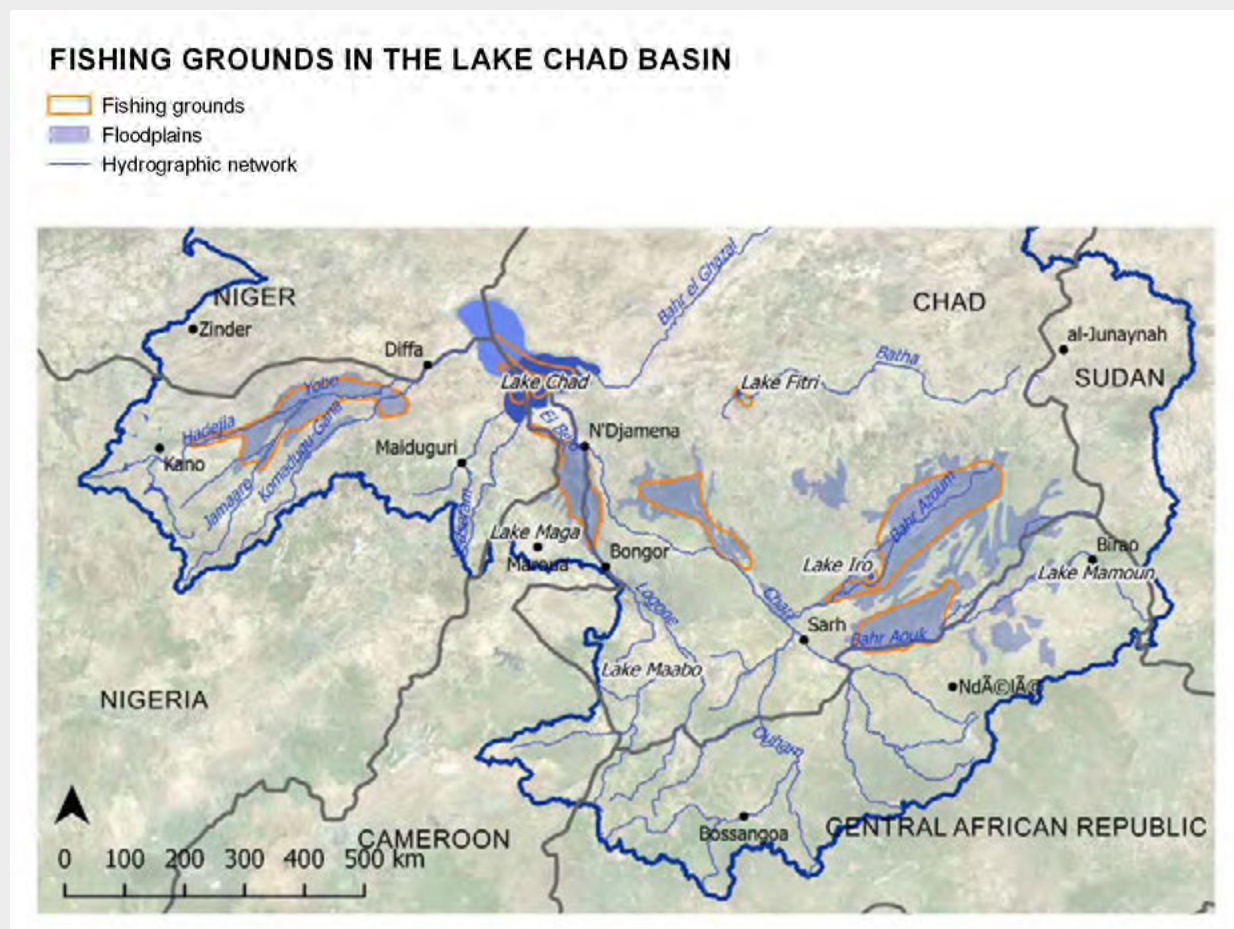
Moreover, extensive transhumant livestock production now faces a range of obstacles, particularly the pressure in certain areas to grow crops in transhumance corridors and also, at the local level, the increasing incursion of crop growing into rangelands traditionally dedicated solely to extensive livestock production. Conflicts between livestock farmers and crop farmers are a recurrent issue.

#### The fishing sector

Fishing is a common activity in all the communities living in the vicinity of water bodies (rivers, lakes reservoirs etc.) in the Lake Chad basin. It represents a significant source of income for households and contributes to the food self-sufficiency of national economies. However reliable and current data are still scarce and most available statistics are based on studies dating as far back as the 1970s. More recent national reports exist but the data collection methods result in either incomplete data or data that is not comparable across borders.

Fish catches are significant, particularly in the four countries bordering Lake Chad, with Nigeria dominating, followed by Niger, Cameroon and Chad. At least eight different-water bodies are used for fishing: small seasonal bodies of water and channels with receding waters are heavily fished, followed by the main watercourses, Lake Chad (open waters), small permanent bodies of water and ox-bow lakes, tributaries, artificial reservoirs, irrigation channels and floodplains. The floodplains are rich in organic matter and minerals that accumulate over the dry season and serve as an important natural fishing reserve, providing ideal conditions for fish breeding and growth. Between 120 and 140 species of fish have been identified in the Lake Chad basin.

Map 18: Fishing Grounds in the lake Chad basin



Source: Atlas de l'Afrique - Tchad, 2012

### The actors in the fishery sector

There are three main groups of fishermen active in the sector: the professionals, who mainly come from abroad (particularly from Nigeria, Mali, Ghana and Benin), are well equipped and mostly operate on Lake Chad and other larger water bodies practicing seine fishing; the non-professionals who fish seasonally and often in parallel with other activities (crop growing, livestock rearing); and an indeterminate number of occasional fishers. The fishing lucrative sector provides income for more than 200,000 people across the basin. The main fishing communities around Lake Chad are the Boudouma, Kotoko, Musgum, Masa, Arab, Sara, Hausa, Kanuri and Malian communities.

Other direct and indirect actors benefit from the fishing sector, include fish processors, resellers and transporters, the handlers, the ice sellers, the boat, rope and net makers, etc. However, given the informal nature of their work, their numbers are not known.

### Fishery management and fishing practices

Fishing is primarily practised by men, while women are more involved in the processing and sale of fish.

Fishermen are sometimes organised into groups, associations and cooperatives. Fisheries are mainly managed in three ways:

- Traditional systems where fisheries are managed by traditional authorities. This is particularly the case in Cameroon. Here, state authorities principally play an oversight and awareness-raising role.
- Mixed systems – i.e. systems that involve the participation of traditional and modern administrations. This kind of system is widespread in Chad and Nigeria.
- Modern systems managed exclusively by government authorities have been applied sporadically in Chad and Nigeria.

The main tasks of these traditional and modern systems are: to regulate the fishing seasons, allowing fish to reproduce; define fishing areas; and to impose and collect taxes.

Fishing in Lake Chad is wholly artisanal, and less than one per cent of the fishing fleet is motorised. Currently, around 31,000 canoes are used for fishing. These canoes can be made from simple planks of wood or plywood or even be dug out from a single tree trunk.

Depending on the depth of water and the fish species available, fishermen use a range of fishing methods, not all of which respect environmental standards. They include: gillnets (floating and fixed), baited and unbaited long-lines, traps including dumbas (fences of chamber traps), fishing while floating on calabashes, beach seines, casting nets, mosquito nets, etc.

#### *Fish processing and marketing*

Fish catches in Lake Chad are important to all four border countries of the lake, with Nigeria particularly dominant (38%), followed by Niger (32%), Cameroon (21%) and Chad (9%). In 2012, the estimated fish production of the lake was set at about 100,000 tonnes. This production can vary widely from year to year, depending on both the volume of rainfall and the pressure exerted by fishermen on the resource.

The majority of fish is marketed in Nigeria, where demand is particularly high. In Cameroon, there are six major fishing areas: the Cameroonian part of Lake Chad, Lake Guéré (shared between Cameroon and Chad), Lake Maga, the Logone River, the Logomatya river and the Waza-Logone floodplain. In the northern basin of Lake Chad, the fishing zones are located around several villages and settlements between the Department of N'guigmi and the rural district of Bosso.

Various fish processing techniques are used including smoking, charring, sun-drying and frying. This work is generally carried out by fishermen and their families (particularly the women). Drying is the oldest technique and requires little investment. Smoking is useful as it guarantees the longest preservation of the fish and adds flavour when used in sauces and stews. It also ensures the availability of protein for people throughout the years. Fishing communities employ two main smoking techniques (braising in grass and smoked over a wood fire) to satisfy the taste particularly of the Nigerian market.

Locally, fish is sold fresh on the banks of fishing sites, on quaysides or in local markets, where processed fish can also be purchased. Fish is also sold in markets outside the local area. In this case, the fish is mainly processed, due to the lack adequate cold storage facilities. A large amount of the smoked fish produced around Lake Maga is transported to the regional markets in the north of the country and to Nigeria and Chad in particular.



from top to bottom:  
91: Line fishing on Lake Maga, Cameroon  
92: Beach seine  
93: Dumbas dam

Table 18: Quantity of fish sold each year in Lake Chad in 2002 and 2003

Country	Volume of fish sold (tonnes, dry weight converted to wet weight)	Value of the fish sold (USD)	% of the total value	Main markets served
Cameroon	24,800	8,000,000	14%	Local, urban, Nigeria
Chad	10,873	6,400,000	12%	Local, urban, Nigeria
Niger	37,840	14,800,000	27%	Local, Nigeria
Nigeria	45,864	26,000,000	47%	Local, urban, southern Nigeria
<b>Total</b>	<b>119,377</b>	<b>55,200,000<sup>1</sup></b>	<b>100%</b>	

Source: Neiland and Béné, 2004

<sup>1</sup> Figure for 2002/2003



In N'Djamena there is a huge demand for fresh fish, but supply is limited due to the poor road network linking fishing sites to the city and by the poor development of cold chains, needed to keep the fish fresh. The modernisation of the Guité-N'Djamena main road, completed in 2007, has eased the transport of fresh fish to the capital. Smoked and dried fish are in most cases destined for markets in neighbouring states (Nigeria, Cameroon and the Central African Republic). Cross border transport towards Nigeria from Chad can occur by motorcycle or even by bus, however, most is transported in articulated lorries, such as the level of demand in Nigeria.



94+95+96: Fish transformation techniques, from top to bottom: drying, smoking and frying



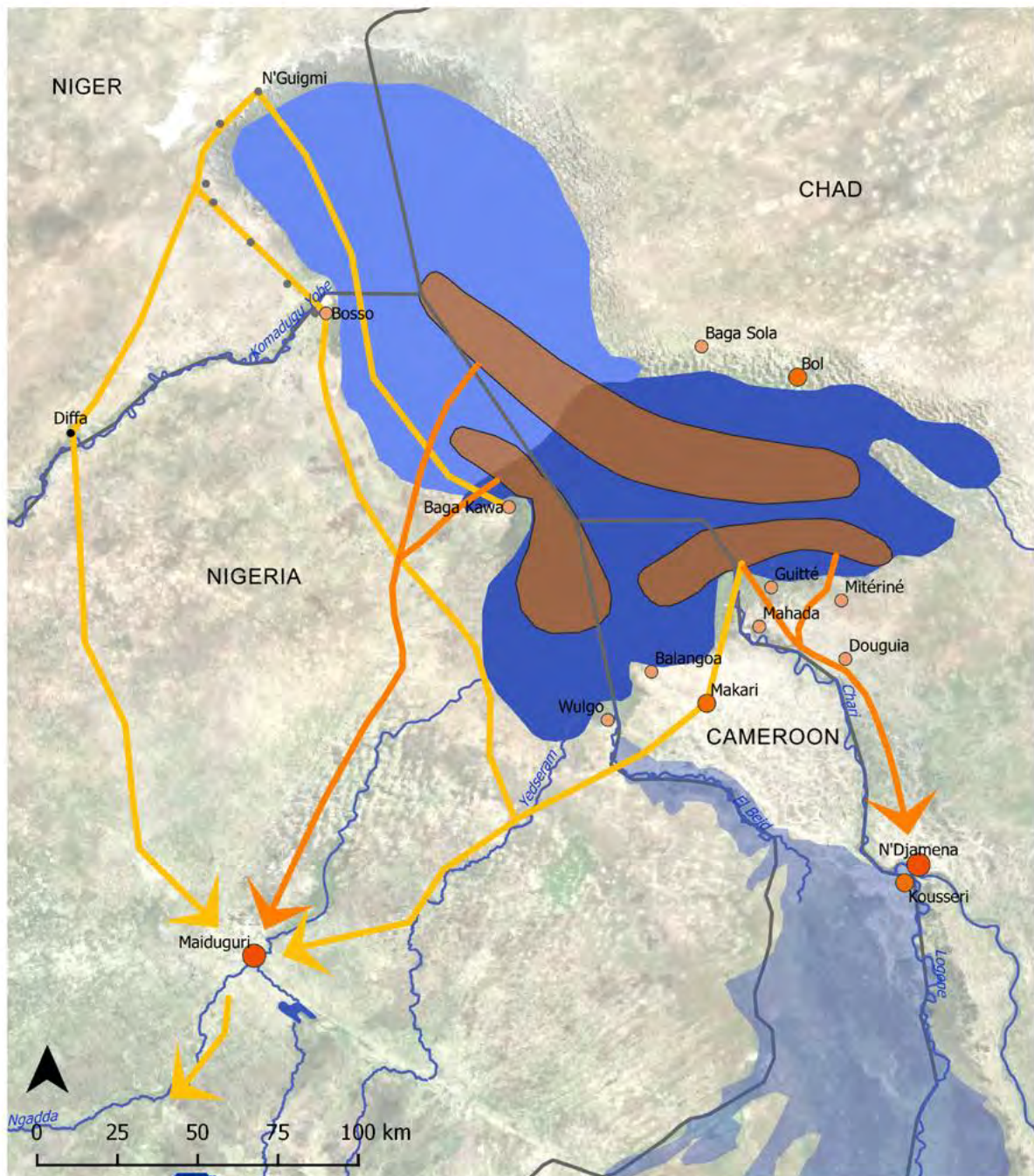
97: Marketing smoked fish is an activity reserved for men



Map 19: Fishing activities around Lake Chad

### FISHING ACTIVITIES AROUND LAKE CHAD

- Fishing grounds
  - Fish fluxes**
  - Fresh fish
  - Smoked or dried fish
  - Mayor fish markets**
  - Primary
  - Secondary
  - Tertiary
  - Floodplains
- Lake Chad**
- Irregularly flooded areas
  - Regularly flooded areas
  - Other villages and camps mentioned in the text



Source: LCBC et IRD

### Income from the sale of fish

Most of the available data on fishing activities is more than 10 years old. It is estimated that commercial fish production for the whole basin in 2002–2003 stood at 120,000 tonnes per year against a potential production in the region of 250,000 tonnes per year. Nearly one third of this tonnage would come from the southern pool of Lake Chad.

Fish is either consumed by the fishing families and / or sold fresh, smoked or dried on local markets. The price of fish varies according to the country, the size of the fish, its species and the market. In N'Djamena, fish prices can vary between 3,000 F CFA to 20,000 F CFA francs depending on the species and the weight. Fishing therefore clearly contributes to food security and to combating poverty for thousands of people.

A study carried out only within the Nigerien part of the basin in 2003 estimated the revenue from the the export

of smoked fish to Nigeria to have generated an inflow of foreign currency of 7,409,225,000 CFA francs or 12,740,000 US dollars, and customs revenues of just over 102,241,297 CFA francs or 175,855 US dollars in the same year.

The total commercial value of catches in the year 2003 was USD 55 million. In 2012 the estimates provided in the Ecosystem Approach to Fisheries (EAF) national reference reports considered annual production in Lake Chad to be around 100,000 tonnes, with a value of around USD 220 million, contributing 0.06% to the BIP.

### Constraints in the fishery sector

The fishers sector in Chad has suffered decades of drought, which has seen water levels recede, floodplain areas shrink, water sources dry up and lakes silt up due to accelerating rates of erosion.

In the course of their work, local fishermen employ illegal and harmful techniques, involving such things as toxic products, explosives, non-selective nets and canal fish traps (more than 3,000 such canals have been counted in the Waza-Logone floodplain in Cameroon).

With a lack of employment opportunities in other sectors, the fishery sector has substantially developed around the lake, attracting large numbers of migrant fishermen and young people. It even draws men and women away from other sectors. Established fisherment take a dim view of this competition, and conflicts regularly arise.

The fishery sector suffers from a lack of reliable statistical data on the workforce engaged in fishing, fish production and the composition of catches.

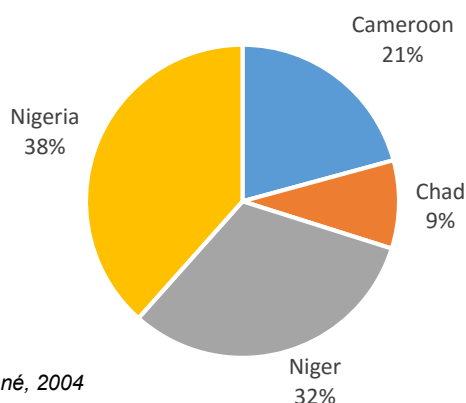
Table 19: Fish production in Lake Chad by country in 2002–2003 based on market information

Country	Volume of fish traded (tonnes, wet weight)
Cameroon	24,800
Chad	10,873
Niger	37,840
Nigeria	45,864
<b>Total</b>	<b>119,377</b>

Source: Neiland and Béné, 2004

Figure 25: Shares in fish trade per country in 2002 – 2003 according to market surveys (as a %, wet weight)

### Shares in fish trade per country in 2002–2003 according to market surveys (as a %, wet weight)



Source : Neiland and Béné, 2004

### Fisheries and Climate Change in Lake Chad

Climate change along with the pressure exerted by fishermen has profoundly influenced fishing in the Lake Chad basin. For 40 years the receded lake was only been present in the southern pool and to a certain extent in the marshes, in spite of high-flow rates occurring elsewhere. The relative flatness of the terrain means that variations of a few centimetres can flood the islands, as happened in 2012, or see the lake shoreline recede by several kilometres.

Such variations have not, however, not been beneficial to fish reproduction. Lake Chad’s northern pool remained dewatered for a long period (1976–2008), forcing fishermen to diversify their activities and move into farming, due to the uncertainty and insecurity caused by the varying water levels of the lake. The species of fish currently caught by fishermen, although once plentiful and varied, are struggling to survive the onslaught of overfishing and the drop in water levels caused by the variable of the climate. This situation has negatively affected not only the aquatic ecosystems but also the fishing communities, leading them into poverty and food insecurity.

As such, the fishing sector remains exposed to a number of external and internal risks, such as the recurrent droughts that have affected the basin since 1973, the siltation of water bodies and watercourses, the proliferation of invasive aquatic plants, premature dewatering, the reduced biodiversity, increasing water pollution, and harmful fishing practices.

At the national level, fishing remains insufficiently integrated into climate change policies and strategies, and no

detailed study has been conducted on the sector. However, the evidence points to a serious decline in fish production over several decades and the disappearance of even once common species.

At regional level, the strategies adopted by the fisheries services in order to integrate the sector focus largely on strengthening the capacities of fishing communities, supporting them with fishing materials and equipment and facilitating access to basic social services.

Local adaptation strategies for climate change have been widely developed. Farming has become increasingly popular amongst fishing communities for the following reasons:

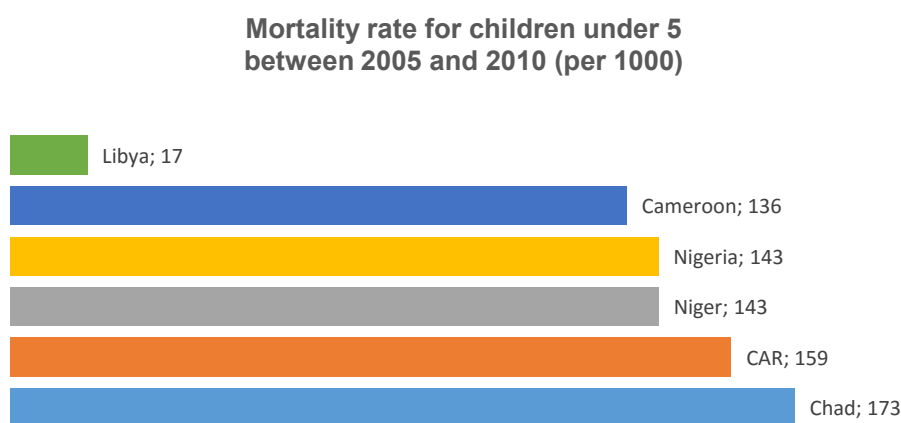
- the retreating shorelines near a number of villages and encampments have helped to expose fertile land for farming;
- livestock farming has intensified due to the appearance of new grazing areas formed by the changing aquatic ecosystem;
- the small-scale trading of farm produce, cattle and manufactured goods has profited from cross-border trade between Chad and Nigeria;
- temporary and even permanent migration flows have intensified;
- precautionary savings (in the form of cattle or their exchange value with gold or jewellery) are being set aside.

### Food security

Ensuring food security is one of the major challenges facing the nations of the Lake Chad basin. In the current

context, with an unfavourable climate, extreme population pressure, internal and regional military conflicts, a particularly high level of poverty, inadequate policies and weak institutions, the challenge is daunting.

Figure 26: Mortality rate for children under 5 between 2005 and 2010 (per 1000)



Source: UNDP Human Development Report 2012

Nearly 46% of the population's diet consists of cereals, and 20% of tubers. These foodstuffs primarily provide energy but do not contain sufficient levels of the vitamins, mineral salts, proteins and lipids required for a balanced diet. The Lake Chad basin is thus a region of widespread malnutrition, with a dietary energy supply of less than 2,000 kilocalories per person per day.

All the Lake Chad basin countries have alarming levels of hunger, with some witnessing extreme levels. The Global Hunger Index (GHI) is a multidimensional statistical tool that describes the state of hunger in different countries. The GHI value for Chad is over 30 and is between 20 and 29.9 for the other basin countries. It is expected that this will worsen in the coming years, as the security and economic situations have reached a critical point, demograph-

ic growth is large and climate change is negatively affecting agriculture. With poverty conspicuous throughout the basin, many young people seek to flee the region or join armed groups leading to increased social unrest.

The countries of the Lake Chad basin depend heavily on imported goods and lack national food reserves, increasing their vulnerability to food shortages. With the exception of Libya, many of the basin countries rely on cross-border trade to ensure their food security. This involves trading livestock and farm produce with Nigeria and Cameroon, the only basin countries with direct access to the sea. Overall, the states are structurally deficient in terms of the availability of dry cereals (rice, millet, maize, sorghum). However, the long borders between countries and the states' agropastoral and socio-economic complementarities serve to considerably facilitate

Figure 27: Global Hunger Index national trends from 1990 to 2012

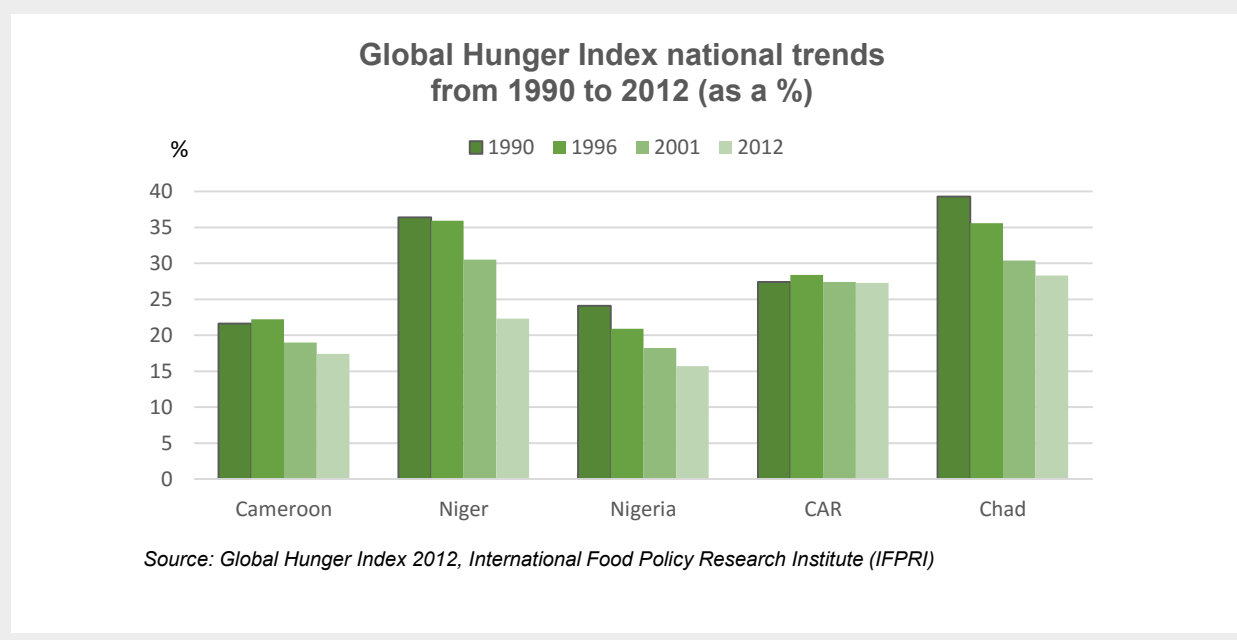
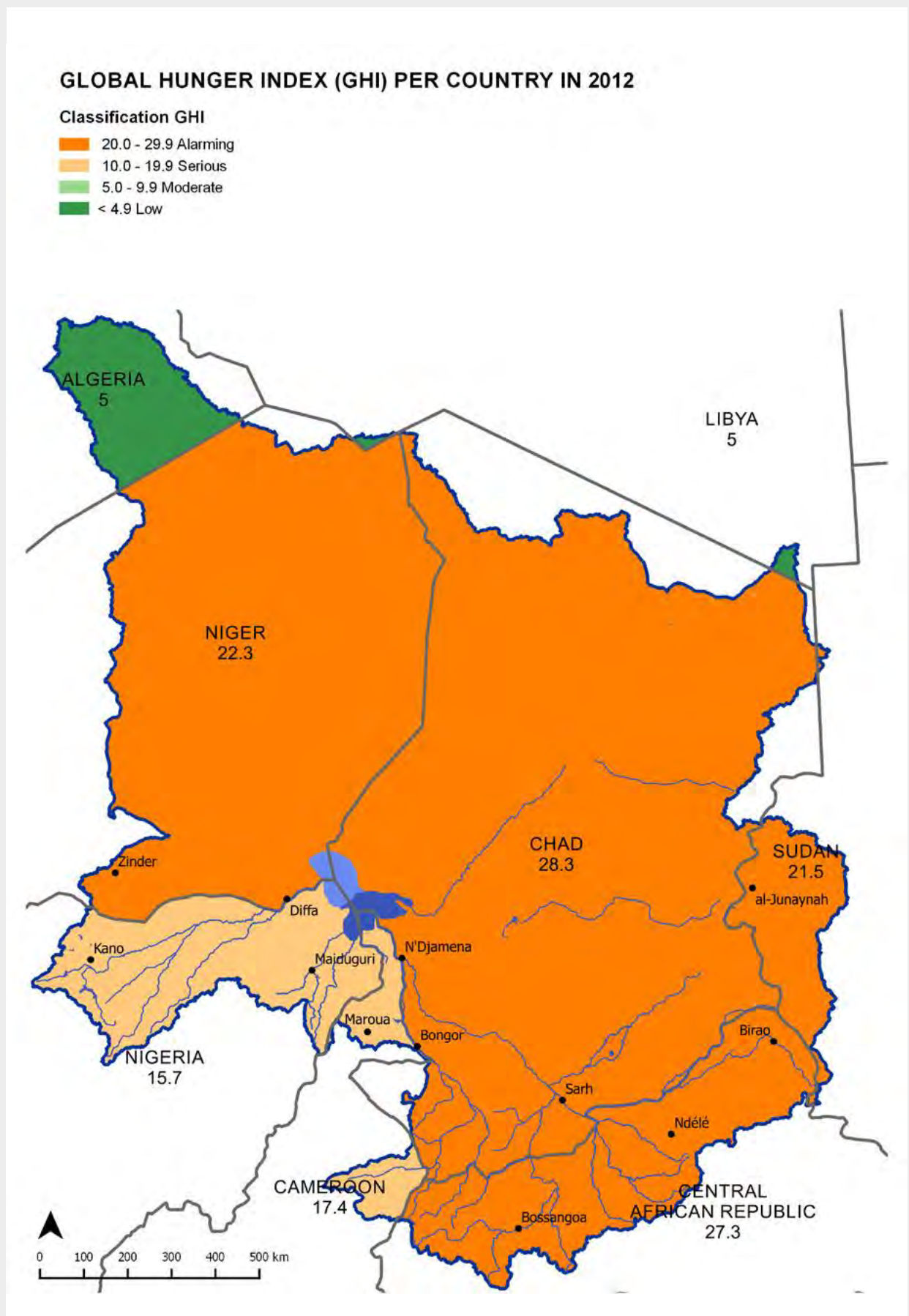


Table 20: Data used to calculate the Global Hunger Index in 2012

	Proportion of undernourished people	Prevalence of wasting in children under five	Under-five mortality rate
Cameroon	22%	16.6%	13.6%
Libya	1%	5.6%	1.7%
The Niger	16%	36.6%	14.3%
Nigeria	6%	26.7%	14.3%
Central African Republic	40%	26.1%	15.9%
Chad	39%	28.7%	17.3%

Source: Global Hunger Index 2012, IFPRI

Map 20: Global Hunger Index (GHI) per country in 2012



Source: Global Hunger Index (GHI) by country in 2012

trade. Trade between Nigeria and Niger includes cereals, cowpeas, bell peppers, cattle and manufactured goods. Between Cameroon, Chad, the CAR and Nigeria it involves cereals, bananas, potatoes, onions and also manufactured goods.

That said, the international crises in 1973, 2005 and 2010 have exposed the limits of food supply strategies that rely on neighbouring countries. Niger's experience in 2005 is a case in point, as Nigeria, upon which Niger is largely dependent, was no longer able to satisfy import needs.

The causes of these deficits in gross cereal production in the Lake Chad basin countries are manifold, with locust swarms and low rainfall principal among them. They are exacerbated by armed conflicts such as those in Nigeria, Libya and the Central African Republic in 2012, which prevented farmers from cultivating thus interrupted the flow of trade between countries and within the region.

Certain basin countries such as Niger have mechanisms in place at the regional level to analyse, prevent or managing food crises, such as the Permanent Interstates Committee for Drought Control in the Sahel (CILSS). The CILSS draws up maps displaying each country's vulner-

abilities to food insecurity, which are then consolidated for the whole region at the analysis stage. The analyses assess the state of vegetation (maps showing vegetation anomalies, cumulative normalised difference vegetation indices [NDVI], evaluations of the vegetation by area) and rainfall, and are based on satellite data and water source and wetland monitoring. Analyses of the crop year in terms

### Lake Chad's role in ensuring food security

The fertility of Lake Chad's soils and the use of family-farming-based crop-growing techniques make the area around the lake a major cereal producer. Opportunities for growing different agricultural produce around Lake Chad include growing cowpea on the southern shores, bell pepper along the Komadugu-Yobe and diverse vegetables on the southern and south-eastern shores. The Lake also produces sources of animal protein that are competitive against imports and suited to local dietary habits. Lake Chad therefore not only produces foodstuffs and provides employment, but also contributes to the region's food security and to improving local people's living conditions.

Table 21: Factors influencing food security in the Lake Chad basin

<b>Natural factors</b>	
<b>Irregularity and duration of rainfall</b>	Rains are either early or late, too much or too little, or even fail, thus damaging crops.
<b>Drought</b>	Droughts are long, and intermittent and watercourses dry up quite quickly, which jeopardises irrigation systems.
<b>Flood</b>	Excessive rain in July and August harms crops and washes away plantations, human habitats and infrastructure.
<b>Seed-eating insects and birds</b>	Locusts, red-billed quelea, caterpillars, termites and rodents attack crops. The means for their control are not sufficiently developed.
<b>Pachyderms</b>	During their seasonal migration, elephants damage fields and homes.
<b>Diseases</b>	Cattle are hit by epidemics, such as rinderpest and foot-and-mouth disease, and may be left decimated.
<b>Human factors</b>	
<b>Poor harvest management</b>	Farmers sell off their entire harvest to large-scale traders, often not retaining some stocks and set aside some earnings.
<b>Deforestation</b>	In generally Sahelian environments, slash-and-burn farming and other unsustainable wood harvesting practices leave the terrain vulnerable to desertification.
<b>World food crises</b>	The prices of agricultural raw materials and basic foodstuffs are rising.
<b>Poorly functioning markets</b>	Traders are poorly structured and organised: <ul style="list-style-type: none"> <li>• capacities for financing trading activities are very limited (access to credit is still very rare and loans are expensive);</li> <li>• storage practices are very underdeveloped;</li> <li>• the transport system is not very effective.</li> </ul>
<b>Conflicts</b>	Social conflicts inhibit commerce and cross-border trade. Armed conflicts displace populations who lose their labour force, livestock, fields, seed beds and tools.
<b>Low agricultural yields</b>	Because farmers' equipment is archaic (hoe, daba, machete, etc.), they fail to produce enough crops to meet rising demand. The mechanisation of agriculture remains a distant objective.
<b>Inefficient water use</b>	Water is managed irrationally on a case-by-case basis and without coordination.

of cereal production, of rangeland in terms of the availability of biomass for cattle and of water source replenishment are also considered. Factors associated with nutrition and mortality are also included, as well as transitory factors, such as conflicts, locust activity and market-related risks.

Conversely, other countries such as the Central African Republic do not have long-term and effective mechanisms in place to monitor their population's food security and to coordinate interventions. The problems facing statistics offices make it impossible to regularly formulate indicators and gather the information required to draw up short, medium and long-term response strategies.

### Gender and productive activities

Gender inequalities with regard to food security are common in the Lake Chad basin. Gender roles are clearly and rigidly defined, so that the distribution of income from productive activities in the basin is uneven. In the agricultural and livestock sector for example, men control the capital, i.e. the fields for agriculture or livestock for breeding. Women and children are generally considered as «free» labour for agriculture sector: they work on the preparation of fields for sowing and in harvesting without the direct benefit of product revenue. In the livestock sector, women play an important role in the processing and marketing of products and reap the profits. In the fishing industry, fish processing is an exclusively female activity, as is the marketing of fresh fish and fish sales through small restaurants, but men are responsible for the sale of smoked fish, which generates substantial revenues. Women generally have less access to land and when they do have land it is limited to small areas with little productive resources (inputs, equipment, etc.) due to their smaller revenue base.



98: The sale of jujube fruits



99: Selling grilled fish in Maroua, Cameroon



100: A local market on the border to Nigeria attracts a large number of Cameroonians

## Public health and water-related diseases

### Water-related diseases

Waterborne diseases are primarily caused when people drink water contaminated with human or animal faeces. These diseases include cholera, typhoid, dysentery and diarrhoea. In the Lake Chad basin, these diseases are very prevalent and diarrhoeal diseases are the main cause of child mortality. Children and pregnant women are most vulnerable to water borne infections caused by the consumption of non-potable water.

Diseases spread by water related vectors are also very common and include malaria, yellow fever, dengue fever, filariasis (e.g. elephantiasis and river blindness) and trypanosomiasis. In general, the vectors causing these pathologies bite or breed near open water. The female Anopheles mosquito, which transmits malaria, is one such case, given it lays its eggs on the surface of stagnant water. Water based diseases are caused by aquatic organisms that spend part of their life cycle in the water and another part as parasite of animals and include schistosomiasis and Guinea worm. In 2015 Chad reported 41% of all Guinea worm disease cases worldwide, which is spread through exposure to standing water and drinking water contaminated with the worm's larvae.

A further category of water related diseases in the basin are due to poor hygiene practices resulting from the limited availability of water, known as water washed diseases. These include skin, eye and respiratory tract infections as well as louse borne typhus.

According to the Ministry of Public Health in Niger, eight of the country's ten most common diseases are water related.

The rainy season is a period of heightened risk for many water related diseases, with increased faecal contamination of water sources, and increased standing water. Providing access to protected, treated drinking water supplies, safe and appropriate sanitation, sleeping mosquito nets and ensuring the evacuation of stormwater would all help dramatically lower the massive impact of water related diseases on the population of the basin.

### Despite the progress made, sanitary living conditions have not been secured

In the countries of the Lake Chad basin the lack of potable water and poor levels of sanitation and hygiene are the main causes of mortality and morbidity among the population. 45% of the rural population have access to an improved water supply, whilst 70% in urban areas have access. In some remote areas children and women walk miles each day to fetch water.

Access to improved sanitation in the basin is extremely poor. In rural areas, open defecation is practiced by the vast majority of people and in urban areas an average of only 30% of the population have access to improved facilities (excluding Libya and Cameroon). Access to sanitation facilities and hygiene are key factors in preventing waterborne diseases.

Although development policies have undeniably delivered some progress in recent years, it has been insufficient to ensure that people living in urban and rural areas have potable water and appropriate sanitation facilities.

In recent years the Cameroonian government has been rolling out major potable water supply programmes in urban, periurban and rural areas. This has included an extensive awareness-raising campaign, during which water connection fees were halved in order to substantially open up access to drinking water.



101: Water has multiple uses: fishing, maintaining bicycles, bathing and for laundry...



Other diseases

*In spite of the intensification of awareness-raising campaigns, malaria is still rife*

Mortality factors in the Lake Chad area include a number of water-related diseases such as malaria, which occurs in wet areas where vector-mosquito populations can rapidly multiply. Bouts of malaria, known locally as the ‘fever’, are responsible for a large number of deaths among young children. Around 50% of the diagnoses recorded in health clinics are for malaria.

*A high prevalence of sexually transmitted infections in the Lake Chad area*

According to a study carried out by the Lake Chad Initiative Support Programme to reduce STI/HIV/AIDS vulnerability and risks (PAIBLT), seroprevalence across the five countries is fairly high at 10.1%. Within each country there are disparities between social categories and also regionally between towns and villages on the one hand and between states on the other.

The situation is particularly disconcerting in Nigeria where nearly a quarter (24.1%) of those who had blood taken and tested under the PAIBLT project were shown to be HIV

Figure 28: Access to improved water supplies in 2011

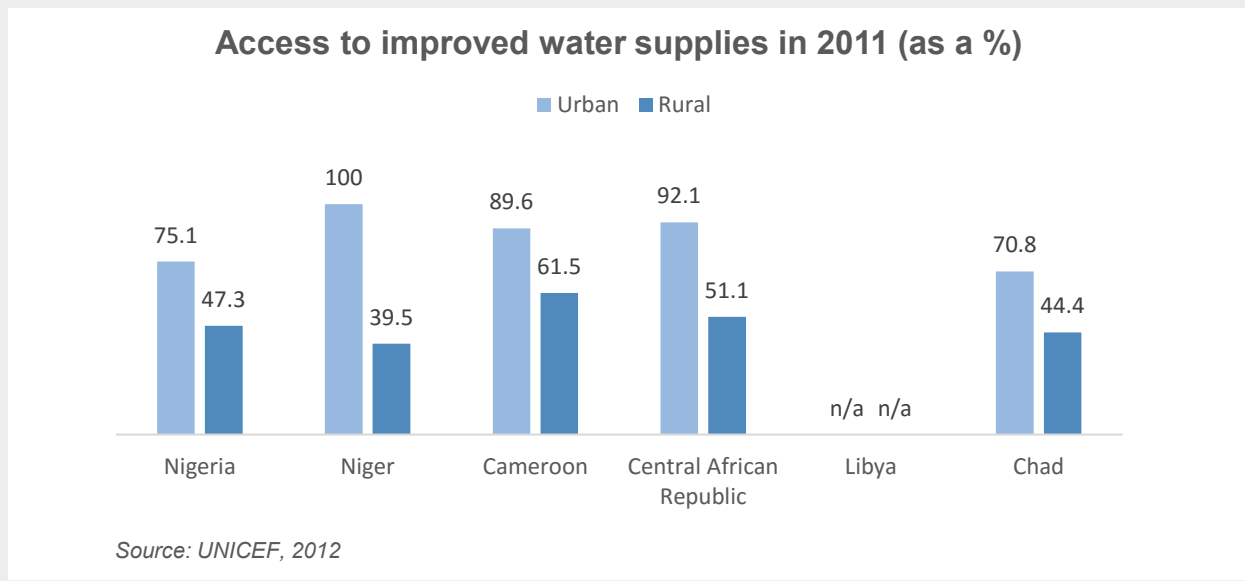


Figure 29: Access to improved sanitation in 2011

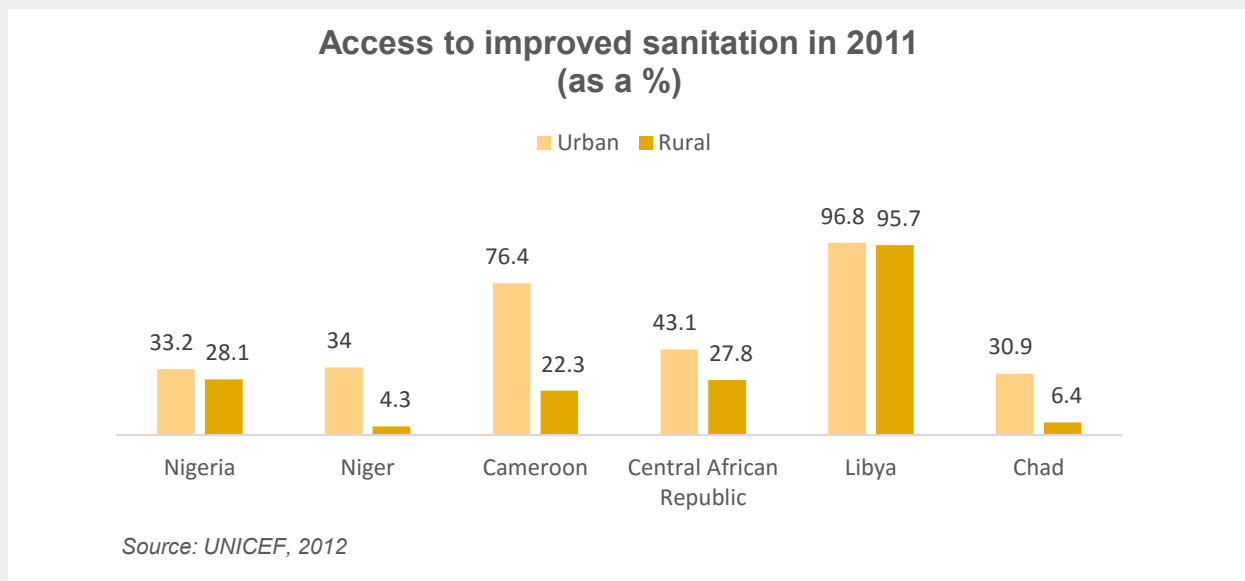
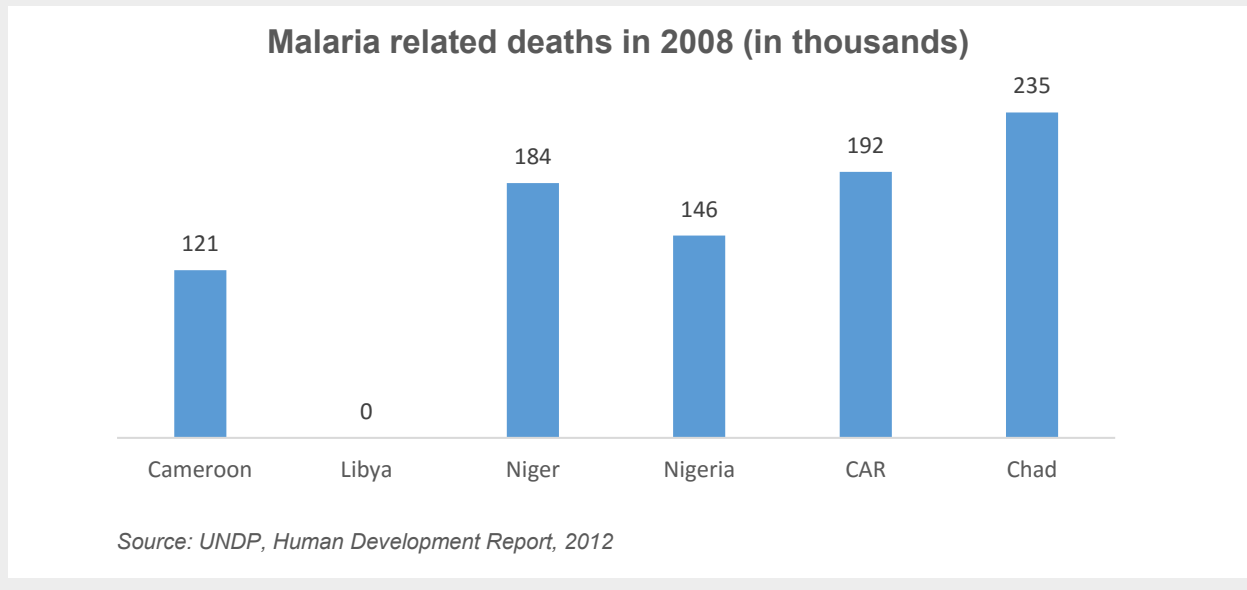


Figure 30: Malaria related deaths in 2008 (in thousands)



positive. The CAR ranks second with a seroprevalence rate of 7.3%, and Chad third with 5.4%. Cameroon’s seroprevalence rate is 2.5% and Niger’s is 1.8%. The situation on the islands is particularly alarming and requires an urgent response. Kinasserom Island, with a population of around 10,000 inhabitants, has a prevalence rate of 18.5% (according to a 2009 study).

This study shows that on average more men are infected (10.4%) than women (7.9%). The highest levels of male seroprevalence were recorded in Nigeria (24.6%) and the lowest in Niger (0.8%). Female seroprevalence is likewise highest in Nigeria (22.8%), but is lowest in Cameroon (2.1%). Migration and mobility have exacerbated the problem of sexually transmitted infections (HIV/AIDS, gonorrhoea, herpes, etc.) among men and young migrants, who then pass these diseases on to women and girls in the basin.

Efforts by basin states have not been enough to achieve the Millennium Development Goals. The relative isolation of Lake Chad, the lack of hospital and road infrastructure as well as security problems do not encourage health workers to work in the area.

Efforts by States are not enough to achieve the Millennium Development Goals. Isolation of Lake Chad, lack of hospital and road infrastructure as well as security problems do not encourage health workers to want to work in the area.



from top to bottom:  
 102: LCBC’s awareness-raising campaign  
 103: Location of Kinasserom, Chad

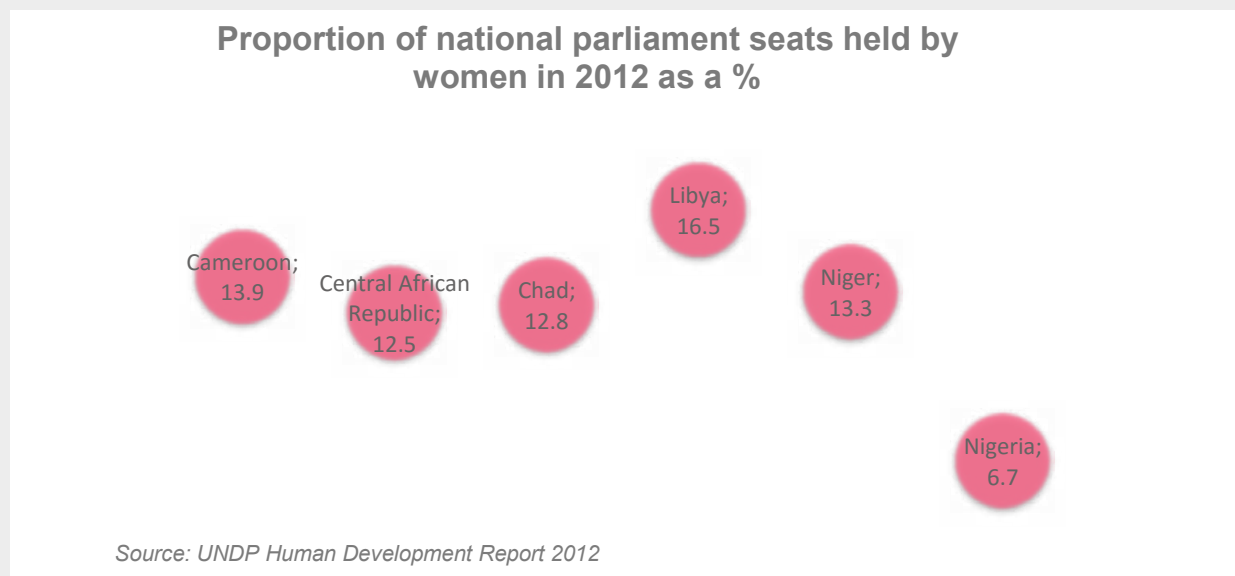
### Gender

The issue of gender is defined by the notion of inequality between men and women. To bring about equality between the sexes, legal instruments designed to eliminate all practices that discriminate against women and to promote positive discrimination are in place. National gender policies need to be aligned with relevant national and international instruments such as the Beijing Platform for Action, the New Partnership for Africa’s Development (NEPAD), the African Union’s Solemn Declaration on Gender Equality in Africa, the Protocol to the African Charter on Human and Peoples’ Rights on the Rights of Women in Africa, the Convention on the Elimination of All Forms of Discrimination against Women (CEDAW), the Programme of Action of the International Conference on Population and Development, the Millennium Development Goals and a wide range of other sectoral strategies.

In the Lake Chad basin, the issue of gender is a major socio-cultural problem, in view of the immense disparity between men and women in terms of their participation in development processes and, above all, their contribution and share of GDP. This issue is made manifest in, among other things, the limited participation of women in politics.

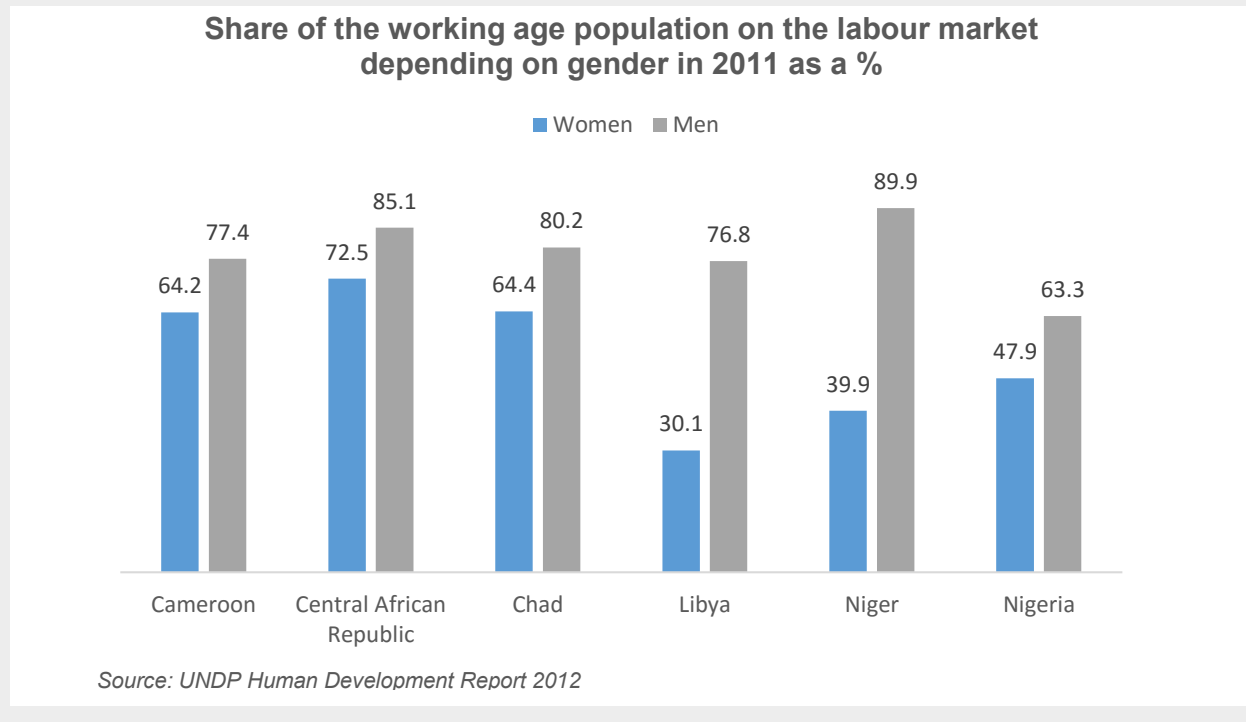
Most women face severe discrimination in all aspects of life in the countries of the Lake Chad basin. This discrimination is exacerbated by powerful cultural influences, particularly in the Far North region of Cameroon, part of Chad, the Niger and, above all, the north of Nigeria. In these parts of the basin, the early marriage of girls is given precedence over formal education, and women are required to keep house and rear the children. In the north of Cameroon and the south of Chad, the traditional ancestral practices of forced marriage and female genital mutilation (excision) predominate, with the latter attributed to certain tribal groups like

Figure 31: Proportion of national parliament seats held by women in 2012



104: Ensuring drinking water in the home is a task generally seen to be for women and children

Figure 32: Share of the working age population on the labour market depending on gender in 2011



the Banda from the north of the Central African Republic. Gender-based violence, which is rooted in social roles, is commonplace and attributed to men everywhere in the basin. In Chad, for example, an MICS report (Survey by MICS 2010) shows that “18% of women aged 15-49 were beaten (physical abuse) and 12% were victims of sexual violence. The rate of female genital mutilation is 44%”. This violence constitutes a public health issue and is one that is common in all basin countries, as is poverty, which is feminised throughout these countries. The poor management of public finances, humanitarian crises that separate children from their families, sexual harassment in educational institutions are all causal factors with regard to gender issues in the states of the Lake Chad basin.



105: Women spend several hours a day collecting firewood in rural areas

### National strategies and an assessment of gender inequality

In general, women and girls are discriminated against in many areas of public life including health and education, political representation, the labour market, etc. The negative impact on the choices then available to women and girls are enormous. These repercussions are measured using the Gender Inequality Index (GII), which assesses inequalities in three important areas of human development: reproductive health, measured using the maternal mortality rate and the adolescent birth rate; empowerment, measured by calculating the share of parliamentary seats held by women and the proportion of adult women and men aged 25 or over who have completed at least one stage of secondary education; and economic status, expressed in terms of women's participation in the labour market and measured using the labour force participation rates of women and men aged 15 and over.

In 2011 the GII ranking of the 187 countries that had been assessed in this regard placed the Lake Chad basin states in the group of ten countries with heightened gender inequality and therefore a more unequal distribution of human development. Chad (183) and Niger (186) are the two most unequal countries in terms of gender, followed by the Central African Republic (179), Nigeria (156), Cameroon (150) and Libya (64). To reduce these inequalities a number of reforms have been pushed forward across the basin:

- In Niger, a ministerial department responsible for the advancement of women has been established and a gender policy adopted

- The Government of Chad has made considerable progress with the schooling of young girls. This has helped improve gender parity in relation to primary education, with the proportion rising from 61% in 2000 to 70% in 2010.
- Nigeria's new National Gender Policy recognises the need to develop gender equality strategies and to transform the institutions perpetuating both inequality between the sexes and poverty in order to promote sustainable development and democratic governance in the country. Women make up around 49.6% of the total population of Nigeria, yet they hold less than 5% of political or elected positions. The nominations for ministerial positions still fall below the minimum level for women's representation, which should be at least 30% according to international requirements.
- In the Central African Republic, the law grants men and women the same inheritance and property rights, although this often conflicts with customary practices. However, the coming into force of the Family Code in this country has reinforced women's rights – e.g. one ordinance bans female genital mutilation (excision and infibulation).
- Despite shortcomings, Cameroon has made some progress in terms of the representation of women in local politics: from zero female mayors in 1982, there were 23 in 2007. Women occupied 6.6% of all alderman positions in 1982 and 13.1% in 2002 before experiencing a decline in 2007 (6.9%).



106: Women are supported to develop income generating activities through the intervention of different projects



107: Women are responsible for the transformation and preservation of fish

## Governance

The overall objective in terms of governance is to strengthen the rule of law and the effectiveness and transparency of public administration. The institutional, social and economic reforms undertaken by Lake Chad basin states in recent years are based on the principles of responsibility, accountability, transparency, respect for the law, the fight against corruption and public participation.

### Water governance at the national level

The legal arsenal to enforce the integrated management of water resources in the Lake Chad basin is in place in all the LCBC member states. It is established through a water code, a land code and an environmental code.

**The water codes:** These cover resource-sharing issues, environmental protection and sometimes decentralised management. These codes were developed in the 1990s based on the key IWRM principles emerging at that time.

These key principles are the management of resources at the river basin level, taking into account the social and economic value of water, cross-sectoral and coordinated management, the principle of subsidiarity, environmental sustainability and participatory governance.

**The land codes:** The land codes of all the basin states are considerably older than the water codes but their implementation remains challenging, and the coexistence of customary law and traditional law is sometimes problematic.

**The environmental codes:** All basin states, with the exception of Nigeria, have environmental codes in place. Nigeria has only one law in this area on the evaluation of environmental impacts associated with human activities.

Whilst these codes do exist, legislation for implementation is lacking across the board, as are efforts to roll the codes out nationally. Only Cameroon and Niger have implementing legislation in place for their environmental codes.

Table 22: Overview of national water management policies

<b>Cameroon</b>	<p>Water governance falls to three ministries in Cameroon: Mines, Water and Energy; Agriculture; and the Centre for Hydrological Research (Ministry of Scientific and Technical Research).</p> <p>Since the irrigation and water sector was privatised following the crisis in the 1980s, productivity has fallen. In response, the state is now directing its policy towards the farming of existing schemes, small-scale irrigation and the promotion of private sector investment in irrigation.</p> <p>Since 1998 Cameroon has had a law in place aimed at protecting against pollution and preserving water resources and drinking water quality (Law No 98/005 of 14 April 1998).</p>
<b>Libya</b>	<p>With regard to agricultural irrigation, the Ministry of Agriculture and Livestock is responsible for implementing major irrigation projects. The Ministry of Municipalities is in charge of urban water supplies.</p> <p>The General Water Authority (GWA) is responsible for monitoring and evaluating/estimating water resources, particularly with regard to irrigation and drainage projects.</p>
<b>The Niger</b>	<p>Ordinance No. 2010-09 of 1 April 2010 establishing the Water Code in the Niger sets out the ways in which water will be managed throughout the country. It specifies the conditions pertaining to the organisation of water supplies for people and livestock on the one hand, and pertaining to irrigation schemes on the other. It also defines the missions and responsibilities of the National Water and Sanitation Commission (CNEA) and the Regional Water and Sanitation Commissions (CREA). Regarding water governance, the Ministry of Hydraulics and the Environment, the Ministry of Agriculture and the Ministry of Livestock direct water policy in the Niger.</p> <p>The Niger set out its IWRM vision in two founding texts: the Economic and Social Development Plan 2012, which aims to strengthen service provision in terms of access to drinking water, hygiene and sanitation at the local authority level, and the 3N Plan (Les Nigériens Nourrissent les Nigériens – the people of the Niger feeding the people of the Niger), which aims to ensure the food security and self-sufficiency of the country by increasing the amount of land under irrigation to 125,000 ha by 2015.</p>

<b>Nigeria</b>	<p>The Ministry of Water Resources is the principal coordinating body with regard to water policy in Nigeria. It handles irrigation, hydrological and meteorological statistics and studies, as well as legislation.</p> <p>Other Nigerian institutions are involved in the formulation of water policies, particularly the National Council of Water Resources, the National Technical Committee on Water Resources, the Ministry of Agriculture and Rural Development and the River Basin Development Authorities.</p> <p>The key feature of water management in Nigeria is that its administration is decentralised but lacks adequate coordination. Integrated water resource management has not been enshrined in a single founding policy instrument, but is instead embedded in a range of legislation relating to irrigation, agriculture, decentralisation and navigation.</p>
<b>Central African Republic</b>	<p>The Central African Republic has placed water resource governance under different central government ministries: Agriculture and Livestock; Public Works; Environment and Ecology; Water, Forests, Hunting and Fishing; Mines, Energy and Hydraulics; and Rural Development.</p> <p>There are also three regional directorates for hydraulics, which come under the Ministry of Mines, Energy and Hydraulics and its General Directorate of Hydraulics.</p> <p>The IWRM approach was defined in 1995 through the National Policy and Strategies for Water and Sanitation, which were produced with the assistance of the project supported by the National Committee for Water and Sanitation.</p>
<b>Chad</b>	<p>Water governance in Chad is distributed among several ministries and public and quasi-public institutions, some of which operate regional services. They comprise:</p> <ul style="list-style-type: none"> <li>• the Ministry of the Environment and Water, which is responsible for managing and developing water resources;</li> <li>• the Ministry of Agriculture's Directorate of Rural Engineering and Agricultural Hydraulics (DGRHA), which is responsible for the development of irrigation;</li> <li>• the National Office of Rural Development (ONDR), which is the quasi-public implementing agency for agricultural development programmes;</li> <li>• the Lake Chad Development Company (SODELAC);</li> <li>• the Ministry of Livestock.</li> </ul> <p>The water sector remained fairly unregulated up until the National Assembly's adoption in 1999 of the Water Code (Law No. 016/PR/99). This aims to regulate the sector and at the same time deliver decentralisation and substantially involve the private and voluntary sectors as well as end-users. Legislation approving irrigation schemes has come into force, but is being poorly implemented.</p>

### *Weaknesses in water governance*

In addition to poor implementation of legislative provisions, countries are faced with various challenges:

- Problems in transposing international and subregional guidelines into national policy programmes.
- Specifically, current delays in ratifying the Lake Chad Basin Water Charter illustrate this.
- Integrated water resource management is a concept that is still poorly understood. In spite of the agreement reached by states on integrated water resource management, consultation remains weak, giving precedence to national interests.

Specifically: Irrigation schemes and their associated dam building, which impact on ecosystems and communities, are generally carried out without any consultation with neighbouring countries.

- Poor alignment of national development policies: Development policies sometimes end up competing against each other while broadly working towards the same objective, namely the fight against poverty, economic development and environmental conservation.

With consultation lacking, these strategies also contribute to regressing the situation in a number of areas that are equally important policy-wise.

Specifically: Cameroon's aspirations in terms of rice production, for example, have negatively impacted on the forest ecosystems of Waza National Park, drying up its natural ponds, which has led to the flight and even death of many of its wild animals.

- Unstable institutions blighted by a staff turnover: endless institutional reforms and ministerial turnover do not favour the continuity of policy implementation.
- Low levels of political will: Water governance is not given a high political priority by the Lake Chad basin states and combined with corruption at various levels has led to inertia in implementing the environmental policy adopted thus far.
- Support for local practices and customary laws, and limited access to environmental education.

Table 23: Similarities and differences between countries in terms of IWRM principles

IWRM principles	Countries	Recognition and implementation
Management at the river basin level	Cameroon	Legal recognition. Provision for creating basin committees.
	Niger	Limited recognition.
	Nigeria	Limited to parts of catchment areas and does not cover hydrological units.
	CAR	Included in the Water and Sanitation Code.
	Chad	Not included in the Chadian framework.
Consideration of the economic and social value of water	Cameroon	Provisions for ensuring that water supply is not free of charge.
	Niger	Not factored into the Water Code to give precedence to social aspects.
	Nigeria	The economic value of water was removed from legislation to give precedence to social and agricultural development.
	CAR	Given its constant availability, water supply is customarily free of charge. The state manages the social aspect as part of its public duties.
	Chad	Polluter-pays principle established as a remedy in the environmental code.
Cross-sectoral and coordinated management	Cameroon	A National Water Committee is in place.
	Niger	No formal consultation frameworks (in the legislation) to enable coordinated management at different levels.
	Nigeria	This principle is recognised, but management is not coordinated across all hydrological units. No mechanisms in place for consultation between basin authorities.
	CAR	Planned but not yet instituted.
	Chad	Mentioned but no practical implementation.
Principle of subsidiarity	Cameroon	NGOs manage water sources in rural areas.
	Niger	Absent from policy and legislation.
	Nigeria	Not included in legal measures.
	CAR	At the legislative principle stage.
	Chad	Mentioned but no practical implementation.
Environmental sustainability	Cameroon	Water has been protected against negative impacts since 1998.
	Niger	Provided for in the National Environment Plan (PNEDD).
	Nigeria	Reflected in legislation on environmental impacts.
	CAR	The international standards laid down in the legal corpus and in the management framework for water resources and natural ecosystems have been incorporated into national legislation.
	Chad	General principles to protect and sustainably manage the environment included in legislation.
Participatory governance	Cameroon	Undertaken by traditional authorities at the local level.
	Niger	Undertaken by water source management committees, but women's participation in these committees is low.
	Nigeria	Informal.
	CAR	Institutional framework at three levels (local, regional and national).
	Chad	Mentioned but no practical implementation.

### Water governance at the sub-regional level: institutions and tools

#### *The Africa Water Vision for 2025*

In 2000 the African Ministers' Council on Water (AMCOW) drew up the Africa Water Vision, which serves as a frame of reference for water resource management in all of Africa's countries. The objective of the Africa Water Vision is the

equitable and sustainable use and management of water resources for poverty reduction, socio-economic development, regional cooperation and environmental protection.

The African Water Facility (AWF), the instrument for implementing the Africa Water Vision, is an initiative run by the AMCOW and is designed to mobilise resources to finance water resource development activities in Africa.



**May 2007** – The Lake Chad Basin Commission (LCBC) received a donation of EUR 890,000 for the purpose of supporting the creation of a Lake Chad water charter for the four countries bordering the lake – Cameroon, Chad, the Niger and Nigeria – and also Libya (and the Sudan). This will act as a policy and legal instrument for equitable water distribution, joint investments and environmental management.

**December 2007** – The Government of Chad received a donation of EUR 490,000 for the purpose of drawing up a complete inventory of water supply and sanitation installations in the country’s rural areas. This inventory provides information on gaps in access and guides decision-making relating to planning and development in order to improve the water supply and sanitation services of rural populations where needs are greatest.

**July 2009** – The Government of the Central African Republic received a donation of EUR 2 million for the purpose of putting in place an institutional and regulatory framework designed to strengthen governance and institutional capacity in the water and sanitation sector in order to attract more funding and undertake more sustainable investments. The project sought to strengthen national capacities in terms of water governance, monitoring, management and water resource planning.

In view of the debate on the actual effectiveness of dams, ECOWAS has launched a regional consultation project on water-related infrastructure projects which aims to facilitate the exchange of experience and the sharing of good practices among countries.

*Tools of the Lake Chad Basin Commission (LCBC)*

Set up in 1964, the Lake Chad Basin Commission (LCBC) has undergone major internal reforms over the last 20 years to ensure that it functions more effectively. A blueprint for the LCBC was approved in 1994, followed by a first wave of restructuring in 1997 which sought to strengthen regional coordination. A second round of restructuring was carried out in 2010 to equip the LCBC with an effective team suited to the implementation of the Strategic Action Programme (SAP), drawn up in 2008.

The SAP, implemented by the Direction for Project Planning, Monitoring and Evaluation, sets out the intervention areas for the LCBC in the long term (up to 2025). It constitutes the action plan for the LCBC’s 2025 vision, a strategic instrument developed by the Commission. Its objectives comprise the protection of Lake Chad delivered in a sustainable way through the integrated water resources management (IWRM) of the basin. This will be a collaborative process that ensures the empowerment and participation of all the actors involved

*Water resource coordination units within the regional economic communities*

The Economic Community of Central African States (ECCAS) and the Economic Community of West African States (ECOWAS) are two international organisations created for the economic, social and cultural development of Africa. The former comprises nine member states, including Cameroon, the Central African Republic and Chad, and the latter 15, including Nigeria and the Niger.

The two organisations work in integrated water resources management and both contain water resources coordination units. The mission of the coordination units is to promote, coordinate and ensure the implementation of community policy on water resources management.

The following are two of the instruments and concepts instituted by these regional structures:

ECCAS, within the framework of its Regional Water Policy, has provided for the development of a Regional Action Plan for Integrated Water Resources Management in Central Africa (RAPIWRM-CA). This instrument aims, among other things, to restore the ecosystem of the Lake Chad basin. This ECCAS framework also provides for an impact assessment on the Congo basin in relation to the Inter-basin Water Transfer Project in which water could be transferred from the Ubangi basin to the Lake Chad basin.



**3- DIRECTION DE L'OBSERVATOIRE DU BASSIN (DOB)**

COUSSE I	Indicateurs	2014	Budget	Financement	Statut
Résultat visé en 2014 à l'Action 1.01					
1.01.1	Élaborer les conditions de facturation des services de gestion de la qualité de l'eau du Bassin du Lac Tchad				
1.01.2	Élaborer les conditions de facturation des services de gestion de la qualité de l'eau du Bassin du Lac Tchad				
1.01.3	Élaborer les conditions de facturation des services de gestion de la qualité de l'eau du Bassin du Lac Tchad				
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from top to bottom:  
108: The expert offices of LacBO  
109: Planning LacBO activities based on the PAS

Since 2010 the LCBC has also operated the Lake Chad Basin Observatory (LACBO), which seeks to enhance knowledge and to develop an integrated regional system to (a) provide information, (b) support decision-making and (c) monitor and evaluate progress towards achieving the effective protection and conservation of Lake Chad basin's ecosystems from a sustainable development perspective.

Its role includes managing the water data, information and knowledge on hydrology, hydrogeology, uses, users, needs, socio-economic matters, the legal/institutional frame-

work, and on the ecosystems, lands and environment of the whole basin required for sound decision-making. This observatory is tasked with providing information to the LCBC and any future consultation bodies of the member states, so that they have current knowledge on the different aspects of water management.

Additionally, the LCBC implements diverse development projects for lakeside populations in the areas of the environment, socio-economic development and health.

### The Lake Chad Water Charter

The Lake Chad Water Charter was officially adopted at the 14th Summit of Heads of State and Government of the Lake Chad Basin Commission, held on 30 April 2012 in N'Djamena, Chad, with ratification foreseen for 2013. Four of the six signatories were the presidents of the Niger, Nigeria, Chad and the CAR who personally ratified the document; the remaining two signatories for Cameroon and Libya were official representatives. The Charter is the first legally binding instrument concerning the Lake Chad basin to be collectively ratified by the highest political authorities since the Fort Lamy Convention of 1964.

The Lake Chad Water Charter is a contractual framework which establishes rights, obligations, duties, restrictions and procedures for the effective management of Lake Chad's resources.

The Charter's main objectives are

- the quantitative and qualitative management of water resources and wetlands,
- the management of groundwater, ecosystems and biodiversity,
- the procedures for approving new projects and installations of common interest,
- national and regional responsibilities,
- the dissemination and exchange of data,

- the prevention and resolution of conflicts, and
- the socio-economic development of lakeside populations.

The Charter makes provisions for, among other things, appropriate mechanisms to ensure the protection of the rights of lakeside populations to use water and other resources in terms of their right to water and sanitation, to information, to gender protection, to customary laws and to the support of NGOs. The good governance and socio-economic development of the sub-region and beyond is therefore considered to be of critical importance.

Furthermore, the Water Charter establishes or reinforces institutional frameworks aimed at ensuring sub-regional cooperation and integration. One of these, the Regional Parliamentary Commission for the Lake Chad Basin, was set up in 2004 with the primary aim of supporting the effective implementation of the scheme to transfer water from the Congo basin to Lake Chad. In addition to this Commission, the Charter has also recognised other subsidiary bodies, such as the Technical Committee of Experts, the Advisory Committee on Water Resources, the Advisory Committee on Planning, Sciences and the Environment and the national bodies of the LCBC.

However, as with all legal documents, the Charter is merely a document that can only be effective when it is faithfully implemented and upheld. In other words, its usefulness and effectiveness depend entirely on the capacity and will of the parties to adopt the measures required for its implementation.

## Water governance at the international level

The national policies of the LCBC member states' operate within the framework of the major international agreements they have signed and/or ratified. These include the following agreements which are aimed at the conservation of the environment and integrated water management:

- Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Helsinki, 1992);
- Convention on Wetlands (the so-called Ramsar Convention) (Iran, 1971);
- Convention on Biological Diversity (CBD) (Rio Summit, 1992);
- Convention to Combat Desertification in Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa (Paris, 1994).

## Strengths and weaknesses, opportunities and challenges in the institutional arrangements for managing the Lake Chad basin

A number of provisions in the Fort Lamy Convention from 1964 currently undermine the LCBC's management of water resources. No coercive power can be applied against a state that violates an agreement, because each state retains its sovereignty. Member states' national policies on water management still remain very weak and in some states they have yet to materialise. There is a lack of national and regional standards and guidelines for regulating the cost-sharing mechanisms for water, which contributes to the degradation of the environment around the basin and hinders people's access to certain by-products such as electricity.



110: The Executive Secretary in a meeting with the technical and financial partners

## Respect for the Ramsar Convention directives

The Ramsar Convention on Wetlands is applicable to the Lake Chad basin, which is the second largest wetland area in Africa. Article 5 of the Ramsar Convention sets out a well-established mechanism for international cooperation, in particular with regard to fresh water:

1. The Contracting Parties shall consult with each other about implementing obligations arising from this Convention especially in the case of a wetland extending over the territories of more than one Contracting Party or where a water system is shared by Contracting Parties.
2. They shall at the same time endeavour to co-ordinate and support present and future policies and regulations concerning the conservation of wetlands and their flora and fauna.

The Convention's New Guidelines for Management Planning for Ramsar Sites and Other Wetlands provides general directions for managing wetlands and stipulates in its 29th article that 'Wetland management, and particularly the planning process, should be as inclusive as possible'.

Aware of the importance of Ramsar Convention guidelines, the LCBC has committed to a process of cooperation with the Convention Secretariat. Accordingly, a memorandum of cooperation was signed in November 2002 by the two organisations setting the objectives, one of which is the strengthening at the national and basin levels of the organisational partnerships between all stakeholders, state entities, intergovernmental organisations, non-governmental organisations (NGOs) and other partners interested in the conservation and sustainable exploitation of wetlands.

The Ramsar Convention's measures on wetlands in effect provide strong incentives for an integrated approach to basin resource management that takes into account the interests of all stakeholders and places an emphasis on cross-cutting approaches to gender and co-management.

However, the LCBC's current missions and structure prevent it from effectively implementing the commitments undertaken with the signature of the Memorandum of Cooperation for the Implementation of the Ramsar Convention. No framework is envisaged for consulting with other stakeholders. The entire vision, even after the recent restructuring, centres around the states. The intervention areas in this collaborative process are therefore meaningful and concern:

- the efficient use of all the wetlands in the Lake Chad basin and
- the mobilisation of financial resources for the conservation and sustainable use of wetlands at the basin level.

#### *Implementation of the Water Charter*

There is a major risk that member states will not be able to efficiently implement the Water Charter after its ratification. The stumbling blocks relating to issues of national sovereignty are still present, particularly that of the quantitative management of surface water and ground-water resources. Similarly, the Charter has failed to tackle the issue of sanctions against those who break the Charter.

### **Conclusion and recommendations**

In 2012 the population of the Lake Chad basin reached 45 million, the majority of whom are part of the growing demographic of young people. The population, which is unevenly distributed across the basin, is growing at a rate of between 1.5% to 3.7% per year. The highest population densities are found in the major cities, where the strong economic pull factor works to the detriment of rural areas. Child mortality is generally very high, which contrasts with life expectancies at birth which vary between only 47 and 56 years on average.

Harsher climatic conditions, military and political conflicts and military and religious crises are the main causes for migration flows in the basin. These factors make people's incomes less secure in a situation where the distribution of wealth is already highly disparate. The cross-border dimension is an important challenge facing the countries and requires concerted and appropriate development policy.

The unfavorable climatic conditions, high population pressure, national and regional military conflicts and accentuated poverty, inadequate policies and weak institutions combine to cause food insecurity in the basin. However, there is a large potential for improvement.

Agriculture is the sector that contributes most to GDP, although the oil industry is booming. In 2012 the basin produced over 37 million tonnes of cereals, most of which came from Nigeria, the Niger and Cameroon. The Lake Chad area clearly sets itself apart from other basin areas due to its robust economic activity based around food crops as well as traditional livestock-rearing practices, trade, fishing and foraging.

The most common cash crops are cotton and rice, while the most common food crops are millet and sorghum. Farming uses either partial or full water control techniques. Agriculture is rain-fed or irrigated depending on the season.

Other techniques also exist such as dune-land, flood-recession, wadi and polder farming. Systems based on water catchment that were developed in Nigeria and Cameroon make it possible to diversify agricultural production but can have negative impacts for other water users and on resource availability. Although agriculture remains mostly subsistence and extensive, people have developed endogenous techniques that deserve recognition, such as the use polders which could be adopted to a larger scale to mitigate against the effects of climate change and meet the challenges of fighting against poverty and food insecurity. Small irrigation also has many advantages such as crop diversification, the organization of local groups and a more controlled water consumption.

Pastoralism involves the rearing of cattle, goats, sheep and camels. In 2012 a total of 204,438,539 head of livestock were counted in the basin. This activity is essentially based on transhumance and nomadism. However, these practices are dying out as herders increasingly settle in villages and adopt crop growing. Apart from animal health issues, it is feeding livestock that constitutes the major challenge for herders. Given the potential of this sector, it would be appropriate to propose regulating mechanisms to reduce conflicts, develop the sector and protect the soil.

Fishing is a key economic activity that is practised in different areas of the basin (reservoirs, watercourses, lakes and floodplains), and some 13 million people now depend on the fish trade. It has been estimated that, in 2012, fishery production in Lake Chad stood at 100,000 tonnes, and it was found that the majority of the fish caught are sold in Nigeria where demand remains high. Promoting family fish farming, lead the fight against illegal fishing practices and improve monitoring are all possible measures for sustainable development of this sector.

Waterborne diseases occurring in the basin include diarrhoea, dysentery, intestinal parasitic diseases, bilharzia, cholera, typhoid fever and guinea worm. The lack of potable water and, in particular, the poor levels of hygiene are seen as the main causes. In addition to these diseases, HIV/AIDS is present, which is an indirect result of the fishing activities in Lake Chad. Hence, in 2009 Kinasserom Island, with a population of around 10,000 inhabitants, had an HIV/AIDS prevalence rate of 18.5%. Much is being done on this regard, but projects face important constraints: poor health infrastructure, few skilled staff motivated to work in the area, limited access, difficult living conditions and a relatively low level of security.

The issue of gender is a major problem in view of the immense disparity between men and women in terms of their participation in development processes and, above all, their contribution to GDP. Governments have carried out numerous projects in this area, such as improving the parity between girls and boys in primary education, adopting the Family Code, etc.

To respond to the major socio-economic and cultural challenges, member states have engaged in institutional, social and economic reforms based on the principles of responsibility, accountability, transparency, respect for the law, the fight against corruption and public participation. With particular regard to water governance, the LCBC has operated the Lake Chad Basin Observatory (LACBO) since 2010, seeking to enhance knowledge and to develop an

integrated regional system to provide information and support decision-making. The Lake Chad Water Charter, establishing the rights, obligations, duties, restrictions, and procedures for the proper management of the resources of Lake Chad, was officially adopted at the 14th Summit of Heads of State and Government of the Lake Chad Basin Commission, held on 30 April 2012 in N'Djamena, Chad.



## 3

## Water resources and freshwater availability

### Key messages

This chapter looks at water resources in the Lake Chad basin and their potential development and mobilisation. The two main hydro-systems within the catchment are the basins of the Chari-Logone and the Komadougou-Yobé. They are composed of surface water, including bodies of running water (rivers, streams, canals, etc.) and bodies of standing water (lakes, reservoirs, permanent and temporary ponds, etc.) and groundwater mainly stored in the Quaternary and Pliocene aquifers.

Rainfall in the basin is highly variable in time and space, decreasing progressively from south to north. Rainfall patterns are influenced by the movement of air masses and therefore determined by the migration of the Inter-tropical Convergence Zone (ITCZ). Evidently they have a direct impact on river flow and, thus, on the size of Lake Chad. August is generally the wettest month, with the rainy season running from May-June to September-October. The rest of the year is hot and dry, with temperatures and evaporation particularly high between April and May.

Climatological and hydrological field observations remain very limited in the basin. They are performed by the relevant technical services in the basin member states, often in difficult conditions as the necessary resources are often not available. These gaps in field data make water resource planning and ecosystem monitoring extremely difficult. To address this to some degree, some countries have institutional arrangements with regional organisations that provide support to ensure the proper functioning of measuring stations, so that some reliable data is available.

Large flood plains, with high evaporation rates play an important role in draining water into Lake Chad and for the function of other ecosystems in the basin. They are also crucial for fisheries, livestock farming and agriculture.

Artificial lakes are generally created to satisfy agricultural needs, which can, as a result, affect other water users in the basin.

Aquifers, some of which are confined, contain exploitable groundwater resources. Quaternary formations, which contain water-table aquifers, underlie three-quarters of the basin area. This continuous aquifer system is found in sand and sandstone and is the easiest to exploit. Confined or semi-confined aquifers are found in deeper and earlier geological formations, such as the Pliocene and the Continental Terminal. The recharge of these aquifers is extremely limited recharge and they are often artesian.

From 2007 to 2012, water quality studies have been carried out on the Chari-Logone system and on the aquifers shared by Chad and Cameroon. Both physico-chemical properties and bacteriological characteristics were studied.

De 2007 à 2012, des études sur la qualité des eaux du système Chari-Logone et des aquifères partagés entre le Tchad et le Cameroun ont été élaborées. Outre les caractéristiques physico-chimiques de ces eaux, les aspects bactériologiques ont également été étudiés

The central pollution risk observed in the basin was from nitrate contamination caused by agricultural and domestic activities. Abnormally high concentrations of many other naturally occurring chemical substances were also found. While the basin countries require water for their socio-economic development, water resources management and particularly access to water, poses a serious challenge. Groundwater, which is generally of high quality and suitable for human consumption is the main source for meeting the populations basic needs. The basin countries are continuing to develop strategies for improving access to drinking water, based on the use of groundwater, with the

sole aim of halving the proportion of people without access to safe drinking water by 2015.

Population pressure in the basin and the problem of arid soils in some regions have led to Nigeria and Cameroon building specific water infrastructure to support crop and livestock farming. Dams have been constructed to feed irrigation systems, and pastoral wells have been built along main transhumance corridors. Small farmers are settled near rivers and around Lake Chad, taking advantage of the water sources for agriculture. Conflicts persist, however, between different categories of users over water bodies that continue to hold water in the dry season.



111: An arm of Lake Chad dominated by papyrus near Bol, Chad

## Resources

### Surface water

Surface water is water that flows over, or rests on, the surface of a land mass. Thus rivers, lakes, wetlands, seas and oceans or reservoirs or other impounded water bodies are all surface water. Surface water is generally naturally replenished by precipitation and naturally lost through evaporation and infiltration into the ground.

In the Lake Chad basin, all surface water flows towards Lake Chad, although it may not always reach the lake. As it flows towards the lake, the water picks up particles of sediment, organic matter, chemicals, etc. along the way. The course the water follows towards the lake, and therefore its quality and quantity, is determined by land use, the nature of the surface, human activities, infrastructure and floodplains.

The main water courses of the Lake Chad catchment are formed in the Chari-Logone drainage basin and the Komadugu-Yobe drainage basin. There are, however, also smaller catchment areas in the state of Borno in Nigeria, with streams that feed Lake Chad.

### Description of drainage basins

#### 1. Chari-Logone drainage basin

This basin, with an area of 690 000 km<sup>2</sup>, is drained by the Chari and its principal tributary, the Logone, which flow across vast floodplains shared by Cameroon and Chad and converge in N'Djamena before emptying into Lake Chad.

The Chari River is 1,200 km long and has its source at between 1,100 m and 1,900 m in the Bongos mountains in the Central African Republic, while the Logone, which is 1,000 km long, has its source in the north-eastern part of the Adamawa region in Cameroon, at an altitude of 1,200 m above sea level. The Chari-Logone system supplies around 95% of the water to Lake Chad.

The upper part of the Logone-Chari system is called the upstream basin. The Chari is formed from the confluence of the Bamingui, Gribingui and Bangoran rivers, all located in Central African Republic and draining a basin of 80,000 km<sup>2</sup>. The Chari is then joined by Bahr Aouk, which drains an area of 100,000 km<sup>2</sup>, and runs along the border between Chad and the Central African Republic, originating near the Sudanese border. In Chad, the basin then encompasses the



112: Aerial view of the Chari in N'djamena, Chad



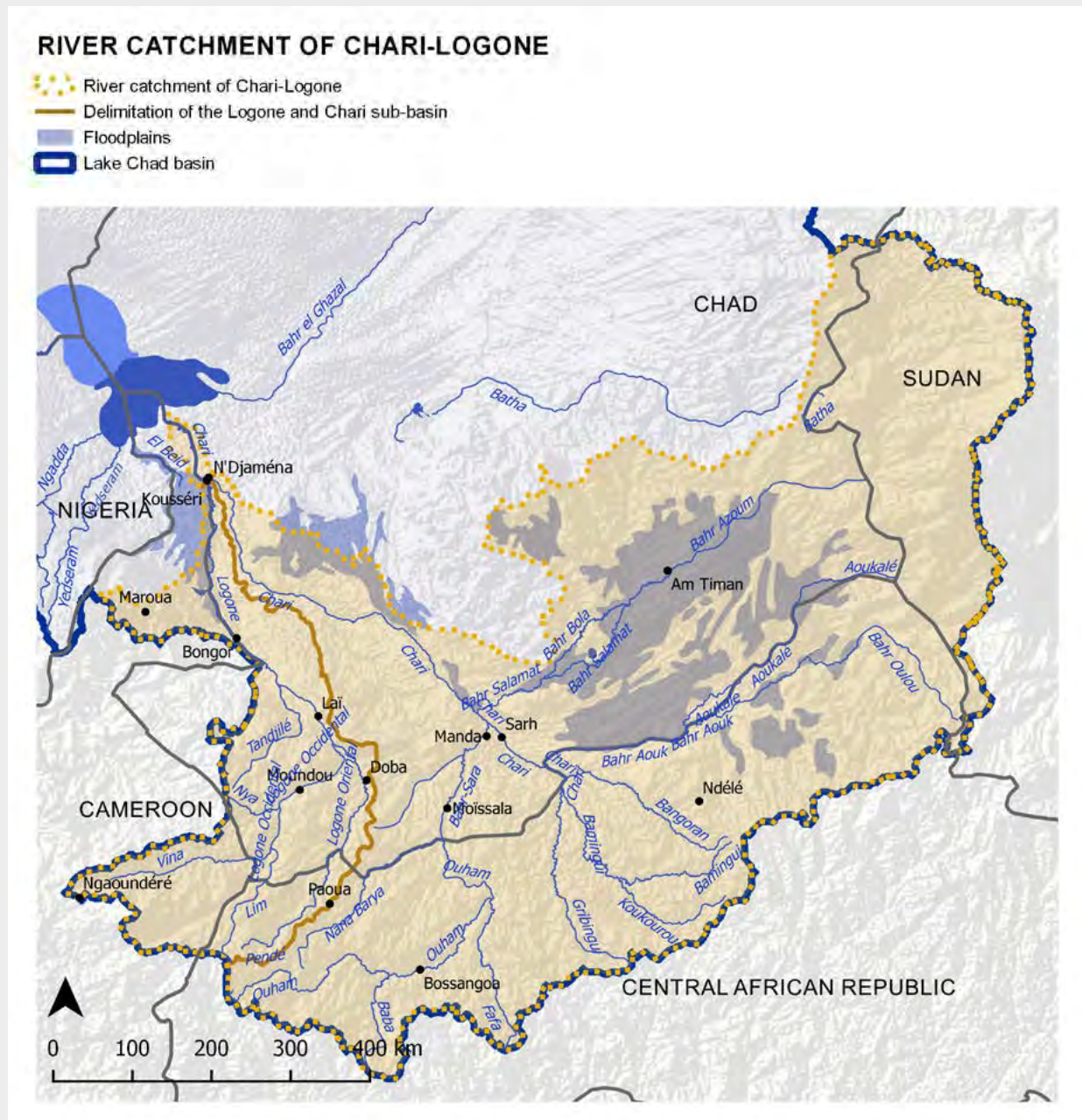
basin of Bahr Sara Manda (80 000 km), the Chari basin in Sarh (193,000 km<sup>2</sup>) and the Logone Basin in Lai (78,000 km<sup>2</sup>).

The Logone is also formed from the confluence of two rivers, that meet at the border between Cameroon and Chad. These are the Vina and the Mbéré (draining an area of approximately 22,000 km<sup>2</sup>). The Logone is joined by other tributaries. These are: the Lim (approx. 4500 km<sup>2</sup>), the Nya (approx. 3000 km<sup>2</sup>) and the Pende (approx. 15,000 km<sup>2</sup>). From Lai onwards the Logone is joined only by the Tandjilé in the northwest.

The lower basin of the Chari extends from Sarh to N'Djamena where the river is fragmented during dry

periods by coarse sand banks. In times of flood, at the end of the rainy season (August to September), the river completely fills its bed and can overflow. The Bahr Aouk, the Bahr Keita, the Bahr Salamat and the Logone fill vast floodplains such as Waza-Logone plain in Cameroon, with an estimated surface of 8000 km<sup>2</sup>. These floodplains play a major ecological and economic role, particularly for people living in these areas and exploiting the resources. The lower basin around N'Djamena, located 140 km from Lake Chad, is the beginning of the Chari delta from which the Serbewel river continues its course to Lake Chad. In times of high water, the Chari overflows and forms the Bahr Erguig filling the Massenya depression.

Map 21: River catchment of Chari-Logone



Source: LCBC

2. Komadugu-Yobe drainage basin

The Komadugu-Yobe is a system of semi-perennial water-courses that feed Lake Chad. The lower reaches of the catchment form around 150 km of the border between the Niger and Nigeria.

The basin has an area of around 148,000 km<sup>2</sup>, 57% of which is in Nigeria with the remainder in Niger. Whilst the basin contributes comparatively little water volume to Lake Chad, it remains important as a large section of the population of the Lake Chad basin live in the catchment.



113: View of the Komadugu-Yobe near Diffa, Niger

Map 22: River catchment of Komadugu-Yobe



Source: LCBC

The Komadugu-Yobe catchment has two distinct sections: the Hadejia-Jama'are sub-basin, where water from the mountains converges, in the Nigerian states of Kano, Jigawa and Bauchi; and the lowlands forming the Yobe River sub-basin in the Nigerian states of Borno and Yobe and in Niger. The Hadejia is formed by the rivers Chawalla and Kano. The Jama'are river begins on the Jos plateau in Nigeria and is joined by the Katagum river before flowing into the Hadejia at Gashua. The Yobe River converges with the Komadugu-Gana river before flowing into Lake Chad. The Hadejia-Nguru floodplains are a wetland area fed by the Hadejia and the Jama'are, tributaries of the Komadugu-Yobe.

### 3. Catchment areas of the Yedseram, Ngadda and El Beid

The cities of Maiduguri and Bama located in the state of Borno (Nigeria) are overlooked by a mountain ridge, one end of which tapers off into a plain which is drained by three seasonal rivers, namely the Yedseram, the Ngadda and the Gubbio, which eventually empty into Lake Chad.

The lower reaches of the Yedseram River have a catchment area of 16,320 km<sup>2</sup>. The Ngadda River, with a catchment area of 14,400 km<sup>2</sup>, feeds numerous small lakes and wetlands from its north-western section, before fingering out across the former bed of Lake Chad.

The El Beid River flows into Lake Chad, forming part of the border between Nigeria and Chad as far as the lake. It receives water mainly from the Mandara mountains and overspill from the Logone River into Cameroon's floodplains. It is the outlet for these inundated areas, draining an area of around 22,640 km<sup>2</sup> for most of the year, beginning in June and ending the following May. Its high-flow period occurs in November or December. Overflow from the Logone River runs into the El Beid when its discharge reaches 1,100 m<sup>3</sup> at Bongor and Logone-Gana, two locations in Chad.



114: Children crossing the Logone in a pirogue

## Precipitation

In this report, the term 'precipitation' means meteoric water that falls on the Lake Chad basin in liquid form (rain) in a given period. It is caused by a change in temperature or pressure and is the direct or indirect product of the condensation of atmospheric water vapour. The distribution of rainfall in the basin is related to the migration of the Inter Tropical Front (ITF) or Inter-Tropical Convergence Zone (ITCZ) which creates the cycle of a short wet period (3 to 4 months) and a longer dry period (8 to 9 months). Rains first occur to the south of the front, then progress northwards crossing the Sudano-Sahelian climate zone (N'Djamena) to mid-May; before returning south at the end of September.

In the north of the basin, rainfall is influenced by the Sahelian climate, characterised by average annual levels of around 300 mm (average of 296 mm calculated for the period 1950–2007 in Diffa, Niger). Rainfall is generally negligible between November and March. The dry season thus lasts around seven months. On average, 90% of yearly rainfall occurs in the months of July, August and September, generally peaking in August, although sometimes in July.

In the region of Kano (northern Nigeria), rainfall averages around 825 mm a year. Here, the dry season lasts from October to the following May, with a short rainy season lasting just four months, from June to September.

The southern part of the Lake Chad basin is by far the wettest, particularly the north-eastern part of the Central African Republic (Bouar, Bossangoa and Ndele), southern Chad (Sarh and Moundou), northern Cameroon (Adamawa) and the Jos plateau region in Nigeria. This area has a wetter Sudanian-type climate; the dry season lasts five months, and the wettest months are July, August and September, when around 60% of the year's rain falls. The highest average rainfall in the Lake Chad basin is recorded in Jos, where it ranges from 1,000 to 1,400 mm a year (average calculated for the period 1950–2007).

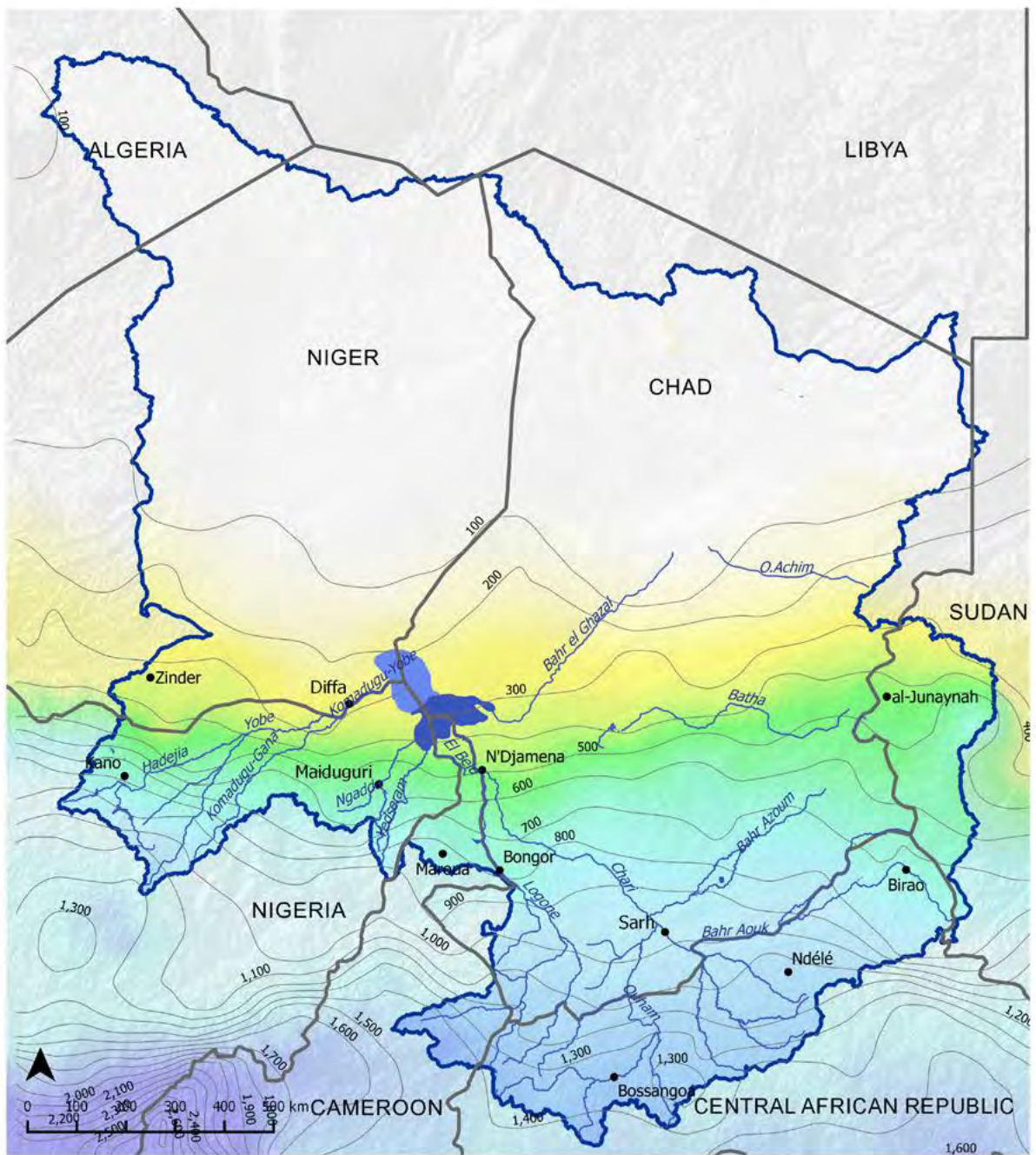
The basin is subject to a high variability in precipitation, between the seasons of the year, from year to year and with regard to space. This variability has a direct impact on the water levels and flow in the basin.

Map 23: Annual rainfall in the Lake Chad basin

### ANNUAL RAINFALL IN THE LAKE CHAD BASIN

Average annual rainfall (1950 - 2012)

- 0 mm
- 100 mm
- 250 mm
- 500 mm
- 1,000 mm
- 2,000 mm
- 5,000 mm
- Isohyets



Source: Raster Images from the Global Precipitation Climatology Centre (GPCC) climatology of precipitation, polylines calculated by AHT

**Rainfall observations**

Rainfall is monitored through field observations made at weather stations operated by national meteorological networks. The basin has a range of different types of weather station including: agro-meteorological stations, synoptic stations, climatological stations and rainfall stations. The most closely monitored stations are the synoptic and rainfall stations. They are partially integrated into global observation networks. Some member states have partnership agreements with the Agency for Aerial Navigation Safety in Africa and Madagascar (ASECNA), a pan-African institution. ASECNA is responsible for data management in collaboration with the World Meteorological Organization (WMO), and national meteorological services, representing the organisation, are responsible for maintaining stations and collecting data.

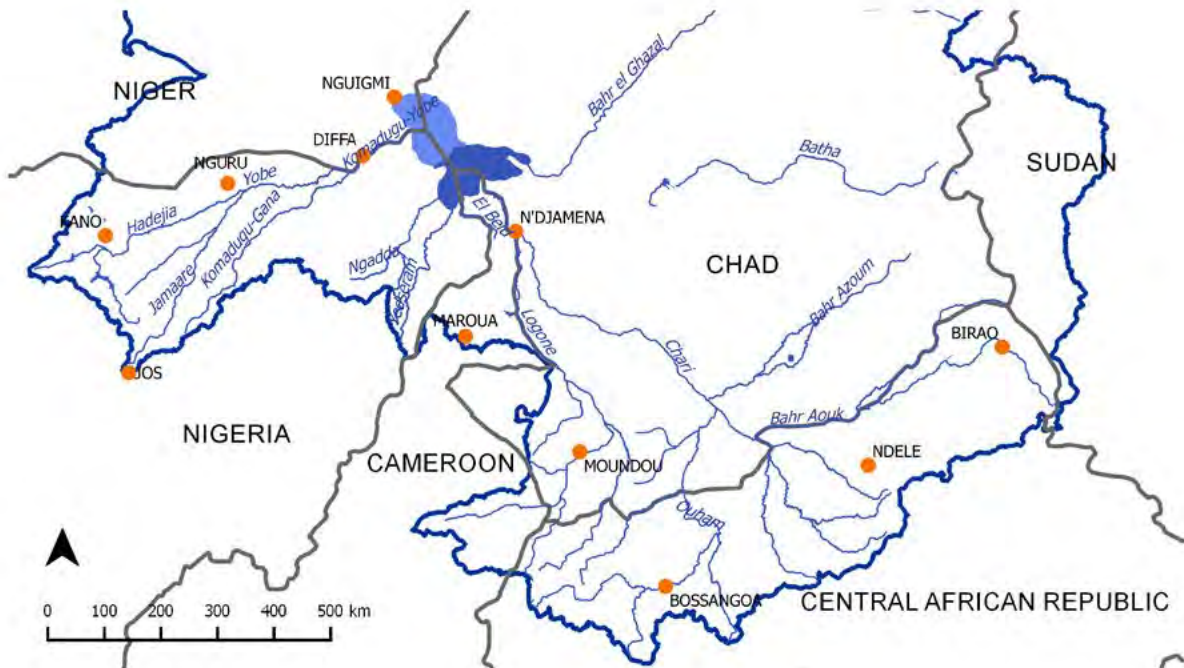


115: Pluviometric station, Chad

Map 24: Rainfall stations referred to in the report

**RAINFALL STATIONS IN THE LAKE CHAD BASIN**

● Main rainfall stations



Source: LCBC

Figure 33: Average monthly precipitation in the period for the period 1905 to 2012 (in mm. 10<sup>-1</sup>)



Source: LCBC

## River discharge

### 1. River stage and discharge measurements

The water level of a river can easily be determined by reading the staff gauge installed at gauging stations. The hydrometric stations across the basin form a network that is operated by the member states. From the water level, the river discharge is calculated based on the stage-discharge relation. This relation is specific to each gauging station and can vary over time, particularly after high-flow events when the channel bed has been scoured or sediment has been deposited.

Table 24: Situation of the hydrometric stations forming part of the national networks of LCBC countries in 2012

Country	Stations recorded in the basin	Stations operating in 2012
Cameroon	9	0
Libya	0	0
Niger	1	1
Nigeria	40	nc
Central African Republic	9	0
Chad	52	36

Streamflow measurements to determine the stage-discharge relation and monitor changes in watercourses are not carried out on a regular basis in the Lake Chad basin. In the 1980s, spot stream gauging was common. However, since the mid-1990s, a lack of resources to maintain hydrometric networks has meant that the majority of observation stations have been closed down.

### 2. Annual and interannual discharge dynamics

In the Lake Chad Basin, the hydrological year follows a clear pattern.

In the Chari-Logone system, the hydrological year begins with the high-flow season in May and ends the following April at the end of the low-flow season. In 2012 the flows observed were higher than in previous years, due to increased rainfall in this sub-basin and the lake area. This was accompanied by severe flooding in Chad and Cameroon.

For Lake Chad in Bol (Chad) and the Komadugu-Yobe in Bagara (Diffa region, Niger), the hydrological year begins in July and ends the following June. The Komadougou Yobe is a water course with a generally low flow and great seasonal irregularity. He knows long periods of low water with complete drying. The Komadugu-Yobe is a river that carries very little water and is characterised by significant seasonal variations.

The Lake Chad basin is characterized by high climate variability. In the last decades, human impact on the basin has seriously disrupted the seasonal regime of the water courses in the catchment. Over the last 65 years there has been a dramatic variation in the water availability in the basin.



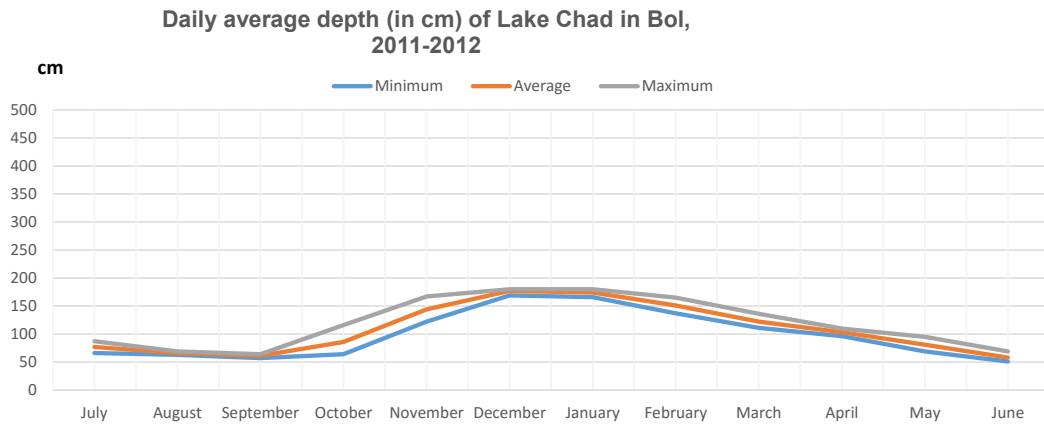
from top to bottom:

116: Shelter for a gauging station, Chad

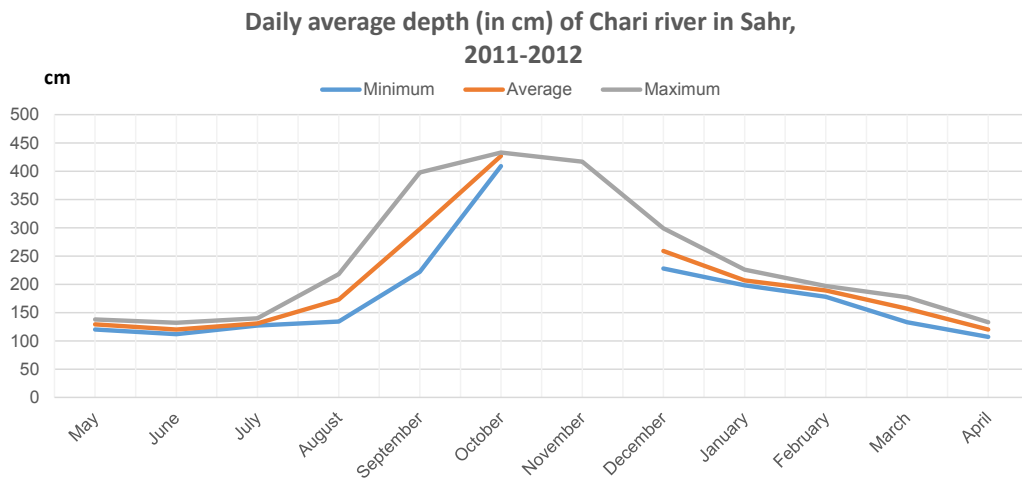
117: Verifying a stick gauge in Katoua, Chad



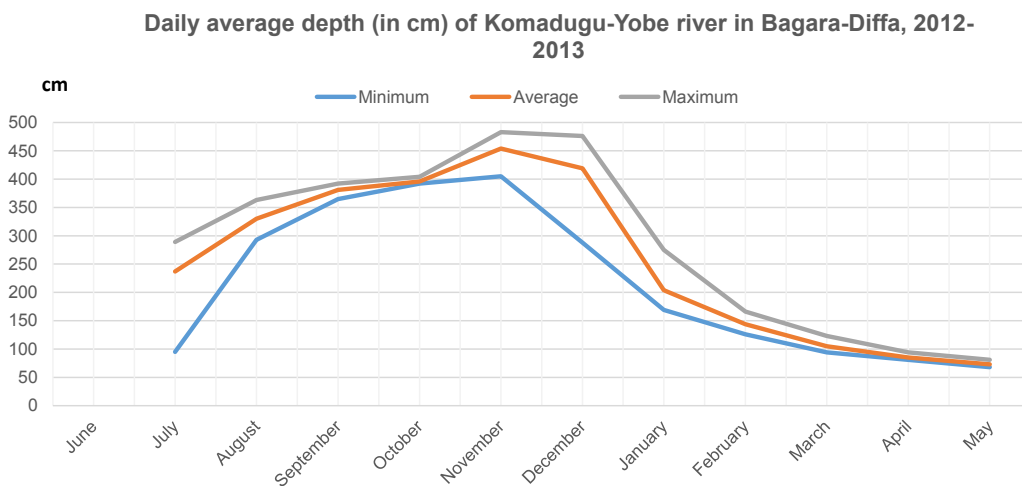
Figure 34: Daily average depths (in cm)



Source: LCBC Hydrological Yearbook, 2011-2012



Source: LCBC Hydrological Yearbook, 2011-2012



Source: LCBC Hydrological Yearbook, 2012-2013

From 1950 to 1970 the basin experienced a humid phase whilst from 1970 to 1990, it underwent a hyper dry period. From 1990 to 2012, the basin appears to have experienced an intermediate phase marked by a slight improvement in the flow of the Chari and with marginally increased rainfall. During the great drought period of 1973 to 1985, the flows of the rivers into the lake decreased as follows: 40% for Chari, 60% for Komadougou Yobe and 83% for the El Beid and other rivers.

The discharge of the Chari is measured at several locations, including at the station N'Djamena TP. Its overall flow has declined since the 1950s with particularly low levels in

years of severe drought. Between 1950 and 1959 flow fell from 1 334 m<sup>3</sup>/s to 688 m<sup>3</sup>/s, and in the 1980's the mean annual flow was 561 m<sup>3</sup>/s. In the last decade the general trend has shown a slight increase in flows, however there is a huge degree of interannual fluctuation

The main gauging stations monitoring the Komadugu-Yobe River as it enters Lake Chad are located in the Niger, the most important being the Bagara station in the Diffa region, located near the point where the river enters Lake Chad. The Komadugu-Yobe is not a perennial river and only carries water in the rainy season. Historical data suggests data an annual average flow of 150 to 700 m<sup>3</sup>/s for

Figure 35: Evolution of the average annual discharge of the Chari (in m<sup>3</sup>/s) and of annual average rainfall in N'Djamena (in mm) from 1953 to 2011

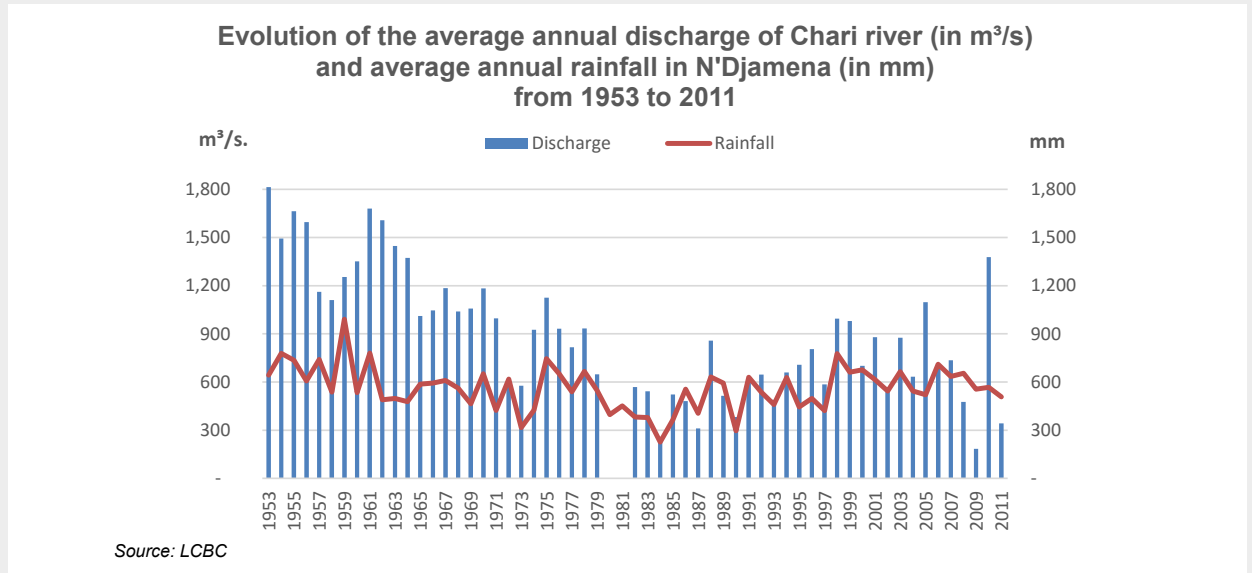
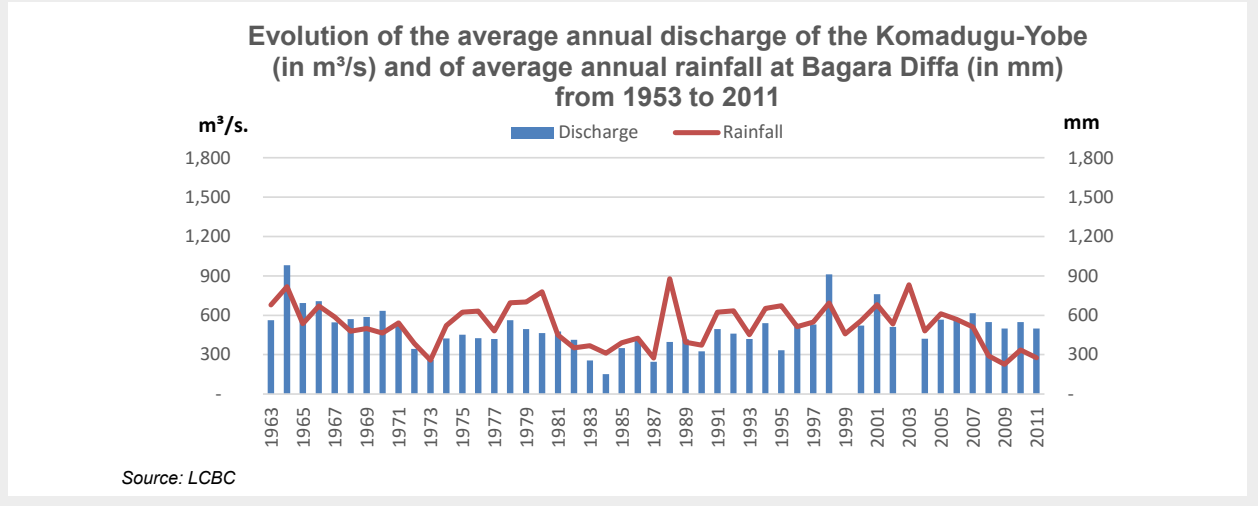


Figure 36: Evolution of the average annual discharge of the Komadugu-Yobe (in m<sup>3</sup>/s) and average annual rainfall at Bagara Diffa (in mm) from 1963 to 2011



the period 1965 to 1985. The flow period has also decreased significantly over this period from more than 300 days per year in the early 60s, to less than 150 days per year in 1983-84, and 200 days per year in 1990.

The arrival of the first flow along the river remains in the first half of July, but the decline of the flow occurs earlier. Currently the Komadougou Yobe contributes barely 1.5% of

the flow to Lake Chad. Only a quarter of the flow measured at Gashua, Nigeria reached Lake Chad, due to both infiltration to the aquifer and evaporation. In addition to this are the effects of deforestation, dams and irrigation which all impacts profoundly on the flow regime. The average monthly observed rating in April-May (when minimum low water occurs) is often 0 m<sup>3</sup>/s, whilst in October, the high water month, it reaches 45.8 m<sup>3</sup>/s.

### Tools developed by the LCBC to improve decision-making

The LCBC accords great importance to collecting hydrological data with the Water Charter providing for tools aimed at improving knowledge management and supporting decision-making by policymakers, with a view to ensuring the sustainable management of water resources in the Lake Chad basin.

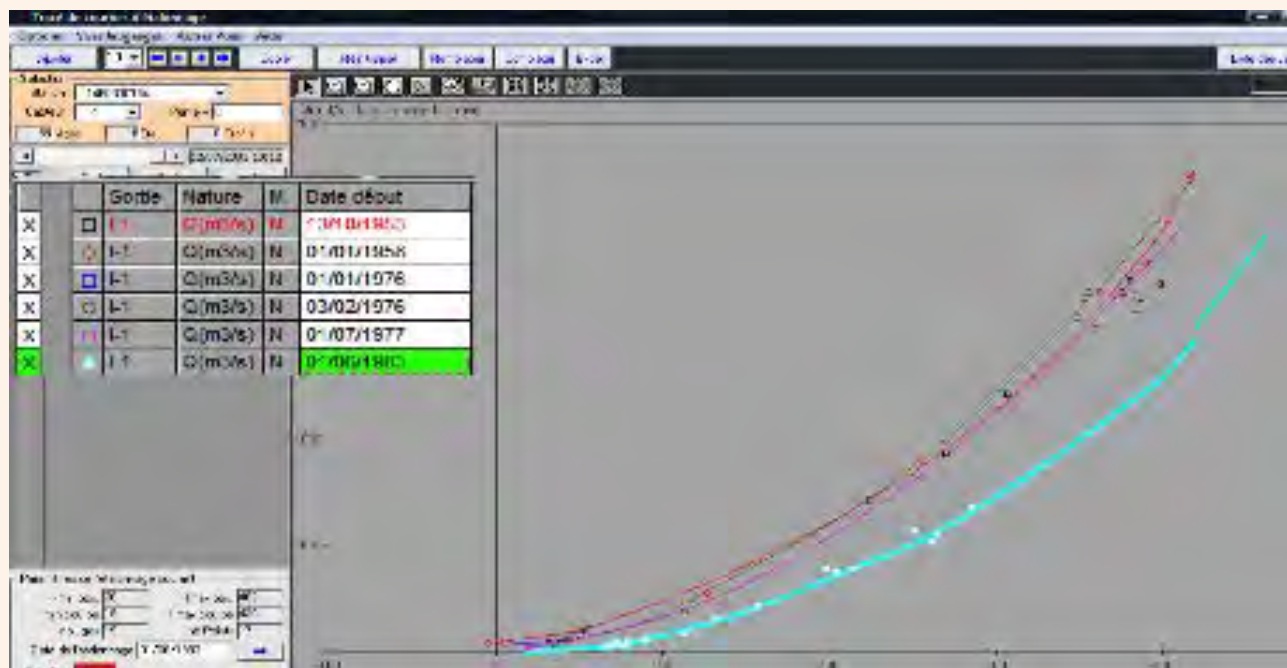
A range of tools are gradually being developed by the Commission for this within the projects and programmes it promotes. Two examples are the water resource planning model created in 2011 and the regional database, which has been operational since 2012.

#### → LCBC regional database

The 2012 Water Charter of the Lake Chad basin supported the creation of a regional database (RDB) for the Lake Chad Basin Commission, to be managed by the Basin Observatory. The RDB centralises information on the basin to facilitate the evaluation and monitoring of the basin,

improving the quality of available data and facilitating regional exchanges of information. The RDB thus promotes synergies between the LCBC's partner institutions, member states, specialised sub-regional institutions, research institutes and aid and cooperation partners. The LCBC's Basin Observatory plays an important role in maintaining the RDB, carrying out tasks including field data collection for key indicators (hydrological, environmental and socio-economic data across the entire basin), data processing, storage and publication, etc. The Observatory's flagship products are its quarterly hydrometeorological bulletins and its hydrological yearbooks.

In 2010 the Basin Observatory evaluated potential sources of hydrometeorological data available to the LCBC Executive Secretariat. From the evaluation it was noted that data from projects promoted by the LCBC and from its technical units could be used as the foundation for the RDB. Data management was moved from Hydrom, Clicom and other early applications to a Hydraccess software application in 2011. In addition to stage and discharge data, the RDB also includes potential evapotranspiration, rainfall, temperature (average, maximum and minimum), wind and solar



118: Screen grab from the Hydraccess software

insolation. This database serves not only to compile and process existing data, but also to facilitate the analysis (management of stage-discharge rating curves, quality analysis and spatialisation). It is also designed to support the projects and programmes that the LCBC promote and must therefore be kept constantly updated.

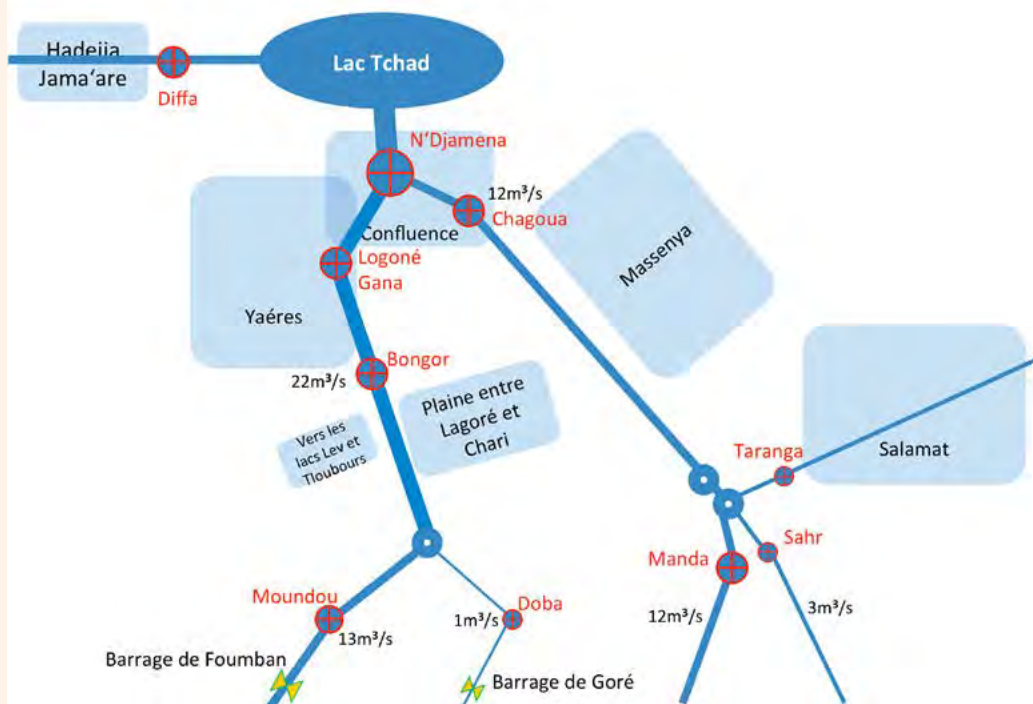
#### → Discharge planning and management model

This model was developed by the LCBC for integrated water resources management in the basin. It combines a rainfall-runoff model (GR2M), a model tracking water withdrawals (Water Evaluation and Planning – WEAP) and a model based on the area of Lake Chad's pools (hydrological model).

The Water Charter of the Lake Chad basin includes an undertaking to maintain target flows during low-flow and high-flow periods in order to preserve and protect ecosystems and the environmental services they provide. Carefully chosen gauging stations are located at key points, with a view to achieving the following objectives:

- ✓ Low-flow objectives: Maintain target minimum flows in the basin's watercourses to preserve the environmental quality of the ecosystems by limiting water abstractions when necessary.

Figure 37: Low water objectives in water courses according to the Water Charter



119: Pumping water

- ✓ High-flow objectives: Quantify the floods that ensure the flooding of major wetlands thus guaranteeing their services.

Figure 38: Flood water objectives in water courses according to the Water Charter



**Runoff - the case of Yaere floodplains**

As an endorheic lake, runoff is of existential importance to Lake Chad. Formally runoff is the water that flows over the ground surface when the rate of precipitation exceeds the rate at which water can infiltrate the ground or be absorbed by the soil. Logically, runoff flowing towards Lake Chad

reaches its peak at the height of the rainy season, which is between August and September. Part of this runoff remains on the vast floodplains over the short wet season before dissipating under the combined action of evaporation and infiltration or, when floods are particularly severe, flowing into the neighbouring Niger basin (as in the case of the Logone River).



120: Yaéré in Chad



121: Planting rice, Chad

The Lake Chad basin has a number of floodplains valued for their economic significance. They include Hadejia-Nguru (Nigeria), Massenya (Chad), Yaere (Cameroon), Salamat (Chad), Aouk (Central African Republic) and other fluvio-lacustrine environments. These plains have a low slope – for example 0.14 m/km from Lai – so that in times of heavy rain, the Logone floods the plain for three to four months.

In a wet year, the flooded areas of the Massenya and Yaere plains together can cover 100,000 km<sup>2</sup>, of which 60,000 km<sup>2</sup> are located in Chad. They are flooded largely as a result of overflows from the Logone and Chari Rivers.

### Course-shift and overflow events in the Chari and Logone Rivers

Before converging at N'Djamena and emptying into Lake Chad, the Logone and Chari Rivers experience numerous flow events as they follow their course across the floodplains. These events have a negative effect on the basin's overall water balance and significantly diminish inflows to Lake Chad.

During the Logone's rising stage, the river overtops its banks when the flow is high and spills into the vast Yaere plains over an area of between 4,000 and 12,000 km<sup>2</sup>. These waters then flow into the El Beid River, the outlet in Cameroon. After the wet period, which lasts from August to October, there is little change until December, when the river dries up as a result of evaporation and infiltration. In Chad, when it reaches its highest level (342.40 m.a.s.l.) and peak discharge (1,900 m<sup>3</sup>/s) in Lai in September or October, it overflows the sill in Dana, near Bongor. This water is then lost to the Niger basin via the Toubouri swamps. A significant volume flows over the sill in Ere at 530 m and into the Sategui floodplains, before reforming the Ba Illi. At the Ere sill, the Logone also loses water to the Niger basin via the Mayo-Kebbi, a tributary of the Benue.

As the Chari flows towards Lake Chad, it feeds the Massenya floodplains, covering an area of 2,526,000 ha, as a result of overflow near Miltou. The Bahr Erguig is formed and rejoins the Chari 300 km downstream on the Mogrom-Bougoumene stretch.

Downstream of N'Djamena, the Serbewel and the Taf Taf are the last left-bank distributaries of the Chari in Cameroon as it flows towards Lake Chad across a small floodplain, where flood-recession and vegetable crops are grown.

A variety of intermittent socio-economic activities have developed in the floodplains, according to the seasons. Rice, corn and millet is farmed in the rainy season; sorghum and transplanted rice are grown in the dry season (flood recession farming); livestock farming, particularly grazing, is practiced in the dry season; and fishing also takes place in the water course. Intensive farming requiring irrigation systems are predominant on the shores of Lake Chad (in Nigeria) and along the banks of the main rivers. The floodplains are a mosaic of biotopes. Chad's fish stocks provide a potential yield of 150,000 tonnes according to FAO estimates. In 2002, fisheries production amounted to 93,000 tonnes. Some of the basin's floodplains also have mineral resources, such as oil reserves, some of which have been developed, while others are at the prospecting stage.

In Nigeria the Borno plains drained by the Yedseram, the Ngadda and the Gubbio receive water from the Mandara mountains, which disappears into marshes and small lakes on the way to Lake Chad.

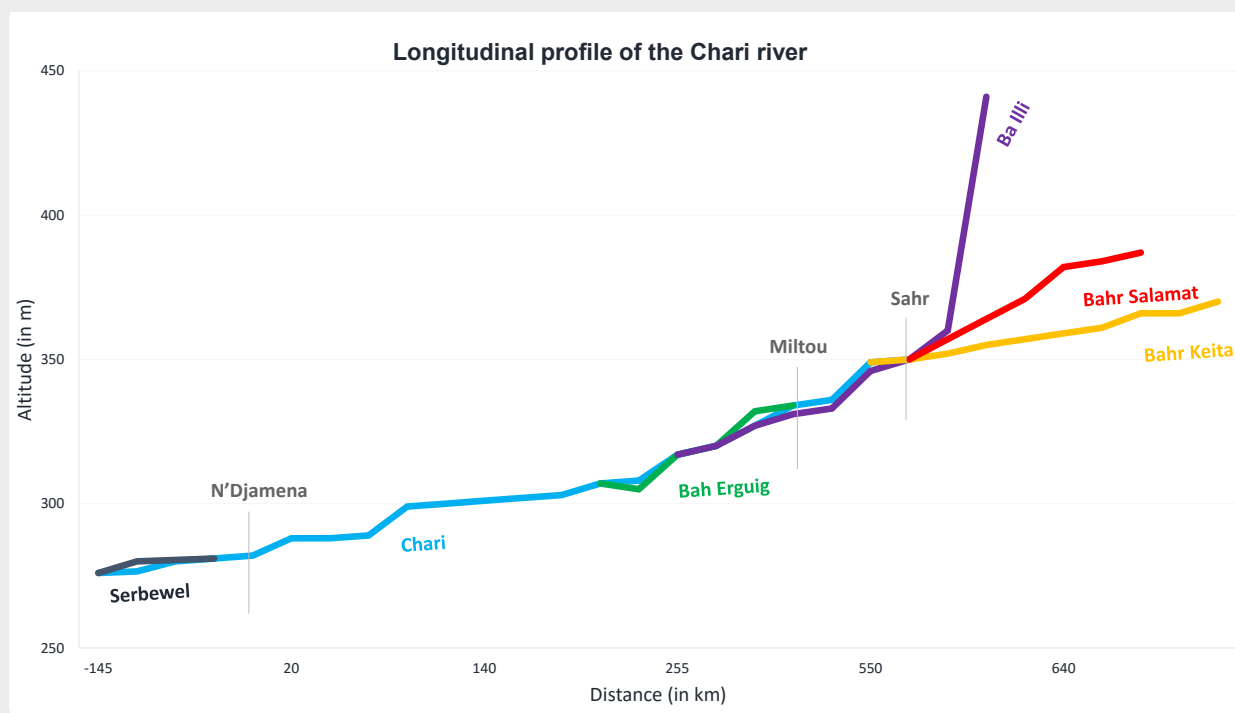
Lake Chad is also known to overflow. In December the lake can overflow into the Bahr el Ghazal, which drains water northward to the Bodele Depression, situated 500 km north-east of the lake and 120 m lower in altitude. These overflows occur when the level of the lake exceeds 282.3 m.a.s.l.

The main overflow thresholds were identified in the early 1950s and the corresponding flow rates determined in terms of the levels of the Logone and the Chari in high-flow periods. However, as this characterisation was established when flow rates were high, it is unlikely to be valid today. Following decades of drought, rainfall and discharge have decreased by between 40% and 50%, and the number of irrigation systems and levees has multiplied.



122: A sand dyke built by the village of Ere to protect against flooding by the Logone and its overflow to the Mayo-Kebbi, a neighbouring river in the Benue basin, Cameroon

Figure 39: Longitudinal profile of the Chari



Source: LCBC

## Lakes, dams and ponds

### 1. Lake Chad, overview of the current situation

In the Palaeolithic period, Lake Chad covered an area of 315,000 km<sup>2</sup>, stretching across the entire south-eastern Sahara. This landscape has been replaced by one featuring reed beds, mud and sand banks and currently over 300 islands. Following a dramatic decrease in the area of the lake in recent decades, it has been slowly increasing in size again since 2010. In 2012 it covered around 4,516 km<sup>2</sup> of open water. Its average depth is about 4 m, and the lake bed is situated between 275 and 284 m above sea level. Lake Chad itself occupies less than 1% of the area of the entire basin, and, when full, can straddle four countries: Niger, Cameroon, Nigeria and Chad.

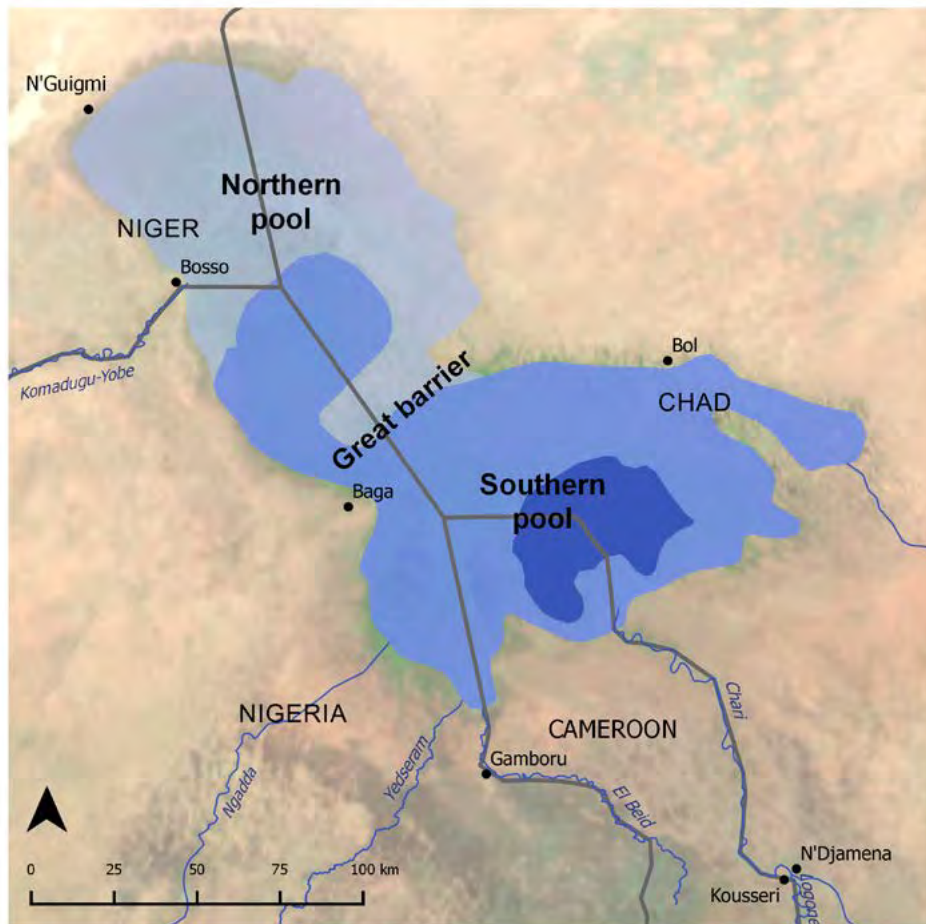
The effects of variations in rainfall and runoff have a strong influence on Lake Chad. A variation of about 10% of rainfall results in a change of around 30% in the contribution of the Chari on the lake. The lake was thus severely affected by the droughts of 1973 and 1985, causing it to shrink by 90%, so that its area decreased from over 25,000 km<sup>2</sup> in the 1960s to 1,600 km<sup>2</sup> in 2009. The flow rates of the Chari and Logone Rivers have been seriously affected by the decline in rainfall, and the lake is now divided into three distinct areas: the open waters of the southern pool, the archipelago, made up of a series of sand dune islands on the north-eastern edge of the lake, and the very irregularly flooded areas of the northern pool. A narrow ridge, referred to as the Great Barrier, separates the two pools. When the water level is high, water from the southern pool can flow into the northern pool. The Yobe River entering the lake on the western side, with its diminished flow, is no longer able to fill the northern pool on its own. In 1996 the northern pool dried up completely, but was flooded again in 1999, when rainfall was higher.

Map 25: Lake Chad in 2012

### LAKE CHAD IN 2012

**Lake Chad in 2012**

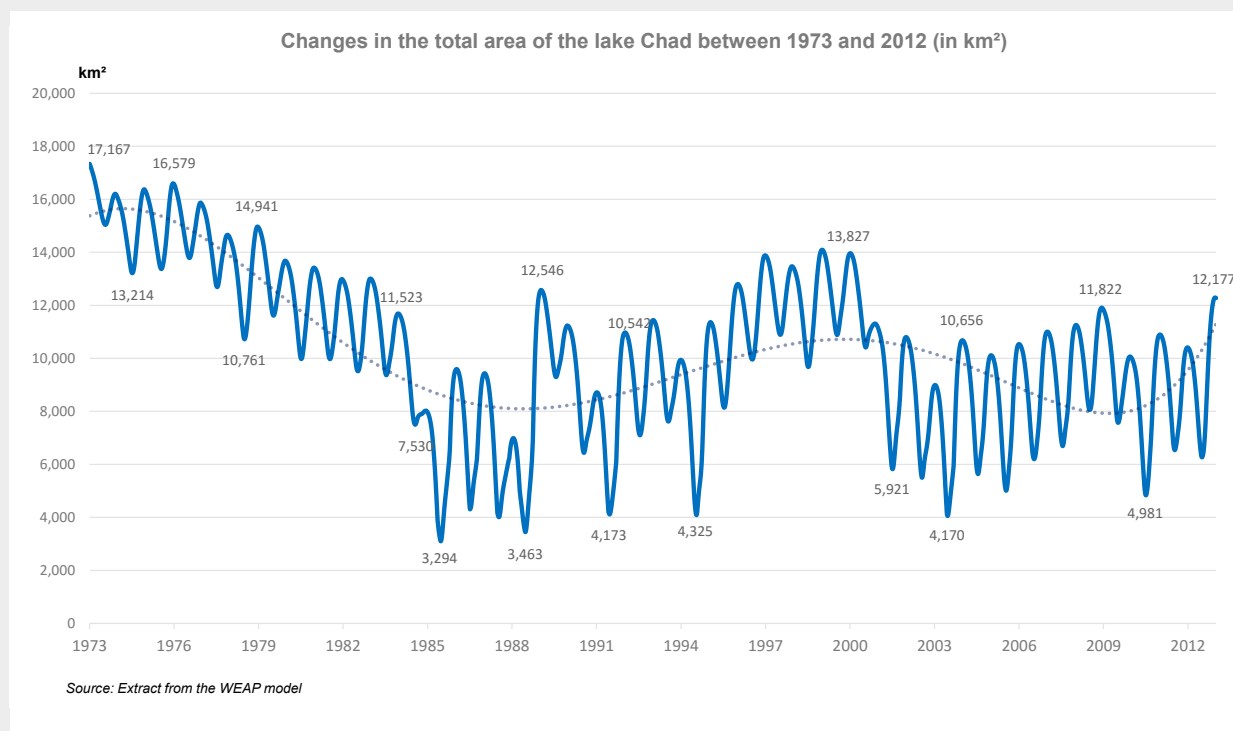
- Permanent open water
- Marshland and quasi-permanent aquatic vegetation
- Irregularly flooded marshland



Source: Atlas de l'Afrique - Tchad, 2012



Figure 40: Changes in the total area of the lake between 1973 and 2012



The effects of climate variation mean that Lake Chad is a depression that is gradually being filled with sodium salts. This process occurs as deposits with sodium salts (naturally occurring sodium bicarbonate) are deposited as the waters recede and with eolian sand and sediments.

The water balance for Lake Chad can be summarised in the following terms: precipitation (200–400 mm/year), + river inflows (Chari-Logone, Komadugu-Yobe, Ngadda, Yedseram and El Beid), - water evaporation (2,000–3,000 mm/year), - losses through infiltration into the ground and - surface and ground water abstractions. This balance has remained negative since the 1990s, in spite of the slight increase in rainfall observed from that year onwards.



123: View of the archipelago at Bol, Chad

Lake Chad is mainly fed by the Chari-Logone system. The remainder of the lake’s inflow come from rainfall directly over the lake and small temporary tributaries, including the Komadugu-Yobe in the north-west and El Beid in the south. These rivers no longer provide the necessary inflows to maintain the lake at historic levels.

Table 25: Balance of Lake Chad gains and losses

	Medium Lake Chad (1954 – 1969)	Small Lake Chad (1988 – 2010)
	km³/year	km³/year
Gains		
Chari	42.0	21.1
El Beid	1.5	0.3
Komadugu-Yobe	0.7	0.5
Direct rainfall	7.4	1.9
<b>Total</b>	<b>51.6</b>	<b>23.8</b>
Losses		
Evaporation	48.8	22.6
Net infiltration	2.3	1.0
Overflows	0.2	0.0
<b>Total</b>	<b>51.3</b>	<b>23.6</b>

Source: IRD, 2014

The lake's gains in the form of rainfall (13%) are immediately lost through rapid evaporation at a rate of around 3 m/year (95% of rainfall gains) and infiltration into the ground. At peak stage, once water levels surpass 282.3 m.a.s.l the waters of the lake drain towards the Bodele Depression via the Bahr el Ghazal. In addition to evaporation losses, between 4% and 9% of the water entering the lake is abstracted, mainly for irrigation purposes.

## 2. Other lakes

In addition to the rivers and streams, the Lake Chad basin also has numerous lakes of varying sizes. These standing water bodies can be natural or artificial, and many of the ponds are temporary. They are essential to food production for local people and also contribute to maintaining the ecological balance in their region. The most important lakes are located in Chad, with smaller pools dotted throughout the basin.

Chad contains seven lakes, in addition to Lake Chad and Lake Fitri, which have suffered from the effects of severe droughts. Most of Chad's lakes dry up and then fill again in the flood season. This occurs for Lake Fitri and Lake Iro (154 km<sup>2</sup>) in south-eastern Chad (Boum-Kebir), which is fed by the Bahr Salamat.

### Lake Fitri: a lake under a Sahelian climate regime

Lake Fitri, located at 12°50' N and 17°30' E, is Chad's second largest lake in terms of area. Like Lake Chad, it is an endorheic lake as its only tributary, the Batha River, spreads its waters across a vast, very flat plain, with no outlet, over an area averaging 420 km<sup>2</sup> in the low-flow season.

Due to its location in the Sahel, combined with its particularly flat morphology, the flooded area varies greatly from year to year. Annual rainfall, which is low (372 mm in Ati), displays high interannual and seasonal variability. The wet season, beginning in June and ending in October, is followed by a long dry season, with high temperatures and rapid evaporation (3,700mm to 4,000 mm per year on average). In a normal year the lake appears as a vast expanse of shallow, freshwater marshland featuring a number of quartzite ridges and the Yao granite inselberg.

In the 1960s the lake covered an estimated area of 1,300 km<sup>2</sup>, which has now shrunk to between 420 and 800 km<sup>2</sup>. Some years the lake is reduced to a series of shallow pools in the low-water season, with the water level rising to 4 m in the high-water period of September-October. Lake Fitri, sometimes referred to as the miniature Lake Chad, has an area of 800 km<sup>2</sup> (2012), and its 'normal' depth is between 1.5 and 2 m.

Fish species living in Lake Fitri are well adapted to its warm, shallow waters (29°C on average). The water temperature can reach levels that are harmful to some species, which is why the fish population is not very large or varied. The following species have been identified in the lake: *Mormyrus* sp., *Alestes nurse*, *Clarias lazera*, *Clarias anguillaris* (African mudfish), *Gnathonemus niger*, *Polypterus* sp., *Protopterus annectens*, *Schilbe mystus*, *Synodontis* sp. and *Tilapia* sp.

## 3. Pools

This term refers to small expanses of water that collect in depressions, as a result of rainfall or flood waters. They may be ox-bow lakes of perennial rivers, hollows in the beds of seasonal streams or rivers or simply depressions filled with rainwater.

At the start of a good wet season, these small pools of water occupy a considerable area. They are very important to the local population and play an important role in conserving biodiversity.

These ponds are a source of water and thus of life for the inhabitants. In addition to being used by villagers for domestic purposes, and in spite of its poor quality, the ponds also teem with fish. They are used for watering livestock, vegetable gardens and local agriculture. The ponds are usually managed according to customary law and often become places for social interaction (ceremonies or fishing, for example).



124: Swamps have an important function for the population

The ponds also provide habitats for wildlife. The exceptional location of the ponds of Gata and Dongolo at the heart of the Central African Republic's Manovo-Gounda St Floris National Park, a UNESCO World Heritage Site, makes them a sanctuary for hippos.

Kalamaloue National Park in the Far North region of Cameroon contains an area that attracts herds of elephants. When they migrate from Waza National Park (Cameroon) to Chad between November and July, they stop off at the ponds in an oxbow lake of the Chari River on the border between these two countries.

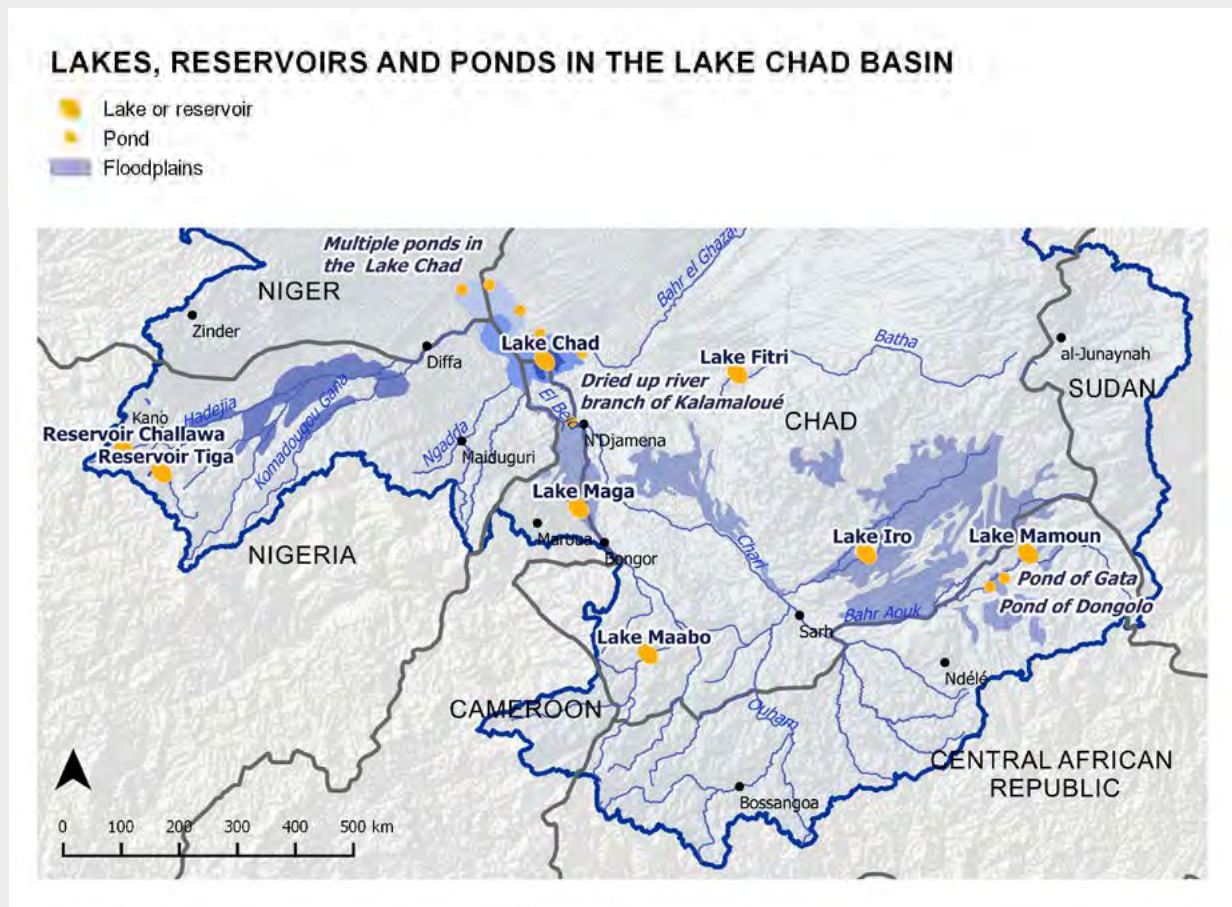
There are small ponds in the hydrographical network in Lake Chad's northern pool that remain for varying periods after the rainy season. Around 120 ponds have been identified in the Komadugu-Yobe basin, most of which (about 100) are temporary and some semi-permanent.

In the upper part of the Chari basin, ponds become wetlands at the height of the rainy season, as occurs with the Bahr Aouk and its tributaries. In the dry season, these flooded areas dry up, and quasi-permanent bodies of standing water are left behind.



125: An ox-bow lake of the Chari, in the Kalamaloue park near Kousseri, Cameroon

Map 26: Lakes, reservoirs and ponds in the Lake Chad basin



Source: LCBC

#### 4. Dams

In addition to losses through evaporation, infiltration and overflows into the Niger basin, a part of the surface water in the basin is impounded by dams and used for irrigation, livestock and market gardens. The impact of these abstractions is more pronounced when flows in the basin are low in the basin.

##### *Chari-Logone basin*

The most recent example is the Maga dam in the floodplains of the Logone River on the Cameroonian side, which was put into operation in 1979. It is a major hydraulic structure with a storage capacity of 625 Mm<sup>3</sup>, designed to provide irrigation for large-scale rice cultivation.

There are also other smaller-scale water impounding structures, such as the Zilim levee in the Logone basin, built in 1985 on the Logomatia to provide water for livestock farming. The upper part of the Chari basin has no water infrastructure, apart from pump irrigation systems.



126: Maga dam, Extreme North, Cameroon

Table 26: Reservoir area and storage capacity

Dam	Area (km <sup>2</sup> )	Capacity (Mm <sup>3</sup> )
Alau	50.00	112.40
Bagauda	3.80	22.10
Birnim Kudu	6.50	1.20
Challawa	100.00	930.00
Galala	4.10	23.00
Gari	13.90	154.00
Gari	3.70	60.00
Guzugozu	6.40	24.60
Hadejia	20.00	14.00
Ibrahim Adamu	2.60	8.00
Jakara	16.60	65.20
Kafin Chiri	8.40	31.10
Karaye	2.00	17.20
Maga	400.00	625.00
Magaga	3.70	19.70
Maladumba	2.00	0.00
Marashi	2.20	6.80
Mokolo	1.00	5.00
Pada	4.10	12.00
Ruwan Kanya	7.50	0.00
Tiga	180.00	1,968.00
Tomas	15.00	60.30
Tudun Wada	3.50	20.80
Warwade	5.30	12.30
Watari	19.60	104.50

Source: LCBC

### Komadugu-Yobe basin

This basin has a considerable number of dams. There are at least 20 on the Nigerian side, in the upper part of the basin, specifically on the Hadejia-Nguru floodplains. Their active storage capacity is over 3.5 billion m<sup>3</sup>. The most important include the Tiga dam built in 1975 on the Kano River for irrigation and the Challawa Gorge dam.

### Hydropower potential in the Chari-Logone basin

The possibility of building multi-purpose infrastructure in the Chadian part of the basin is currently being studied. In 2010 an inventory was drawn up of sites with both high hydropower potential and possibilities for irrigation schemes in the Logone's eastern areas and the middle reaches of the Chari. At present, there are two projects in the pipeline for dams on tributaries of the Logone:

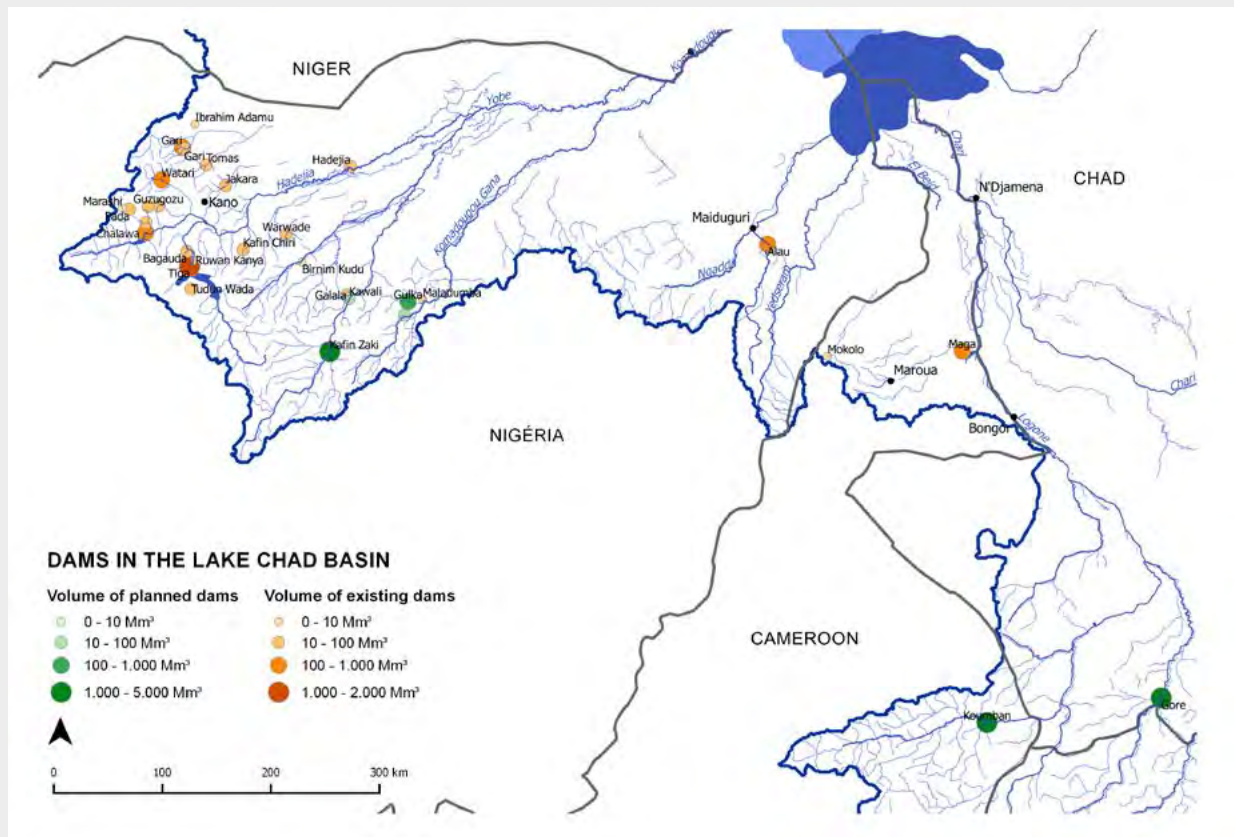
- the Fouban dam on the Vina before its confluence with the Mbere, in Cameroon, with a storage capacity of 5 billion m<sup>3</sup>;
- the Gore dam on the Pende, around 20 km after it enters Chad, with a storage capacity of 2.8 billion m<sup>3</sup>.

According to the hydrological model of the LCBC, the capacity of these dams is approximately equal to the annual discharge of the tributaries. Total power production would be in the region of 100 million kWh a year and the discharge of the Logone in Lai would be:

- minimum discharge of 150 m<sup>3</sup>/s and peak discharge of 2,600 m<sup>3</sup>/s with one dam in operation (Koumban);
- minimum discharge of 250 m<sup>3</sup>/s and peak discharge of 1,500 m<sup>3</sup>/s with two dams in operation.

However, the construction of even one of the dams would have an adverse effect on the flooding of the Yaere plains and the overflow into the Niger basin, which are problems that must be taken into account.

Map 27: Dams in the Lake Chad basin



Source: Compilation from various sources (IRD, LCBC, AHT)

Groundwater

The Lake Chad basin has important groundwater resources. There are vast areas underlain by sedimentary formations (sands and sandstones) containing continuous water-table aquifer systems and deeper confined or semi-confined aquifers.

Main aquifer systems

The most used aquifer systems in the basin are those found in the younger sedimentary formations with widely varying compositions. There are Quaternary formations bearing free groundwater and Lower Pliocene and Continental Terminal formations containing artesian aquifers.

1. Quaternary formations

The Quaternary deposits are composed of sands, sandstones and clays. The thickness of the formation ranges from 50 m on the edge of the basin to 180 m in the centre. The aquifers located in the Quaternary strata form continuous systems and underlie about three-quarters of the basin’s total area. They are heavily exploited in Chad, the Niger and Nigeria. Generally, the water table can be reached at depths of between 1 and 60 m in the vicinity of water bodies. In the Diffa region in the Niger, the Kadzell groundwater depression is confined and situated at

a considerable depth in a low-permeability confining environment. It is estimated to contain groundwater reserves totalling several hundred billion m<sup>3</sup>. However, these reserves remain largely untapped, with abstractions totalling around 12 million m<sup>3</sup> a year in the 1990s.

2. Pliocene formations

Pliocene formations are well represented in the Chadian basin, although because they are overlain by Quaternary deposits, information about them is based mainly on findings made during water and oil drilling. The Pliocene series starts with a 10 to 30 m thick sandy series (Lower Pliocene), followed by a 200 m thick layer of clay sediments that separates the Pliocene deposits from the Quaternary strata. It rests on the Continental Terminal. The boundary with the Quaternary is not well-defined. In Chad it is overlain by the sandy series that contains the water-table aquifer, which is clearly individualised in drill hole samples (see below).

The Pliocene aquifer is found in the central part of the Lake Chad basin, where it is hosted in sand and silt deposits. It has a piezometric level of between 310 and 320 m. It is confined, and wells are generally artesian. This confined aquifer is found at a depth of around 400 m from the surface. The topwall of the aquifer is a thick, even clay layer that completely isolates it from the overlying Quaternary aquifer.

There are Pliocene aquifer outcrops in the Chadian lowlands, and the system extends into the Niger and Nigeria, covering an area of around 6,000 km<sup>2</sup>.

When these aquifers are exploited, a significant proportion of the water is unfit for use or is wasted (losses due to the very poor condition of pipes, creation of unused artificial ponds, etc.).

The Pliocene aquifer is more heavily exploited in Nigeria, and it can be assumed that there has been a decline in groundwater levels as a result. The basin's two major aquifers, the Quaternary and the Pliocene aquifers, which contain the bulk of the region's water resources, run under Lake Chad's northern pool. However, the rate of recharge of the Quaternary aquifer is extremely low; the Pliocene is essentially a fossil water aquifer with no significant renewal.

3. Continental Terminal formation

The Continental Terminal is a geological formation dating from the Tertiary period generally encountered at a depth of between 450 and 620 m below the surface. It extends from Niger and Nigeria far into Cameroon and Chad. It forms an extensive artesian aquifer recharged in the southern part of Lake Chad in Cameroon and Chad. However, this Continental Terminal aquifer, which is confined in the central part of the basin and around Lake Chad, is unconfined in the Chadian lowlands (Bahr El Ghazal) and

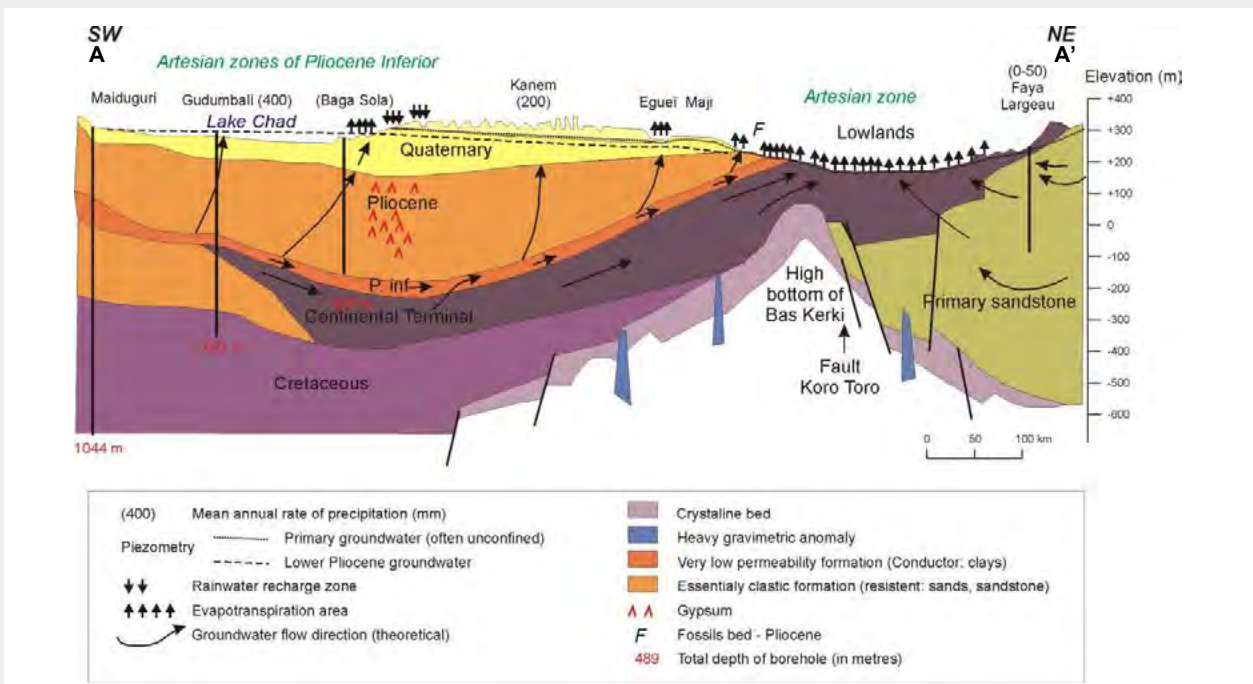
southern Chad. The aquifer is heavily exploited in Nigeria, where a drastic decline in artesian head has been observed (up to 6 m/year).

In addition to the Quaternary and Pliocene aquifers, the cover formations of Lake Chad's topographic basin also contain the following aquifers:

- primary sandstone aquifer, shared by Chad, the Sudan, Libya, the Niger and Algeria;
- Nubian sandstone aquifer, shared by Chad, Libya, Egypt and the Sudan;
- system of stacked aquifers of the Lake Chad basin shared by Chad, Cameroon, the Central African Republic, the Niger and Nigeria;
- the Cretaceous aquifer, in unconformable contact with the crystalline basement.

Aquifers in the Precambrian basement, well represented on the outer edges of the basin, are discontinuous, with water infiltration and circulation localised in fissures, fractures and faults. Where water emerges at the surface, it generally forms perennial flows and is microbiologically safe for human consumption. The best known are those located in Precambrian non-carboniferous formations in the Central African Republic.

Figure 41: Transversal hydrogeological cut showing the geology and the major flow directions at depth



Source: BGR/Schneider, 1992

**Groundwater dynamics**

It is only recently anything has been known about groundwater flows in the Lake Chad basin, and this knowledge is confined to the findings of a number of localised pilot initiatives carried out in certain parts of the basin.

In some places and for some types of aquifer, field data relating to water levels in village wells has provided a better insight into the general direction of groundwater flow.

*1. Quaternary formation*

The Quaternary aquifer formation is characterised by depressions where water collects. The deepest depression reaches a depth of 235 m.a.s.l. The groundwater found in this aquifer has a high salt content. The combination of these two effects indicates that the depression is the result of groundwater evaporation at a rate that exceeds the rate of recharge by rainfall. Evaporation probably occurs through the sands of the palaeo-delta of the Chari River.

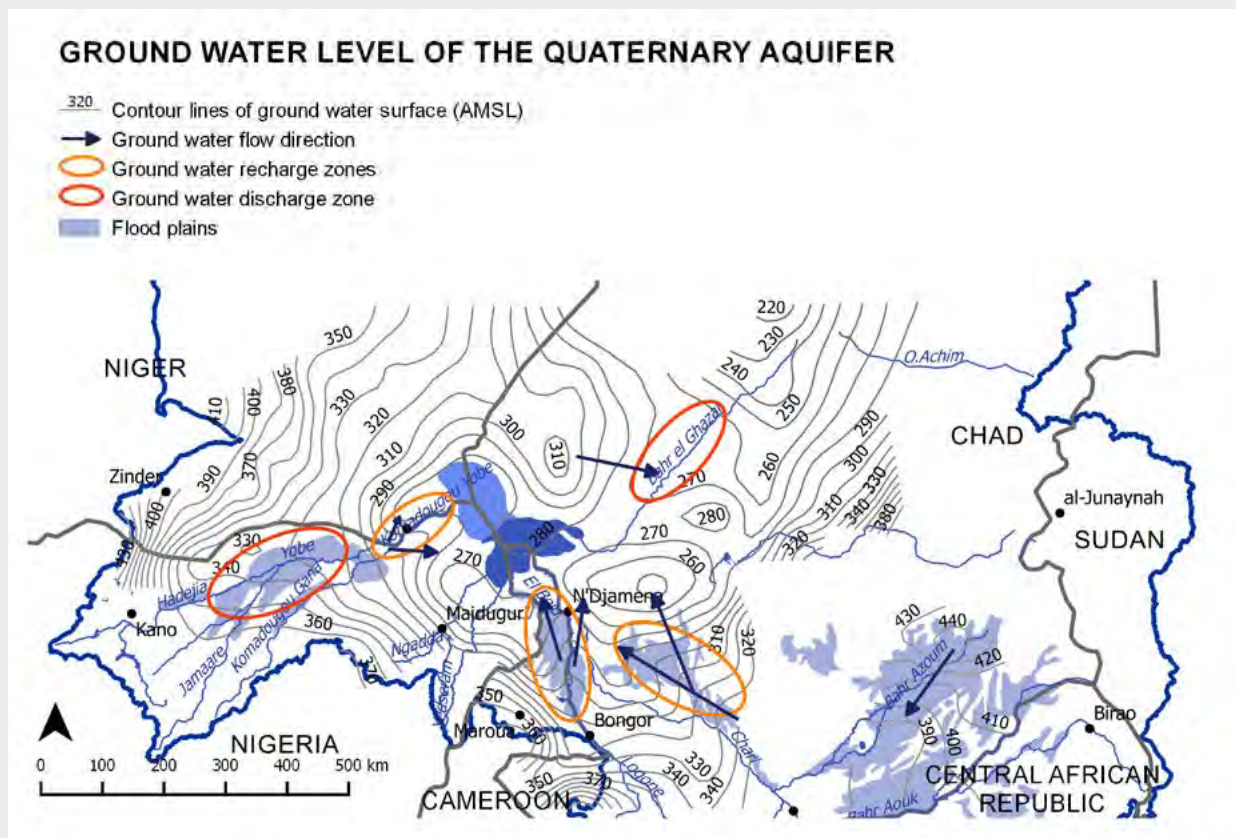
There are three depressions located in different parts of the region: in the unconfined aquifer in the Chari-Baguirmi

area (south-east of Lake Chad), the Komadugu-Yobe area (Nigeria) and the Chadian lowlands. The unconfined aquifer is situated at a depth of 15 – 46 m below the Chari and Massenya wetlands, which recharge it. In 2008 and 2009, the groundwater depression was observed to be deeper (235 m below mean sea level). This was due to the effect of two common phenomena in the region:

- ✓ excessive abstractions, resulting in the overexploitation of groundwater in the region;
- ✓ higher evaporation in the area, resulting in a higher concentration of salt.

In this period, the water table fell significantly, at a rate of 0.4 m a year. However, there was evidence of a recovery of the groundwater level at the end of this period under the Massenya wetlands (maximum rate of 0.6 m/year) and the Chari River (at a rate of 0.2 m/year). It can therefore be seen that the water level of the Quaternary aquifer is highly variable over time. In 1984 the groundwater depression was located at a depth of 240 m below sea level.

Map 28: Ground water level of the Quaternary aquifer



Source: BGR



Groundwater recharge by surface water bodies coincides with increased rainfall in the period in question. After several years of drought, the situation in the region reached a critical level in 1984. With the inversion of the rainfall curve, the Chari floodplains and wetlands receive a little more water and so can contribute to recharging the aquifer.

## 2. Pliocene formation

In the Lower Pliocene sand aquifer, groundwater flows from south to north in the southern part of the basin, but only from north-west to north-east in the northern part. It is a confined artesian aquifer around Lake Chad covering an area of approximately 60,000 km<sup>2</sup>. The levels have fallen drastically owing to uncontrolled losses. Water has been flowing continuously from some boreholes since 1972. If

nothing is done to stop these losses, in several decades' time, the potentiometric surface could recede to the point where the Pliocene aquifer is no longer artesian.

## Recoverable and renewable reserves in the Quaternary aquifer

Due to its hydrogeology, the Lake Chad basin has considerable groundwater resources. The table below provides a summary of the estimated quantities of recoverable and renewable reserves in the Quaternary aquifer. Effective infiltration varies between 5 mm around the 15th parallel and 100 mm around the 10th parallel. Groundwater exploitation was estimated at 438 million m<sup>3</sup> in the early 1990s in the Conventional Basin. This level of exploitation is negligible in relation to available reserves.

Table 27: Piezometric level of artesian wells in the Lake Chad basin

Well	Total depth of well	Static level after well built in 1972	Recent static level
Naala	427 m	5 m above the ground	2011: 1 m above the ground
Bougoumene	302 m	0.8 above the ground	2014: 3.15 m below the ground
Logone Birni 3	298.6 m	2.74 m above the ground	2014: 5.10 m below the ground
Logone Birni 1	200.86 m	8.19 below the ground	2011: 10.80 below the ground

Table 28: Groundwater reserves in the Quaternary aquifer

	Recoverable reserves (billions of m <sup>3</sup> )	Renewable reserves (billions of m <sup>3</sup> )	Infiltration (mm)	Estimation method
Chad (BRGM, 1987)	66 to 141	3.5	15	Effective rainfall modulated for lithology
Niger (UNDP, 1991)	500	0.05	5	
Cameroon (Ngounou, 1993, 2007)	0.9 to 1.08	0.1 to 0.5	25 to 125	Thornthwaite water balance
Nigeria (Edmunds, Fellman and Goni, 2002)		0.25 to 0.88	4 to 49	Chloride mass balance
<b>Total</b>		<b>4</b>		

### Groundwater extraction

Various types of well, borehole and pump are used across the basin, ranging from open cemented wells to boreholes with solar-powered pumps. The cemented wells were mainly built in the colonial times for basic human and

livestock water supply. They have been and still are being replaced by boreholes with hand pumps, pedestal pumps and solar-powered pumps in cities, towns and villages. In some cities in Nigeria and Niger, artesian well provide drinking water, and sometimes also water for irrigation purposes.



from top to bottom:

127: An artesian well and drinking water supply in Baroua, Niger

128: Well with hand pump

129: Pastoral well, Baroua, Niger

from top to bottom:

130: Solar panels and water supply system in Mondo, Chad

131: Well with a pedal pump

132: Artesian well and irrigation near Nguigmi, Niger

### Relation between surface water and groundwater

Isotopic analyses and the quantification approach based on the numerical modelling of flows have been used to study the recharge of the Quaternary aquifer. Recharge depends on surface water and the temporal and spatial distribution of rainfall, the total annual rainfall and the volume of runoff flowing towards topographic depressions. Endorheic depressions concentrate rainfall in temporary ponds which are often connected to the aquifer.

Isotopic analysis of the groundwater of the Waza Logone plain shows that it comes directly from the surface water.

### Relation between Lake Chad and the surrounding groundwater system

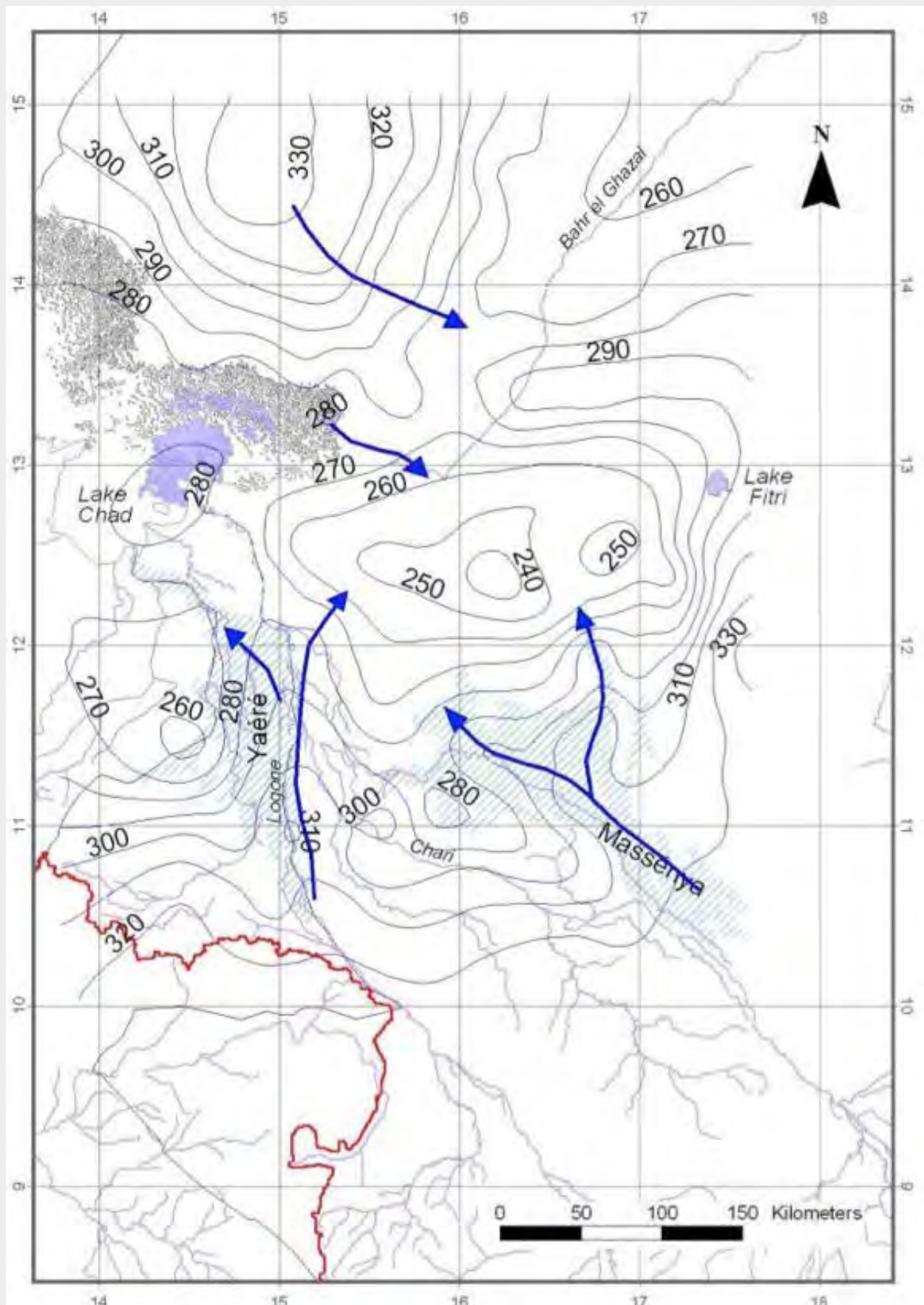
Lake Chad does communicate directly with the underlying aquifer, and its altitude (281 m above sea level in the middle of Chad) in relation to the water table should favour infiltration. However, infiltration is only limited to the edges of the lake, benefitting the upper part of the groundwater system. Isotopic analysis shows that the oxygen-18 content of Lake Chad's water is similar to that of the groundwater in the vicinity of its shoreline. Further in, the isotopic composition varies, indicating recharge due more to precipitation.

The aquifer underlying the dunes on the north-eastern edge of the lake is fed by rainfall in the wet season and by the lake in the high-water season. In the dry season, with the lake at low water, water stored in the dunes flows towards the lake and interdunal depressions where it evaporates, leaving behind salt deposits. This also explains the saline regulation of the lake.

Recent research carried out on the Chadian part of the Quaternary aquifer indicates the direction of groundwater flow in the during the low water phase of the lake. Water flows from the Massenya wetlands towards the north, from the Logone towards Lake Chad, from Lake Chad towards the east and from Kanem towards the south-west. Taking into account that high levels occur in areas where effective percolation is possible, it is the wetlands, Lake Chad and the Logone that recharge the aquifer. Recharge also occurs in the Kanem dunes, thanks to the direct percolation of rainfall. The Chari, it would seem, is not connected to the aquifer.

As a result of droughts and a significant decline in surface water over the past 40 years, groundwater levels have fallen in these areas, and some wells and boreholes have dried up. Since 2000, however, the wetlands and the floodplains have been receiving more water, enabling them to adequately recharge the aquifer.

Map 29: Direction of groundwater flow in the Quaternary aquifer in the Chadian part of the Lake Chad basin



Source: BGR (Vassolo, 2012)

## Water quality

There is little available data on the quality of water in the Lake Chad basin. Water quality is affected by both human and natural factors. Intensive agriculture, dense populations and industry can have a dramatic impact on the physico-chemical and bacteriological quality of water. There is however an absence of adequate field observation networks in basin countries, resulting in poor knowledge of the quality of surface water and groundwater.

### Surface water

In general, changes in water quality increase as the water flows from the upstream basins towards the lake, which can be considered the ultimate receptacle of basin pollution. Changes can also occur in the lake itself, as the islands are inhabited and industries often set up in the vicinity of the lake. One example is the Djarmaya oil refinery in Chad, located just 100 km or so from the lake.

Before water leaves the upstream basins of the Chari-Logone and Komadugu-Yobe systems to join Lake Chad, it has to flow across the Yaere and Hadejia-Nguru floodplains respectively.

These floodplains play a buffering role, trapping sediments and pollutants being carried towards the lake. They reduce the proportion of suspended solids in the water, reduce the dissolved oxygen content and increase acidity and dissolved CO<sub>2</sub>. As the Logone, the basin's most erosive river, overflows into the Yaere plains, a large proportion of the clay particles it carries are trapped on these floodplains, enriching farmland with silt. Lake Maga is filling up with silt as sediments are carried by intermittent streams and runoff from the Mandara mountains into the reservoir in the rainy season.

## Physico-chemical quality

### 1. Agriculture

Generally, across the basin, agriculture close to water bodies is the main source of chemical pollution of surface water. The chemicals that have been identified in the water are those used on cotton crops in Cameroon, on rice and peanut crops in Chad and Nigeria, and for preserving fish. The chemicals used include cypermethrin, glyphosate, diuron and atrazine.

Irrigated farmland around Lake Chad and in Nigeria accounts for over 80% of the total area of cropland in the basin (including flood recession crops). The Logone River leads the ranking of recipient environments, as large amounts of chemicals are used for flood recession crops grown on its alluvial plains (particularly for rice and cotton). The Nigerian rivers also receive significant amounts of chemical pollution from agricultural inputs. Lake Chad is the fourth largest recipient water body, due to surrounding cropland extending over 28,000 ha.

In the upstream areas of Lake Chad's two feeder rivers, where rainfall is higher, there is much more rain-fed agriculture. It is generally intensive agriculture based on slash-and-burn methods. In the rainy season the denuded soil is exposed to surface sealing and watershed erosion. This leads to increased amounts of suspended solids in watercourses, causing changes in turbidity, colour and pH (higher acidity). Rivers become loaded with sediments with a widely varying chemical composition.



133: Industrial activities have an impact on water quality if wastewater is not treated

## 2. Industry

Heavy metal concentrations exceed WHO guideline values for drinking water in the two main tributaries. This is due to industrial effluents being discharged into the water courses. The situation is particularly serious in the Challa-wa River in the Komadugu-Yobe basin in Nigeria.

This situation is due to both a lack of treatment facilities to process wastewater before discharge and a lax enforcement of existing industrial waste management regulations.

According to past estimates, the average annual load of suspended solids in the Chari-Logone system was 81 mg/l, giving an export balance of 3,277,000 tonnes a year. In Chad the Lai section of the Logone contributes over 67.6% to this balance, while the Manda section of the Bahr Sara contributes 23.8% and the Sarh section of the Chari 8.6%.

Mechanical erosion caused by water is very active in the upper part of the Chari-Logone basin, where the pH of the water is generally basic in the dry season and acidic in the rainy season. Variations in pH depend not only on the type of clay (kaolinite or montmorillonite) that the Logone and Chari carry as they flow towards Lake Chad, but also on the concentration of dissolved silica.

The chemical quality of the Chari River water can be classed as good or even very good, as most of the known physico-chemical properties (pH, conductivity, nitrogen, cations and anions) are below WHO and EU guideline values.

The most serious degradation is found in Lake Chad, where nitrate concentrations are close to the 3 mg/l mark. However, the water in Lake Chad is relatively fresh, in spite of the fact that it is an endorheic lake and the rate of evaporation in the region is very high.

### Bacteriological quality

The bacteriological quality of drinking water is a serious concern throughout the basin, as bacterial contamination of water bodies with faecal coliforms is frequent, making water unfit to drink. This is caused by poor access to adequate sanitation facilities across the basin. This type of pollution is particularly serious in the Chari River, where it passes through inhabited areas, especially the city of N'Djamena, on its way to Lake Chad.

## Groundwater

### Physico-chemical quality

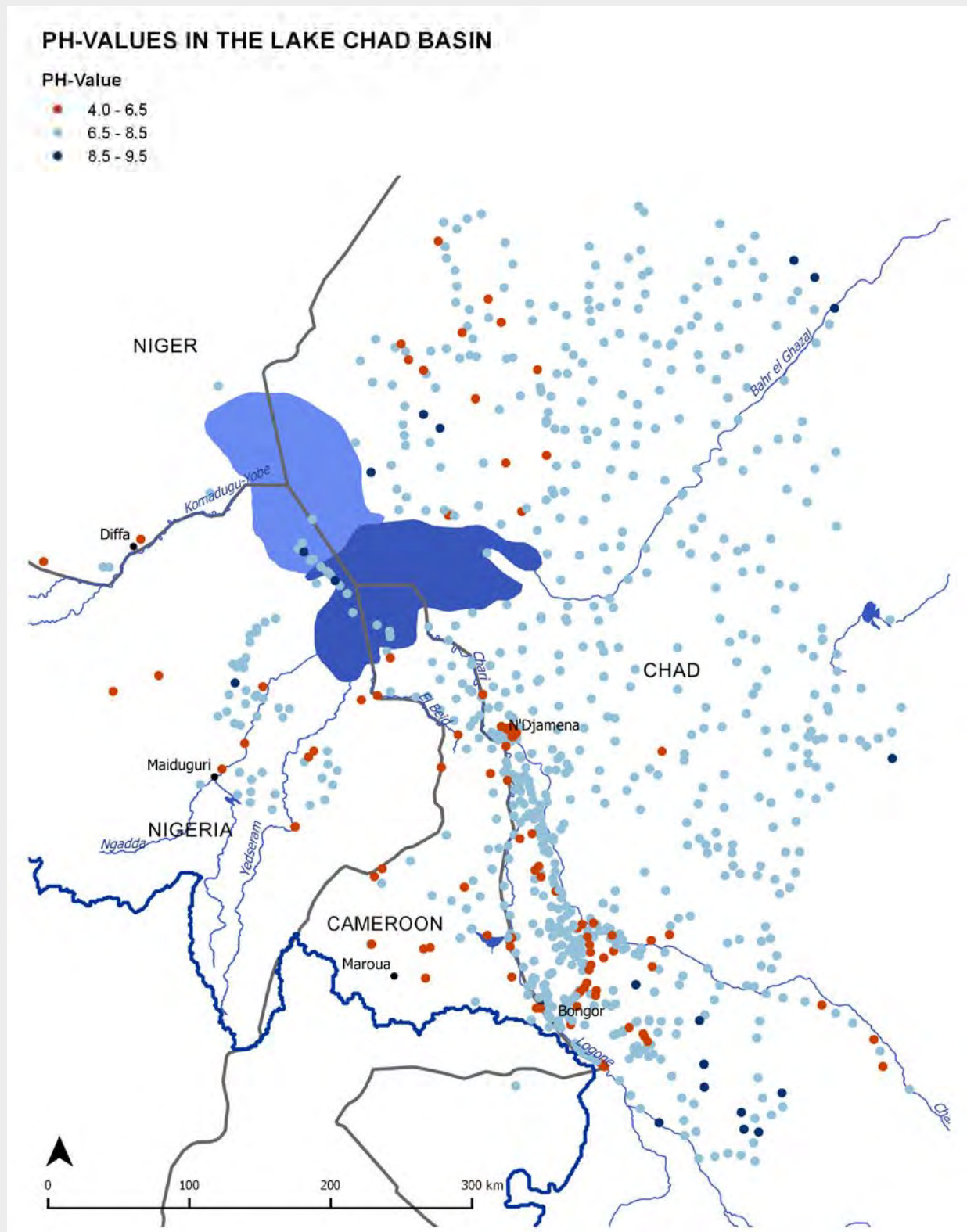
The physico-chemical quality of the groundwater is believed to be generally good in the basin, and it is widely used as drinking water. Mineralisation is low, with low concentrations of inorganic salts such as calcium, magnesium, potassium, sodium, bicarbonate, chloride and sulphate. The content of dissolved organic and inorganic substances (total dissolved solids – TDS) is low, generally less than 1,500 mg/l.

#### 1. pH

The pH value has no direct impact on the health of consumers, as long as the water is not excessively acidic or basic, but it is an important parameter for control several hydrochemical reactions and one of the most important quality control parameters. The pH value must always be measured in situ. Many hydrochemical reactions depend on the pH value, for example the calcium oxide / carbonic acid balance, the solubility of minerals such as iron, manganese and aluminium as well as the surface charge of several minerals and the absorption capacities. The control of pH (along with turbidity) is essential for the effective chlorination and disinfection of water (the pH value < 8) and to minimize the corrosion of pipes (the pH > 7). The WHO has set a target pH value of between 6.5 and 8.5.

In some areas near Lake Chad, particularly in Chad, groundwater is sometimes slightly acidic (pH < 6.5) or slightly more alkaline (pH > 8.5) depending on the location. In some places the groundwater has a high Total Dissolved Solids (TDS) value, as a result of high concentrations of sodium and sulphate. The most alkaline water with pH values over 7.8 is encountered along Bahr el Ghazal. Values between 7.5 and 7.8 are present in the surroundings of Lake Fitri and Lake Chad, as well as along the northern segment of the Chari River. Neutral water with pH values between 6.5 and 7.5 is found in the Massénya swamps and in the Kanem area to the north of the Lake Chad. Acid waters with pH values lower than the recommended minimum of 6.5 are present in five singular cases scattered in the study area. The concentrations of nitrates, fluorine, chloride, sodium, sulphates, calcium, magnesium, potassium and bicarbonate poses little danger to human health, as they occur in small quantities.

Map 30: PH-values in the Lake Chad basin



Source: BGR

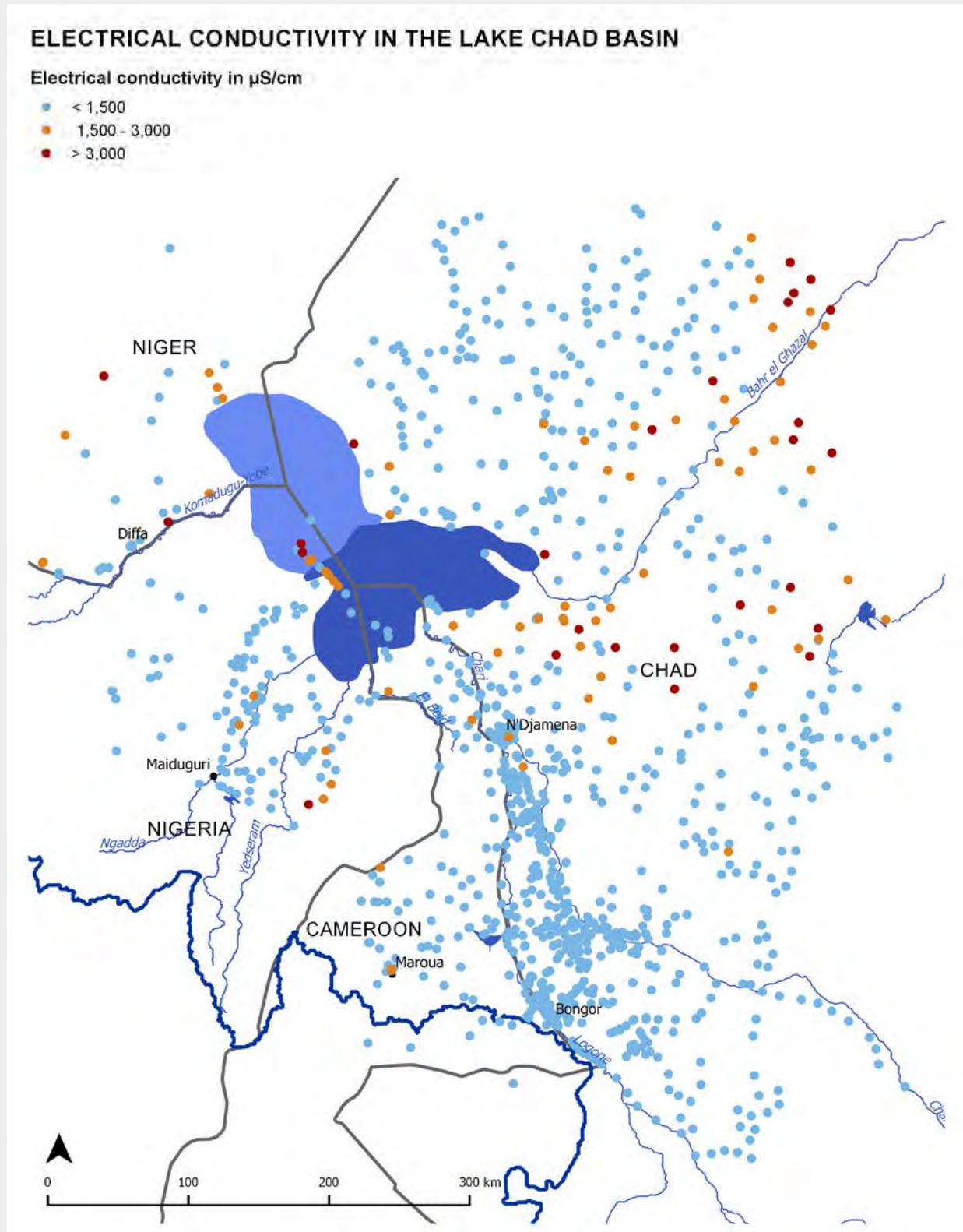
## 2. *Electrical conductivity*

Electrical conductivity is the capacity of water to conduct an electric current, mainly through dissolved ions. The principal ions in the water are non-organic dissolved solids such as carbonate, bicarbonate, sulphate, chloride, nitrate and phosphate (all anions, negatively charged ions) or sodium, potassium, magnesium, calcium, iron and aluminium (all cations, positively charged ions). Conductivity varies with temperature, with higher conductivities at higher temperatures.

In the areas studied, the electrical conductivity varies mainly between 120 to 200  $\mu\text{S}/\text{cm}$ , a typical value for recently recharged groundwater. However, in depression of the aquifer and along the Bahr el Ghazal, the conductivity can be up to 5000  $\mu\text{S}/\text{cm}$ . This high conductivity is due to the presence of salt resulting from the evaporation or stagnant water.



Map 31: Electrical conductivity in the Lake Chad basin



Source: BGR

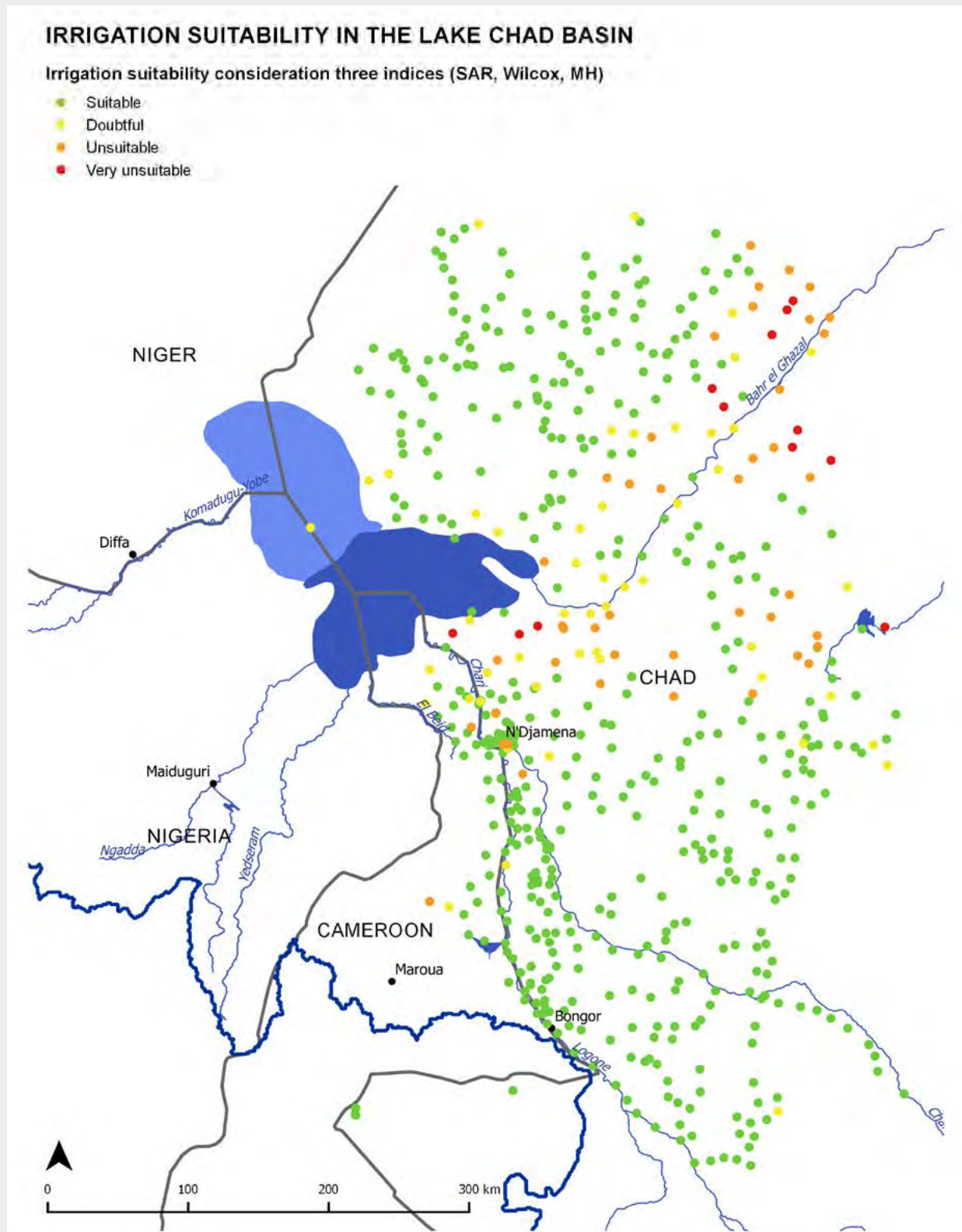
3. Suitability for irrigation

High sodium concentrations limit the use of groundwater for irrigation. If this water is used in agriculture, the sodium is adsorbed in the cation exchange sites in the soil and causes a dispersion of soil aggregates. Thus, the pores in the soil are sealed and it becomes less permeable. The permeability of the soil, especially in the case of montmorillonite clays.

The affected clay soils become anaerobic (low oxygen), saline or compacted (Bauder et al, 2008).

In some areas of Chad, particularly to the east and west of the Bahr el Ghazal and in the vicinity of Lake Fitri, groundwater is typically saline with a high sodium content, making it unfit for drinking or irrigation purposes.

Map 32: Irrigation suitability in the Lake Chad basin



Source: BGR

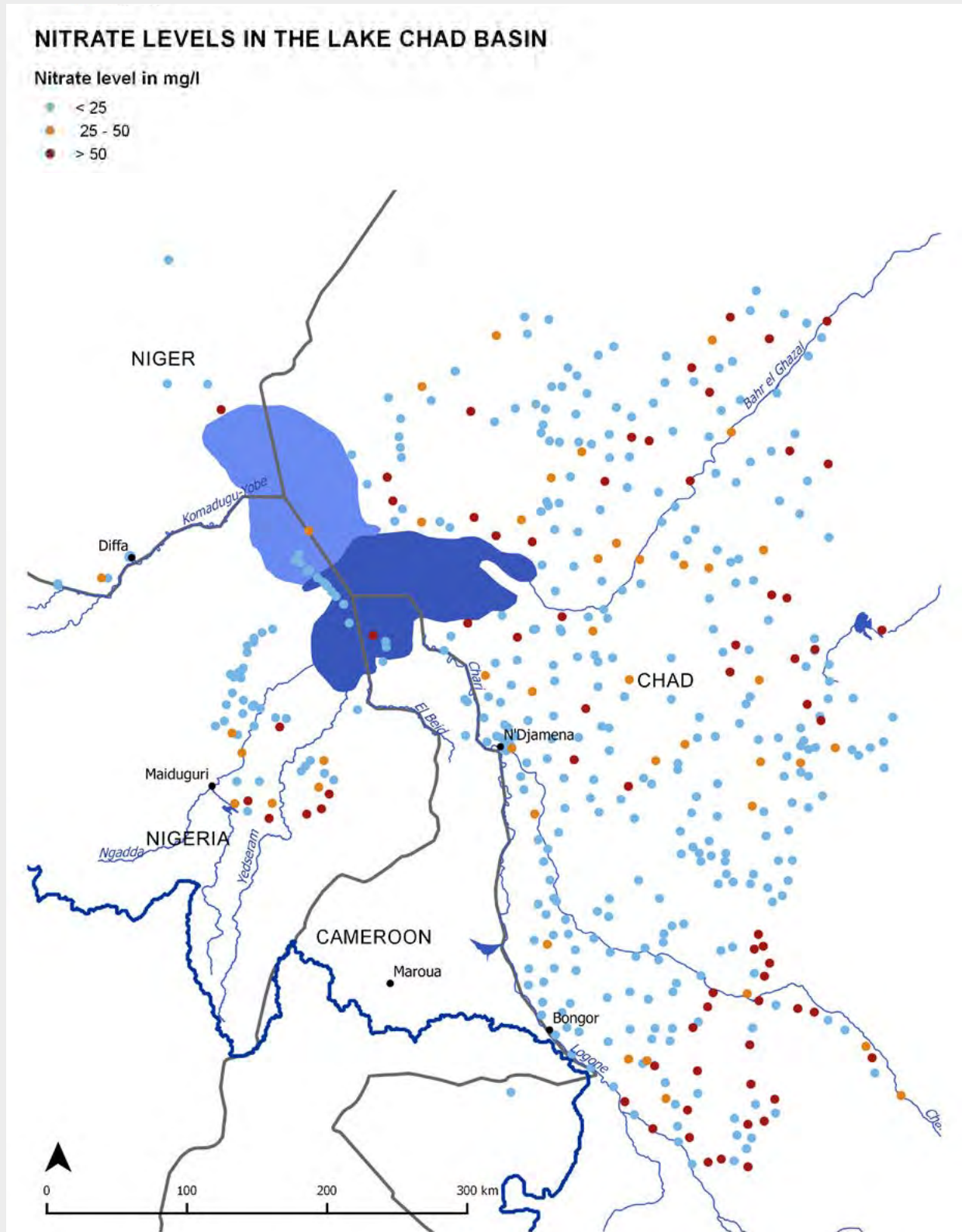
4. Nitrate

Prolonged exposure to high nitrate concentrations can be carcinogenic to adults. For babies and small children, the danger may be even more acute as it has been linked to methemoglobinemia (so called “blue baby syndrome”). The upper limit for nitrate concentrations in WHO standards is 50 mg / l (expressed as NO<sub>3</sub> nitrate). However, the EC

norms consider a concentration of 25 mg / l to be a signal for initiating measures to protect groundwater.

Nitrates from both natural and anthropogenic sources are present in the basin’s groundwater. Nitrates occurring naturally are the result of the mineralisation of soil organic matter accumulated during wet periods and broken down during dry periods. Anthropogenic point sources of nitrate

Map 33: Nitrate levels in the Lake Chad basin



Source: BGR

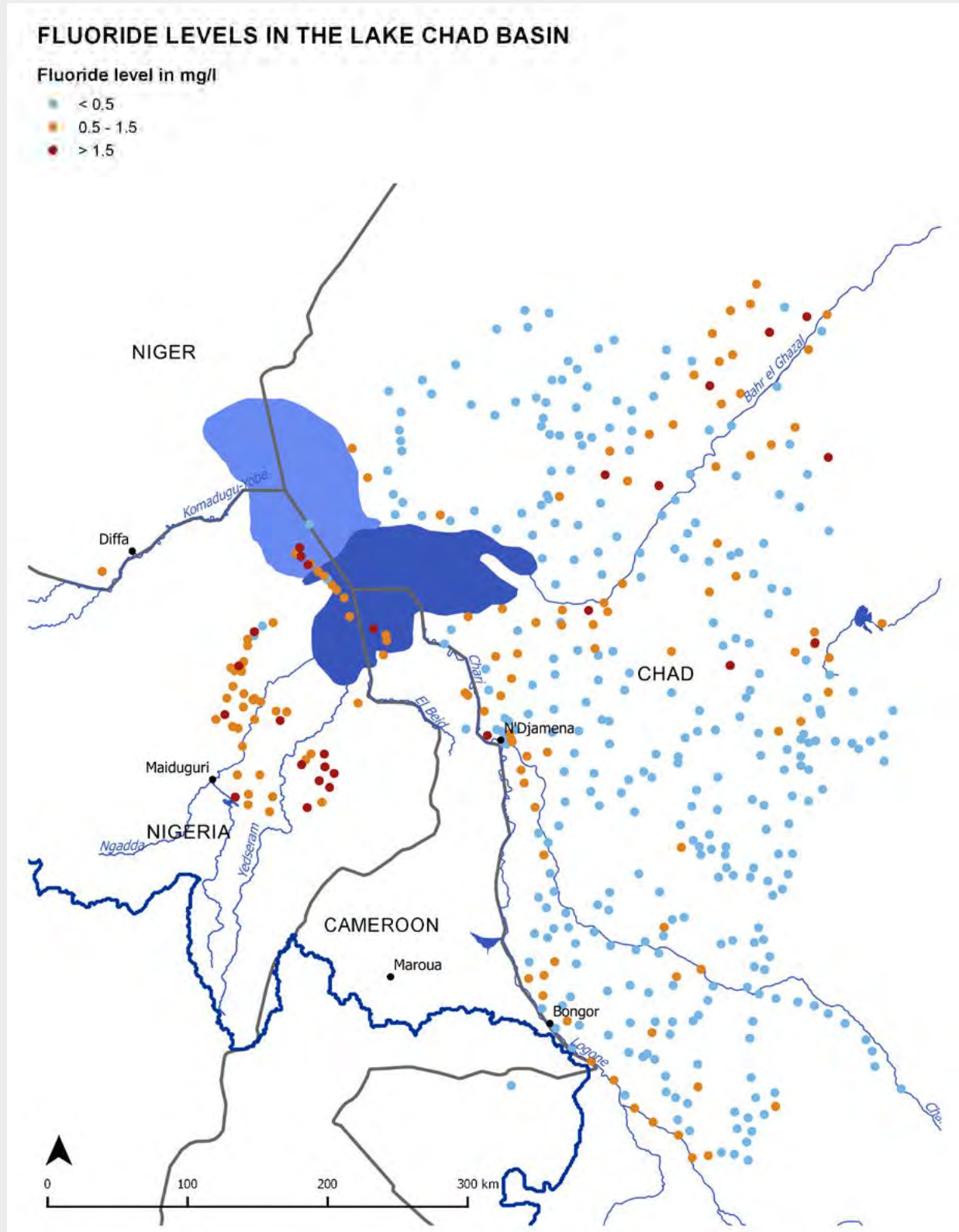
pollution include urine from livestock watered near wells and household latrines, while more diffuse sources come from nitrogen and chloride fertilisers used extensively on rice and cotton crops, and pesticides.

#### 5. Fluorine

The absorption of a certain amount of fluorine is considered necessary for the human body to prevent caries. However, prolonged exposure to concentrations higher than between 0.5 mg/l to 1 mg/l can lead weakened the teeth and changes in the skeleton (fluoride-sclerosis).

Fluorine concentrations in groundwater are above the 1.5 mg/l set by the WHO along the river Bahr el Ghazal, to the south of Lake Chad, and around Lake Fitri. The presence of mica in these areas may explain the high concentration of fluorine. The high concentration of fluorine around Lake Fitri may also be associated with the groundwater passing through highly weathered granitic rocks. Along the Logone, flowing along a fault zone, fluorine concentrations are also high. These high fluoride levels may be indicative of upwelling from the complex to the rocky shallow aquifers.

Map 34: Fluoride levels in the Lake Chad basin



Source: BGR

**Bacteriological quality**

In the basin's large cities, particularly N'Djamena, Kano, Maiduguri and Maroua, where large numbers of people live in unplanned areas, wells supplying drinking water

are often built too near to latrine pits and leaking septic pits. These represent a potentially serious point source of bacterial and chemical pollution in groundwater (faecal coliforms and nitrates).

## Use of water

Water management, which is linked to climate change, agriculture, food security, energy, health and even gender equality, underpins the three pillars of sustainable development, which are economic development, social development and environmental protection

In the Lake Chad basin, water is used for different purposes: drinking water supplies for households, for livestock, irrigation for agriculture, for industry, in transport, to protect nature, etc. Meeting basic water needs is, in itself, a huge challenge, and the issue of access to water resources is also a complex problem.

## Drinking water

Ensuring safe sources of drinking water is a priority as the needs of urban and rural populations of the basin are large and grow. Groundwater is currently the most commonly exploited source for drinking water: it is estimated that there are about 18,694 boreholes (2012) distributed between the Pliocene and Quaternary aquifers, with 11,395 of these in the Quaternary. Data from 2000 estimated an annual drinking water demand of 80 million m<sup>3</sup> in the basin, mainly from groundwater. Wells are particularly concentrated in northern Nigeria. In some cities of Nigeria, Cameroon, Chad and Niger, artesian wells are used for AEP.

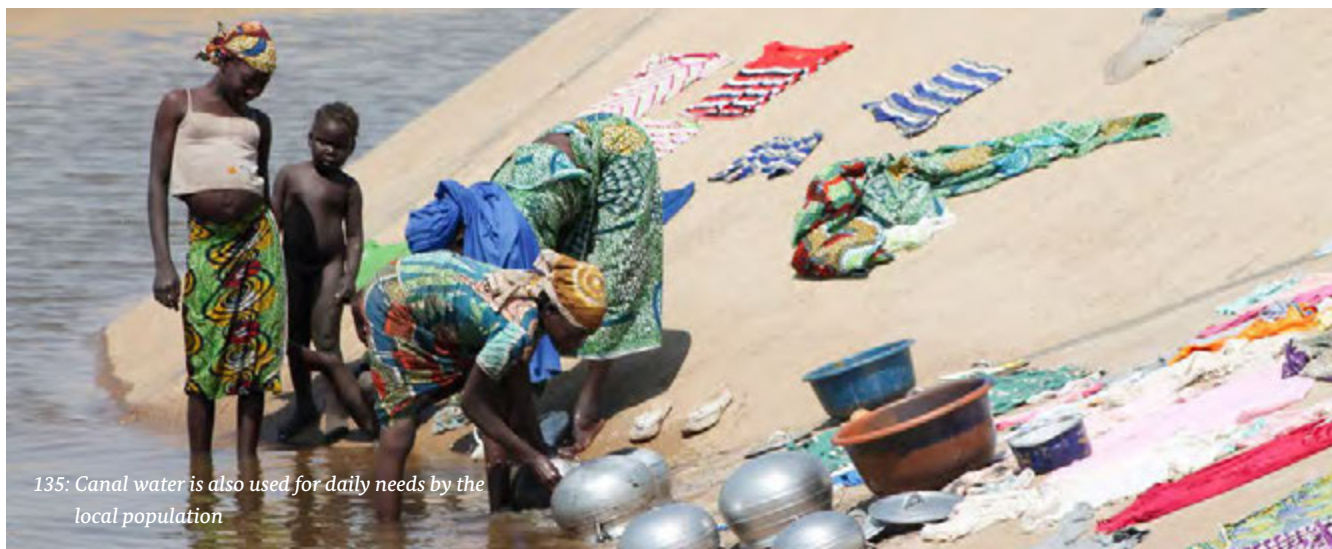
Governments are generally responsible for ensuring the population has access to clean water and appropriate sanitation. Despite the efforts of States to facilitate access to drinking water for their populations, the bulk of investments still from external technical and financial assistance partners. In Niger, for example, between 2000 and 2006, 120 billion CFA francs were invested in the sector, with an annual average of 17 billion FCFA. The sector remains largely dependent on external financing.

Investment to date has mainly been concentrated in rural areas, but investments in urban and semi-urban areas are becoming increasingly important as demand grows. In 2000, Chad, drinking water need were estimated at 20 l/cap/day in rural areas, while urban consumption can reach up to 80 l/cap/day. The drinking water sector in urban areas is managed by the production and distribution of water companies, usually in the form of a stat or parastatal monopoly (STEE Chad, CAR SODECA, SEEN in Niger, SNEC in Cameroon etc.). In rural areas, water is generally managed by communal water management committees.

The question of covering the necessary investment and operating costs in the water supply sector in both urban and rural areas is a real challenge. Often this is because the water supply service is sold at a price below production costs, usually to ensure access to the most vulnerable. This however makes it impossible to maintain the supply system and services can quickly fall into disrepair. Lifting families out of poverty would have a great impact on the available finances in the water sector.



134: Water tower, Niger



135: Canal water is also used for daily needs by the local population

### Investment needs for N'Djamena

With an estimated growth rate of 2.3% between 1993 and 2005 (Ministry of Planning), water demand is expected to grow from over 55 000 m<sup>3</sup>/day in 2010 to 160 000 m<sup>3</sup>/day in 2035. The drinking water supply for N'Djamena may eventually lead problems if the aquifers are overexploited, surpassing their recharge capacity, and if sewage infiltration reaches the groundwater.

Whilst theoretically the Chari does offer an alternative water source, it is not reliable as it can dry out from March to June, with measured monthly average flow rates of 0 m<sup>3</sup>/s in May 1985 or 2 m<sup>3</sup>/s in April 1990 being recorded at Chagoua, just upstream from N'Djamena. With severe droughts occurring regularly there is a risk of the Chari drying up every 16 years. Additionally, the treatment costs to make the Chari water potable would be twice the costs for treating the relatively unpolluted groundwater. The waters of rivers and pools are generally not exploited at the moment for domestic use. It is rather transported by water carriers or used directly in situ mainly to wash laundry.

The volumes of water for these uses is difficult to quantify precisely but has been estimated at 2 million cubic meters per year.

The national water supplier, STEE (Chadian Society for Water and Electricity), within the blueprint for the water supply network of N'Djamena from 2007 N'Djamena, earmarks the exploitation of groundwater, from the Quaternary and Pliocene aquifers, which are of good chemical quality. The investment costs would be four times lower than those required for the exploitation of surface water. To meet the growing demand, 61 new wells would be needed, including 10 in the Pliocene aquifer. At the end of 2006 the STEE had 13 drilling rigs, which was already insufficient to meet requirements. In addition to the extra boreholes, developing the system will also require the strengthening of the distribution system and storage capacities. In order to make the activities of the STEE sustainable and to provide a profitable economic value of water, these investments could be financed by external support but also by price increases of 20% in the short term and 7% every 3 years.

### Crops and livestock

In the basin, agriculture and livestock farming both have significant water requirements, satisfied largely by surface water (rivers, lakes, rainwater). In Chad, agriculture consumes around 190 million m<sup>3</sup> of water per year. Modern irrigation systems have only relatively recently been introduced, mainly following the great drought of 1973. The main irrigated areas are found in the river valleys, the area around Lake Chad and along the wadis. In the Saharan area, all agricultural production requires irrigation. In the Sahelian area, however, farmers combine small-scale irrigation with rain-fed agriculture and livestock farming.

Abstractions from Lake Chad are carried out as part of extensive programmes for agricultural development and the

creation of income-generating activities, aimed particularly at women and improving food security. In Nigeria the Kano River Irrigation Project implemented in the state of Kano requires an estimated 25,000 m<sup>3</sup> of water per ha per year. In the Cameroonian part of the Chari-Logone basin, the main surface water structures built for rice growing include a number of reservoir dams (Maga, with a storage capacity of 625 million m<sup>3</sup>; Mokolo, 5 million m<sup>3</sup>; Tourou, 804,000 m<sup>3</sup>; and Oumbeda, 144,000 m<sup>3</sup>). In Chad a water management scheme provides water for the 1,850 ha Sategui-Deressia rice fields. The water is abstracted from the Logone River via a channel with a capacity of around 50 m<sup>3</sup> an hour. The overall water requirement amounts to 1 million m<sup>3</sup> a year.

Mainly built in Nigeria, the dams have enabled many people to have an improved access to water for agriculture and even



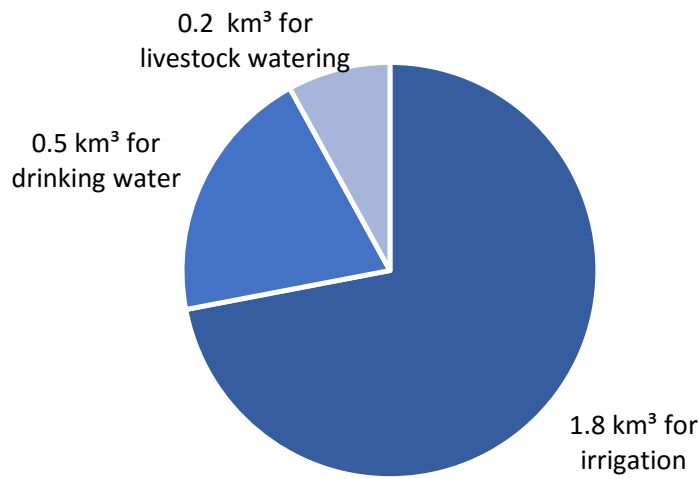
diversify their crop production. An example is the Alau dam that supplies the city of Maiduguri (Nigeria) with water.

Despite the withdrawals from the lake, overall extractions remain negligible. The pie chart shows the estimated volume of withdrawals from Lake Chad, its tributaries and alluvial aquifers, amounting to around 2.5 km<sup>3</sup>/year in 2010. Of this, 0.5 km<sup>3</sup> was used for drinking water, 1.8 km<sup>3</sup> for irrigation and 0.2 km<sup>3</sup> for livestock watering.

The total amount of water withdrawn, which includes abstractions by all the small private holdings along the river banks and around Lake Chad, represents a tiny proportion of the water resources in the basin. For the time being, however, the major irrigation schemes on the edge of Lake Chad in Nigeria (South Chad Irrigation Project and Baga Polder, totalling around 200,000 ha), which could consume over 2 km<sup>3</sup> a year when fully operational, have not contributed to the reduction of the lake's water levels, because they are not in operation.

Figure 42: Water withdrawals from Lake Chad in 2010 (in km<sup>3</sup>)

### Water withdrawals from lake Chad in 2010



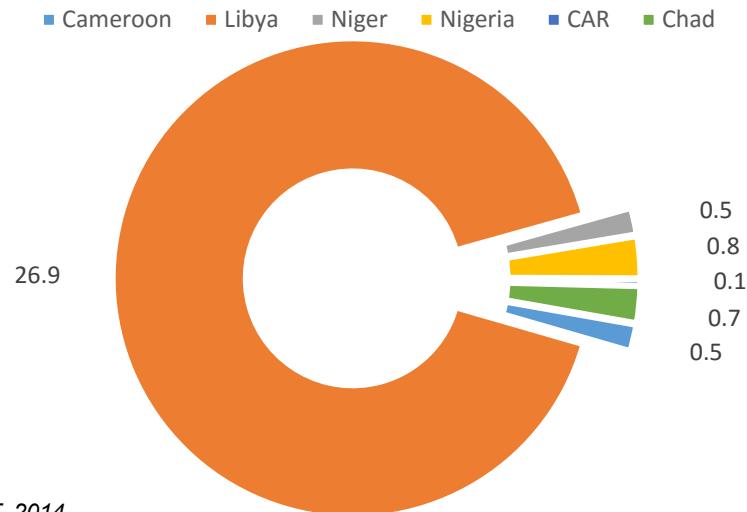
Source: LCBC, 2010



136: Irrigated perimeter in Chad

Figure 43: Proportion of arable land under irrigation by country between 2009 and 2012 (3 year averages)

### Proportion of arable land under irrigation by country between 2009 and 2012 (3 year averages)



Source: FAOSTAT, 2014

One of the limitations of these irrigated areas is related to the management and operation of the areas. Generally, farmers operate small irrigated fields, often practicing a monoculture imposed on them which quickly tires the soil. The observed yields are generally lower than optimal. Although these dams can have harmful repercussions on biodiversity, they have been traded off against potential improvements in the living conditions of local people. Governments are thus planning the construction of new dams in the upper reaches of the Chari-Logone basin and on the Komadugu-Yobe.

Livestock farming also uses surface water and groundwater sources to water the animals. Small dams and pastoral wells have been built along transhumance corridors to meet these requirements. Natural temporary ponds, which normally contain water for several months during the year, serve as water points for herders. Perennial rivers and lakes are also used for this purpose. However, water policy and strategies for pastoralists are poor in the basin, given the importance of livestock.

Access to water by different user groups can be problematic. In addition to issues relating to sharing the resources, there is also the question of whether water used by herders is fit for human consumption. Water bodies that do not dry up are generally used by farmers and fishermen, which can lead to serious social conflicts. In some cases, these water points, which are a source of conflict with herders, are located in protected areas.



from top to bottom:

137: Pastoral wells financed by PRODEBALT

138: Drinking trough built by villagers for their cattle

## Fishing

Although fishing is a seasonal activity, it is an important source of food and income for people living in the basin. According to national figures, annual fishery production in Lake Chad is estimated at around 100,000 tonnes of fish caught by some 200,000 fishermen.

There are numerous bodies of water, including lakes, temporary ponds, rivers and streams, which serve as fishing grounds. Increasingly, however, fish farming is being developed as part of poverty reduction projects. An indirect benefit of this strategy is that it has eased the pressure on fish species caused by overfishing in natural water bodies.

The Chari-Logone Integrated Rural Development Programme currently being implemented in the departments of Logone-et- Chari and Mayo-Danay in Cameroon, aims to create fishponds in order to promote family fish farming. This can be carried out by women and young people as a part-time activity.

Dams are often constructed for the purpose of agricultural development or power generation. An option that is being explored is the possibility of developing the, as yet unrealised, potential of small dams to increase stocks of fish species that have disappeared from the wild.



139: Fishing is practiced in every available water hole in the basin

## Water for industrial use

Many industrial operations require water in the production process and most industries in the basin are located near to water sources. Some are situated above aquifers from which they pump water directly and then discharge effluents into rivers, with some having their own boreholes, and others using surface water to supply their factories.

La plupart des industries dans le bassin sont implantées aux abords des cours d'eau. Certaines résident sur des aquifères où l'eau est directement pompée et rejetée dans le fleuve. Les industries possèdent très souvent leur propre forage, alors que certaines d'entre elles utilisent les eaux de surface pour l'approvisionnement de leurs usines.

Chad's brewery Les Brasseries du Tchad (BDT) and the cotton company CotonTchad are located on the Logone River in Moundou. BDT has three 80 m deep boreholes for its water supply. The plant uses an average of 23,500 m<sup>3</sup> of water each month in the manufacture of mineral water, beer and soft drinks. After the water has been used for a variety of purposes in the processing units, the effluents are discharged directly into the Logone River. More data is needed on the composition of the wastewater for a better understanding of its impact on the environment.

A serious potential source of chemical pollution in the basin is the oil industry, which is starting operations in different parts of the Lake Chad basin countries. Oil prospecting by foreign companies has revealed numerous oil deposits in the basin (arable land, the Yaere floodplains, protected areas and Lake Chad itself).



140: Selling bottled water in Nigeria

## Transport

Road infrastructure is still being developed in the basin. Nigeria and Cameroon intensified their network in the 1970s, with Nigeria tarring the axis Maiduguri - Lake Chad and Cameroon tarring the axis N'Gaoundéré - Kousséri. Niger and Chad lagged behind until 2000s when the mining boom and external aid enabled work on the road network. However, these efforts remain insufficient as the completed major roads are not sufficiently maintained and the secondary roads are not paved.

Nevertheless, river transport exists mainly only for the transportation of fishermen and local residents as well as for floating firewood down the Chari upstream from N'Djamena. Although this is an informal activity, it is struc-

tured and managed by several groups who observe rules dictated by tradition and custom. Traffic on Lake Chad, which is heavier than on the rivers, owing to its geographic location, is also informal. There is no river transport company to speak of or government services responsible for navigation on the two main rivers or on Lake Chad even on a partial or seasonal basis.

Currently, passing through the shallows between the islands and open water and to Baga Kawa, west of the lake is made difficult by heavy vegetation. Navigation in the northern basin is only sporadically possible and depends on regular flooding. Besides vegetation, the wind also poses a problem for navigation, particularly in February and March during the Harmattan, as it creates strong waves making it particularly dangerous for paddlers.



141: Transporting wood on the Chari



142: Pirogues are used by local people to get around

## Tourism

Tourism is not developed in the basin, much less around the lake, due to its isolation and insecurity. Tourism is mainly limited to expatriates and their visiting families and adventurers. But the basin does have a high tourist potential, including lakes and other bodies of water where biodiversity can be an important tourist attraction points. Lake Maga in Cameroon, which hosts many hippopotamuses, benefits greatly from this. The lakes of Borkou-Ennedi-Tibesti (BET), the Lake Chad area with its many islands, the wildlife easily accessible from the tourist resort of Douguia are all attractive areas in Chad. This is also the case for Lake Fitri, a wetland of international importance. The various categories of natural areas such as national parks and wildlife reserves include aquatic ecosystems that are also tourist attractions. This includes, for example, the



from top to bottom:

143: Poor infrastructure makes it hard to access tourist sites

144: A trip in a small boat on Lake Chad

Kalamaloué National Park, in Cameroon but not far from N'Djamena, which is famous for its elephants.

## Park maintenance

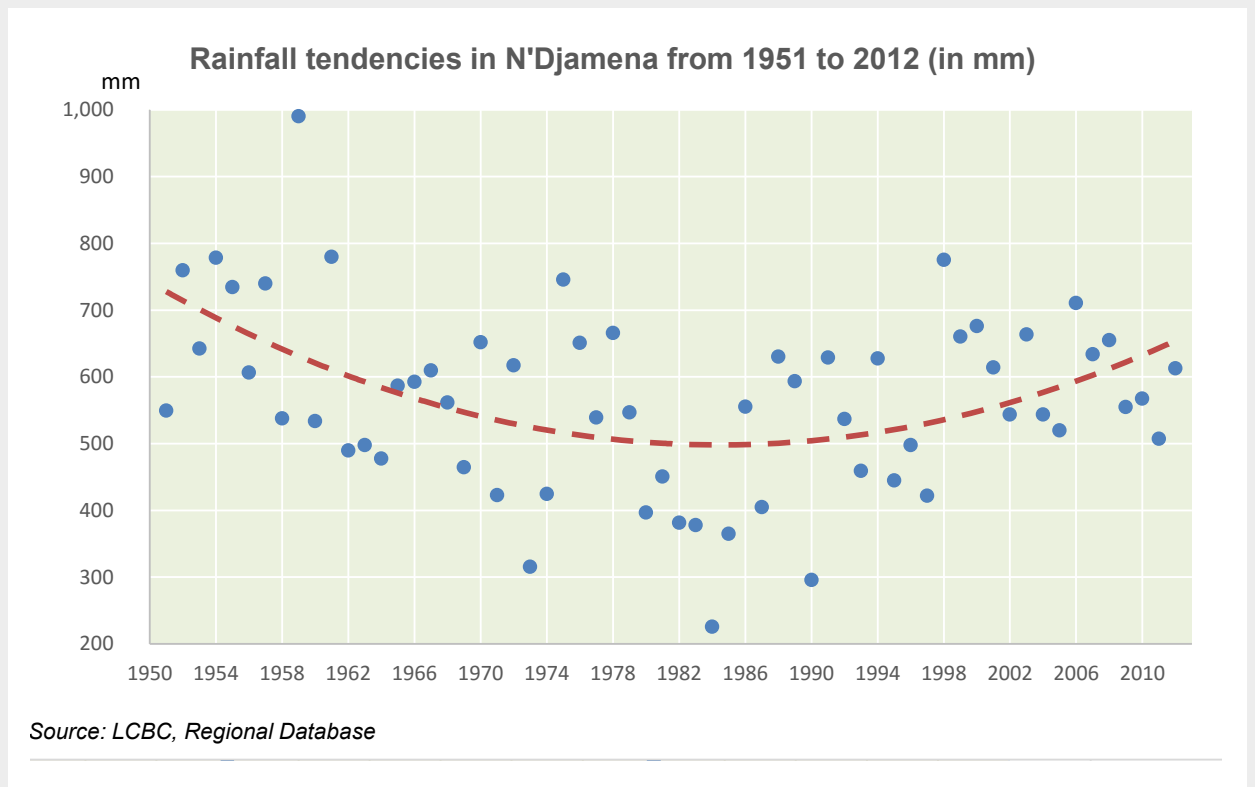
Numerous parks in the basin are maintained thanks to the presence of water bodies, which attract wildlife. Tourism is also an engine for the conservation of parks, supported by the investment policies of basin states.

However, nature conservation is facing huge challenges such as poaching and insecurity in the area. In addition, the conservation of biodiversity has often been neglected leading to a loss of wildlife in the catchment, with animals migrating to more suitable areas. For example, the management of Waza National Park in the Far North region of Cameroon has been disrupted by the construction of the Maga dam. The dam has caused the drying of the main wetland, and park authorities have had to create artificial ponds. These ponds are fed in part by rainfall and in part by groundwater pumped from boreholes. It is, however, very difficult, in these conditions, to retain the herds of elephants that migrate each year between November and January to the neighbouring Kalamaloué National Park in the Far North region of Cameroon, seeking the ponds and blind arms of the Chari River.



145: Some ponds in the Waza park dried out following the construction of the Maga dam

Figure 44: Rainfall tendencies in N'Djamena from 1951 to 2012 (in mm)



Source: LCBC, Regional Database

**A water balance for the catchment**

Climate conditions and the available water resources in the basin have varied widely over the past 50 years. Over the past 10 years there has been a slight increase in rainfall recorded at most of the basin's observation stations. Rainfall

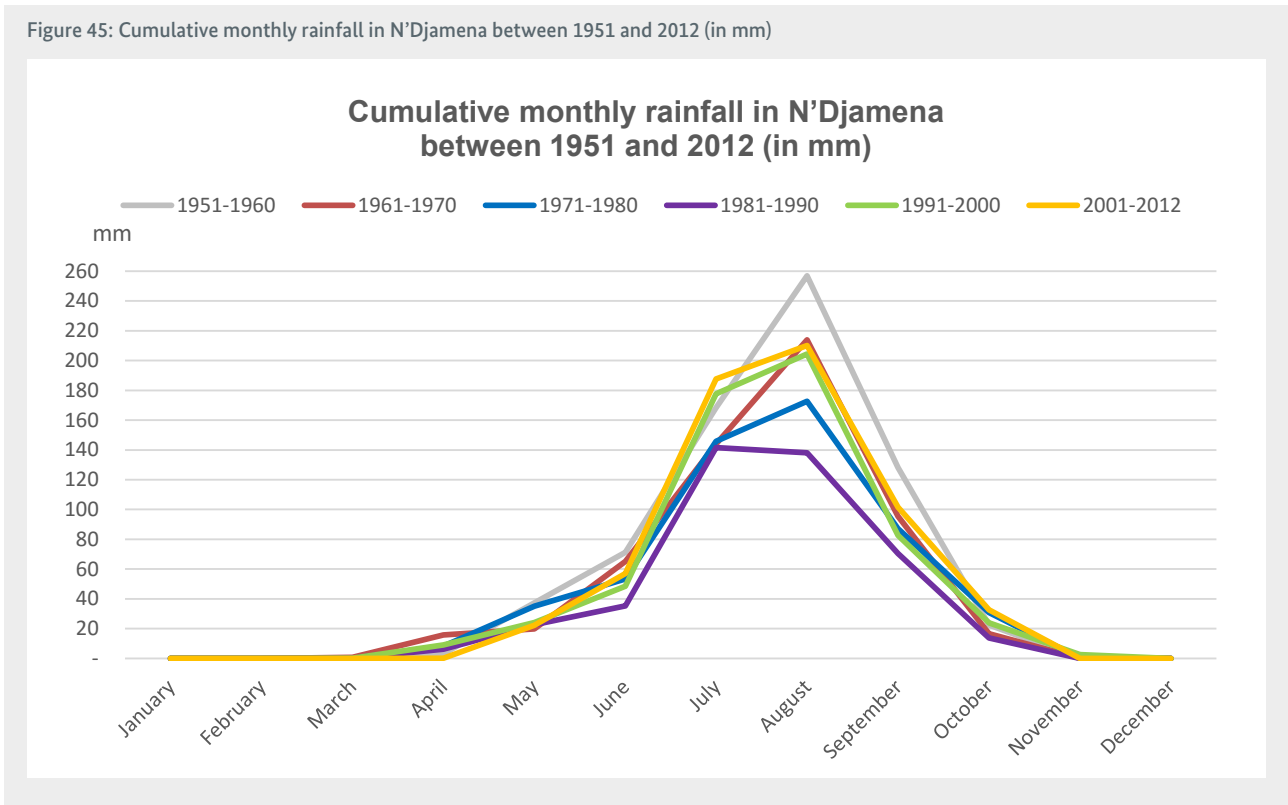
variations have been close to the average value calculated. A long-term analysis of rainfall at the N'Djamena observation station reveals an upward trend since the late-1980s.

This trend can also be observed in average cumulative monthly rainfall figures.



146: A dry water level in Lake Chad

Figure 45: Cumulative monthly rainfall in N'Djamena between 1951 and 2012 (in mm)

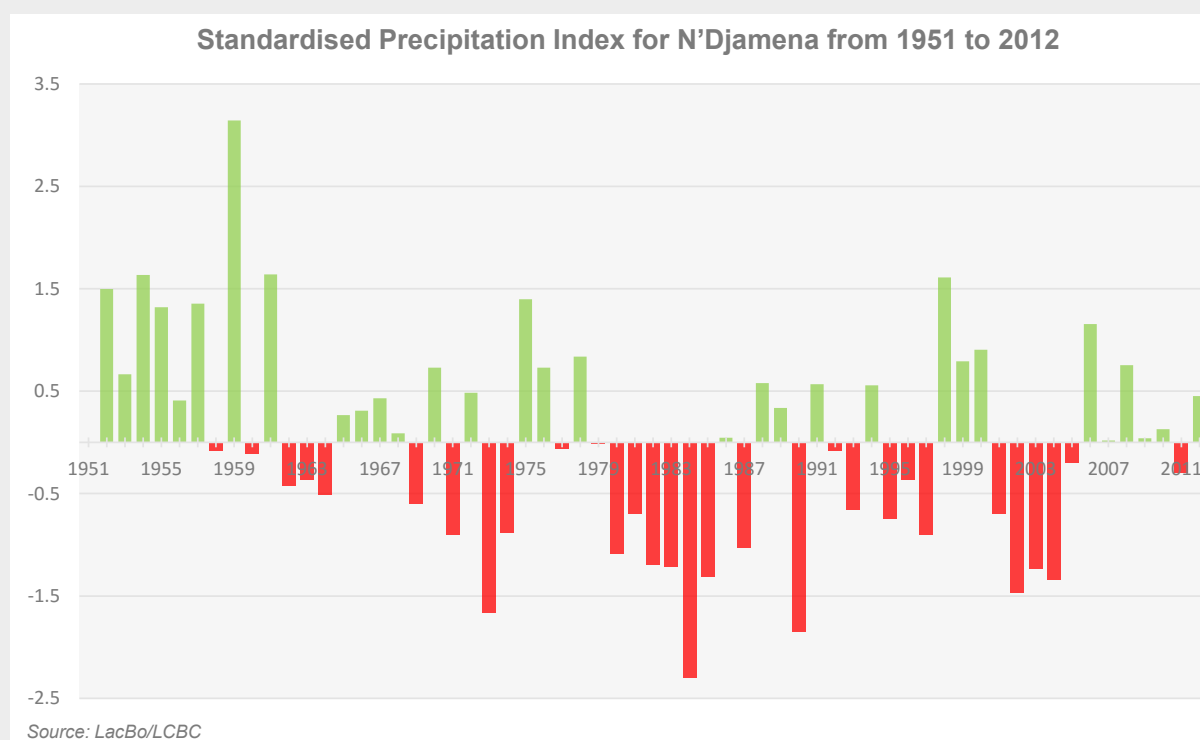


The decades 1951–60 and 1961–70 were two relatively wet periods in the basin as a whole, while the periods 1971–80 and 1981–90 were marked by drought in the Sahel and the Lake Chad basin. This period of drought, which was particularly severe in 1972–73 and 1983–84, shifted isohyets 150 km southwards. In practice, this represents a reduction in rainfall of around 130 mm in the basin as a whole. The 2000s, however, saw average values of the Standard Precipitation Index of between -1.5 in the early-2000s and 1.5 at the end of the decade. This means that year-to-year variations were less pronounced. A situation characterised by greater year-to-year stability and, above all, fewer droughts or fewer floods is beneficial for all sectors of the population and for farmers in particular.

Variations in river discharges into the Lake Chad are a better indicator of variations in rainfall in the basin as they vary proportionally to rainfall. Specifically, discharges vary by around 30% when rainfall varies by around 10%. Projected trends show that there will be no drastic reduction in the discharge of the Chari and other perennial watercourses in the basin in the short term.

In spite of this, the hydrosystems, particularly the Chari-Logone, remain vulnerable to significant anthropogenic pressures, such as deforestation of the drainage basins, which leads to land degradation and the silting and sedimentation of watercourses. River flows decline as a result, causing Lake Chad to shrink further.

Figure 46: Standardised Precipitation Index for N'Djamena from 1951 to 2012



## Conclusion and recommendations

Water resources in the Lake Chad basin essentially consist of surface water in the Chari-Logone and Komadugu-Yobe drainage basins and groundwater stored in sedimentary and foliated crystalline rock formations.

Rainfall patterns are influenced by the movements of the Intertropical Convergence Zone (ITCZ). Variation in the location of the ITCZ, as it moves from south to north, results in the dry and wet seasons of the basin. There are zonal differences in rainfall levels, which decrease slightly from south to north in the basin. In general, August and July are the wettest months, and the rest of the year is dry and hot, with temperatures and evaporation especially high between May and April, particularly in the northern part of the basin. There is a lack of climatological data, because climatological observation has to date been confined to that required for air navigation safety in the basin countries.

The Lake Chad basin is characterised by vast floodplains that play an important role in the flow of water into the lake. The environmental services they provide include supporting fishing, livestock farming and agriculture, maintaining wildlife and wetland habitats and recharging water-table aquifers. Some of these areas are of global significance because of the rich biodiversity they support.

Groundwater is found in the continuous, unconfined Quaternary aquifer system, the Pliocene and Continental Terminal artesian aquifers and discontinuous bodies of water located in crystalline fractures in the Precambrian

basement. While their physico-chemical quality is generally good, their bacteriological quality is not necessarily so. Nitrate levels are high in both surface water and groundwater as a result of human (domestic, agricultural and industrial). Abnormally high concentrations of other naturally occurring chemicals are also found in some aquifers, where they are leached from heavily weathered granite formations. Groundwater is however of generally good quality.

Measures to protect water resources from pollution caused by human activities in the Chari-Logone region are urgently required. Where there are high nitrate concentrations, hand-dug wells should be abandoned and replaced by improved, modern boreholes and improved agricultural extension should reach out to farmers to control fertiliser and pesticide use. Water with a high salt content should not be used for irrigation. This is a problem that affects areas to the east and west of the Bahr el Ghazal, to the south of Lake Chad and in the vicinity of Lake Fitri.

With regard to water use, while it is clear that meeting basic water needs is, in itself, a major challenge, particularly for large cities such as Kano, N'Djamena and Maiduguri, the issue of access to water resources is a complex problem that affects the entire basin. Satisfying drinking water needs is a priority concern, and rural water infrastructure and drinking water supply programmes based on the exploitation of groundwater resources have been implemented with government and international support. Basin governments have developed strategies to improve access to safe drinking water in rural and urban areas, as part of efforts to achieve the water-related targets of the Millennium Development Goals.



Other sectors dependent on access to water resources include livestock farming, agriculture, industry, aquatic ecosystems and navigation. By far the biggest water user in the basin is agriculture, particularly through irrigation systems. It is followed by livestock farming, which uses both surface water and groundwater. Flood recession crops are grown near lakes, temporary ponds, rivers and streams, and industries often use boreholes to extract groundwater for their operations. Many floodplain areas are used for fishing and to graze livestock and grow crops. In spite of its great potential, tourism that takes advantage of the basin's water bodies remains insufficiently developed. River transport consists mainly of floating logs down the river in the rainy season and the transportation of goods across Lake Chad from Nigeria to other regions bordering on the

lake. Both fishers and merchants use water transport for their activities. Many parks in the basin are sustained by the bodies of water they contain, as these attract wildlife such as elephants.

In conclusion, rainfall has improved slightly in the last decade in the Lake Chad basin, although the overall downward trend persists. Water resources have been mobilised to a greater extent than ever for agriculture, livestock farming and fishing, the key sectors of the economy of the Lake Chad basin. The size of Lake Chad, which is an important indicator of water resources in the basin, is gradually increasing; indeed, its area has grown from 6,000 km<sup>2</sup> to 14,000 km<sup>2</sup>. Groundwater levels, on the other hand, are still relatively low.



## 4

## Transboundary environmental problems

### Key messages

The LCBC has identified seven major transboundary environmental problems in the Lake Chad basin and ranked them in order of importance.

**The variability of the hydrological regime and freshwater availability** (environmental problem 1) is the most important natural factor contributing to the degradation of the basin ecosystem. It is due mainly to a sharp decline in rainfall in the 1970s and 1980s, causing a prolonged period of drought, which continued until 2008. Lake Chad, in particular, has been affected by the reduced discharge of the Chari River, which accounts for between 85% and 90% of the total inflow to the lake. As a consequence, there has been a dramatic decline in the area of the lake, the regime of all surface water systems and in groundwater levels. Over the past twelve years, however, there has been a slight improvement in rainfall in the basin, although visible signs of a real increase in river flow or groundwater levels have yet to be observed. In addition to these natural factors, the situation has been further exacerbated by human activities, such as the construction of dams, irrigation schemes, water withdrawals, diversions, etc., which are often the result of poor water management policy and decisions beginning in the 1960s.

**Water pollution** (environmental problem 2) is not a very widespread problem in the basin yet. It is however a cause for serious concern in Kano (Nigeria), which has seen a rapid increase in the number of tanneries and textile factories that are potential sources of pollution. Currently, the level of pollution is relatively low and confined to traces of heavy metals (zinc, mercury, magnesium, etc.). In the Chari-Logone basin, fertilisers, herbicides and insecticides are frequently used on cotton and rice crops. Excessive use could eventually lead to pollution caused by these agricultural inputs (e.g. diffuse nitrate pollution etc.). Microbial pollution of water courses, resulting from extremely low levels of access to appropriate sanitation, is however widespread. Cholera, which recurs regularly in the region claimed large numbers of victims in Chad, the Far North

region of Cameroon, Maiduguri in Nigeria and the Lake Chad region between 2010 and 2012.

**Sedimentation in rivers and standing water bodies** (environmental problem 3) is a problem throughout the central part of the basin, particularly in the Lake Chad region, where both flowing water and wind act as agents of sedimentation. Water-related sedimentation is caused by the erosive action of rain on the sub-basins, runoff flowing over flat land and channel erosion, which occurs when high-flow events degrade waterways and their banks, particularly in deforested areas or areas stripped of vegetation. In the low-flow season, the sediment in the Chari-Logone system reduces the flow of water. In settlements floods are common, as meanders and sandbanks caused by deposited sediment divert watercourses from their usual channels. Sedimentation also affects fishing and transport on the lake and other water bodies in the basin.

Aeolian sedimentation is caused by sand particles transported by the wind from dunes located in the Sahelian and Saharan regions. It silts up the northern part of Lake Chad, reducing the area of open water.

**The decline in biological diversity** (environmental problem 4) in the basin is a major concern. However, it is difficult to ascertain the extent of the problem with any accuracy due to a lack of available data and with the current security problems in the basin affecting almost all the protected areas. Figures obtained from studies in 2008 revealed a serious decline in biodiversity resulting from the intensification of human activities and the subsequent damage and changes to ecosystems. For example, deforestation caused by the rising demand for fuel wood and shifting cultivation is a widespread problem in all the basin countries. However, the improvement in rainfall levels in recent years has restored vegetation cover in some places, particularly in areas affected by armed conflicts, where people have abandoned their land to flee the fighting.

The basin's ecosystem is affected by three major **invasive species** (environmental problem 5), particularly in the

regions around Lake Chad. The first is the bulrush (*Typha*), a plant species that has invaded the Hadejia Nguru wetlands in Nigeria. The hydrological regime of the Komadugu-Yobe River, already diminished by numerous upstream dams, is being disrupted by the proliferation of these bulrushes. The second is the mesquite (*Prosopis africana*), a tree species that is particularly abundant in the Diffa region (in Niger), forming dense forests. In the Lake Chad region, mesquite trees cause problems for herders, farmers and fishers. The third is the red-billed quelea (*Quelea quelea*), an invasive bird species which interacts with the environment in the same way as locusts, ravaging rice, millet and sorghum crops. There are also many other as yet unresearched invasive land and aquatic species in the basin.

The rate of **population growth** (environmental problem 6) has increased significantly in recent years, with the number of people living in the basin area rising to 45 million in 2012. This growth is accompanied by high unemployment,

rapid urbanisation in towns and large cities, such as Kano, Maiduguri and N'Djamena, and increasing insecurity in the region. These demographic factors have increased the pressure on all natural resources, particularly water resources, including the lake, raising potential conflict with regard to water use and sharing.

The impact of **climate change** (environment problem 7) is still being debated by the scientific community, particularly regarding the uncertainty of rainfall predictions. Nevertheless, the LCBC acknowledges that climate change is already having adverse effects on the production systems, size and biodiversity of Lake Chad and of the entire basin. A link between climate change and fishing in the basin's waters has been established and widely documented. It has also been observed that the people living in the basin have a high capacity to adapt to the region's new climate conditions, particularly through family farming.

Subject to strong environmental pressures, changes negatively impacting natural resources were observed in the Lake Chad basin. These changes are associated with natural

factors (for example, rainfall variability) and a large anthropogenic influence on the environment. The work of the LCBC is focused on finding solutions to these challenges.

Table 29: Classification of environmental problems

Type of problem		Description of problem
Problems related to the state of water resources	Variation in the volume of surface water	<ul style="list-style-type: none"> <li>Loss of water by evaporation in reservoirs and lakes</li> <li>Reduced runoff</li> <li>Increased transportation of solid matter and sedimentation</li> <li>Increase in sandbanks and their mobility</li> <li>Water shortages owing to the effects of climate change</li> </ul>
	Variation in the volume of groundwater	<ul style="list-style-type: none"> <li>Fall in the water table owing to climate variability</li> </ul>
	Variation in the quality of surface water and groundwater	<ul style="list-style-type: none"> <li>Change in the quality of water owing to invasive plant species</li> </ul>
Problems related to the impact of human activities on the water resources	Agriculture	<ul style="list-style-type: none"> <li>Soil over exploitation and exhaustion</li> </ul>
	Livestock	<ul style="list-style-type: none"> <li>Overgrazing and decline in forage crops</li> <li>Degradation of erosion control infrastructure</li> <li>Poor control of animal waste</li> </ul>
	Forestry operations	<ul style="list-style-type: none"> <li>Vast expanses of land converted into savannah</li> <li>Exposure of deforested land to mechanical erosion</li> </ul>
	Mining operations	<ul style="list-style-type: none"> <li>Water pollution caused by effluents from ore washing operations</li> <li>Erosion of stream channels</li> <li>Destruction and alteration of wetlands owing to changes in river flow patterns</li> </ul>
	Power generation	<ul style="list-style-type: none"> <li>Destruction of biodiversity and habitats</li> <li>Destruction of extensive expanses of forest</li> </ul>
	Housing and urbanisation	<ul style="list-style-type: none"> <li>Strong pressure on vegetation cover and uncontrolled occupation of land</li> </ul>
	Industries and transport	<ul style="list-style-type: none"> <li>Pollution caused by oil waste and industrial effluents</li> </ul>

## Variability of the hydrological regime and freshwater availability

### Lake Chad

Around the mid-1960s, high levels of rainfall in the basin saw Lake Chad reach a record level, with the lake forming a continuous expanse of open water stretching from north to south.

Between 1973 and 1984 the lake began to shrink in area and volume by between 20% and 50% as a result of severe droughts, characterised by a rise in temperature, increased evapotranspiration and a drastic decline in rainfall levels. When rainfall was at its lowest, the Chari-Logone basin began to dry up. The total discharge of the Chari River in 1984 was 50% lower than its long-term average (around 600 m<sup>3</sup>/s compared with 1,200 m<sup>3</sup>/s). The monthly discharge recorded for May in 1985 in N'Djamena (Chad) was 0 m<sup>3</sup>/s.

The area of the lake varies according to season, and from year to year, although the overall trend currently observed is an increase in size. There has been an average increase in area of around 3.5% per year since 2000.

While the situation of Lake Chad today is better than it was in the 1970s and 1980s, it remains small when compared to the lake during the wet period of the 1950s. The lake consists of an area of 13,000 km<sup>2</sup> that is regularly flooded,

formed by the northern pool, permanent and seasonal wetlands and dominant aquatic vegetation; and the southern pool, which is an open expanse of water around 1,800 km<sup>2</sup>, facing the Chari delta. Current observations reveal a flow rate in the Chari River in N'Djamena of 21.7 km<sup>3</sup>/year (17.7 km<sup>3</sup>/year for the period 1980–89) and rainfall amounting to 974 mm/year (877 mm/year for the same period and location).

### Watercourses

The improvement in rainfall observed across the basin has not been accompanied by the corresponding increase in the discharge of rivers flowing into the lake, as has been seen in other basins. However, the ecosystem in the basin does seem to be developing towards more stable and favourable conditions:

- the general trend in annual rainfall volumes has been improving since 1995, despite the occasional year where decreases have been recorded;
- cumulative rainfall is relatively higher than normal, although the overall evolution of rainfall since 1950 is still showing a downward trend;
- river flow rates are improving and are not expected to decline significantly in the short term.

Table 30: Average rainfall over the basin and average flow rate of the Chari River since 1950

Period	Average rainfall over the basin (mm/year)	Average flow rate of the Chari (m <sup>3</sup> /s)
1950–1959	1,114	1,334
1960–1969	1,059	1,278
1970–1979	929	866
1980–1989	877	561
1990–1999	974	688
2000–2009		672

Source: data from Chad's Water Resources and Meteorology Department (DREM) and the Cambridge Research Unit (CRU, United Kingdom)

## Groundwater

As river flows decline in the basin, groundwater levels also fall, aquifers are no longer recharged by rainfall and the Chari-Logone and Komadugu-Yobe river systems. In some areas near the lake, some wells and boreholes that have dried up completely.

## Socio-ecological impact

The drop in water levels in Lake Chad's has led to socio-ecological changes. Social tensions rose when the northern pool dried up completely in 1976, and fishers of all nationalities moved to the southern pool, an area shared by Cameroon and Chad. Many fishermen decided to become farmers, and it was hoped that it would be possible to adapt to these new conditions. However, disputes have arisen between farmers and herders, on the one hand, and between farmers and local fishers, on the other, as they compete for access to dwindling water resources.

On the environmental front, the lake is no longer able to provide some of the environmental services that earned it a place on the Ramsar List of Wetlands of International Importance. These services include recharging aquifers and supporting biological diversity by providing habitats for wetland plant species and some rare breeds of cattle such as the kuri, which are only found in the Lake Chad region and the Komadugu-Yobe basin. Other services include providing ecological niches for colonies of 372 species of migrating aquatic birds, contributing to the conservation of wildlife species such as the sitatunga or marshbuck (swamp-dwelling antelope found in the lake area) and providing habitats for 120 fish species.

## Water pollution

Little data is available on water pollution, although some pollutants have been clearly identified and documented. Municipal and industrial wastewater, dune sand, sediments and runoff are the main sources of pollution found in the basin.

## Chemical pollution

The most common industrial sources of chemical pollution are tanneries, breweries, slaughterhouses and textile plants. These industries are very often located near watercourses, so that untreated effluents can be directly discharged into them. This is very common in Chad and Nigeria, where wastewater treatment plants are sorely lacking.

Specific studies conducted by the UNDP in the 1990s on the Chari River, the Logone River and Lake Chad revealed no evidence of fish being contaminated with heavy metals in Chad. However, traces of chemical pollutants, such as zinc, chrome, mercury and magnesium, were found in water samples taken at different points along the Chari River. In the Challawa River in Kano (Nigeria), the concentrations of heavy metals are much higher, owing to the uncontrolled installation of numerous tanneries in the area.

In Cameroon, the Central African Republic and Chad, intensive cotton and rice cultivation requires the use of chemical fertilisers, herbicides and insecticides. The use of DDT (dichlorodiphenyltrichloroethane), a pesticide which in some forms is very toxic, can pose a threat to human health in the long term in the event of prolonged use. When used these chemical release toxic substances into surface water and groundwater.

Oil operations also pose chemical pollution risk. New oil fields are being discovered in regions in LCBC member states. A considerable number of prospecting operations have revealed economically viable oil deposits in areas of great environmental value, such as the Yaere floodplains, protected areas and underneath Lake Chad itself. Two refineries are already operating near Zinder in Niger and in Djarmaya, near N'Djamena (Chad).

### Environmental challenges associated with oil production in Chad

The oil potential of southern Chad has been known for thirty years (since 1973), but oil drilling only began in October 2000 with the construction of the Doba field and with the export of the first barrel in October 2003. The Doba project introduced a sophisticated petroleum exploitation system in the Sudanian savanna of southern Chad. It is being implemented by a predominantly American consortium formed in 2000 by Exxon, which has a 40% interest.

The three fields of Komé, and Bolobo Miandoum are located fifteen kilometers southwest of the city of Doba. In early 2005, more than 200 of the 300 wells planned were in operation with an output capacity of around 180,000 barrels a day, expected to gradually reach 225,000 barrels per day, for a period of 25 to 30 years. Current production has however decreased to around 100,000 barrels per day.

Before exploitation began, the consortium declared its commitment to mitigating the environmental impact of the project. A very detailed environmental and social management plan (ESMP) was drawn up in 1997 to establish the rules for conducting operations during the infrastructure construction phase and beyond.

However, the oil production infrastructure in Doba has impacted on the ecological balance in the region. The construction work that began in 2002 to build a bridge on the road between Galaba and the Kome Base and earthworks in the stream bed of the Nya River for the laying of the Nya-Moundouli pipeline have had an adverse impact on the surrounding gallery forest. Trees started to die off in 2008 and 2009, and the situation worsened in 2010 and 2011, affecting the other bank along a 20 km stretch. Water remains within the banks of the river during high- and low-flow periods, which means that the adjacent areas are not flooded. It is therefore no longer possible to cultivate the crops that used to be grown in these areas, such as rice. Lake Chad has so far not been adversely affected by oil exploitation, as the production field is indeed quite far from

the lake. From the oil fields, the crude oil is conditioned and heated at the Komé V works, then is piped 1,070 km to the floating storage and unloading terminal in Kribi, Cameroon, far to the south.

Lake Chad is currently not directly affected by oil exploitation, although much prospection has been carried out. The Djarmaya refinery is however located much closer to the lake, at 35 km northeast N'Djamena. Per year the refinery can produce nearly 700,000 tons of gasoline and kerosene, 20,000 tons of diesel fuel, 25,000 tons of polypropylene, 60,000 tons of liquefied petroleum gas and 40 000 tonnes of fuel oil (fuel). The refinery poses a significant risk to the ecosystem of the basin, particularly as it discharges its wastewater into the Chari.

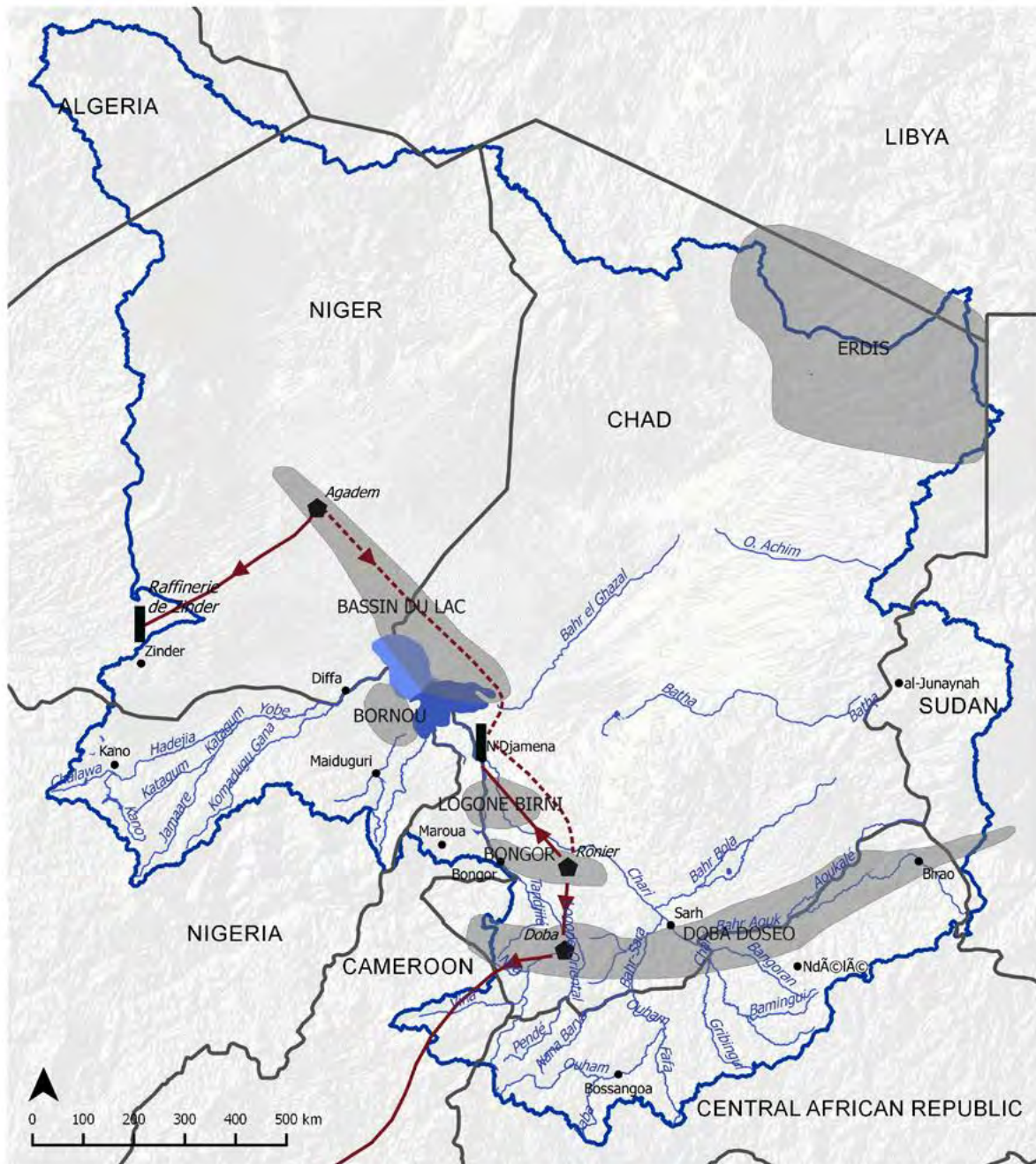


147: Dead trees in an oil producing region

Map 35: Oil in the Lake Chad basin

### OIL IN THE LAKE CHAD BASIN

- Oil field
- Oil field in use
- Refinery
- Oil pipeline with flow direction**
- Existing pipeline
- Planned pipeline



Source: IRD



## Microbial pollution

Microbial pollution is most commonly found around human settlements, with large towns and cities such as N'Djamena, Maiduguri, Kano and Diffa being most dramatically effected, due to low levels of access to functioning sanitation systems and poor hygiene practices. Access to improved drinking water supplies in the basin is generally low, and only 30% of people living in urban and rural areas (with the exception of Libya) have access to sanitary facilities.



from top to bottom:

148: Island dwellers on Lake Chad draw their water directly from the lake

149: Dumped solid waste has an impact on water quality

Coliform contamination of groundwater, the main source of drinking water, is common indicating faecal contamination. In many settled areas, wells and boreholes are often built too close to leaking latrine pits and septic. In towns and cities, repairs to deteriorated water supply systems are not always carried out promptly. In these conditions, water supplies can easily become contaminated with faecal bacteria, leading to increased outbreaks of diarrhoea particularly in the rainy season.

Cholera epidemics are a regular occurrence in the basin, with particularly serious outbreaks in 2010, 2011 and 2012. Cholera is an intestinal infection transmitted mainly through the faecal-oral route, meaning food and water comes into contact with the watery diarrhoea of a person infected with the disease before being ingested by another person. Regions with poor hygiene and sanitation are particularly vulnerable to the disease. The lack of latrines and safe drinking water contributed to the spread of the infection throughout a large part of the basin.

According to reports in the local press in Chad, around 11,000 people contracted cholera in 2011 and 17,000 in 2012. In Maroua, Cameroon, the disease claimed the lives of at least 94 of the 1,300 people affected in 2010, and Nigeria reported 41,787 cases, including 1,716 deaths, in 18 of the country's states, with Borno, Bauchi and Katsina the most seriously affected in the same year. In Niger almost a thousand patients were treated by relief organisations with 20 deaths reported.

The lack of health and other infrastructure, in addition to low access to energy and a lack of qualified health staff represent development challenges requiring major public investment.

### Sedimentation of rivers and lakes

Sedimentation affects all rivers and reservoirs of the Lake Chad Basin. It is particularly problematic when rainfall is high, and the runoff erodes the increasingly large areas that have been stripped of vegetation. Lake Chad is particularly hit by sedimentation, with hundreds of small islands forming year after year making it the largest freshwater island system in the region. It has been estimated that the sedimentation rate in the lake is between 0.5 and 4 mm per year. Whilst some of the form islands are settled only with mobile fishing camps, others have been settled for over 40 years and are integrated into existing administrative systems, as is the case for Kinesserom, located on the Chadian side of the lake.

The data currently available to the LCBC does not allow a proper assessment of the situation in the basin with regard to the siltation of rivers and streams.

The sedimentation of Lake Chad occurs as a combination of two distinct phenomena: wind and water erosion and sedimentation deposits. It has a negative impact on fisheries and transport between the islands of the lake. However, it does have a large positive impact on market gardening, as the deposits are still rich in silt. Sedimentation diverts the course of the Chari and Logone and changes the position of villages on the river. It can happen that these changes along the Logone, which forms the natural border between Chad and Cameroon, can lead to a village moving from one country to another and vice versa. The situation is even more pronounced at the Komadougou-Yobe river which regularly changes its course, causing transboundary conflicts.

The problem of sedimentation (and siltation) is inextricably linked to that of land degradation in the watershed and the erosion of the banks of rivers flowing into Lake Chad. The main sediments are usually clays and sands. It is estimated an annual average of about 2.4 million tons of suspended solids (SS) are deposited in Lake Chad. Over a long period, the median value is 2.5 and 2.6 million tonnes, 60% of which are deposited between July and September, as water levels begin to rise.

These materials are carried off usually by stormwater runoff into rivers, where they eventually settle when velocities decrease, forming sandbanks and reducing the hydraulic capacity of channels. The sediment load carried in the Chari, Logone and Komadougou Yobe reduce the area of open water of Lake Chad and lead to the flooding of the islands during rainy periods. Between 2010 and 2012, the Chari flooded many parts of the city N'Djamena, while the rising waters of the Logone and its intrusion into the reservoir behind the Maga dam almost lead to the dam failure.

Several approaches to reducing erosion have been considered by the LCBC. They include the control of land use, notably shoreline, riverbank and soil stabilization using various methods, including plant engineering, reforestation, the development of waterways, flow control, etc. Tools such as to land use maps and digital terrain models have also been used in this respect.

### Dust from the Bodélé depression

The Bodélé depression was once part of the bed of Lake Chad from the period when the lake was immensely large. Now a desiccated depression, it serves as the main source of mineral dust for the Amazon rainforest, transported as aerosol from West Africa across the Atlantic. Dust plays a multiple role in the global ecosystem and controls the climate by reflecting sunlight and absorbs radiant heat emanating from the earth. It can also change the characteristics of clouds and rain and can increase the rate of transfer of CO<sub>2</sub> from the atmosphere to the biosphere by fertilizing phytoplankton in the oceans and plants in large ecosystems such as the Amazon rainforest. The dust provides nutrients necessary for plant growth. Estimates from satellite observations of BODEx, estimate the total Bodélé dust emissions at between 60 and 180 billion tons per year. The aerosols are generated by the Harmattan wind transporting up to 45 billion tons per year, half of which arrives in South America and the Amazon within less than ten days.



150: Flooding in N'Djamena in 2012

### Anti-erosion measures

Aeolian erosion (wind erosion) is a localized phenomenon in the Lake Chad basin. It results mainly from cultivation, and is the source of dune formation (around Bol in Chad and Diffa in Niger).

Traditional methods of reducing wind erosion are based on local knowledge. The most common technique is the use of windbreaks made of vegetation, a mechanical technique, to stabilizing mobile dunes. Mulching is by far the most widely spread wind erosion control measure technique practiced on farmland in the basin.

Erosion caused by running water is mainly a result human pressure on the environment. The conversion of naturally vegetated areas to agricultural or pastoral land results in sheet and rill erosion (as can be seen in the Mandara Mountains in Cameroon). Linear erosion (or mass erosion) is very marked in the basin, particularly in hydraulic sections of the Logone–Chari system. It is particularly active in the Logone, where the banks are moving away from each other, causing loss of field and the displacement of villages. The waterways silt up and the draft for boats falls accordingly.

Biological techniques are the most common way of reducing the formation of meanders and of preventing banks from being undermined due to human activities.



151: Erosion along the banks of the Logone river, Chad

### The viability of biological resources

The viability of biological resources declines when the regeneration of animal and plant life is unable to keep pace with the exploitation of resources and the disruption caused by socio-economic activities.

Biological diversity in the Lake Chad basin is recognised as being of global importance. However, it is undergoing a process of continuous decline and degradation. Although it is evident that vegetation cover plays an important role in protecting water resources, by preventing erosion, desertification, etc., for a variety of reasons, its destruction and alteration continue at an alarming pace. Local communities have no ownership of the sustainable development strategies established by the basin countries, rendering them ineffective on the ground. The new transboundary management approaches adopted by the LCBC are based on the premise that it is possible to reverse the situation in some places where the ecosystem has deteriorated. Numerous pilot areas have been identified across the basin, and actions are being implemented with national NGOs acting as implementing agencies.

#### Increased demand for fuel wood

In environments rendered fragile by low rainfall levels, such as northern Chad, south-east Niger, the Far North region of Cameroon and northern Nigeria, overgrazing, the collection of fuel wood and shifting cultivation are factors that affect biological resources and reduce their viability.

In Kano and N'Djamena, the nearest place where fuel wood can be obtained is now over 300 km away, as the rate of regeneration of the vegetation cover is much lower than the rate of exploitation. Numerous plant species, including *Terminalia avicennoides*, *Anogoneissus leiocarpus*, *Scleorcaria birrea* and *Lannea*, disappeared from the basin decades ago as a result of the charcoal demand, which is used to fire bricks among other things.



152: Whilst tree felling is prohibited, it remains a reality in the north of Cameroon

Endangered tree species in Chad include the African fan palm (*Borassus aethiopum*), which is used for timber (roofing) and the African locust bean tree (*Parkia biglobosa*), which is used to make charcoal, despite of its high commercial and nutritional value. Chad officially banned all tree felling in 2008, as well as the production and sale of charcoal in the country, in an attempt to find a long term solution to ease the pressure on standing timber.

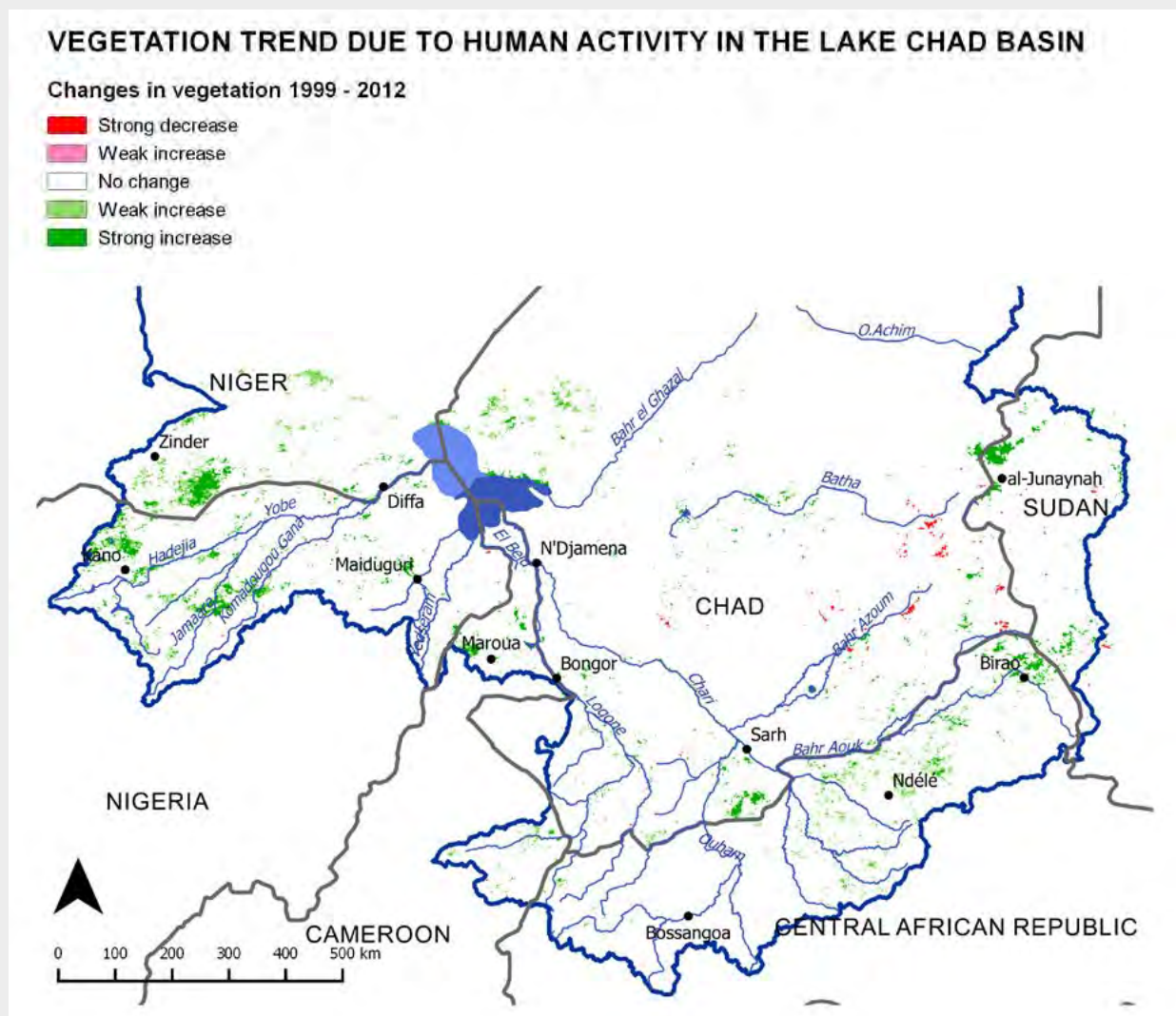
Despite subsidised butane gas and projects to increase access to electricity, pressure on forest resources continues to grow. Cameroon is bearing the brunt of this situation with up to 60,000 tonnes of charcoal being exported from northern Cameroon to N'Djamena.

As part of the Mega Chad project, the LCBC recently supported an initiative for the development of biogas in the Zafaya region in Chad and in Maklingaye in Cameroon in partnership with the University of Maiduguri in Nigeria. This initiative was accompanied by the creation of village reforestation schemes that served as a basis for subsequent interventions with technical and financial partners (UNEP in 2007, GEF in 2008, AfDB in 2010).

The impact of conflict on natural resources

Armed conflicts in the north of Nigeria and the north-east of the Central African Republic have led to the displacement of farmers, forced to abandon their land, and the loss of crop seed, such as peanut, sesame and corn seed. With populations fleeing violence, the pressure on the ecosystem has lessened and numerous plant species have recovered.

Map 36: Vegetation trend due to human activity in the Lake Chad basin



Source: IRD

Vegetation cover has therefore improved, as farmers no longer work the land and herders are not grazing livestock.

The map above shows changes in vegetation in Lake Chad's active drainage basin. Dark green shading indicates areas where there has been a considerable increase in vegetation in the period 1999–2012. The increase in vegetation can be attributed to an increase in farming, a proliferation of wetland vegetation and the regeneration of forests on abandoned land.

The red line indicates the boundaries of Lake Chad's hydrological basin. Refugee camps were set up in Farchana and Goz Beida, in eastern Chad, for refugees fleeing the fighting in the Darfur region in the Sudan. The conflict and the displacement of refugees began in 2003 and ended in 2010.

At the Farchana site there has been a decline in vegetation cover from 2004 onwards, with the biggest decrease

recorded in 2008. This coincides with the outbreak of the conflict in Darfur in 2003 and the progressive displacement of people to the refugee camps in eastern Chad from 2004 onwards. In locations where refugee camps were established, such as Farchana and Goz Beida, a gradual decline in vegetation was observed, as the camps grew in size and the natural resources in the area around them were used. The opposite occurred in the region of Ganeina in western Darfur, where vegetation increased, because thousands of people fled their homes, abandoning their land.

This analysis of vegetation over a 13-year period highlights that population movements have exerted pressure on natural resources and increased desertification in these parts of the basin where refugees have settled, whereas there has been, to a certain extent, a recovery in areas where populations were forced to flee.

Figure 47: Normalized Differenced Vegetation Index (NDVI) in the Forchana refugee camp, Chad, between 1999 and 2012

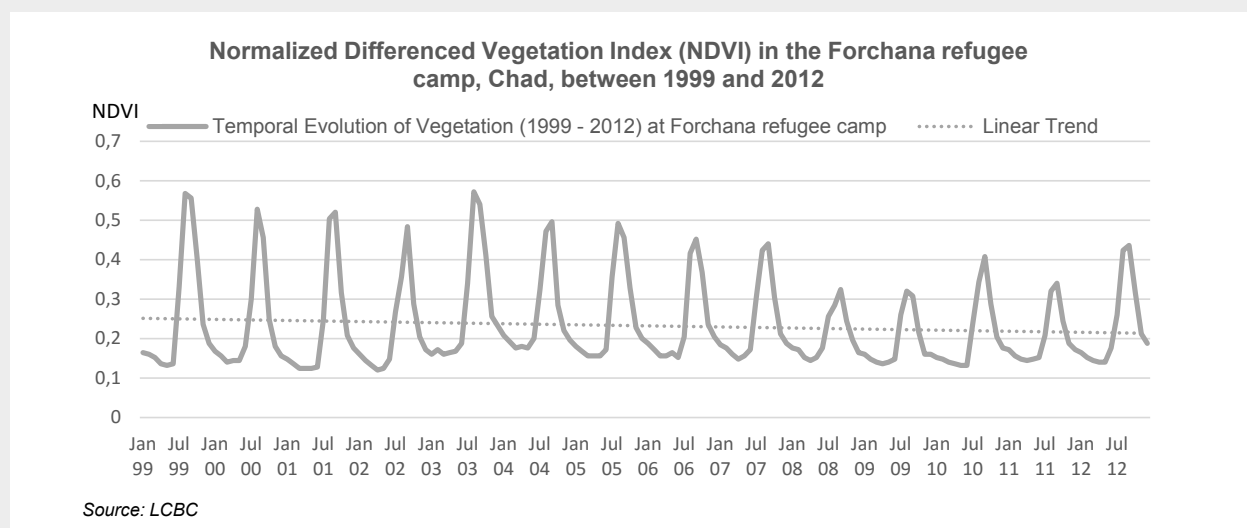
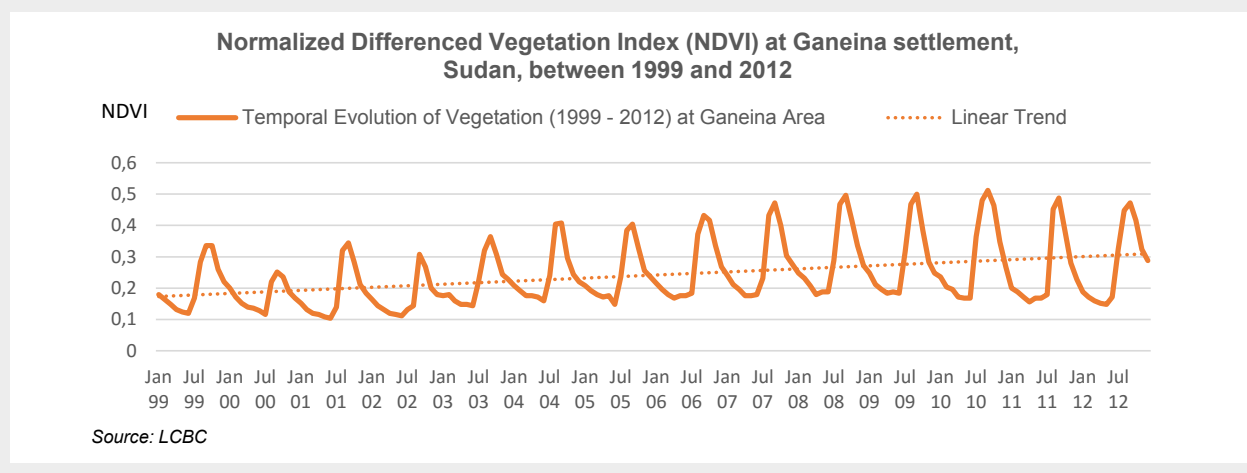


Figure 48: Normalized Differenced Vegetation Index (NDVI) at Ganeina settlement, Sudan, between 1999 and 2012



**Fishery resources**

The Lake Chad basin contains habitats supporting a rich biodiversity, with over 100 fish species. In the absence of recent studies, it is supposed that this number is decreasing daily, owing to an overall decrease in rainfall in the last half century, increased pressure on fishery resources, and the impact of human activity that has an adverse effect on the aquatic environment.

In the space of 50 years, Lake Chad has changed from being an expanse of open water to being a sandy, swampy environment, with the destruction of around 50% of the wetlands. The drying up of fish spawning and nursery grounds is a problem made worse by the construction of dams. Erosion and sand encroachment leads to the disappearance of habitats, spawning grounds and drainage ditches, which are ideal places for fish reproduction.

*1. Impact of the decline in rainfall on fishery resources*

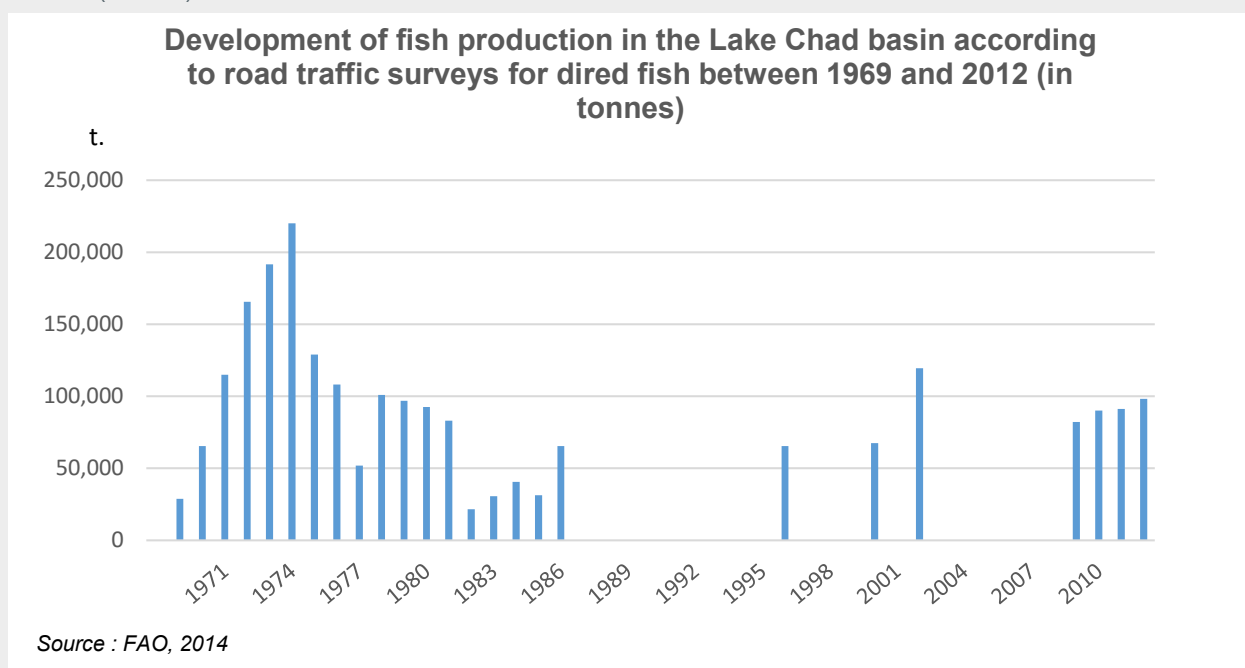
In Lake Chad in its current state, there are three fishing seasons: when the lake begins to fill from July to September (low catches), when the lake is full from October to January (medium catches) and when the waters are receding (high catches).

On the floodplains, the flood waters provide fish with the nutrients they need for growth and reproduction in a place

generally safe from predators. When the waters recede, the fish group together in shoals and are easy to catch. This is why catches in recent years, averaging an estimated 100,000 tonnes a year, differ only slightly from those of previous years before the droughts. In other words, annual catches have not declined in proportion to the reduction in the surface area of the lake. In fact, 1974 was an exceptionally good year, with catches totalling around 220,000 tonnes according to surveys conducted on the amount of dried fish transported by road. This was because the lake shrank considerably in size, as a result of the 1973 drought, so that all the fish were grouped together in the remaining areas of water, making it very easy to catch them. In the following years, however, catches were much lower, owing to the drying up of the lake's northern pool.

The size of catches does not, however, reflect changes in the type and number of fishery resources. Fish species found in large numbers in the lake's open waters in the past are now largely endangered species and some have disappeared completely, while species dwelling in the swamps and marshlands often reproduce in greater numbers. In Niger, for example, the *Heterotis niloticus* disappeared completely when Lake Chad's northern pool dried up in 1976. Diminished river flows and higher water temperatures lead to the loss of oxygen from the water and an increase in the level of water pollution.

Figure 49: Development of fish production in the Lake Chad basin according to road traffic surveys for dried fish between 1969 and 2012 (in tonnes)



## 2. Impact of human activities on fishery resources

Human activities exert pressure on fishery resources, increasing as the basin population grows. A large number of dams have been built in Nigeria, contributing to the depletion of fish stocks in the Komadugu-Yobe, affecting up to 100 species in this region, five of them endemic.

Many of the fishing techniques used are harmful to the environment. They decimate the juvenile fish population, cause the disappearance of many species and risk depleting stocks of many others. The most seriously affected species is the silverside (*Alestes baremoze*), which, according to figures provided by the LCBC for 2008, is on the brink of disappearing. The species *Tilapia niloticus*, *Hydrocynus sp.*, *Citharinus* and *Alestes dentex* disappeared from Lake Maga in Cameroon ten or so years ago.

Harmful fishing methods commonly used are fine-mesh nets and canal fish traps. Fish canals are used extensively in the Far North region of Cameroon. They are also used in some parts of Chad (in the Bongor region), but to a much lesser extent. Fish canals are dug between two pools, with a fish barrier at the river end of each canal to methodically trap fish. NGOs in the region are calling on the authorities to take action to put a stop to this practice. Fishing communities have established a system of over 3,000 fish canals

on the Waza-Logone floodplains. However, efforts made within and outside the country are reducing the use of this method. They include initiatives for the joint management with fishers, bilateral cooperation and specific interventions carried out as part of comprehensive fishing projects.

## Other endangered species and habitats

With regard to the protection of habitats, consideration of the treatment of protected areas is revealing. States are currently unable to fulfil their responsibilities for a range of reasons (lack of resources, lack of capacity, lack of transparency) and face various challenges:

- The region suffers from the activities of wildlife poachers, made particularly difficult to control as states have failed to agree on or implement a common policy against poaching.
- Bush fires are a serious problem, particularly around the lake and in the southeast of the basin, where national parks are located. Bush fires are usually lit by farmers to renew pasture, as part of slash and burn agricultural techniques or inadvertently. They reduce the vegetation and prevent it from regenerating after months of drought. Ultimately, bushfires lead to a loss of habitats.

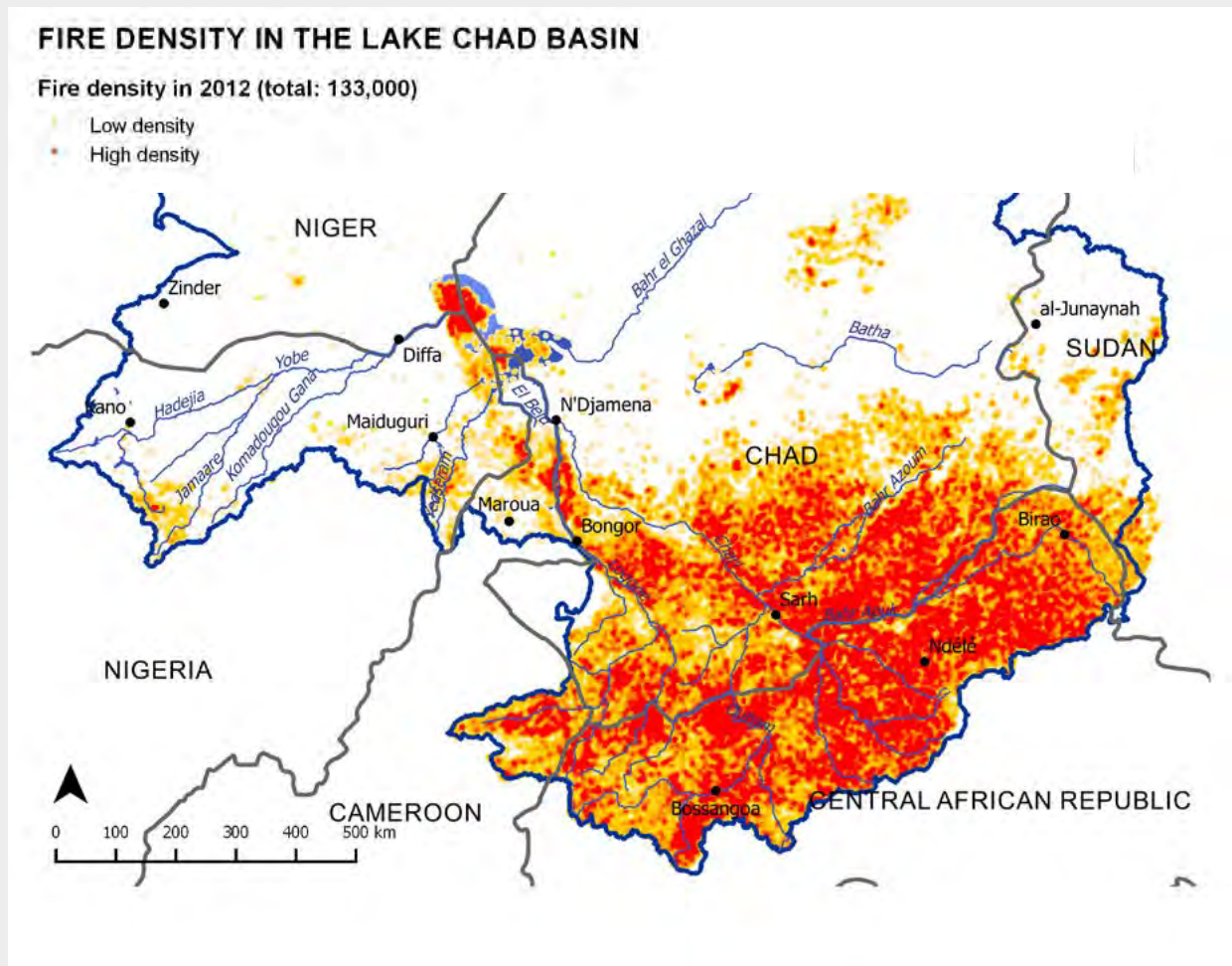


153: The mesh of the nets used by fishermen are often too small



154: Fishing channels are commonly used in Cameroon and Chad

Map 37: Density of bushfires in the lake Chad Basin



Source: IRD



155: Bushfire set as part of slash and burn agriculture



156: Working the fields in slash and burn agriculture



Table 31: Critically endangered species and endangered species according to the red list of IUCN

Scientific name	Name	Cameroon	Niger	Nigeria	CAR	Chad
<b>Species in critical danger</b>						
Addax nasomaculatus	White antelope		x			x
Astylosternus ngantanus	Amphibian	x				
Diceros bicornis	Black rhinoceros	x				
Gabbiella neothaumaeformis	Freshwater snail		x			x
Mecistops cataphractus	Slender snouted crocodile	x				
Nager dama	Dama gazelle		x			x
Vanellus gregarius	Sociable lapwing	x		x		x
<b>Species in danger</b>						
Amietophrynus djohongesis	Amphibian	x				
Biomphalaria tchadiensis	Freshwater snail	x		x		x
Gabbiella tchadiensis	Freshwater snail	x				x
Gazella leptoceros	Slender horned gazelle	x			x	
Gyps africanus	White backed vulture	x	x	x	x	x
Gyps rueppelli	Rüppell's vulture	x	x	x	x	x
Lycaon pictus	African wild dog	x			x	x
Necrosyrtes monactis	Hooded vulture	x	x	x	x	x
Neophron percnopterus	Egyptian vulture	x	x	x	x	x

This destruction of habitat has a direct impact on biodiversity. According to the red list of the IUCN, between one and four species per basin country are critically endangered and

between five and eight are in danger. Examples include the white antelope, the sociable lapwing, different species of vulture and gazelles.

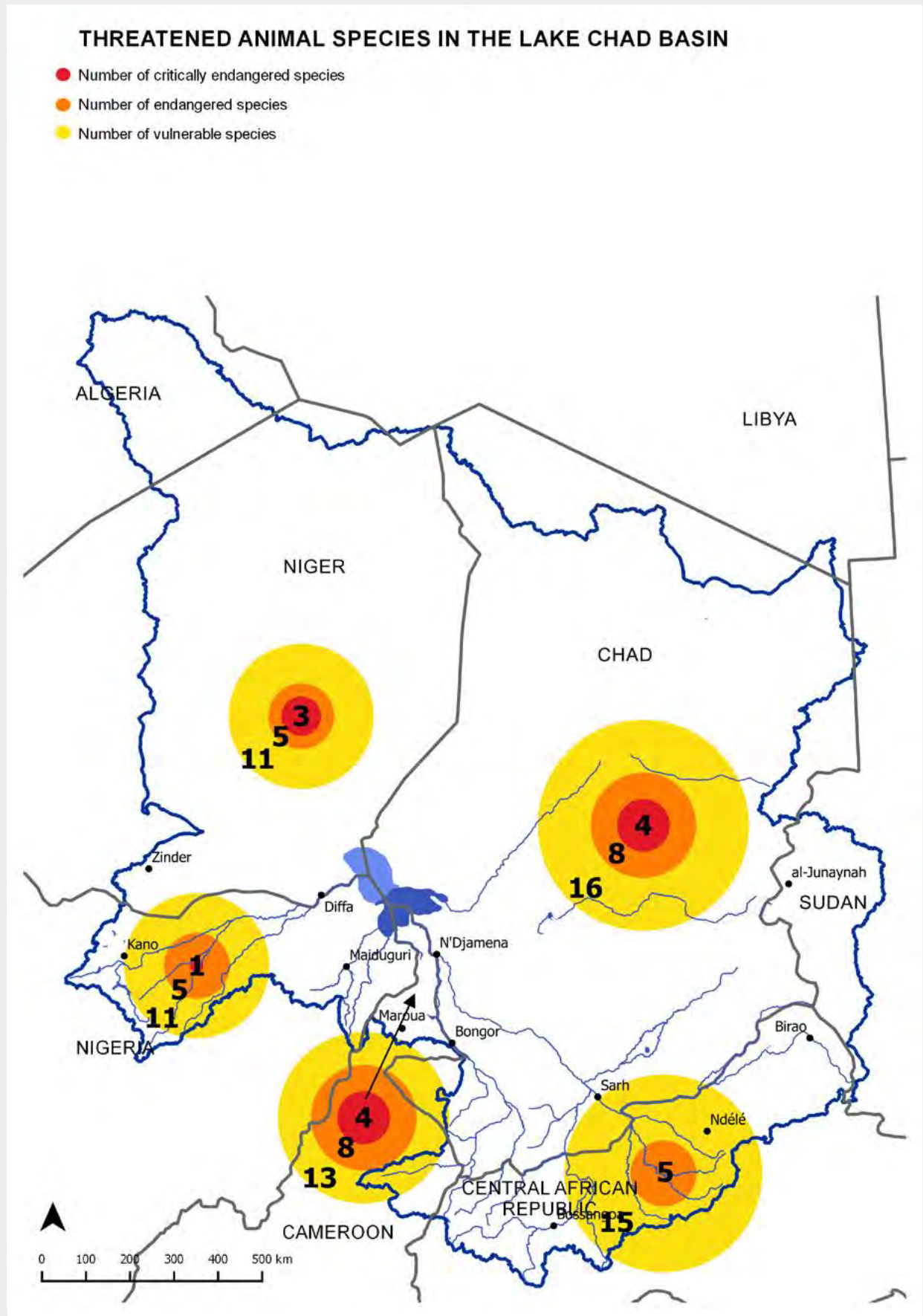


157: Dama Gazelle



158: Sociable lapwing

Map 38: Threatened animal species in the Lake Chad basin



Source: Data from the red list of the IUCN

## Elephant massacres

In 2012 in the Central African Republic, Chad and Cameroon, hundreds of elephants were slaughtered on national reserves. Elephant hunting is prohibited in all basin states, and a ban has been imposed on the ivory trade. However, the black market is thriving, fuelled by the ivory plundered by poachers who have no qualms about killing whole patrols of gamekeepers and any law enforcement agents who get in their way.

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (also known by the acronym CITES or as the Washington Convention) is an international agreement among nations which aims to ensure that international trade in specimens of wild animals, such as elephants, and plants, does not threaten the survival of the species in the wild.

However, with the price of ivory so high, the illicit trade remains a very lucrative business. On the black market, a kilo of ivory fetches between 800 and 1,200 euros, depending on the country it is exported to, while in the home country, the price is between 150 and 200 €/kg. Today, trade in protected wild species is considered to be as serious as arms trafficking, human trafficking and forgery.

Poachers kitted out like soldiers carry out large-scale massacres, making it difficult for governments to control the situation, given their lack of resources and capacities and the high level of corruption. In Cameroon, after the Boubba Ndjidda massacre, on the border with Chad, the government sent in troops to deal with the situation. Zakouma Park in Chad is also protected by soldiers.



159: Elephant poaching

## Damage and changes to the ecosystem

The degradation of the basin's ecosystem continues under strong climatic and anthropogenic pressures. The growing demand for timber and fuel wood and the practice of using bushfires to clear land for farming or grazing are the main causes of the destruction of natural habitats. The general strategies of the LCBC member states seek to prevent deforestation, with a view to stopping desertification and ensuring the conservation of wildlife and plant species. As well as impoverishing cultivable land, deforestation also leads to the disruption of the water cycle, a decline in biodiversity and the destruction of land habitats and wetlands.

The ecological importance of the wetlands in the basin is internationally recognised, although some of them have lost their ecological value due to the impact of climate change and the construction of upstream irrigation systems. The wetlands have been accorded top priority in conservation efforts, with a special emphasis on the conservation of rare fish species.

In recent years there has been less damage inflicted upon aquatic ecosystems. The construction of the Kafin Zaki dam in Nigeria was suspended, and there are no new water infrastructure projects of any significance in the pipeline for the basin. There have, in fact, been a number of initiatives aimed at improving the flow regime of the Chari-Logone system, with a view to increasing the size of Lake Chad and restoring the parts of the Yaere floodplains that had dried up. Numerous initiatives have also been undertaken to deal with deforestation. For example, each country has instituted an official international tree-planting day, on which tree-planting ceremonies are held. The LCBC member states have also ratified the United Nations Convention to Combat Desertification.

With regard to the impact of dams, they have both positive and negative potentials. They provide a highly effective means of combating poverty, guaranteeing food security and supplying power to local people, but have an undeniably detrimental impact on water and forest ecosystems. Alternatives focussing on more sustainable development emphasise innovative practices, with the development of rainwater management, solar and wind power and small-scale irrigation.

### Impact of the Maga dam on temporary ponds in the Waza National Park

Between 1950 and 1970 Chad and Cameroon built up to 50 km of levees downstream of Bongor, in order to control the flood waters of the Logone, which forms part of the border between the two countries. The main aim of the levees was to protect irrigated rice fields developed under the SEMRY-I project in Cameroon and the Casier A project in Bongor, Chad.

In 1979, Cameroon began work on the Maga irrigation dam as part of a large-scale rice-growing project (SEMRY-II), with a to meet existing food needs and improve food security. The Maga dam scheme included a 7,000 ha plantation equipped with a full-control gravity-fed irrigation system. The reservoir has a storage capacity of 600 million m<sup>3</sup> of water for an area of 39,000 ha. It is fed by the Tsanaga and Boula streams, which together receive 70% of total flows from the Mandara mountains. It also receives water from the Guerleo stream, the Logone River's main distributary in Yagoua.

This infrastructure completely altered the ecosystem of the Waza-Logone floodplains. The area of land that is naturally flooded was reduced to 60% of its former capacity as a result of the levees and the dam itself. The levees constructed on both sides of the Logone certainly contributed to containing flood waters and preventing them from damaging surrounding villages, but they also deprived cultivable land of the valuable silt and dissolved minerals that are deposited by flood waters and which play an important role in enriching the soil and increasing its fertility. The dam caused the wetlands in Waza National Park to dry up, driving wild animals from their natural habitats. Each year, large herds of elephants migrate in the dry season to Kalamaloue National Park in search of water in the ponds of the blind arm of the Chari River.

### Invasive species

Invasive species are plants, animals and microorganisms that reproduce rapidly outside their natural environment. The invasive species dominates a habitat, causing harm to other species usually found in it.

Invasive species are either introduced intentionally for economic or agricultural purposes or accidentally as a result of tourism, travel or trade. Invasive species can come from other countries or from others parts of the same region or country. Once introduced, these harmful species spread rapidly and threaten the existence of native species and, once established, their impact is difficult to manage.

The three main invasive species found in the Lake Chad basin are bulrushes (*Typha*), red-billed queleas (*Quelea quelea*) and mesquite trees (*Prosopis sp.*).

#### 1. Bulrush

Bulrushes (*Typha*) are the most common invasive plant species in the basin, particularly in the Hadejia Nguru wetlands in Nigeria, where they cover an area of over 1,000 km<sup>2</sup>. Their presence in the Komadugu-Yobe contributes to the diversion of the course of this seasonal river which feeds Lake Chad. They clog and dry up irrigation canals, depriving around 60% of farms in the area of water in the dry season. Efforts to control bulrushes are currently only being carried out by NGOs, using essentially mechanical measures – for example, turning them into briquettes for use as household fuel, a practice that is now widespread. However, this approach has not solved the problem, as it has failed to control the growth and spread of this plant.

#### 2. Red-billed quelea

In the Komadugu-Yobe area, huge colonies of red-billed queleas (*Quelea quelea*) roost in the mesquite trees. They act like locusts, flocking in large numbers and causing terrible damage to sorghum, millet and rice crops. Farmers have developed various methods for dealing with these birds, although they are largely deterrent measures.

#### 3. Mesquite trees

Mesquite trees (*Prosopis sp.*) have invaded the northern pool of Lake Chad, particularly in the proximity of Bol in Chad and N'Guigmi in Niger, where very thick mesquite



from top to bottom:  
160: Bulrush invasion  
161: *Quelea quelea*

forests have formed. These forests hinder the activities of nomadic herders and vegetable farmers. They also cause serious problems for fishers who are unable to navigate the shallow waters of Lake Chad because their movements are obstructed by mesquite trees and their roots.

This invasive plant species was introduced to Niger in 1977, as part of a dune stabilisation programme. What was at the outset a small area of mesquite trees covering around 10 ha has grown into a 300,000 ha expanse of forest. Efforts to control the spread of mesquite trees are confined to cutting them down to be used as fuel wood.

#### 4. Other invasive species

There are also aquatic plants that cover large areas of the rivers, streams, lakes and the basin. In Lake Chad, they are a serious hindrance to fishing activities and navigation between the islands. The dominant aquatic plant species include *Cyperus papyrus* and *Phragmites australis* as well as floating plant species, such as *Nymphaea* spp., *Ipomea aquatica* and *Pistia stratiotes*. From an ecological point of view, these plants protect fish from predators and provide good breeding grounds.



from top to bottom:  
162: Mesquite forest  
163: The abundance of aquatic plant species make passage by boat difficult

## Climate change

Of all the world's major basins, the Lake Chad basin is probably the one most seriously affected by climate change, with high rainfall variability and disrupted flow patterns.

Climate change has resulted in a 0.8°C rise in global temperature since the last century. Reliable scientific evidence indicates that this rise is directly attributable to global warming caused by the increase in anthropogenic greenhouse gas emissions. The main greenhouse gas is carbon dioxide.

Scientific models agree on forecasts of temperature rises in the long term, but not on rain forecasts, which could either rise or fall.

An increase of between 1 and 1.5°C in the average temperature in the basin has been observed since 1950 (GIZ/LCBC, 2009) with the rainy season getting shorter.

The period during which water flows in the Komadugu-Yobe has been reduced from nine to four months, as a result of large withdrawals from the river, infiltration to the water table and increased groundwater withdrawal.

The flow from the Chari River into Lake Chad has been halved, and the lake itself shrank from 25,000 km<sup>2</sup> in the 1960s to 2,500 km<sup>2</sup> in the 1970s and 1980s, increasing to 12 000 km<sup>2</sup> in 2012.



164: Deforestation has a negative impact on the climate

### 1. Climate change affects ecosystems

Water and forestry resources are the two sectors most vulnerable to climate change. As economic stability is heavily reliant on natural resources, climate change represents a direct threat to people living in the basin in terms of food security and health.

The physiological behaviour of the species that make up the biodiversity of the basin is strongly influenced by climate variations, particularly certain plant varieties. From around 20 different types of vegetation in the 1960s there remains only five today. The problem is that vegetation has become more uniform across the ecosystem, as the more vulnerable species disappear. In more general terms, the impact of climate change contributes to deforestation, the sanding over of cropland, the degradation of transhumance corridors, the depletion of fish stocks due to falling water levels, etc. Deforestation and forest degradation undermine ecosystem services provided by forests and contribute to greenhouse gas emissions. They also reduce carbon sequestration capacity.

According to some forecasts (Second National Communication submitted by Niger), the temperature will rise by between 2.5 and 3°C over the next 50 years in Niger. This increase in temperature will lead to a decline in agricultural productivity and a reduction in drinking water resources for rural communities. In general, the agricultural calendar is completely disrupted, so that there is uncertainty about when the rains will start and fears of flooding or dry spells during the rainy period.

### 2. Climate change threatens the population

The effects of climate change can also cause disasters that affect the lives of people living in the basin.

Fluctuations in temperature contribute to the spread of many vector-borne diseases, which affect animals and can

intensify the activity of plant pests. People also lose their lives as a result of these fluctuations: directly, due to events like flooding and, indirectly, because of alterations in the vectors of disease (mosquitoes, for example), waterborne pathogens (cholera) and water and air quality.

Severe flooding occurred in Niger, Nigeria, Chad and Cameroon in 2010 and 2012 and claimed many lives. In contrast, water in some areas of the basin is a luxury for some struggling to get just the amount of water recommended daily.

Methods have been devised to assess the future availability of water, for example, the results of general circulation models (GCMs) that have been carried out for Lake Chad. These tools can be used to estimate the effects of global warming on water resources. The main methods are based on the use of instrumental records, palaeoclimate proxies and GCM results. The GCM typically has four components: atmosphere, land, ocean and sea ice. GCMs are the only reliable tools for predicting climate change and providing input data for models. However, it is difficult at this point to forecast which way climate change will affect rainfall levels in the basin, as there is no suitable climate model. Proposals have been made for a major interbasin transfer from the Congo River to the Chari basin. It is estimated that this would provide the lake with an annual inflow of 1,250 km<sup>3</sup>.

All the basin states have agreed on a shared strategy, which is to strengthen the resilience and adaptive capacity of the agriculture, water and forestry sectors in order to cope with climate change. National climate change adaptation programmes are being developed and supported by the United Nations Framework Convention on Climate Change. The LCBC, for its part, is developing a programme for the rehabilitation and conservation of the productive capacity of the basin's ecosystems by adapting production systems to



165: Wells built by nomadic groups



166: Programmes are being carried out to mitigate the effects of climate change on the population

climate change. As part of this programme, specific activities are being carried out to promote reforestation and limit the exploitation of forests.

### Population pressure

As ecosystems and water resources become irreversibly degraded, owing in particular to the deterioration of the climate, the basin's population continues to grow rapidly, further increasing pressure on environmental resources and on governments. The basin's current population (2012) is estimated at around 45 million and is growing at an annual rate of between 1.5% (in Libya) and 3.7% (in Niger). The most densely populated cities are Kano and N'Djamena in Chad, with a population of over one million. The lake has attracted migrants from all over the Sahel, and the basin's population is set to double over the next 20 years. There are around two million people living in the vicinity of the lake, on its islands, on its shores and in a 30 km area around it.

There is a direct link between the exploitation of natural resources, the degradation of the environment and population growth. It is the use of the lake's water resources rather than its changing size that poses the real challenge. It leads to conflicts or threats among competing groups of users in regions that are already fragile. Disputes between farmers and herders over access to water and grazing are common in Chad and the Niger. Improving and increasing the use of water resources for agricultural and livestock production in order to ensure food security is a major challenge in the basin. Other challenges posed by population pressure include poverty reduction, conflict management, access to education and adequate basic services, etc.



167: Access to education will contribute to preserving the basin

### 1. Population pressure, water sharing and the impact on resources

The increase in population has an adverse impact on water resources and particularly on the basin's traditional economies weakened, in some cases, by military and political crises. Environmental services provided by wetland areas have been severely affected, leading to social tensions as competing groups of users vie for dwindling water resources. Access to natural resources and rules of access are a daunting challenge for the basin. Rural areas have to supply foodstuffs to the cities in a climate of great insecurity, caused by highway robbers and racketeers.

In areas with high population density, such as the states of Yobe and Borno in Nigeria and the southern regions of Chad, cropland is overfarmed and the vegetation cover has been destroyed or reduced to a sparse herbaceous layer. Severe erosion can also be observed in these areas, along with soil hardening, which prevents the infiltration of water and therefore contributes to a decline in the water table. In regions situated in southern Chad, northern Cameroon and the north-eastern part of the Central African Republic, shifting cotton cultivation has led to the systematic destruction of savannah woodland. (insert photo)

Cattle farming, which is one of the most important economic activities in the basin, is a major cause of soil hardening in areas where the ground is trampled by cattle. Cross-border transhumance reduces grazing capacity, and there are conflicts between herders and crop farmers about livestock movements.

Following the shrinking of Lake Chad in the 70's and 80's, fishermen from the northern pool from Niger and Nigeria have been able to easily cross the borders into the southern pool in Cameroon and Chad. The arrival of these migrants often leads to confrontations with local fishers.



168: Demographic pressure has a direct impact on water resources

Table 32: Economic activities and constraints on conservation in the Lake Chad basin

Agriculture	<ul style="list-style-type: none"> <li>• extensive farming and slash-and-burn agriculture</li> <li>• frequent bushfires</li> <li>• overuse of floodplains</li> <li>• soil not restored with manure</li> <li>• use of unsuitable techniques</li> <li>• lack of appropriate technologies and techniques for farmers</li> <li>• frequent conflicts between farmers and herders</li> </ul>
Forest resources	<ul style="list-style-type: none"> <li>• excessive cutting of trees to clear land for farming or for household fuel</li> <li>• periodic bushfires</li> <li>• deforestation</li> <li>• increased pressure on land as herders become sedentary</li> </ul>
Wildlife	<ul style="list-style-type: none"> <li>• disappearance or decline of wildlife and birds, as habitats are used for other purposes (crops, grazing, etc.)</li> <li>• overuse of the floodplains, reducing bird populations</li> <li>• poaching</li> <li>• limited knowledge of wildlife and bird species</li> </ul>
Fishery resources	<ul style="list-style-type: none"> <li>• poor knowledge of fishery resources and changes in stocks, making planning and programming difficult</li> <li>• impact of environmental changes (climate) and human activities on the composition of fishery resources</li> <li>• lack of financial, human and material resources to manage and control natural resources</li> <li>• use of prohibited fishing methods and/or gear</li> <li>• disappearance and/or reduction of some fish species</li> <li>• no control over catches</li> </ul>
Livestock	<ul style="list-style-type: none"> <li>• extensive livestock farming</li> <li>• poor livestock health coverage</li> <li>• conflicts over the use of resources (lack of rangeland and water points)</li> <li>• lack of data on livestock</li> </ul>
Rangelands	<ul style="list-style-type: none"> <li>• frequent late bushfires</li> <li>• partial knowledge of rangeland resources (space and quality)</li> <li>• poor rangeland management</li> <li>• poor quality of rangelands</li> </ul>

## 2. Population pressure, food security and cross-border crime

Cross-border security is a problem, with permeable borders permitting arms trafficking from Libya and the development of a smuggling industry, at times in the hands of religious fundamentalist terrorist groups. The jobless young are recruited by terrorist and armed guerrilla groups, particularly in Nigeria, the Central African Republic, Chad and Libya, where the humanitarian situation is becoming critical, owing to the influx of refugees fleeing armed conflicts and growing food insecurity.

For a long time now, Cameroon has been plagued by the problem of highway robbers in its Far North region. Road traffic in this area is economically important, as it is the

main import route from Chad. The government has set up a special rapid response unit, which succeeded in reducing and even eradicating the problem of highway robbers, who had been killing and robbing innocent people. However, as a result of porous borders, Cameroon is facing the problem of Boko Haram as it increases its power.

Political instability and a rising crime rate have had a direct impact on the population and food security. Major hauliers tend to avoid roads where highway robbers operate. Food prices therefore rise, as products are in short supply and because of the serious risks involved in transporting them. The more politically stable countries, such as Niger, have a lower price volatility index.



Figure 50: Evolution of the index of instability of food prices between 2008 and 2012

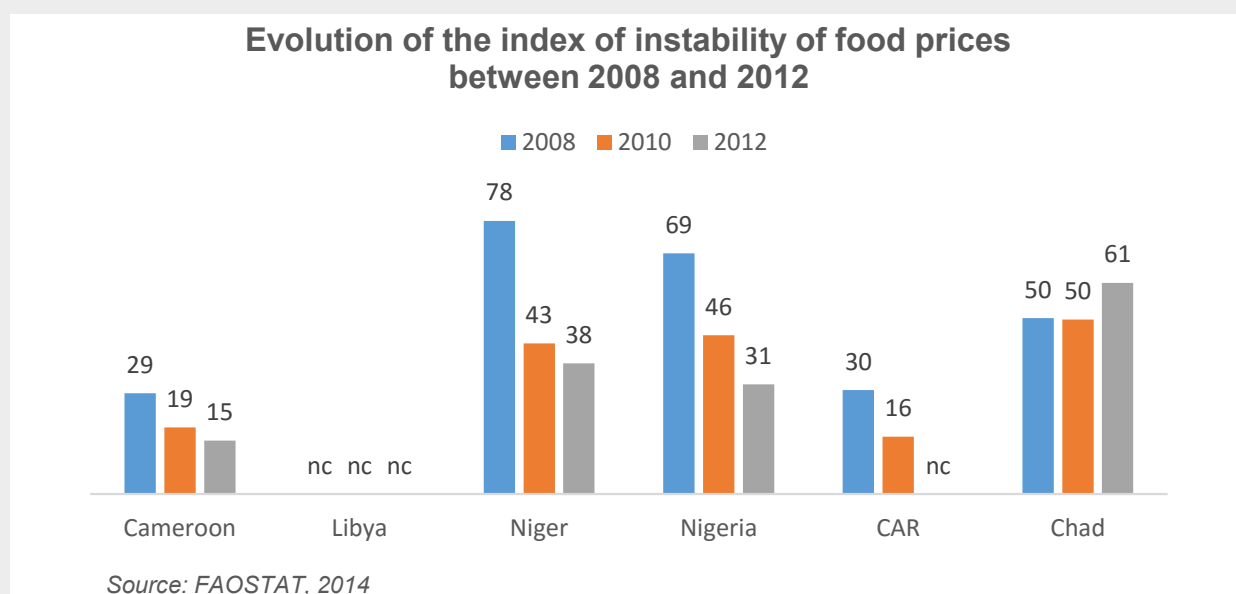
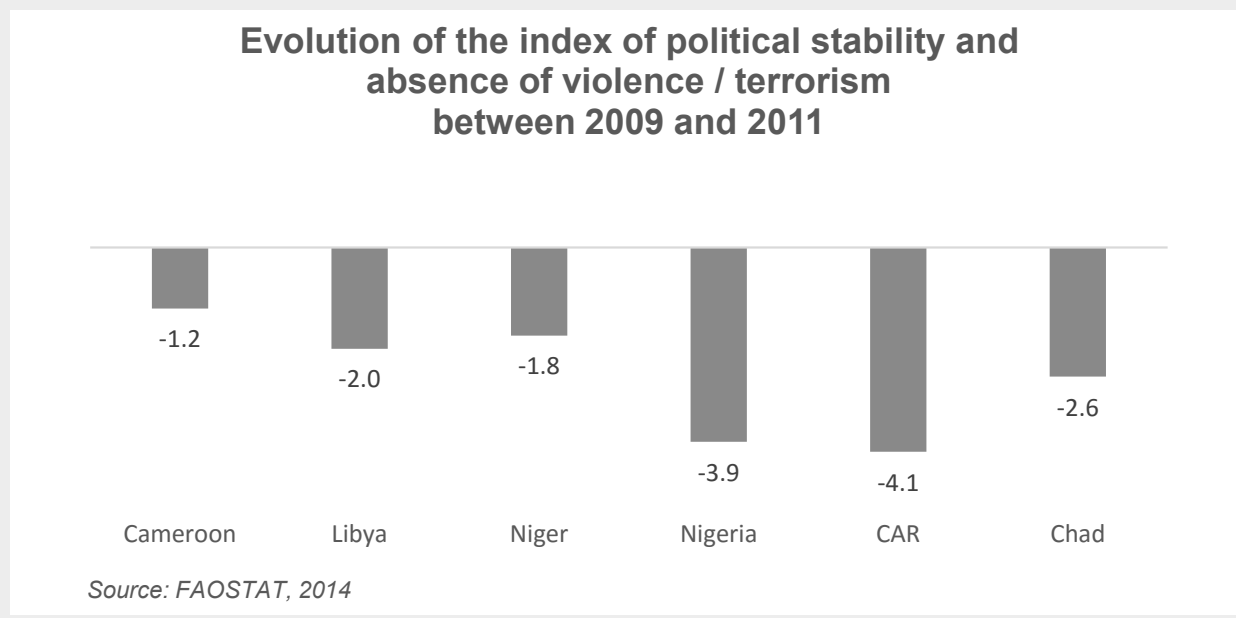


Figure 51: Evolution of the index of political stability and absence of violence / terrorism between 2009 and 2011



### Conclusion and recommendations

One of the biggest problems facing the Lake Chad basin is the variability of its hydrological regime and freshwater availability. Lake Chad shrank by 90% as a result of recurrent droughts in the period from 1970 to 2008 and the declining discharge of the rivers that feed it. Over this period, groundwater levels followed the same trend as surface water levels, showing a significant decline. Since the 1990s, however, rainfall has remained relatively stable, close to its yearly average. This has led to a slight improvement in the situation. The flow rate of the Chari River now varies between 15 km<sup>3</sup>/year and 34 km<sup>3</sup>/year and, as a result, the size of Lake Chad has increased from 6,000 to 14,000 km<sup>2</sup>. In spite of this, the overall downward trend of rainfall levels and flow rates persists.

Water pollution is not yet a major problem in the basin, but is becoming an issue. Unsustainable natural resource development strategies and low public awareness of environmental, health and hygiene issues are largely to blame. In big cities, the microbial pollution and high nitrate contamination of drinking water reach critical levels during rainy periods, leading to the outbreak and spread of waterborne diseases such as cholera and typhoid. The agricultural sector also contributes to the problem, with the uncontrolled use of chemical fertilisers on rice and cotton crops that end up contaminating surface water and groundwater with nitrates. Nigeria is affected by heavy metal pollution, caused by effluents from tanneries and textile factories in Kano, which are discharged directly into the Challawa River. Oil operations in Chad and Niger have also increased the risk of oil pollution.

Sedimentation in rivers and standing water bodies is a problem caused chiefly by human activities such as the destruction of vegetation cover, which results in soil degradation. The matter transported by surface runoff or by the wind is deposited on river beds, leading to the silting and sanding up of rivers and a decline in river flow. Around 80% of the basin is prone to erosion. The areas most at risk from erosion are Lake Chad, Maroua and Kano, and vulnerable areas include those situated between Maroua, Maiduguri and N'Djamena and between Diffa and Zinder. Sedimentation can also be caused by the wind; the Harmattan, which blows from November to February, transports and deposits desert sand.

The decline in biological diversity is a recurrent problem associated with the diminishing viability of biological resources, the deterioration of biodiversity and the destruction and alteration of ecosystems. Factors contributing to this include human activities, such as the overcutting of trees, shifting cultivation and slash-and-burn agriculture. Irregular rainfall in the basin is another factor that further exacerbates the decline of biological diversity. However, with the overall improvement in rainfall levels since 2000, a regeneration of wildlife and plant species can be observed in areas where human activity has ceased.

Mesquite trees, bulrushes and red-billed queleas are the three main invasive species found in the vicinity of Lake Chad. There are also other species that have invaded the basin's lands and waters, although there is as yet very little research on them. Mesquite trees and bulrushes clog up rivers, reducing the flow of water and harming fish fauna. The red-billed queleas are seed-eating birds that, similar to locusts, destroy rice and wheat crops in the Lake Chad region and the Komadugu-Yobe valley.

Population pressure affects the living conditions of people in the Lake Chad basin and puts a strain on dwindling nat-

ural resources. The basin's population grew from 22 million in 1991 to 37 million in 2002 and 45 million in 2012. Not counting the big cities, there are two million people living on the shores of Lake Chad and within a 30 km area around it. Land degradation caused by overfarming and the growth of shantytowns without any kind of sanitary infrastructure are some of the consequences of mounting population pressure in the basin. Excessive use of water from the lake by local people further reduces its size and leads to disputes among different groups of users. Youth unemployment and poverty have contributed to increasing cross-border insecurity. This climate of insecurity limits cross-border trade, which is essential to maintaining food security in the basin countries. Cameroon is still struggling with the problem of highway robbers on its northern border with Nigeria, and Nigeria has the same difficulty in addition to problems caused by the rise of Boko Haram.

Climate change is manifest in the basin in the form of droughts and flooding, posing a real threat to the lives of the people living in the region. While the drought of 2008 led to a famine in some parts of the basin, serious floods claimed many lives and destroyed crops in Cameroon, the Niger and Chad in 2010 and 2012. Climate change affects the size of Lake Chad, influences socio-economic activities and reduces food security.

A possible way forward could involve the LCBC member states granting Lake Chad and its immediate surroundings special status as an area of great environmental value. A partnership agreement could be signed with UNESCO to make Lake Chad a biosphere reserve. All the environmental problems described are being addressed by the LCBC through projects and programmes implemented in collaboration with different international and national organisations, which are keen to increase their support to the LCBC for the good of the regional and global environment.





## 5

## Interventions in the Lake Chad basin

**Key messages**

The Lake Chad basin has been facing decades of environmental problems that were clearly identified in a trans-boundary diagnostic analysis conducted in 2008. The current situation in the basin is a result of unsustainable natural resource management by the basin states and a lack of public environmental education and information.

The LCBC has developed a Strategic Action Programme (SAP), establishing as its overall goal the 'Reversal of Land and Water Degradation Trends in the Lake Chad Basin Ecosystem', resulting from the transboundary environmental problems. The SAP sets five Ecosystem Quality and Water Resource Objectives (EQWROs) and specifies the actions to be implemented in the period from 2008 to 2025.

National Action Plans (NAP) have also been formulated, with a view to identifying effective solutions to these environmental problems in the LCBC member countries. Within this framework, a variety of projects have been and are being implemented by member states, including: the IUCN-MINFOF-HIPC project in Cameroon, the Community Action Project for Climate Resilience (PACRC) in Niger, the South Chad Irrigation Project (SCIP) in Nigeria, the multi-sectoral emergency support project for Health and

Education and HIV / AIDS in the Central African Republic and the Support Programme for Local Development and Natural Resources Management (PADL-GRN) in Chad.

In addition, the LCBC has undertaken a large number of high-priority initiatives, including the Lake Chad Basin Sustainable Development Programme (PRODEBALT), the Interbasin Water Transfer Project, the Programme for Integrated Water Resources Management in Transboundary River Basins in Africa (Lake Chad basin component), the Project in Support of the Lake Chad Basin Initiative to Reduce STI / HIV / AIDS Vulnerability and Risks (PAIBLT), Sustainable Water Resources Management of the Lake Chad Basin, and Groundwater Management in the Lake Chad Basin.

Numerous local initiatives have also been carried out by civil society organisations in the LCBC member states, such as the Cameroonian Association for Environmental Education (ACEEN), the Contribution to Wetland Management Association (COGEZOH), the Nigerian Conservation Foundation (NCF), the Association of Environmental Assessment Practitioners of the Central African Republic (ACAPEE) and the Chadian NGO Humanitarian and Development Organisation (OHD), based in Bol.

The Strategic Action Plan (SAP) was developed in 2008, for a planning period of 15 years. A five-year investment plan

is to be drawn up in 2013 to implement the SAP activities. The table below provides information on these projects.

Table 33: Description of SAP activities

<b>COMPONENT 1</b>	<b>SUSTAINABLE NATURAL RESOURCES MANAGEMENT AND CONSERVATION OF ECOSYSTEMS</b> (3 programmes, 14 actions, 33 tasks)
Programme 1.1	Support for economic and sector development (4 actions, 11 tasks)
Programme 1.2	Protection of food crops around Lake Chad (3 actions, 8 tasks)
Programme 1.3	Conservation of ecosystems in Lake Chad and its basin (7 actions, 14 tasks)
<b>COMPONENT 2</b>	<b>IMPROVEMENT OF THE QUANTITY AND QUALITY OF WATER IN THE LAKE CHAD BASIN</b> (6 programmes, 16 actions, 38 tasks)
Programme 2.1	Improvement of river flows in the Chari-Logone system (3 actions, 7 tasks)
Programme 2.2	Reduction of water pollution risks (3 actions, 7 tasks)
Programme 2.3	Measures to improve Lake Chad (3 actions, 10 tasks)
Programme 2.4	Final project design (FPD) studies for the Interbasin Water Transfer from the Ubangi River to Lake Chad project (4 actions, 12 tasks)
Programme 2.5	Improved knowledge of groundwater and surface water (2 actions, 5 tasks)
Programme 2.6	Regional integration and security in the Lake Chad basin (1 action, 4 tasks)
<b>COMPONENT 3</b>	<b>IMPLEMENTATION OF NATIONAL ACTION PLANS FOR INTEGRATED WATER RESOURCES MANAGEMENT IN THE LAKE CHAD BASIN MEMBER COUNTRIES</b> (6 programmes, 34 actions, 175 tasks)
Programme 3.1	Action plan for integrated water resources management in Cameroon's part of the Lake Chad basin (7 actions, 21 tasks).
Programme 3.2	Action plan for integrated water resources management in the Central African Republic's part of the Lake Chad basin (5 actions, 39 tasks)
Programme 3.3	Action plan for integrated water resources management in the Niger's part of the Lake Chad basin (7 actions, 38 tasks)
Programme 3.4	Action plan for integrated water resources management in Nigeria's part of the Lake Chad basin (5 actions, 37 tasks)
Programme 3.5	Action plan for integrated water resources management in Chad's part of the Lake Chad basin (6 actions, 31 tasks)
Programme 3.6	Action plan for integrated water resources management in Libya's part of the Lake Chad basin (4 actions, 9 tasks)

## Regional projects

Project title	LAKE CHAD BASIN SUSTAINABLE DEVELOPMENT PROGRAMME (PRO-DEBALT)
Area of intervention	Lake Chad basin
Funding source	African Development Bank
Funding amount	41.84 billion CFA francs
Overall term	2009–2015 (6 years)
Overall goal	Sustainably reduce poverty among the population dependent on the resources of Lake Chad and its basin

This intervention represents the most extensive programme to implement the Strategic Action Plan of the Lake Chad Basin Commission in keeping with its Vision 2025. It aims at increasing the incomes of the target population groups, particularly women, by an average of 67% and to improve food security.

### Specific objectives

- Contribute to the rehabilitation and conservation of the productive capacities of the ecosystems of Lake Chad and its basin.
- Adapt production systems to meet the challenges of climate change.

### Four components

1. Protection of Lake Chad and its basin
2. Adaptation of production systems to climate change
3. Institutional support through capacity building
4. Programme coordination and management

### Programme achievements by 2012

- Eight nurseries were created, and 224,000 plants were produced. Of these, 75,000 were planted in a 168 ha area in Chad to stabilise sand dunes, to protect and restore soil, and to regenerate rangeland.
- Six biogas digesters were constructed in Cameroon to pilot the use of alternative household energy sources.
- An agroforestry initiative was carried out, planting 100,000 fertilising plants on a 230 ha area in Chad.

- Various partnership agreements were signed with the technical departments of line ministries in the basin countries for the implementation of activities in the field.



from top to bottom:

169: Irrigation system to fields

170: Fishing communities receive material support appropriate for their activity

171: Domestic biogas unit

Project title	INTERBASIN WATER TRANSFER PROJECT
Area of intervention	Lake Chad basin
Funding source	LCBC member states
Overall term	2010–11
Funding amount	5.8 million US dollars
Overall goal	Reduce poverty among the populations dependent on the resources of Lake Chad and its basin

The water transfer project dates back to a study conducted by the Italian consulting firm BONIFICA in 1988 with a second project developed by Nigeria's National Electric Power Authority (NEPA). Initially, the aim of the project was to transfer water from the Congo basin (Ubangi sub-basin) to the Lake Chad basin (Chari sub-basin) by means of a 184 km-long tunnel linking the Ubangi River to the Fafa River, the Ouham River (the Bahr-Sara River in Chad), the Chari River and Lake Chad. A link would also be established between the Chari and the Benue River, connecting the Congo basin, the Lake Chad basin and the Niger basin and Bangui to N'Djamena and Port Harcourt, which would open up the whole region.

#### *Findings of the study*

It is technically feasible to transfer water from the Congo basin via the Ubangi River to the Lake Chad Basin, by constructing a combined interbasin transfer, involving a transfer by pumping from the Palambo dam on the Ubangi River and a transfer by gravity flow from the Bria dam,

diverting the Kotto River. This would increase the overall level of the lake by around 1 m, with the area of the lake increasing by approximately 5,500 km<sup>2</sup>.

An economic analysis of the findings reveals that:

- it is financially viable to transfer water using both interbasin transfer options;
- the most financially advantageous option is the transfer by gravity from the Bria dam and the Kotto River, with an internal rate of return of 24.83% and net present value of 3,980.3 billion CFA francs;
- the sale of electricity produced by the two dams is a profitable operation, with an internal rate of return of up to 32.5%.

#### *Conclusions of the study*

The study concluded that the project is technically feasible, but the cost is very high. As a first step the Summit of Heads of State decided in 2012 to commission the study for the final project design, including measures to improve flows in the Chari-Logone system and the condition of Lake Chad (removal of sand, silt and vegetation).



Project title	PROGRAMME FOR INTEGRATED WATER RESOURCES MANAGEMENT IN TRANS-BOUNDARY RIVER BASINS IN AFRICA – LAKE CHAD BASIN COMPONENT
Area of intervention	Lake Chad basin
Funding source	European Union
Funding amount	1,261,097,775 CFA francs
Overall term	2009–2011
Overall goal	Contribute to the reduction of poverty and environmental degradation and increasing food insecurity in the Lake Chad basin

### Specific objective

Ensure that member states of the Lake Chad Basin Commission undertake regional, sustainable, operational and equitable management of the water resources in the Lake Chad basin.

### Components of the project

1. Collection of hydrometeorological data
2. Improvement of the measuring network
3. Development of the water allocation model

### Some achievements

- A revised and updated hydrometeorological database was delivered to the LCBC.

## Technical water resources management and planning tool

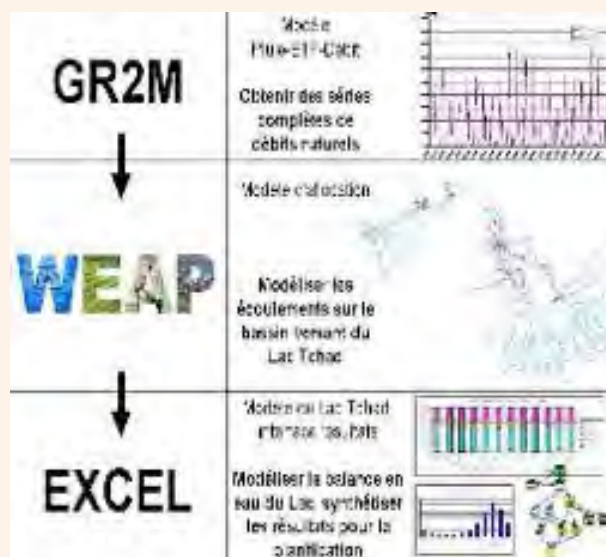
The Hydro-Chad model (a surface water simulation for the rivers feeding Lake Chad) was developed by Mott MacDonald in 1993. It ran under DOS with a command line interface and covered the conventional basin as it was at that time. The extended model, covering the current basin area, was developed using the software tool WEAP (Stockholm Environment Institute, Boston, USA), with a more user-friendly interface, and was made available on-line. It is designed to manage water resource allocation in the Lake Chad basin and, using Excel®, the water balance in Lake Chad's two pools. The period studied was 1950 to 2007 with a monthly time step.

The technical water resource planning tool has been developed based on the experience gained through the Hydro-Chad model. It is a hydrological model combined with general circulation models to incorporate the climate variability. The model includes surface water balances by river section and abstractions by river section and water use. It also provides an economic assessment of different sectors and infrastructure (environmental flows, water supply, irrigation, fishing, dams, etc.).

The tool should serve as a reference for water resources management in the Lake Chad basin to be used by LCBC member states with the LCBC acting as the lead authority. All member states would thus use the same planning tool and submit their development projects to the LCBC for regional



172: Irrigation canal in Bongor, Chad



- Key hydrometeorological stations were selected for repair / rehabilitation, and technical specifications were established for the equipment to be acquired.
- The final version of the model was delivered to the LCBC, with relevant training for senior staff.
- Institutional and technical capacity strengthening of the LCBC:
  - specific support provided by a legal expert;
  - training for LCBC management staff in international cooperation (international organisations and transboundary river basin management rules);
  - active participation of the LCBC in developing the water allocation model.

Project title	PROJECT IN SUPPORT OF THE LAKE CHAD BASIN INITIATIVE TO REDUCE STI/HIV/AIDS VULNERABILITY AND RISKS (PAIBLT)
Area of intervention	Lake Chad basin
Funding source	LCBC/African Development Fund (ADF)
Funding amount	8.5 milliards CFA francs
Overall term	2006–2010 (5 years) extended to 2013
Overall goal	Contribute to reducing the spread of HIV/AIDS

According to the survey report on the National AIDS Programme by the Swiss Tropical and Public Health Institute in 2000, up to 26% of people living around Lake Chad could be HIV-positive. There is a growing need for health facilities equipped to provide the services and care that people with HIV need.

#### *Specific objectives*

Reduce HIV/AIDS vulnerability and risks among people living in the Lake Chad basin.

#### *Components of the project*

1. Strengthening the capacities of health care systems to deal with STIs and HIV/AIDS.
2. Reducing high-risk sexual behaviour among migrants and the people in contact with them.
3. Strengthening the capacities of the communities concerned with a view to participation in STI/HIV/AIDS prevention, care and support activities.



173: Project in support of the Lake Chad Basin initiative to reduce STI/HIV/AIDS vulnerability

### Some achievements

- Five mobile laboratories were acquired for HIV testing (one per country), and national coordination units were established.
- Fifty health centres were equipped for voluntary counselling and testing and the prevention of mother-to-child transmission of HIV (ten per country), and five regional laboratories were equipped for voluntary counselling and testing and STI surveillance (one per country).
- Drugs and testing reagents were procured and distributed to health facilities in the target areas in each country involved in the initiative.
- Training was provided for 1,500 health workers (300 per country), 100 laboratory technicians (20 per country), 1,250 members of non-governmental organisations and community-based organisations in information-education-communication (IEC) and behaviour change communication (BCC), and 500 peers and community-based condom distributors. Refresher training was also provided.
- Support was provided for the organisation of awareness campaigns and HIV testing in the countries involved in the initiative (Niger, Nigeria, Chad, Central African Republic and Cameroon).

Project title	SUSTAINABLE WATER RESOURCES MANAGEMENT OF THE LAKE CHAD BASIN
Funding source	BMZ
Executing agency	GIZ
Funding amount	2.75 million euros
Overall term	2005–2007 2007–2011
Overall goal	Improve the capacities of the Executive Secretariat of the LCBC to effectively coordinate and monitor of projects with a transboundary impact.

The first phase of the LCBC/GIZ project, which ran from 2005 to 2007, sought to improve the LCBC's knowledge management system. In the second phase, implemented between 2008 and 2011, efforts focused on assessing the state of surface water resources and evaluating water withdrawals in the conventional basin as a whole.

### Specific objectives

Improve cooperation between the LCBC and partner institutions in the member countries.

### Components of the project

1. Organisational advisory services
2. Promotion of integrated water resources management
3. Implementation of data and knowledge management systems



174: GIZ support team to the LCBC

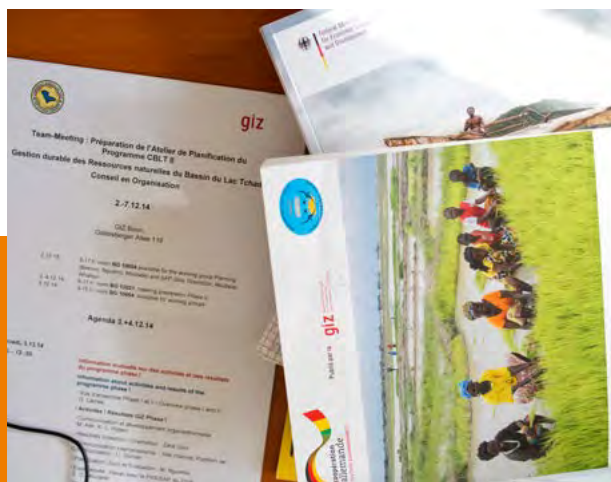
### Some achievements

- A central database for the LCBC was developed (data transmission, PostgreSQL, PostGIS, Geoserver).
- Capacities were strengthened (training in Hydraccess, web services, technical advice).
- Remote sensing: case study – analysis of regional biomass trends using low-resolution satellite data (Advanced Very High Resolution Radiometer of the National Oceanic and Atmospheric Administration – NOAA-AVHRR).
- Support was provided to establish a communication plan and create the LCBC website with a view to enhancing visibility.

### Outlook

The German cooperation programme Sustainable Water Resources Management of the Lake Chad Basin (2011–18) currently in progress was restructured in 2010 in cooperation with the German Federal Institute for Geosciences and Natural Resources (BGR). In its current form it is divided into two modules: a technical module (BGR) and an organisational/institutional module (GIZ).

These two modules were created to help the LCBC meet institutional, organisational and technical requirements. The programme started in August 2011 and will end in June 2018. The budget for this programme is 8.5 million euros.



175: Supporting the planning process and knowledge circulation, GIZ

Project title	GROUNDWATER MANAGEMENT OF THE LAKE CHAD BASIN
Funding source	BMZ
Executing agency	BGR
Funding amount	1 million euros
Overall term	2007–2011
Overall objective	Contribute to improving knowledge of groundwater resources in the Lake Chad basin

German cooperation has been providing support to the LCBC since September 2007 with the implementation of this complementary project concerned with groundwater resources.

### Specific objectives

The project aims to improve coordination and data sharing in relation to groundwater resources among member states and to incorporate this data in a management system, to support the development of effective strategies for the sustainable use of water resources in the Lake Chad basin.

### Components of the project

1. Development of a hydrological data-sharing protocol, including all information on groundwater, with a view to integrated water management.
2. Establishment of mechanisms for cooperation and communication with the national authorities concerned in the member countries, with a view to the submission of groundwater data to the LCBC on a regular basis, in accordance with agreed requirements (data-sharing protocol).
3. Groundwater data stored in a geographic information system available for consultation via the knowledge management system.



176: BGR planning workshop in 2012

4. Assistance to set up a unit within the LCBC to collect and analyse meteorological, hydrological and hydrogeological information relating to the availability of transboundary groundwater resources in accordance with integrated water resources management.

#### *Some achievements*

- A data-sharing protocol is already being used by the LCBC to compile the necessary data, although it has not yet been ratified by the member states. The requirements for effective data sharing have still to be met.
- A total of 441 water points (422 groundwater points and 19 surface water points) were sampled and laboratory tested during the course of the project to determine the chemical composition of the water found in them.
- Existing hydrological and hydrogeological data were collected, evaluated and processed.
- LCBC member states have presented findings at national and international meetings.
- Based on these findings, specific recommendations were made to national line ministries – for example, in relation to an irrigation project in Nigeria and to the drinking water supply of a village in Cameroon.
- The LCBC has established a groundwater monitoring network.
- A Water Resources Committee was set up within the Water Department.
- A communication network system (server and cabling) was installed in LCBC offices.

#### *Outlook*

In 2011 the two projects (GIZ and BGR) began a new phase under the same programme (phase 1: 2011–14), with BGR funding amounting to 2 million euros.

The next phase (2014–18) focuses primarily on strengthening the LCBC Executive Secretariat's information, analysis and monitoring system for groundwater and surface water data. To this end, new data must be collected, analysed and recorded in a database. A pilot area was selected at a workshop held to plan the new phase, which will involve analysis of groundwater quality, interaction between surface water and groundwater, and groundwater sources. The findings will be used to inform and adjust integrated water management strategies.



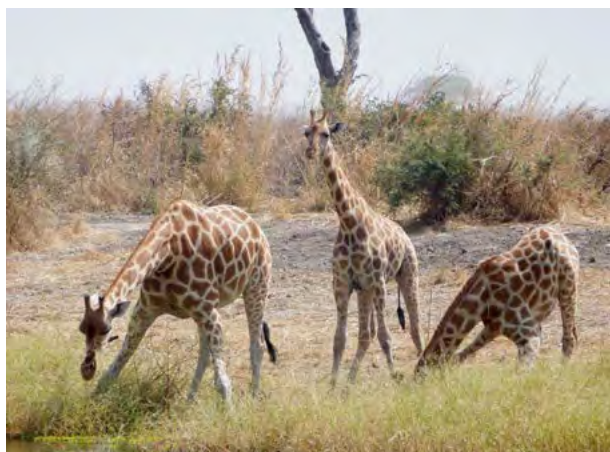
177: Piezometric study of the BGR

## Projects implemented by member states

### 1. In Cameroon

A joint project of the IUCN, Cameroon's Ministry of Forests and Wildlife (MINFOF) and the Heavily Indebted Poor Countries (HIPC) Initiative, running from 2010 to 2015, aims to secure the livelihoods of communities through the sustainable development of the Waza National Park and the surrounding area. To this end, 69 fishing, agriculture and livestock micro-projects were financed, transhumance corridors were improved, boreholes were sunk and the co-management of natural resources was promoted, based on a participatory approach involving local people and administrative and forest authorities.

Another example from Cameroon is the Chari-Logone Integrated Rural Development Programme, which is jointly funded by the Government of Cameroon, the Fund for International Development of the Organization of Petroleum Exporting Countries (OPEC) and the Islamic Development Bank (IDB). This project aims to improve food security by developing fisheries production, irrigated cultivation, the construction of wells, the creation of artificial ponds



from top to bottom:  
178: Development programmes aiming to preserve biodiversity  
179: Projects contributing to improving access to drinking water

and the construction of grain silos and storage facilities to reduce losses after crops are harvested.

A number of activities were carried out as part of Cameroon-Japan cooperation efforts, including the construction of a fisheries centre in Maga, the equipping of a workshop for the production of canoes and other fishing equipment, training for fishers and women involved in fish processing, the creation of fish farming ponds and the donation of an ice-making unit to a women's Common Initiative Group in Maga.

### 2. In Niger

The Community Action Project for Climate Resilience (PACRC) aims to improve the resilience of communities and production systems to climate change, with a view to increasing food security in the Niger. It is a nationwide project, targeting 38 communes in the country's eight regions. The project activities were officially launched on 22nd October 2012 under the direction of the General Planning Department of the Ministry of Planning, Land Use and Community Development.



from top to bottom:  
180: Some of the basin population are using climate change mitigation and adaptation techniques  
181: Women's capacities are strengthened and incomes improved

Also in Niger, the Household Food Security Support Project, running from 2010 to 2013, is funded by the French Development Agency (1,400,000 euros; 918,339,800 CFA francs). It targets the regions of Zinder and Diffa, aiming to improve food security among vulnerable households in the departments of Maine Soroa and Goure and to provide support for the implementation of the national food security policy.

The Project to Support Local Development in the Region of Diffa (PADL Diffa) ran from 2004 to 2011. It was funded by the African Development Bank and aimed to improve sustainable agriculture and livestock production in the Diffa region. The deterioration of climate conditions and the shrinking of Lake Chad have resulted in a decline in cereal productivity in this region, which is also affected by a massive seasonal exodus. The improvements introduced under the project strengthened agricultural and livestock production in the region, increasing food security, the income of rural households and rural employment.

The Project to Strengthen the Resilience of the Agricultural Sector to Climate Change aims at implementing priority climate change adaptation measures in the field. It is funded by the United Nations Development Programme (UNDP), the Global Environment Facility (GEF), the Government of Niger and other technical and financial partners. The project started in 2009 and will end in 2013. It targets eight communities identified as vulnerable in Niger's National Adaptation Programme of Action, including one in Tanout, Zinder region, and another in Chetimari, Diffa region.

### 3. In Nigeria

The South Chad Irrigation Project (SCIP) is the largest irrigation scheme being implemented in the country. It is located around 120 km north-east of Maiduguri, capital of Borno state. It was designed to irrigate 67,000 ha of land and is being implemented in three phases: Phase I – 22,000 ha, Phase II – 27,000 ha and Phase III – 18,000 ha.

The Baga Polder Project (BPP) is another irrigation being implemented in Nigeria. It was taken over by the authorities of the North-East region, under the supervision of the Ministry of Agriculture and Natural Resources, in 1975. It is situated around 200 km north of Maiduguri. When fully operational, the project will meet the irrigation requirements of 4,500 farming families and make an important contribution to the country's agricultural production, with around 26,000 tonnes of wheat, 28,000 tonnes of corn and 14,000 tonnes of peanuts a year, in addition to large quantities of vegetables and potatoes.

The Alau Dam Project was started in 1984, although construction work did not begin in earnest until 1986. The dam is situated about 22 km along the Maiduguri–Bama road. It was originally planned to supply water to the 8,000 ha rice-growing scheme in Jere, but when it was discovered

that groundwater resources, the main source of the water supplied to the city of Maiduguri, were being depleted, it was decided that the urban drinking water supply had to be given precedence. The reservoir is fed by the Ngadda and Yedseram Rivers.

The Chad Basin Development Authority has implemented a number of Flood Control Projects as part of its efforts to protect the environment. They include Phases I and II of the erosion control scheme in Ngaddabul; erosion control measures in Galtimari and Polo, in Ngelzerma, in Sambisa and in the Nguru-Hadejia wetlands; Phases I and II of the erosion control scheme in Gashua; and flood control projects in Potiskum.

### 4. In the Central African Republic

The Multisectoral HIV/AIDS, Health and Education Emergency Support Project is the result of an agreement between the Government of the Central African Republic and a number of donors, including the World Bank, to provide funding for the development of the health and education sectors. Several prefectures situated in the Lake Chad basin received support under this project, specifically eight communes, seven in Kemo (Sibut, Ngoumbele, Dekoa, Guiffa, Tilo, Galafondo and Galabadja) and one in Nana Gribizi (Mbres).

It finances small projects prepared by community organisations to address urgent health needs, involving the following:

- small rural drinking water supply systems;
- the drainage of marshlands to reduce the reproduction and spread of mosquitoes and related activities;
- emergency provision of equipment, services and works identified by communities as priority needs (supplies, minor rehabilitation works and training of health workers and members of the community in basic preventive care).

Through these activities, the project seeks to make a multi-faceted contribution to the global development goals of the Central African Republic, achieving results at the local level and generally or nationally, as part of the decentralisation and deconcentration of responsibilities and services. It adopts a participatory approach to ensure that beneficiary communities take full ownership of the initiatives undertaken to improve their living conditions (community-driven development – CDD).

### 5. In Chad

The Support Programme for Local Development and Natural Resources Management (PADL-GRN) has been awarded funding from the 10th European Development Fund (EDF) amounting to around 21 billion CFA francs (32,000,000

euros) for a six-year period (2010–16). The main objectives of the PADL-GRN are to improve the living conditions and food security of rural communities and strengthen participatory processes for local development and natural resources management. The PADL-GRN targets 13 regions and 70% of the rural population, that is, around 3,000,000 inhabitants.

The National Programme for Food Security (NPFS), which was started in 2006, has an overall term of ten years (two five-year phases). The overall goal of the programme is to contribute to eradicating hunger and combating food insecurity throughout the country by 2015, by achieving sustainable increases in productivity and production. It also includes measures to ensure that people have access to food of sufficient quality and quantity, coupled with activities to promote the conservation of basic natural resources. The National Programme for Food Security has an overall budget of 103 billion CFA francs. The Government of Chad undertakes to finance 50% of this amount and seeks donors to fund the remaining amount.



from top to bottom:

182: Women are implicated in decision making processes

183: Civil Society Organisations are active in the Lake Chad basin

## Projects implemented by civil society

### 1. Cameroon

The Cameroonian Association for Environmental Education (ACEEN), founded in 2000, is implementing a project for the sustainable development of the Logone River floodplain ecosystem and poverty reduction among the communities living in the area. It is a five-year project (2011–15) funded by the Ecosystem Alliance, a partnership between the IUCN National Committee of the Netherlands, Both ENDS and Wetlands International.

The approach adopted by ACEEN mainly involves carrying out lobbying and advocacy activities, with the organisation of discussion meetings, supporting the development of co-management rules, facilitating communication among stakeholders and providing advisory support and capacity building for beneficiaries in areas agreed in advance. These advocacy activities are effective in reducing conflicts between resource users, encouraging political leaders to do more to prevent damage associated with oil exploitation and raising awareness about natural resources management, the devastating consequences of the use of fuel wood in the region, etc.

### 2. Niger

The Contribution to Wetland Management Association (COGEZOH) was created in 2000, with a view to improving living conditions, particularly for people living in rural areas. More specifically, it focuses on providing information and raising awareness to ensure that current and future generations are familiar with and have a clear understanding of best practices for wetland areas.

The association has carried out activities to ensure that those concerned, particularly young people, are well informed about wetland management issues. It also promotes market gardening, providing support for the identification and fencing of sites, the construction of drainage wells, garden layout and training for committees in production techniques. It has constructed or rehabilitated four village wells and formed and trained water management committees. Other activities have also been carried out in areas such as ecotourism and beekeeping.

### 3. Nigeria

The Nigerian Conservation Foundation (NCF) is the first non-governmental organisation (NGO) concerned with both nature conservation and sustainable development in Nigeria. The NCF, which was created in 1980, is implementing an initiative called the Living on the Edge Project in the north-eastern part of the country. The overall goal of the project is to improve people's livelihoods and the habitats of migratory birds in the Sahel regions of the four West African countries, namely Nigeria, Burkina Faso, Senegal and Mauritania.



The project, funded by the Dutch Postcode Lottery, carries out interventions in the field aimed at restoring and conserving natural habitats in arid and wetland areas and at improving living conditions for people living in those areas. These field interventions have three main objectives: to make a difference to birds and their habitats; to raise public awareness about the sustainable use of natural resources and improve living conditions; and to use experience gained in the field, that is, lessons learned, to identify best practices for combined natural resources management and conservation in the Sahel.

#### 4. Central African Republic

The Association of Environmental Assessment Practitioners of the Central African Republic (ACAPEE) contributes to strengthening stakeholder capacities to enable them to use environmental assessment as a tool for improving the decision-making process. Created in 2008, it has contributed to the drafting of the Environment Code of the Central African Republic, a number of decrees on the application of the Environment Code (environmental impact assessments, strategic environmental assessments, community sessions and environmental audits) and other regulatory instruments.

#### 5. Chad

The Humanitarian and Development Organisation (OHD) is a Chadian NGO founded in 2005 in Bol. The NGO focuses efforts on activities aimed at reducing food insecurity, such as the smoking of fish in traditional ovens and the use of dead hedges to fence off cultivable areas in the wadis. The NGO has worked with the LCBC on mapping Lake Chad's southern pool.

### Conclusion and recommendations

There have been numerous interventions implemented across the basin to support the livelihoods of the population and stabilise the environment. They have been carried out by the LCBC in the form of transboundary initiatives, by individual member countries, based on the National Action Plan, or by NGOs as part of civil society activities.

The LCBC's Strategic Action Programme (SAP), formulated in 2008, sets five Ecosystem Quality and Water Resource Objectives (EQWROs), which are:

- ✓ increased quantity and quality of water in the Lake Chad Basin;
- ✓ the restoration, conservation and sustainable use of bioresources;
- ✓ the conservation of biodiversity;
- ✓ the restoration and preservation of ecosystems;

- ✓ strengthened stakeholder participation and capacities and institutional and legal frameworks for environmental stewardship.

However, the implementation of the programme has been hindered by numerous problems, such as population growth, climate change and many others that were not accounted for when the plan was formulated.

The LCBC has developed a range of initiatives, in keeping with Vision 2025, to implement the SAP. These include:

- ✓ The Lake Chad Basin Sustainable Development Programme (PRODEBALT), which aims to increase the incomes of vulnerable people by an average 67% and strengthen food security.
- ✓ The Interbasin Water Transfer Project, which essentially aims to open up the region, improve river transport, generate hydropower and restore Lake Chad to its 1960 state.
- ✓ The Programme for Integrated Water Resources Management in Transboundary River Basins in Africa (Lake Chad basin component), which seeks to engage Lake Chad basin member states in the regional, sustainable, operational and equitable management of water resources.
- ✓ The Project in Support of the Lake Chad Basin Initiative to Reduce STI/HIV/AIDS Vulnerability and Risks (PAIBLT), which aims to provide care for the 26% of lakeside dwellers affected by HIV/AIDS and reduce risks exacerbated by vulnerability.
- ✓ The projects Sustainable Water Resources Management and Groundwater Management of the Lake Chad Basin, which are implemented by German cooperation as part of efforts to improve the LCBC's knowledge management systems in relation to surface water and groundwater.

The National Action Plan (NAP) was formulated by the LCBC and its member states to complement the SAP. It has given rise to a number of important initiatives, including the following:

- ✓ The project of the IUCN, Cameroon's Ministry of Forests and Wildlife and the Heavily Indebted Poor Countries (HIPC) Initiative aims to improve the livelihood security of communities for the sustainable development of Waza National Park.
- ✓ The Community Action Project for Climate Resilience (PACRC) in the Niger aims to improve the resilience of communities and production systems to climate change, with a view to increasing food security in the country.

- ✓ The South Chad Irrigation Project (SCIP) is designed to irrigate 67,000 ha of land located north-east of Maiduguri, capital of Borno state.
- ✓ The Multisectoral HIV/AIDS, Health and Education Emergency Support Project in the Central African Republic is being implemented under an agreement with the World Bank. A number of prefectures have received funding to carry out activities in this area.
- ✓ The Support Programme for Local Development and Natural Resources Management (PADL-GRN) aims to improve the living conditions and food security of rural communities and strengthen participatory processes for local development and natural resources management.

Many other local initiatives have been carried out by civil society organisations in the different LCBC member countries, with a view to making an effective contribution to sustainable development in the Lake Chad basin.

These organisations do not work with each other or in an organised network that the LCBC could support or promote, a constraint that needs to be addressed. The LCBC did, in fact, attempt to do so some years ago, seeking to establish a dialogue with all the basin's stakeholders. On that occasion a strategy was formulated, but there were delays in implementing it for various reasons, including a lack of public participation and regional cooperation programmes and international partnerships. The IUCN, which signed a cooperation agreement with the LCBC, could use its know-how in this area to help further the process. The Global Water Partnership (GWP), which has extensive experience in partnership building, could also play a useful role.



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