Regional definition

This section describes the boundaries and the main physical and socio-economic characteristics of the region in order to define the area considered in the regional GIWA Assessment and to provide sufficient background information to establish the context within which the assessment was conducted.

Boundaries of the Lake Chad region

The Lake Chad Basin (GIWA region 43) is situated in Central Africa between 6° to 24° N and 8° to 24° E. It comprises a vast expanse of land made up of several catchments that feed Lake Chad. Figure 1 shows a general map of the Lake Chad Basin with the GIWA region 43 boundaries. The entire geographical basin covers an area of 2 434 000 km^2

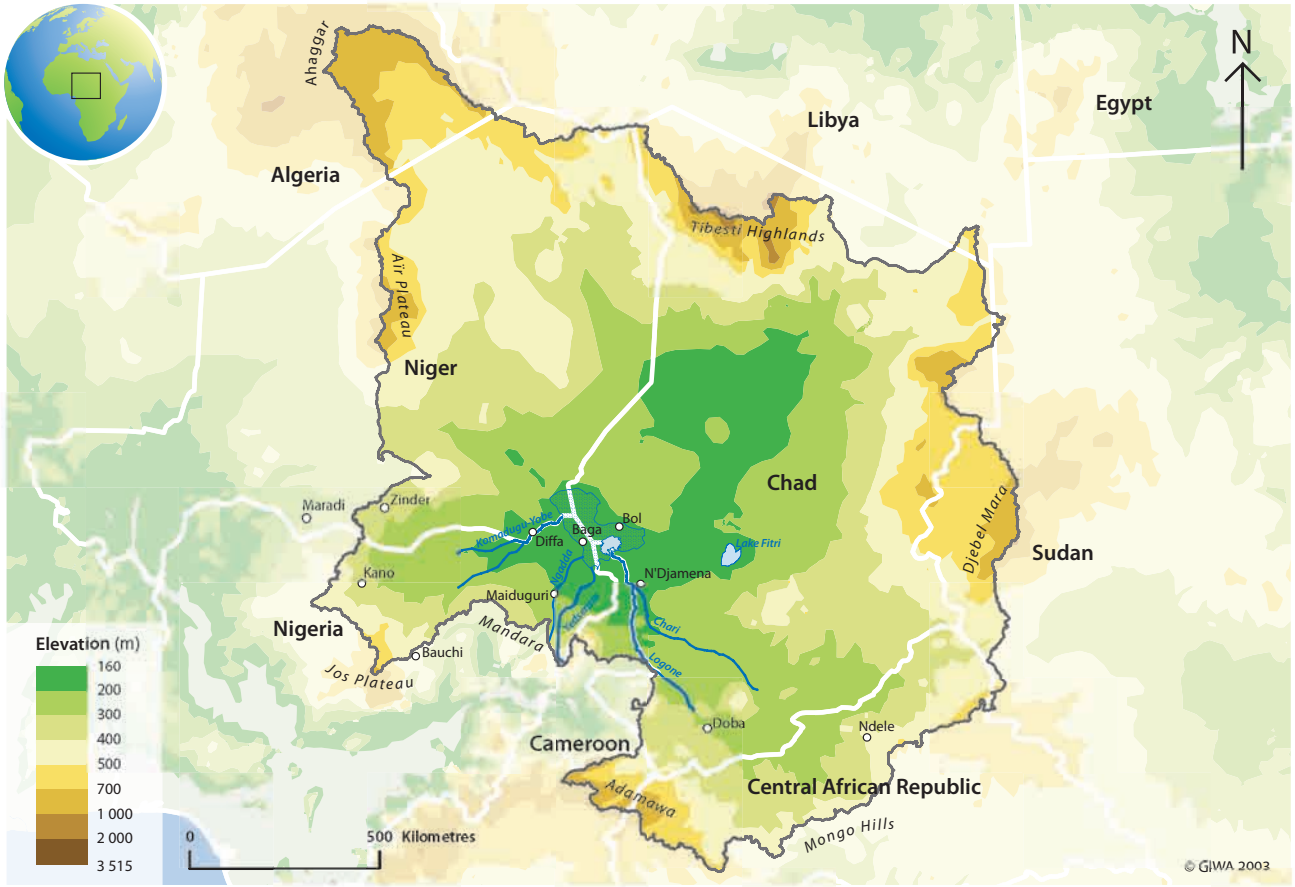


Figure 1 The Lake Chad Basin.

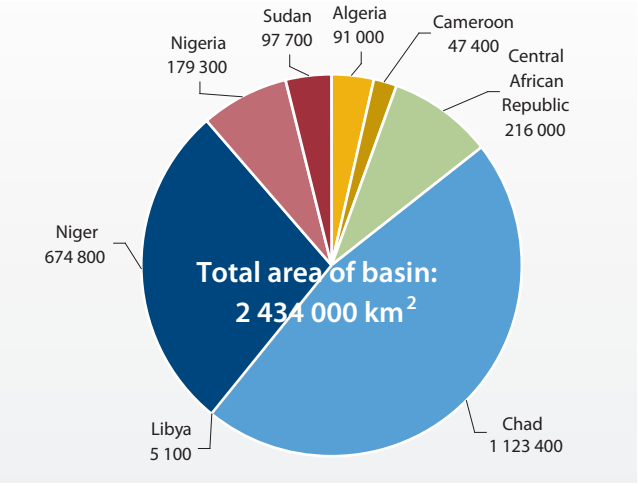


Figure 2 Area coverage per country within the Lake Chad Basin (km²).
(Source: Based on HYDRO 1K Elevation Derivative Database, EROS Data Center 2002)

(based on EROS Data Center 2002), or 8% of the surface area of the African continent, shared between the countries of Algeria, Cameroon, Central African Republic (CAR), Chad, Libya, Niger, Nigeria and Sudan (Figure 2).

The region is bounded to the north by the Ahaggar Mountains in Algeria. From this summit, the border descends southwards towards the Tibesti Highlands that forms the border between Libya and Chad, and continues to about 19° N near the Djebel Mara volcanic mountains in Sudan. The southern border is defined by the Mongos Hills in CAR and the Adamawa Mountains at about 6° N and further west by the Mandaras in northern Cameroon at approximately 10° N. The Jos Plateau marks the western boundary in the Nigerian sector of the Basin and further north the Aïr Plateau in Niger.

Physical characteristics

Geophysical and geological characteristics

The Tibesti and Ahaggar Highlands in Algeria (see Figure 3) form the highest elevations within the Lake Chad Basin region. Their summits rise to an elevation between 2 500 to 3 400 m above mean sea level. They are built up of basalt and crowned with a series of craters. The Djebel Mara volcanic mountains in western Sudan have an elevation of 3 088 m above mean sea level and these mountains gradually decrease to approximately 300 m above mean sea level towards the Lake Chad tectonic depression. Most of the interior of the region is a depression with heights not more than 500 m above mean sea level in altitude, the lowest point being about 160 m in the Chad lowlands (UNDP/FAO 1972). Figure 1 shows these topographic features.

The Lake Chad Basin was formed by extensional tectonic forces during the Cretaceous Period (Burke 1976 in Isiorho & Nkereuwem 1996) with the geological and geomorphological development of the Basin being conditioned by the slow and 'cool' rifting of the West and Central African Rift System. This has formed a regional hydrological sink (World Bank 2002b) known as the Chad Artesian Basin that consists of the Lake Chad (Chad Syneclise) and the Chari-Logone system (Chari-Logone Artesian Basin) located southwest of the Basin. These sub-systems are underlain by a basement complex in the upper source areas and by a progressively thick sequence of sedimentary deposits towards the Lake (World Bank 2002b).

The Chad Syneclise is part of the major meridional zone of depressions extending from the Gulf of Gabes in the North of Africa to the Karoo aquifer in the south. It borders the Mali-Niger aquifer in the west, the Benue Graben in the southwest, and is surrounded by the Aïr Plateau, the Ahaggar and Tibesti Highlands and the Dahomey-Nigeria and Cameroon massifs. This basin is situated in the intersection of the northeastern and northwestern faults. The water supply of the Chad Basin is drawn from the southern Ahaggar and Tibesti Highlands, the Aïr, Ennedi, Darfour and Ouaddai plateaux and other uplands. In the internal recharge and storage area situated in the Chad Syneclise aquifer, water is present in Paleozoic "Continental Intercalaire", Upper Cretaceous, "Continental Terminal" and Quaternary formations.

Figure 3 Ahaggar Mountains, Algeria.
(Photo: Corbis)

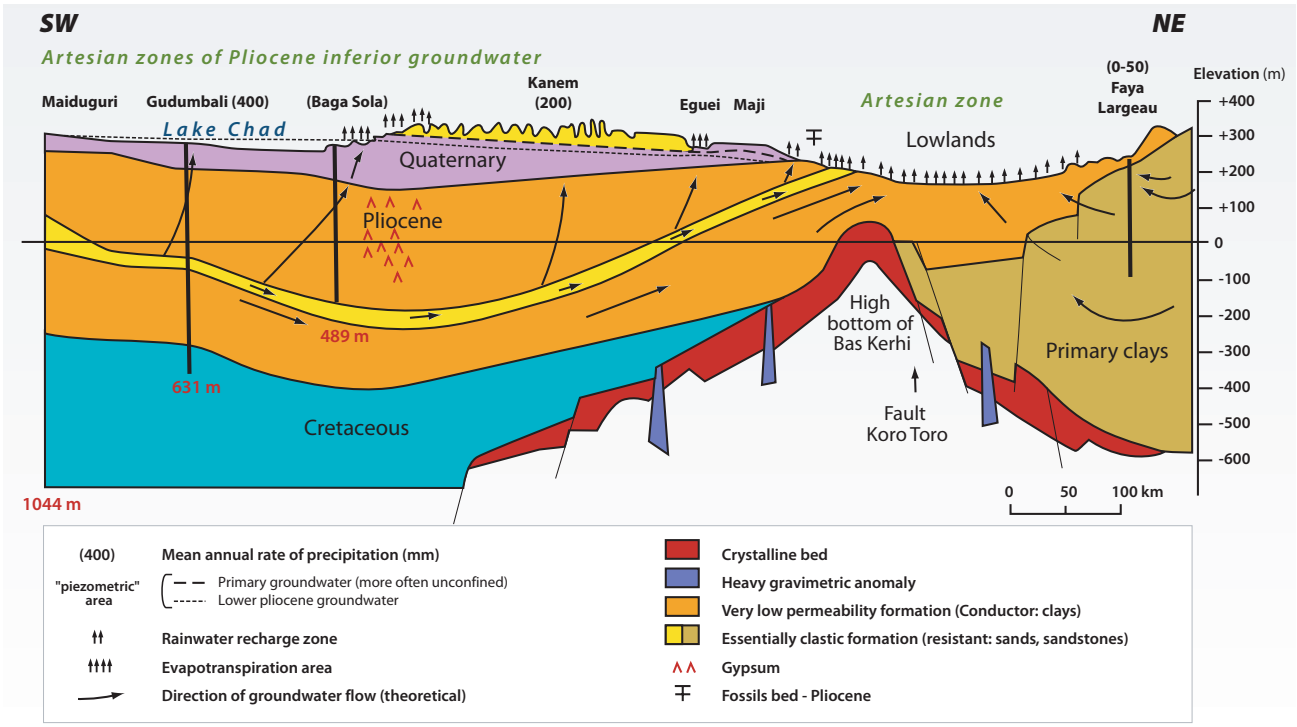


Figure 4 Schematic hydro-geological cross section.
(Source: Redrawn from Schneider 1991)

The Chari-Logone Artesian Basin is situated southeast of the Lake Chad. It includes the extensive Chari-Logone plain, as an inner recharge area, and the Adamawa, Bongas, Ouaddai and other mountains surrounding the plain, as an outer recharge area. Most significant reserves of groundwater in this basin are found in the "Continental Terminal" sequence and in the alluvium of the Chari and Logone valleys. This water is widely used for economic purposes. Much of the soil in the Chari Basin consists of clay particles which swell together when wet, so that water runs off as rapid sheetwash rather than slow percolation (USGS 2001).

Hydrostratigraphy

There is limited knowledge regarding the sedimentary aquifers underlying the Lake, and the hydrodynamics of the groundwater flow into the Lake Chad water body are therefore hypothetical (World Bank 2002b). In the southwest portion of the Basin, the Chad Formation is composed of three aquifers referred to as the upper, middle and lower aquifers shared by the four countries bordering the Lake Chad (Niger, Chad, Cameroon and Nigeria). The systematic hydro-geological cross section in Figure 4 shows the Chad formation, which these aquifers are contained within and also demonstrates the hydrodynamic linkages with the Lake Chad. The formation is overlain by aeolian sands, fluvial, deltaic and lacustrine deposits approximately 1 to 6 m thick. Most of the fluvial deposits occur along stream valleys which are made up of two units: the old alluvium and the young alluvium (Hammand & Abdou 1982 in Isiorho & Nkereuwem 1996). The old alluvium consists of deposits of old rivers, while the young alluvium contains recent riverbeds and flood plains (Isiorho & Nkereuwem 1996).

The upper aquifer consists of a quaternary phreatic aquifer that is made up of fine-grained sediments approximately 30 m thick, and is hydrologically connected to Lake Chad (Isiorho & Matisoff 1990). The phreatic aquifer is not continous all over the basin area, and recharge conditions are poor. Natural recharge occurs primarily by influent seepage from seasonal streams and perennial rivers. The quality of this groundwater is suitable for domestic consumption of the local population and livestock. This aquifer is separated from the underlying middle aquifer by the lower pliocene aquifer found at depths of between 150 and 400 m, and is approximately 200 m of clay-rich sediment (Kindler et al. 1990). In some parts of the Basin, this aquifer is artesian.

The middle aquifer is a continental terminal aquifer that essentially comprises an alternation of sandstone and clay encountered between 450 and 620 m from the surface, extends from Niger and Nigeria into Cameroon and Chad (Kindler et al. 1990). The suitability of this water for irrigation is debatable because of the cost of abstraction, it is essentially used for domestic water supply to the local population and livestock.

Figure 5 Rainfall distribution.
(Source: ESRI 1996)

The lower aquifer is a continental hamadian aquifer that consists of sediments deposited in the cretaceous. There is very little information on this aquifer in the Lake Chad Basin but it is however known to be an important aquifer in the West African region.

Climate

The climate of most parts of the region is hot and dry, with rainfall varying between 1 500 mm per year in the southern parts of the region to less than 100 mm in the northern parts of Chad, Libya and Algeria. Figure 5 shows the distribution of rainfall across the region. In the absence of any specific orographic factors, the reduction in rainfall is about 100 mm for each 100 km of distance (Beauvilain 1996).

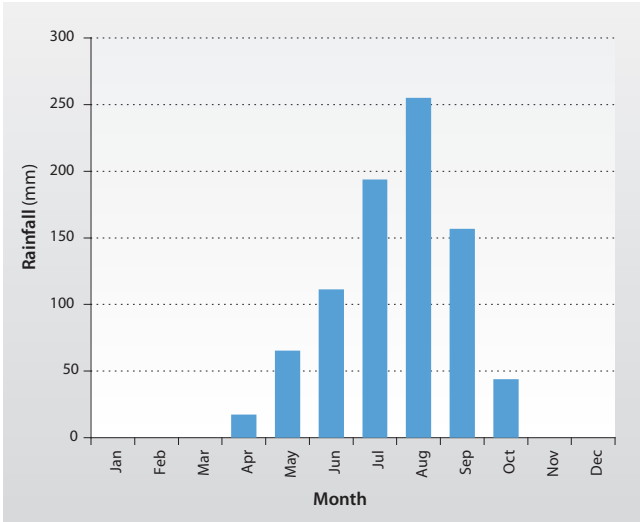


Figure 6 Annual distribution of rainfall in Chad. Readings from eleven meteorological stations (1932-1999).
(Source: Based on Republic of Chad, Meteorological Office)

The Basin is predominantly located in the transition zone between the Sahara desert and savannah grasslands called the Sahel. Rainfall is the single most important factor conditioning the hydrology and the climate in this region. Lake Chad is under the influence of the Inter-Tropical Convergence Zone (ITCZ), which oscillates seasonally between about 15° N and 15° S (Nieuwolf 1977 in Le Barbé & Lebel 1997). North of the ITCZ, high pressure originating from the Sahara prevents rainfall, except during the Boreal winter when occasionally cold air descends from the north. Rain therefore only occurs over the region after the ITCZ has moved past this area towards the north (Le Barbé & Lebel 1997).

From April to October, rainfall occurs but is generally heaviest in August, corresponding with the maximum northward extent of the ITCZ, followed by July and then September. About 90% of the rain falls from June to September (Le Barbé & Lebel 1997). The movement of the ITCZ northern edge is not regular which is often the cause of erratic starts of the rainy season. Even when the rainy season is well established sudden retreats southward of the ITCZ are not uncommon. Figure 6 shows the average annual distribution of rainfall in Chad (1932-1999). Low-rainfall regions are usually also variable-rainfall regions. On the dry, northeast side of Lake Chad, at the town of Bol, rainfall from 1954 to 1972 ranged from 125 to 565 mm per year, averaging 315 mm (USGS 2001).

Annual average rainfall varies from about 500 mm along the southern margins of the actual lake to less than 200 mm near the northern end (Hughes & Hughes 1992). Although rainfall is greatest in July and August the Lake suddenly rises in September. This can be attributed to the fact that rivers provide almost all water supplied to the Lake, so there is a time lag between rain falling in the watershed and reaching the Lake (Holz et al. 1984). Highest lake levels are correspondingly found in December, tapering off slowly for several months (USGS 2001).

The July +30°C isotherm runs across the region. Temperatures are as high as 35-40°C particularly in the northern parts of the region. During the dry season lasting from November to March the basin area is dominated by the Saharan northeasterly winds called the Harmattan. Figure 7 shows dust storms from the Sahara in 2003.

The Lake Chad Basin has a history of drought episodes and in the past 40 years there have been a series of severe drought events. From the middle of the 1960s, rainfall started to drop intermittently but relentlessly until the big drought of 1972-1974. There was then a second occurrence of drought in 1983 and 1984. These droughts have consequently compromised freshwater inputs to the region (see section on Freshwater shortage in Assessment).

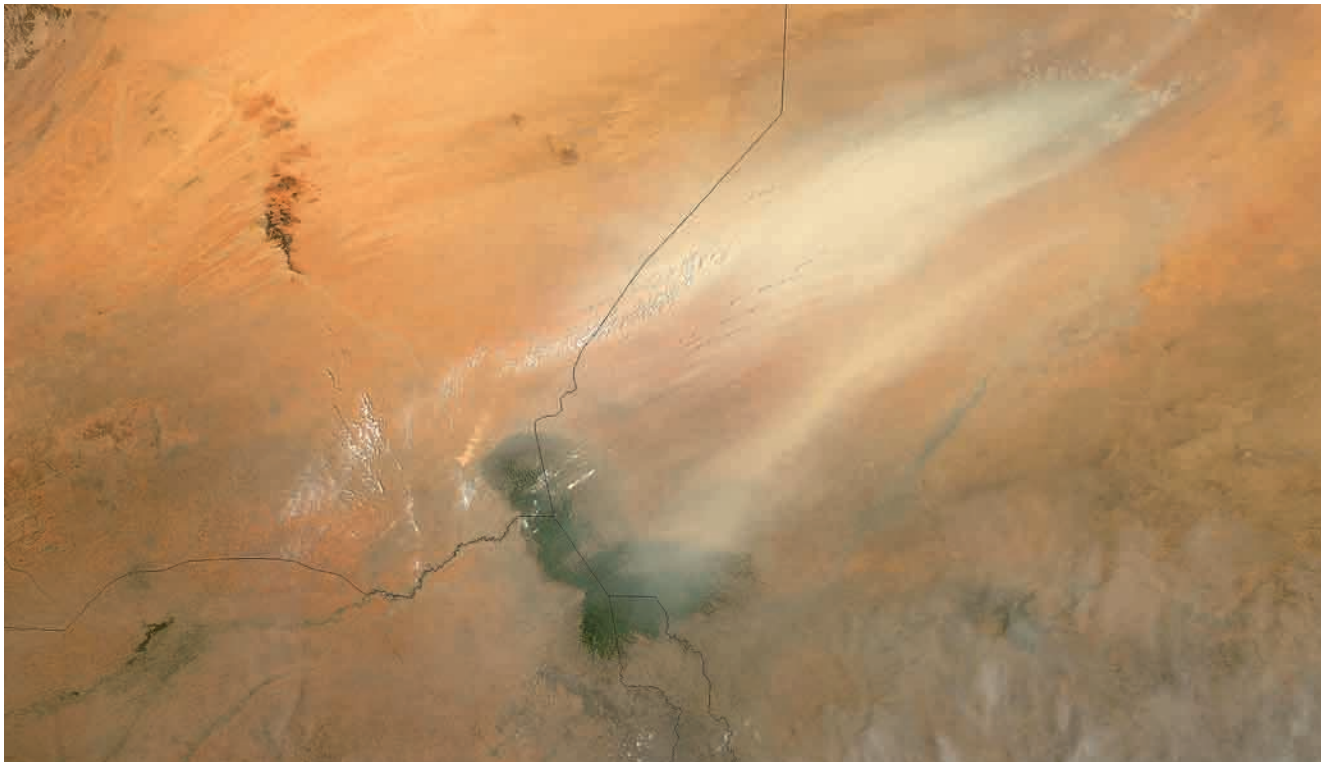


Figure 7 Dust storms from the Sahara regularly whip through central Africa. This image shows Lake Chad (green).
(Photo: Schmaltz, MODIS Sensor Terra satellite, April 2003)

Major climatic zones

According to the UNEP/GRID and UEA/CRU Global Humidity Index (Deichmann & Eklundh 1991) based on a ratio of annual precipitation and potential evapotranspiration (P/PET), the climate of the Lake Chad Basin can be divided broadly into five zones:

- Hyper-arid zone where P/PET < 0.05
- Arid zone where 0.05 <= P/PET < 0.2
- Semi-arid zone where 0.2 <= P/PET < 0.5
- Dry sub-humid zone where 0.5 <= P/PET < 0.65
- Humid zone where 0.65 <= P/PET

The geographic distribution of these climatic zones is illustrated in Figure 8.

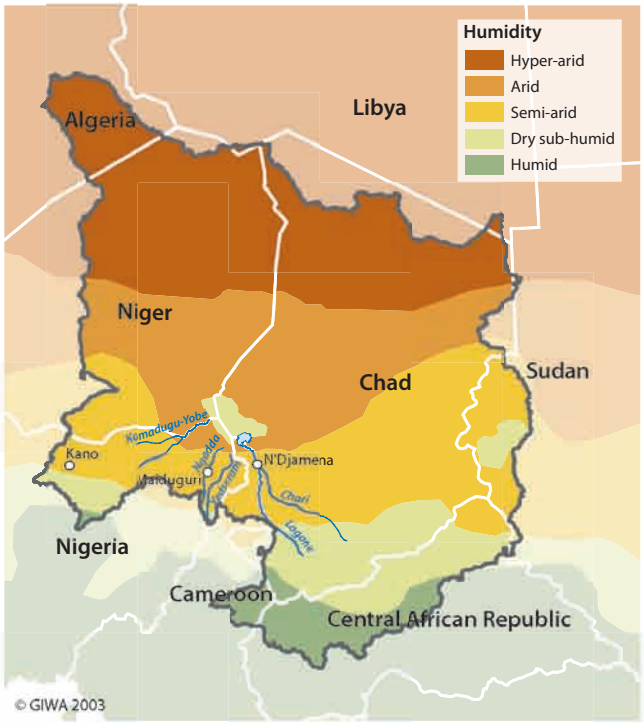


Figure 8 The five main climatic zones found in the Lake Chad region.
(Source: Deichmann & Eklund 1991)

The Lake Chad

Lake Chad is a terminal depression with the eight basin countries grouped around it, of which four are in direct contact with the Lake: Nigeria, Niger, Chad and Cameroon. The Lake occupies less than 1% of the drainage basin (Coe & Foley 2001).

It is extremely shallow, with a mean depth of 4 m (Carmouze & Lemoalle 1983). Therefore any increase in lake volume means a substantial

Figure 9 Bathymetric map of Lake Chad 1983.
Note: Although these depths are not applicable for today, it does demonstrate the bathymetry of the Lake.
(Source: Carmouze & Lemoalle 1983)

increase in lake area and shoreline (see review: Burgess et al. In press); seasonal and interannual variations in water level are about 0.5 and 5 m, respectively (Carmouze & Lemoalle 1983).

The bottoms of the northern pool range from 277.5 to 275.5 m above mean sea level and those of the southern pool from 280 to 278.5m (Carmouze & Lemoalle 1983). There is also morphological evidence of a sand ridge between 320 and 330 m of a 'Mega Chad' higher than and 10 times the size of today's Lake Chad (Schneider 1991). Figure 9 is a bathymetry map showing the depths in 1983, demonstrating that the northern pool is deeper than the southern pool.

ORSTOM during the 1970s and early 1980s studied the physical and chemical characteristics of the Lake. The annual average temperature of the Lake Chad water varies between 25.5 and 27.5°C (1956-1975) and is closely related to the annual, seasonal and diurnal variation in air temperature. The water chemistry of the Lake changes throughout the environment and varies seasonally and annually. Wind contributes to the mixing of the shallow, polymictic lake, so that waters are always turbid. Transparency is subsequently low and fluctuates according to water level: in the southern pool transparency decreased from 20 to 100 cm in 1964 when the water level was high, to 25 to 30 cm in 1973 at the time of the Sahelian drought. It is clearest in the southern open waters in December to January, being approximately 100 cm in a 'Normal Chad'[1] hydrological period, and most opaque in August, when it is about 20 cm (Carmouze et al. 1983a). Both pH and salinity become higher with increasing distance from the Chari delta. The pH levels in the Chari are between 7 and 8, and subsequently in the southern pool of the Lake it does not exceed 8, but can reach 9 in the northern pool. In a 'Normal Chad', salinity varies between 40-50 mg/l in the Chari River, 60-120 mg/l in the open waters of the southern pool and 250-400 mg/l in the open waters of the northern pool. Close to the Chari delta, the waters are low in calcium and magnesium carbonates but there is considerable seasonal variation (Carmouze et al. 1983a).

The Lake Chad water balance

There is a close interaction between rainfall, evaporation, the generation of lateral inflow to the Lake, groundwater leakage under the body of the Lake and human abstraction. These factors all influence the overall lake water balance. A distinction has to be made between hydrological and hydro-geological context of each influent tributary, and the aggregate water balance of Lake Chad itself (World Bank 2002b).

By virtue of its location, the Lake Chad region has limited surface and groundwater resources. The water supply is primarily from rainfall and the Chari-Logone and the Komadugu-Yobe rivers. Lake input is seasonal, the majority originating as precipitation on the Adamawa Plateau brought to Lake Chad via the Chari-Logone River (see review: Burgess et al. In press), draining Central African Republic, Cameroon and Chad. The Komadugu-Yobe River and tributaries drain Nigeria and Niger.

The Harmattan winds and dry season aridity contribute to high evaporation that often equals or exceeds water influx and can reach rates of 2 300 mm per year (see review: Thieme et al. In preparation). The annual losses through evaporation from the floodplains (called the Yaéré in Cameroon) are estimated at over 5 billion m^3 per year, or about 30% of the annual run-off from the Logone (see review: Jauro 1998). Despite the high rates of evaporation, Lake Chad has low levels of salinity because the more saline waters sink and leave the Lake through subterranean conduits in the north (see review: Thieme et al. In preparation). This water percolates along the dry bed of the Bahr El Gazal River to feed the oases of the Bodele depression about 40 km to the northeast (ILEC 1999). The surprisingly fresh water is also due to the Chari River putting few dissolved solids into the Lake, as many of its suspended solids settle as sediment onto its wide floodplain. Once in the Lake dissolved solids either precipitate or are absorbed by plants (USGS 2001).

Isiorho et al. (1996) showed that 18 to 32% of the total input to the groundwater system is recharged by Lake Chad. Most of the water is believed to be within the shallow upper aquifer that underlies the Lake. There have been no studies that document the recharge of the deeper aquifers through the lake bed but attempts are being made to identify whether the Lake's water reaches this aquifer.

[1] *Normal Chad refers to when the Lake had a open water surface area of about 20 000 km^2. See History of Lake Chad Variability.*

Table 1 Tentative illustration of the theoretical water balance of Lake Chad under steady state assumptions for two climatic scenarios.

Type of persistent climatic conditions	Inflow (km^3/year)				Direct rainfall inflows (km^3/year)	Outflow (km^3/year)			Area of Lake and wetlands surface (km^2)
	Chari-Logone	Komadugu-Yobe	El Beid and others	Total inflow		Evapotran-spiration	Infiltration (est.)	Total outflow	
Long-term mean rainfall	37.8	1.0	1.2	40.0	6.0	43.0	3.0	46.0	18 000
Mean of period 1971-1990	21.8	0.4	0.2	22.4	2.1	23.1	1.4	24.5	9 400

(Sources: adapted from Olivry, Mott Mac Donald and Pdf-B projects in World Bank 2002b)

The water balance of Lake Chad is highly variable resulting in fluctuating open surface waters that have exhibited dramatic expansion and contraction over geologic and recent history. During the 20th century, an irregular cycle of wet and dry periods occurred due to the climatic regime and to a certain extent by regional hydrological persistence. It has been observed that in general, after five to ten years a new mean level equilibrium is established for each persistent period of "humid", "normal" or "dry" conditions. In an inter-annual balance established in 1984, Table 1 illustrates under steady state assumptions (no change between initial and final levels) the hydrological balance. This illustrative water balance applies to "intermediate conditions" at a level of 281.5 m (surface maximum of 18 000 km^2) and also for a small water body at lower levels under much drier conditions (World Bank 2002b).

History of lake level variability[2]

Lake Chad is extremely dynamic. The norm is a variable state of constantly changing size, shape and depth, which occurs both annually and over decades and centuries. Modern Lake Chad is a brackish water remnant of the Pleistocene Lake Mega Chad (10 000-5 000 years ago). Paleo-shoreline studies have shown that Mega Chad covered at least 300 000-350 000 km^2. Since at least 5 000 years ago, the sub-Sahara zone of Africa known as the Sahel has been progressively desiccated. Paleo-environmental evidence shows conclusively that the Lake completely disappeared several times in the past (Holz et al. 1984). Figure 10 demonstrates how Lake Chad has dried out around year 1450, 1550, 1750, 1850 and 1900.

There is geologic evidence from the Chad Basin of lake level oscillations from the late Pleistocene to the present. From 40 000 to 20 000 years ago, numerous isolated smaller lakes occupied the Chad Basin. From 20 000 to 13 000 years ago, the Basin dried up, allowing the development of dunes on the basin floor, orientated north-northwesterly, south-southeasterly (Nicholson & Flohn 1979 in Holz et al. 1984, Servant & Servant 1983). Dune remnants are still present causing an irregular relief in the Lake Basin, especially along the eastern shore. Dunes are evident on the space imagery taken in 1982, shown in Figure 11 (Holz et al. 1984).

The Basin was occupied by small inter-dunal lakes from 13 000 to 10 000 years ago that also fluctuated in their extent through time (Servant &

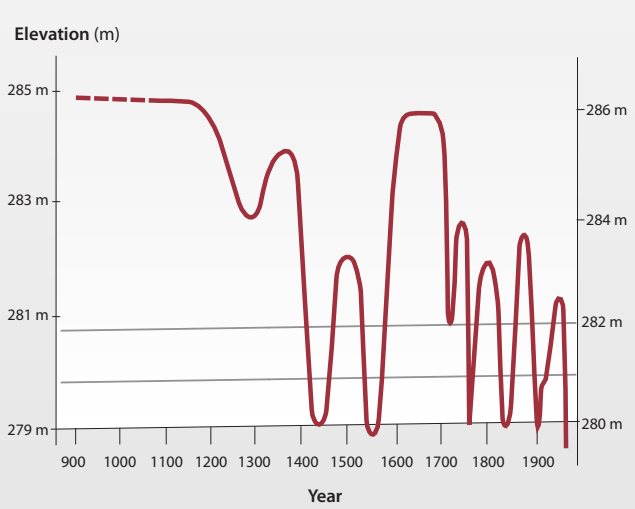


Figure 10 Evolution of Lake Chad in the last millennium. The graph demonstrates the fluctuations in the elevation (above sea level) of the Lake Chad's water level.
(Source: Redrawn from Olivry et al. 1996)

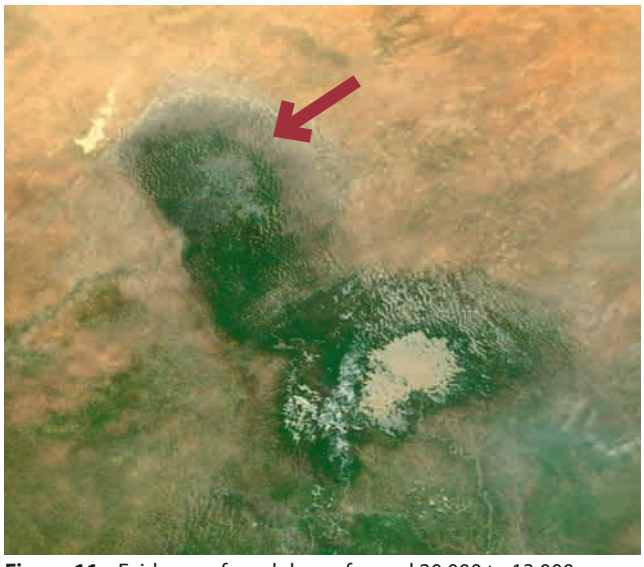


Figure 11 Evidence of sand dunes formed 20 000 to 13 000 years ago (red arrow).
(Photo: Lake Chad, 1982 STS-5 photograph, NASA1982)

[2]*The following section is extracted from Holz et al. 1984.*

Servant 1983). The period from 10 000 to 5 000 years ago is known as Mega Chad (lake area of 300 000-350 000 km^2). At that time the Lake is thought to have approached the area and volume of the Caspian Sea; presently the largest lake in the world. A strandline ridge that represents the old shoreline of Mega Chad can be traced through Borno, Nigeria, and to the northeast of the present lake. The ridge also extends 130 km further southwest than the present shoreline. When Mega Chad stood at its maximum, its waters over-flowed from the Basin into the Benue river valley reaching the Atlantic Ocean through Niger (Grove and Pullam 1963).

In the 19th century, reports of early explorers suggest that the Lake may have reached a higher water level than that during the present century (Tilho 1910). Other observations suggest water level of the Lake Chad in the 19th century varied significantly, decreasing up to 50% in depth and extent (Servant & Servant 1983). In the early 20th century, there was a continued decline of the Lake Chad water level until it eventually turned into marshland, unfit for navigation (Servant & Servant 1983).

Four hydrological periods that are characteristic of the trends in the fluctuating water levels of Lake Chad (first three defined by Tilho in 1910 and the fourth by Holz et al. 1984):

- Greater Chad: open water area of 25 000 km^2 or more.
- Normal Chad: open water area of about 20 000 km^2.
- Lesser Chad: open water area between 6 000 and 15 000 km^2.
- Alimnetric Chad: period of no open water (lake has disappeared).

Recent Lake Chad variability

Up until 1960, Lake Chad was the sixth largest lake in the world. In 1973, it covered an area of 23 000 km^2 (Grove 1996) and occupied first place among the endorheic lakes ahead of Lake Balkhash (18 400 km^2) in Kazakhstan (Nami 2002). The volume and area of the Lake decreased between the 1960s and 1990s. Figure 12 shows the decline in the surface area of the Lake between 1960 and 1999.

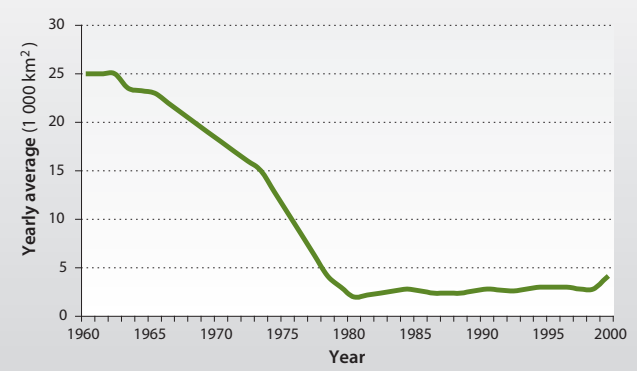


Figure 12 Open surface area of Lake Chad (1960-1999).
(Source: LCBC 2000b)

Lake Chad responds rapidly to precipitation and run-off changes, in part due its shallowness. As a result, Lake Chad has been reduced to a small area covering 1 350 km^2 today (Neiland & Béné 2003) a very significant decrease of around 90% since the 1960s (Lemoalle 1991, USGS 2001) making it now the 15th largest lake in Africa (World Bank 2002a). Receding waters during the 1970s caused Lake Chad to separate into two pools with the "Great Barrier" between them. Since the 1970s the northern pool has only held some temporary waters, and has consequently impeded access for Nigeria and Niger to the open waters of the Lake (Box 1).

Following a wet year in 1999 there were some signs that water flows in the rivers entering Lake Chad were rising, and the floodplains were increasing. The northern pool again began to experience some flooding (Diouf 2000). However the Lake still remains in its Lesser Chad state and wet years are isolated, rather than a sustained upward trend (L'Hôte et al. 2002). It is therefore premature to state whether this most recent cycle is part of a larger climatic trend. Human-based factors in the Basin could also be playing a role in surface water inflows and corresponding aggregate lake levels. Figure 13 shows scientists measuring lake water levels at Kindjeria (centre of the northern pool).

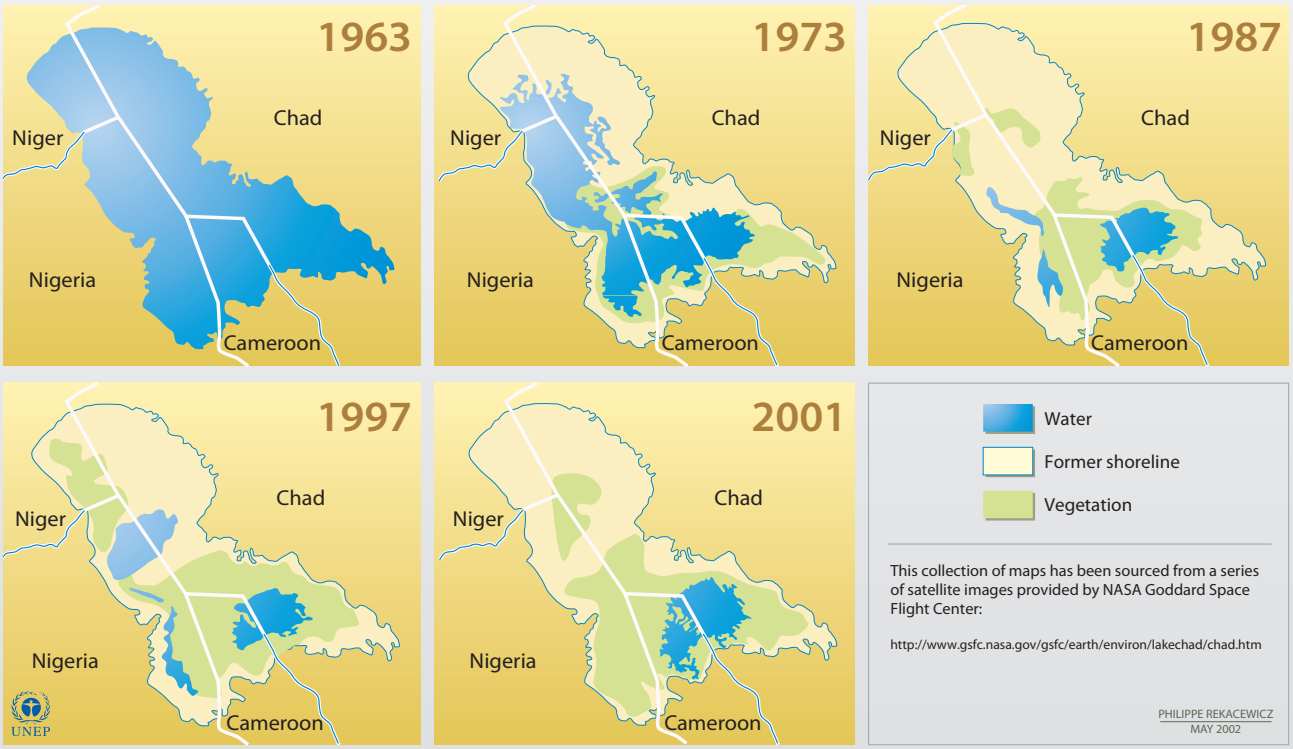
Figure 13 Measuring water levels at Kindjeria (centre of northern pool) in 1975. This gauge is presently not in operation.
(Photo: Chouret in USGS 2001)

Drainage basins of the region

The Chari-Logone sub-system

The Chari-Logone River has a basin area of approximately 650 000 km^2 and the Chari River extends 1 400 km in length (Froese & Pauly 2003). The Chari and Logone rivers have a tropical regime with a single flood occurring at the end of the rainy season, which lasts from August to November (FAO 1997) and feeds the extensive Waza-Logone floodplains and Yaérés. Figure 14 shows the monthly average discharge of the Chari-Logone at N'Djamena. The largest area of the Waza-Logone

Box 1 Chronology of Lake Chad variability: 1960s to present.



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

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

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

1963: Open water is approximately 23 000 km² and each basin is connected by open water.

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

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

1997: There was little variation over the previous decade with open water estimated to vary inter-annually in area between 1 500 to 2 000 km², plus a larger surrounding area of mixed permanent and temporary swampland of between 2 000 to 4 000 km².

2001: The state of open water flooding estimated to be 1 350 km² with around 4 000 km² of swampland (Neiland & Béné 2003). The expansion in the Lake is masked by the proliferation of floating vegetation.

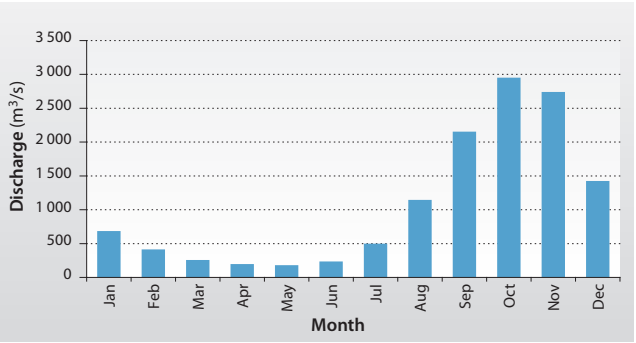


Figure 14 Monthly average discharge from Chari-Logone River at N´Djamena (1933-1991).
(Source: RIVDIS database 1991)

floodplain covers about 8 000 km² and is used for pasture, fishing, flooded rice production and flood recession cropping (FAO 1997). The rivers contribute 95% of all riverine inputs into the Lake, an average of 37.8 km³/year (discharges have been regularly measured at N'Djamena since 1932) (World Bank 2002b).

Water from the Chari-Logone River flow into the Lake at its southern extreme and flows northward and outwards encouraged by the Lake's gradient and prevailing winds (Sarch 2001). These floodwaters take between one and two months to reach the southwest shore. The flow is at its minimum in May/June at the beginning of next year's rainy season.

Various rivers flow in this region, in particular the tributaries of the Chari and the Pende, a tributary of the Logone, which becomes the Logone oriental (eastern branch of the Logone) on entering Chad. Two rivers, the Vina and Mbere, feed the western branch of the Logone from Cameroon. Rainfall reaches 1 400 mm/year in the CAR and on the Adamawa Plateau in Cameroon. The El Beid comes from the Mandara Mountains (northern Cameroon) and forms an overflow for flooding in the Yaérés, which in certain abundant years comes from the Logone. The regime of the El Beid, which forms the frontier between Cameroon and Nigeria and then flows into Lake Chad, depends to a great extent upon the flood levels in the Yaérés when the Logone overflows (LCBC 1998).

The area of the Waza-Logone floodplain inundated in any year depends on over-bank flow from the Logone River, flow from seasonal streams called "mayos" flowing out of adjacent upland areas, direct rainfall onto the floodplain and water released from the Maga Dam, whose reservoir is fed by the same three sources of water (LCBC 2002). However, in the last 40 years the mean Chari discharge has decreased significantly due to the persistent change in rainfall patterns over the contributing catchment.

Figure 15 The main rivers in the Lake Chad Basin.

The Yedseram and Ngadda sub-system

The Yedseram and Ngadda rivers and their tributaries rise in the Mandara Hills (northern Cameroon) and they lose most of their waters while flowing northwards through a 7 km wide flood plain (Figure 15). Further downstream of the Ngadda River (Nigeria) a 80 km^2 swamp is formed from where the river does not maintain a definable water course to the Lake (FAO 1997). The system contains the Alau Dam (162 million m^3 reservoir), which is located southeast of Maiduguri.

The Komadugu-Yobe sub-system

The Komadugu-Yobe River system has a basin area of 148 000 km^2 (World Bank 2002b) but contributes less than 2.5% of the total riverine inflow to Lake Chad (see review: Burgess et al. In press). The Komadugu-Yobe River is the border between Nigeria and Niger over the last 160 km and is the only perennial river system flowing into the northern pool of Lake Chad. The Komadugu-Yobe is formed by various tributaries, in particular the Jama'are River which flows from the Jos Plateau (Nigeria), and the Hadejia River which flows from the area around Kano (Nigeria). The two rivers join to the southwest of Gashua (northeastern Nigeria). The Hadejia River for the first 48 km of its course maintains a gradient of approximately 1 m/km. As it descends the gradient reduces abruptly with the channel diverging forming numerous oxbow lakes. The Jama'are begins with a relatively high gradient from the Jos Plateau before entering the Chad syncline northeast of Foggo (Nigeria). It is also supplied by the Misau, which comes from the north of Bauchi (Nigeria) and joins the Komadugu-Yobe River 120 km from Lake Chad (LCBC 1998). Most of the headwaters carry a high sediment load of silt and fine sands that are deposited downstream, and there are resulting aggraded valleys of poorly defined channels with numerous small oxbow lakes (Oyebande 2001).

Upstream of the confluence of the Hadejia and Jama'are rivers the Hadejia-Nguru wetlands (fadamas) in Nigeria start. Peak inflow to the wetlands occurs in late August, resulting in extensive shallow flooding (see review: Burgess et al. In press). These wetlands cover a total area of about 6 000 km^2, with a water surface area of 2 000 km^2 (FAO 1997). Referred to as an inland delta, the floodplain has a maximum width of 65 km at the confluence of the two rivers, but then diminishes to a 5 km span that continues for several hundred kilometres.

Many patches of higher, unflooded ground are mixed within the floodplain (see review: Burgess et al. In press). Much of the Hadejia-Nguru floodplain is dry for some or all of the year. It provides a wide range of resources including fertile agricultural soils, grazing, non-timber forest products, fuel wood and fisheries. In addition the wetlands are a unique migratory habitat for many wildfowl and wader species (LCBC 2002).

The River Hadejia is controlled by three large dams at Tiga (1 400 million m^3 reservoir), Challawa Gorge (972 million m^3 reservoir), and Hadejia (1 200 million m^3 reservoir), and many small dam structures. The upper basins contribute a total long-term natural yield of approximately 7 km^3/year, the bulk of which is impounded at these reservoirs within the Kano province. More impoundment is anticipated on the Jama'are River, in Bauchi province if the Kafin Zaki Dam (2 700 million m^3 reservoir) is constructed, although presently due to lack of funding and strong opposition it is unclear if, or when, the dam will be completed. Consequently, due to impoundment, siltation and blockage by invasive weeds, the major part of this sub-system has not been able to establish a natural regime through the downstream Yobe River in Nigeria and Niger for more than 20 years.

An analysis of four years of records before the construction of dams (e.g. Tiga) between 1964 and 1967 in the Komadugu-Yobe river system indicates that an average of more than 68% of measured run-off was lost upstream of Gashua. Only 18% of total run-off reached Geidam (Oyebande & Nwa 1980 in Oyebande 2001). A water balance model developed by Adams and Hollis (1988) showed that evaporation from the inundated area and flooded soils represent 64% of the volume of the river inflow to the Hadejia-Nguru wetlands. Along the Misau River the average flow lost between Kari and Dapchi was 68% of the flow at Kari. The river discharge at Gashua, represents only 24% of the rivers original flow. Based upon this research it is estimated that only 10% of the total surface run-off from the Komadugu-Yobe system reached Lake Chad even before the construction of dams (see Assessment, Freshwater shortage, Modification of Komadugu-Yobe River) (Oyebande 2001).

Lake Fitri

Lake Fitri is located in Chad and has a surface area of 300 km^2 and during the dry season is part of a large biosphere reserve covering 1 950 km^2. It is normally a freshwater Sahelian lake, fed by seasonal rainfall and run-off from the seasonal Batha River. Unlike Lake Chad, it is one of the few Sahelian water bodies that has not experienced large-scale hydrological change, although it became desiccated during the 1984-1985 severe drought (World Bank 2002a).

North of Lake Chad

The north of Lake Chad is the largest drainage area of the Basin that encompasses north Chad and the Algerian sector of the Lake Chad Basin. Algeria possesses few renewable water resources and there are virtually no surface flows from the north into the Lake and what little drainage pattern there is flows away from the Lake.

East of Lake Chad

To the east is Sudan with Wadi Kaya and Wadi Azum, both seasonal wadis with spate flows that originate on the western slopes of the Djebel Mara. The Wadi Azum's waters flow onto the Salamat floodplain and fill Lake Iro before finally joining the Chari River. The alluvial aquifers of these wadis have the potential to provide about 0.08 km^3/year of excellent quality freshwater (FAO 1997).

The Lake Chad Basin's ecological regions

The Lake Chad Basin contains a variety of habitats, including deserts, shrub steppes, savannahs, forests, lakes, wetlands and mountains. These terrestrial and aquatic habitats form a unique sanctuary for the diverse fauna of the region that includes ostriches, cheetahs, hyraxes, crocodiles, hippopotamus and elephants. These habitats also have a good stock of water birds, migratory birds and waders that thrive in the river valleys depending primarily on the waters of the numerous small lakes that are formed during periods of receding floods. The humid zones of the Basin and the Lake itself constitute a unique ecosystem in this area of the Sahel, and a preserve of biodiversity of global importance. For example, 140 species of fish (Neiland & Béne 2003) and 372 species of birds, of which one third are migratory species have been listed (see review: Nami 2002). The integrity of the ecosystems is an essential shield against desertification.

Figure 16 shows nine ecological zones in the Basin that have been classified using the WWF Ecoregions (2001). The following text has also been extracted from WWF Ecoregions (Burgess et al. In press) and references therein. The Lake Chad Flooded Savannah Ecoregion also contains additional data extracted from other sources that are cited in text.

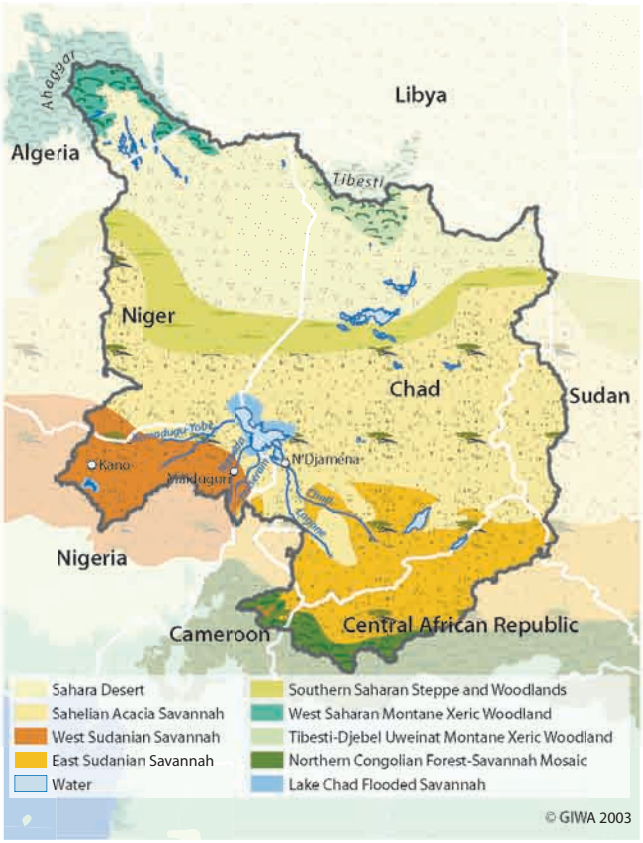


Figure 16 Ecoregions of the Lake Chad Basin.
(Source: WWF 2001)

Sahara Desert

Physical features: The surface of the desert ranges from large areas of sand dunes (Erg, Chech, Raoui), to stone plateaus (hamadas), gravel plains (reg), dry riverbeds (wadis), and salt flats. Vast underground aquifers that underlie much of the region sometimes penetrate the surface, forming oases. Mechanical and chemical weathering of rocks over the past 50 million years has produced the soils that include yemosols (over hamadas and regs), regosols (sandy soils), fluvisols (within non-saline valleys) and solonchaks (within saline depressions). The annual rainfall is below 25 mm and mean annual temperatures are around 25°C. In the hottest months, temperatures can rise over 50°C, and temperatures can fall below freezing in the winter. Figure 17 shows the Sahara desert in Libya.

Flora: The flora of the central Sahara Desert is very poor and estimated to include only 500 species. As many as 162 of the plant species are endemic to the Sahara. The flora of the region shows strictly Sahara-Arabian affinities and exceptional adaptations to aridity. Perennial vegetation is found in wadis, channels, runnels, depressions and hill slopes.

Fauna: The fauna of the central Sahara is richer than earlier believed. Arthropods are numerous, especially ants. Among the Sahara-Sindian biome avifauna are greater hoopoe-lark (*Alaemon alaudipes*) and desert sparrow (*Passer simplex*).

South Saharan Steppe and Woodlands

Physical features: Rainfall is between 100 and 200 mm per year and in the Sahelian portion of the ecoregion temperatures are between 26°C and 30°C. It serves as a transition from the Sahara to the Sahel.

Flora: The northern border of the ecoregion lies several hundred kilometres north of the 100 mm rainfall isohyet, which is the northern limit of summer grassland pasture composed of the grasses *Eragrostis*, *Aristida*, and *Stipagrostis* spp. with the herbs *Tribulus*, *Heliotropium*, and *Pulicharia*. Woody species include *Acacia tortilis* and *Acacia ehrenbergiana*, which mainly grow along wadis. In the south, the vegetation of the ecoregion grades into the Sahelian Acacia Savannah ecoregion, and includes steppes of *Panicum turgidum* perennial tussock grass.

Fauna: Notable animal species that once occurred throughout the ecoregion, but have now been reduced to extremely small and scattered populations include the following: addax (*Addax nasomaculatus*), slender-horned gazelle (*Gazella leptoceros*), dama gazelle (*Gazella dama*), striped hyena (*Hyaena hyaena*), cheetah (*Acinonyx jubatus*), wild dog (*Lycaon pictus*), and ostrich (*Struthio camelus*).

Sahelian Acacia Savannah

Physical: This is the largest ecoregion in the Basin and encompasses the Lake Chad savannah floodplains. Located in the Sahel south of the South Saharan Steppe it represents the transition zone where

Figure 17 Sahara Desert in Libya.
(Photo: R. Pelisson SaharaMet)

savannah meets the Sahara Desert. The topography is mainly flat and the climate is tropical, hot, and strongly seasonal. The monthly mean maximum temperatures vary from 33 to 36°C and monthly mean minimum temperatures are between 18 to 21°C. The annual rainfall is around 600 mm in the south of the ecoregion, but declines rapidly to the north to around 200 mm. The soils of the ecoregion are mainly entisols, with some aridisols, and most are sandy and highly permeable, so that permanent surface water is rare.

Flora: Wooded grassland is widespread on sandy soils in the southern Sahel, with many thorny shrubs and small trees including several Ziziphus species. Grass cover is continuous but often dominated by short annual species such as *Aristida mutabil, Chloris prieurii*, and *Cenchrus biflorus*. In the northern Sahel, short grasslands grow on deep, sandy soils, with widely dispersed shrubs. Most plant species are widespread and fairly common. There are a number of endemic plants such as the *Indigofera sengalenisis* and *Panicum laetum*.

Fauna: This ecoregion host several endemic animals, mainly small rodents adapted to arid conditions. Three bird species are considered near-endemic: the rusty lark (*Mirafra rufa*), the masked shrike (*Lanius nubicus*), and the sennar penduline-tit (*Anthoscopus punctifrons*). For reptiles, endemism is more pronounced, with 10 species regarded as strictly endemic. Prior to the 20th century vast herds of ungulates and other large animals, including elephant, giraffe and ostrich were found in this ecoregion. Most of the large populations have been reduced to scattered remnants due to unregulated hunting with modern firearms. The scimitar-horned oryx (*Oryx dammah*) is presumed to be extinct in the wild. Other species are only found in a handful of protected areas e.g. the western giraffe (*Giraffa camelopardus peralta*). The pronounced dry season signals a significant migration of fauna within the ecoregion. This includes the annual passage of large numbers of migrant birds on the Afrotropical-Palaearctic flyway.

West Sudanian Savannah

Physical features: The ecoregion is mainly flat and the climate is tropical and strongly seasonal. The highest average daily temperatures vary from 35 to 40°C whilst the lowest average daily temperatures are between 15 and 20°C. Mean annual precipitation ranges up to 1 600 mm in the south, but declines to 600 mm per year on the northern border with the Sahelian Acacia Savannah. The rainfall in this northern region of the ecoregion is close to 600 mm. The Mandara Plateau, in northwest Nigeria and northern Cameroon, separates the West and East Sudanian Savannahs. Soil fertility is relatively low in the heavily weathered lateritic soils.

Flora: The vegetation is comprised of woodland with a understory of long grasses, shrubs, and herbs. The northern portion hosts mainly grasslands dominated by numerous short grasses. Shrubland is scattered in patches throughout the ecoregion. Riparian forests occur along many waterways and small areas of adaphic vegetation such as grassy floodplains, or fadamas are found in the Komadugu-Yobe Basin.

Fauna: The West Sudanian Savannah supports a relatively rich fauna, including a number of endemic species. Common large animals are bushbuck (*Tragelaphus scriptus*), warthog (*Phacochoerus africanus*), vervet monkey (*Chlorocebus aethiops*), baboon (*Papio hamadryas papio* and *P.h. anubis*), and savannah monitor lizard (*Varanus exanthematicus*). Most large mammals have been heavily hunted and many species only survive sparsely, mainly in protected areas. The pronounced dry season signals a migration of fauna within the ecoregion. This includes the annual passage of migrant birds on the Afrotropical-Palaearctic flyway.

East Sudanian Savannah

Physical features: This ecoregion lies south of the Sahel and is mainly flat, with a climate that is tropical and highly seasonal. Average high temperatures range from 30 to 33°C and lows fall between 18 to 21°C. Annual rainfall is as high as 1 000 mm in the south. During the rainy season, which lasts from April to October, large areas of southern Chad and northern Central African Republic become totally flooded and inaccessible. During the dry season, however, most of the trees lose their leaves, and the grasses dry up and may burn. The soils are mainly ultisols and alfisols in the south and entisols in the north.

Flora: The vegetation is undifferentiated woodland with trees that are mainly deciduous in the dry season, with an understory of grasses, shrubs and herbs. Typical trees in the Lake Chad Basin sector of this ecoregion include *Anogeissus leiocarpus*, *Kigelia aethiopica*, *Acacia seyal* and species of *Combretum* and *Terminalia*.

Fauna: The East Sudanian Savannah ecoregion closely resembles the West Sudanian Savannah in habitat structure and species composition. The two ecoregions differ somewhat in terms of their species assemblages and the degree to which the habitat and mammal assemblages are intact. The Eastern Sudanian Savannah has low rates of faunal endemism. For example there is only one endemic mammal (a mouse, *Mus goundae*) and two strictly endemic reptiles (*Rhamphiophis maradiensis* and *Panaspis wilsoni*). Threatened mammal species include large herds of elephant (*Loxodonta africana*) in Chad and Central African Republic and wild dog (*Lycaon pictus*), cheetah (*Acinonyx jubatus*) and lion (*Panthera leo*).

West Saharan Montane Xeric Woodlands

Physical: This mountain range is found within the Sahara Desert and is predominantly of volcanic origin. The Aïr in northern Niger is included in this ecoregion. Climatically, it is cold and dry in the winter and hot and dry in the summer. Rainfall is variable, but averages less than 150 mm per year, with most falling at higher elevations. The mean maximum temperature reaches 30°C at the lower elevations and 18 to 12°C at the highest elevations, whereas the mean minimum temperatures are as low as 3°C at the highest elevations. Frosts are common, and snow can be found on the higher peaks in the winter. Throughout the ecoregion permanent water holes, called gueltas, are protected from the sun in narrow gorges, which reduces evaporation and increases the permanence of the pools; it is primarily these areas that give the ecoregion its floral and faunal values.

Flora: Vegetation within this ecoregion varies according to elevation and landscape features. At lower elevations, the vegetation is mapped as regs, hamadas and wadis, but at the highest altitudes there is a transition to saharomontane vegetation. This ecoregion supports an interesting relict flora, with Mediterranean, Sudano-Deccan and Saharo-Sindien affinities and contains a number of endemic and rare species. The most notable of these is Duprey cypress, or tarout (*Cupressus depreziana*), wild olive (*Olea lapperrini*) and myrtle (*Myrtus nivellei*), all of which are relict Saharan-Mediterranean species.

Fauna: The plateaus that comprise this ecoregion are biologically important, and function as one of the last refuges for some species. These include populations of globally threatened antelope, such as dorcas gazelle (*Gazella dorcas*) and dama gazelle (*Gazella dama*). Migratory birds use this ecoregion as a rest area because of the year round water and cooler temperatures. Many reptiles are also present including the snakes *Telescopus obtusus* and *Echis leucogaster.* Amphibians include the European green toad (*Bufo viridis).*

Tibesti-Djebel Uweinat Montane Xeric Woodlands

Physical: Tibesti Mountains consist of seven inactive volcanoes where rainfall is more regular, although still probably under 600 mm per year. Lowland wadis areas receive their water from the mountains down storm channels. The mean maximum temperature is approximately 30°C in the lowlands and falls to 20°C in the highest elevations. Mean minimum temperatures are 12°C in the lowlands, but fall to 9°C over most of the ecoregion and are as low as 0°C at the highest elevations during winter months.

Flora: The Tibesti mountain vegetation varies according to elevation and slope. Large wadis areas radiate from the southwestern slopes supporting tree species such as the doum palm (*Hyphaene thebaica*), *Salvadora persica*, *Tamarix articulata*, and *Acacia albida*, and other tropical herbs in the genera *Abutilon*, *Hibiscus*, and *Tephrosia*. The Saharomontane vegetation of the higher elevations supports the endemic *Ficus teloukat*, which grows on the south and southwestern slopes, *Myrtus nivellei* on the western slopes, and *Tamarix gallica nilotica* on the wetter northern slopes. Remnant tropical and Mediterranean plant species are seen throughout this ecoregion, including palms, *Hibiscus* sp. and *Rhynchosia* sp.

Fauna: The ecoregion supports populations of several important Saharan large mammals including the dorcas gazelle (*Gazella dorcas*), Barbary sheep (*Ammotragus lervia*) and cheetah (*Acinonyx jubatus*). Small mammals and their predators are also abundant, including hyrax (*Procavia capensis*), brown hare (*Lepus capensis*) and spiny mouse (*Acomys* spp.). The reptile and amphibian fauna is poor in this area.

Lake Chad Flooded Savannah

(See review: Burgess et al. In press and references therein, Thieme et al. In preparation, Verhoeye & De Wulf 2001, World Bank 2002b, Carmouze et al. 1983b).

Physical: The physical features of the Lake are discussed in the section on Lake Chad and drainage basins.

Flora: The surface of the Lake is covered with a mixture of island archipelagoes, reed beds, and open water (Iltis & Lemoalle 1983, Dumont 1992 in Thieme et al. In preparation). Separating the Lake into the north and south pools is the Great Barrier, a ridge of land submerged when the Lake is fully inundated. Areas of open water persist in the southern pool, mostly near the Chari River inflow. Swamps are found to the west of this open water. Vegetation in the southern pool consists of *Cyperus papyrus, Phragmites mauritianus, Vossia cuspidata*, and other wetland plants. *Phragmites australis* and *Typha australis* grow in the more saline north pool. Occasionally, the floating plant Nile lettuce (*Pistia stratiotes*) covers large areas of open water (see review: Burgess et al. In press). Normal Chad was classified as a tropical lake rich in phytoplankton and surveys have shown that algal biomass increased as the Lake reduced in size (Compère & Iltis 1983). Over 1 000 species of algae have been described from the Lake (Thieme et al. In preparation).

Seasonal Yaéré grasslands grow on the southern lake shore where flooding is prolonged and water depth reaches 1 to 2 m. Vegetation consists of *Echinochloa pyramidalis, Vetiveria nigritana, Oryza longistaminata* and *Hyparrhenia rufa* (see Figure 18). The Yaéré dries up completely during the dry season. In areas with less prolonged

Figure 18 Sparse and short wetland vegetation (e.g. *Oryza longistaminata*) growing in open water. This type of vegetation can be found at the edges of the wetland. *(Photo: Verhoeye & De Wulf 2001)*

flooding, 'karal' or 'firki' woodland vegetation is present. *Acacia seyal* is the dominant species here, but is replaced by *A. nilotica nilotica* in depressions. Below the trees, a layer of tall herbs and coarse grasses grows to 2 to 3 m in height, including *Caperonia palustris*, *Echinochloa colona*, *Hibiscus asper, Hygrophila auriculata*, and *Schoenfeldia gracilis* (see review: Burgess et al. in press).

Historically, the most pronounced feature of the Lake Chad Basin has been its wetlands. Lake Chad itself is the second largest wetland in Africa, and with biodiversity of global significance (World Bank 2002b). There are extensive wetlands and floodplains along the Chari-Logone and Komadugu-Yobe and also around the lake area. In total an estimated surface area of 2.5 million ha of floodplains and wetlands of international significance have been recorded by the Ramsar Convention on Wetlands. The Hadejia-Nguru floodplain in northern Nigeria (Komadugu-Yobe River Basin) contains wetlands that cover a total area of about 6 000 km^2 (see review: Burgess et al. In press). Referred to as an inland delta, the floodplain has a maximum width of 65 km at the confluence of the two rivers, but then diminishes to a 5 km span that continues for several hundred kilometres. Many patches of higher, unflooded ground are mixed within the floodplain.

The major wetland plant communities present in the Lake Chad Basin can be assigned to three broad categories: 1) floating "sudd" communities; 2) permanent reed swamps; and 3) seasonal herbaceous swamps (edaphic grasslands) (Verhoeye & De Wulf 2001).

The term "sudd" is used to describe a floating vegetation mat along the fringes of permanent swamps. The floating islands of Lake Chad are typically formed by *Pycreus mundtii*, with several other plants of minor importance commonly encountered, such as *Echinochloa scabra*, *Ipomoea aquatica*, *Vossia cuspidata. Cyperus papyrus* is usually associated with this vegetation type. Permanent reed swamps usually occur in the transition zone between the floating "sudd" communities and the seasonal herbaceous swamps. They are typically dominated by a single reed species, such as *Phragmites*, *Typha* or *Cyperus* (particularly *C. papyrus*) (Verhoeye & De Wulf 2001).

The species composition of seasonal herbaceous swamps is very variable, since it is determined by factors such as rainfall, soil type and salinity, flooding depth and duration. Plant community borders are often indistinct because flood regimes vary from year to year. The most common sequence, from long and deep flooding to short and shallow inundation, is *Vossia*, *Oryza, Echinochloa and Hyparrhenia* (Verhoeye & De Wulf 2001).

The natural dry land vegetation consists of woodland savannah, but is now largely replaced by small-scale agriculture and grassy areas with thorny shrubs. Dependent upon local conditions, this degraded vegetation may vary from sparse and short to dense and tall grasses. Woody vegetation may likewise vary from small (less than 0.5 m) bushes to tall (more than 5 m) trees. Factors that appear to determine the condition of the vegetation are agricultural practice (cultivation of dry season millet), and distance from the nearest village (Verhoeye & De Wulf 2001).

Fauna: This ecoregion has highest biological importance for the large numbers of migrant birds, especially ducks and waders that spend the Palearctic winter period in Africa. Seventeen species of waterfowl and 49 other wetland bird species have been recorded, with varying abundance from year to year. The most abundant bird is the wader ruff (*Philomachus pugnax*), with more than one million seen on the Lake at one time (Keith & Plowes 1997). In the Hadejia-Nguru wetlands the most common waterbirds are white-faced whistling duck (*Dendrocygna viduata*), garganey (*Anas querquedula*), northern pintail (*Anas acuta*), and ruff (*Philomachus pugnax*) (see review: Burgess et al. In press).

Lake Chad also supports two near-endemic bird species, the river prinia (*Prinia fluviatilis*) and the somewhat more widespread rusty lark (*Mirafra rufa*). One other bird of note is the marbled teal (*Marmaronetta angustirostris*), which is occasionally seen on Lake Chad and in northern Chad; it is thought to be declining worldwide (see review: Burgess et al. In press).

Two near-endemic rodent species are found, *Mastomys verheyeni* and the Lake Chad gerbil (*Taterillus lacustris*). The wetlands of Lake Chad and the Hadejia-Nguru wetlands formerly supported herds of large mammals. Savannah species included red-fronted gazelle, dama gazelle, and dorcas gazelle (*Gazella rufifrons, G. dama, G. dorcas*), patas

monkey (*Erythrocebus patas)*, striped hyena (*Hyaena hyaena*), cheetah (*Acinonyx jubatus*) and caracal (*Felis caracal*). Species more adapted to the wetland habitats included African Elephant (*Loxodonta africana*) two species of otter (*Lutra maculicollis*, *Aonyx capensis*), hippopotamus (*Hippopotamus amphibius*), sitatunga (*Tragelaphus spekei*) and kob (*Kobus kob*). Most of the large animals have now been hunted and replaced by large numbers of cattle. Nile crocodiles (*Crocodylus niloticus*) are now extremely rare and may have been wiped out (see review: Burgess et al. In press).

Large fish migrations correspond with seasonal inputs, the fish navigating to the rich floodplains to eat and to breed. Flooding brings high periphyton and zooplankton productivity to the floodplains, as well as increased macrophytic growth, creating ideal feeding and spawning habitat (Thieme et al. In preparation). An exceptionally rich fish fauna comes to capitalise on these resources; the inland waters of the Lake Chad Basin harbour a relatively high fish biodiversity and have at times had abundant quantities of fish. There are reported to be 140 species of fish, which can be grouped into 21 major genera or family groups (Neiland & Béné 2003). Migratory species that move to the floodplains include *Alestres baremose*, *A. dentex* and *Districhodus rostratus* (Thieme et al. In preparation). Aquatic vertebrate groups other than fish include the Batrachia, which are abundant in reed islands (Dejoux 1983).

The zooplankton community is particularly diverse, which may be due to the large size of the Lake and abundance of food. In periods of high water the Lake contained nine abundant species (Saint-Jean 1983). The majority of benthic fauna consists of three groups of macroinvertebrates, namely worms e.g. *Alluroides tanganykae*, molluscs e.g. *Melania tuberculata* and insects e.g. *Chironomus formosipennis*. There are no endemic benthic fauna (Lévêque et al. 1983). The major invertebrate groups are found in areas of abundant aquatic vegetation e.g. Chironomidae, Hemiptera and Ostracods (Dejoux 1983).

Northern Congolian Forest-Savannah Mosaic

Physical features: This ecoregion is a narrow transition zone marked by an abrupt habitat discontinuity between the extensive Congolian rainforests and Sudanian/Sahelian grasslands. It contains the northernmost savannah woodlands in Africa. The forest savannah mosaics with their characteristically diverse habitat complexes, support a high proportion of ecotonal habitats, which have high species richness and are possible loci of tropical differentiation and speciation. This ecoregion lies in the tropical savannah climate zone. Mean annual precipitation ranges locally from about 1 200 mm to 1 600 mm per year. This ecoregion experiences small seasonal temperature fluctuations, with rainy season mean daily maximum temperatures of 31 to 34°C and dry season mean daily minimum temperatures of 13 to 18°C. The Lake Chad Basin proportion of this ecoregion consists of western CAR, which is underlain by relatively new and unweathered entisols, and central Cameroon, which consists of a mixture of oxisols and ultisols, highly weathered soils that often contain a fragipan.

Flora: Vegetation common either to the Sudanian or Congolian provinces characterises much of the region. In the relatively arid corners in the northeast Cameroon and northwest portion of the ecoregion, the transitional *Isoberlinia* spp. dominated Sudanian woodlands and wooded savannahs characterise the flora where cultivation has not drastically altered the system.

Fauna: The savannah sub-species of elephant (*Loxodonta africana africana*) occupies the savannah woodlands where it denudes trees and suppresses sapling growth, effectively creating a more fire-prone system. The ecoregion provides a unique set of habitats and resources that supports moderate levels of diversity, including many species with broad distributions in tropical Africa. The red-flanked duiker (*Cephalophus rufilatis*) inhabits forest patches within the savannah matrix across the Guineo-Congolian/Sudanian transition zone. Widespread mammals in these savannah forest mosaics include the black rhinoceros (*Diceros bicornis longipes*) (now however restricted to a few individuals remaining in Cameroon), giant eland (*Taurotragus derbianus*) and in the eastern sector, bongo (*Tragelaphus eurycerus*).

Socio-economic characteristics

Over the centuries the people of this part of Central and West Africa have eked out a living through exploitation of land and its viable resources. Water bodies in the region have not only provided domestic services but have additionally provided access for the people to its aquatic resources such as fish. As droughts and expansion of the Sahel continued, so also has the southward migration mainly of people searching for fundamentals of survival for themselves and for their domesticated animals. The trend has not spared the natural resources from degradation through overexploitation. Drainage systems have been the centres of refuge and at the same time the victim of degradation (Le Barbé & Lebel 1997). Aspects of this nature transcends national borders and in themselves also promote inter ethnic, sectorial and national conflicts. Against this backdrop, it becomes clearer why human settlements are concentrated in the southern parts of the region and not the northern. It also explains why economic developments are centred in these densely settled areas.

The quality of socio-economic data is limited by the fact that data and socio-economic research is country specific rather than basin wide. Regional disparities within the countries must therefore be taken into account. For example Niamey, the capital of Niger, is outside of the Lake Chad Basin but clearly stands apart from other regions in Niger with a higher quality of living, where as Zinder (Niger) is located in the Lake Chad Basin and has the greatest deficit in terms of its peoples poverty and vulnerability, according to infant mortality and child malnutrition indicators (Government of Niger 2002).

Social and cultural aspects

According to Kindler et al. (1990), the Basin exhibits a socio-historical unity based on a history shared by the established population groups some of which straddle national boundaries. Many trading circuits remain controlled by the groups who have long considered them their specialty (e.g. the Hausa and Kanuri).

There are numerous ethnic groups present in the Lake Chad Basin, many of which are present in several countries; altogether, there are more than 70 ethnic groups, each exploiting the natural environment by a range of activities. The majority of the populations speak several local and an official language. The main languages used in the area reflect the political roles exercised during the pre-colonial period: Kanuri (Niger and Nigeria), Fulfulde (Niger, Nigeria, Cameroon), and Arabic (Chad). These include a very diverse range of ethno-linguistic groups; in Nigeria alone there are 394 linguistic units (Otite 1990). The French and English colonial powers have also imposed their languages, and legal and administrative systems, upon the traditional ones; customary laws, regulations, and structures still determine land use systems in large measure.

The old Islamicised states (Kanem, Borno, the Peul Empire of Sokoto, Wadai and Baguirmi) are largely responsible for the present distribution of populations in the Basin, including the small groups that took refuge in the Mandara Mountains and the Mayo Kebbi regions. The Western shore of Lake Chad, where the majority of the Basin's population resides, is under the jurisdiction of Borno (one of the 36 states of Federal Republic of Nigeria) and is dominated by the Kanuri ethnic group. Migration during the latter part of the millennium has brought Shuwa Arabs from the east and Fulani pastoralists from the west and recently during the 1970s Hausa families from across northern Nigeria who were attracted by fishing opportunities at the Lake (Neiland & Verinumbe 1990, Sarch 2001).

Most of the countries of the Lake Chad Basin have experienced considerable political instability and a history of domestic and international conflict since 1960 when they gained their independence from the colonial regimes of the United Kingdom and France. Nigeria has had 11 changes of government, military coups and a civil war, Chad has experienced almost continuous unrest and war, and only Cameroon has had a stable government (Neiland & Béné 2003). Outbreaks of armed clashes and rebel activity on islands in the Lake have persisted since the 1970s and are largely associated with the succession of civil wars in the Republic of Chad and the migration of Nigerian fishermen following the receding lake south eastwards. A multi-national 'Joint Patrol' was created in response to these outbreaks and has been monitoring the Lake to prevent further violence (Sarch 2001).

Population dynamics

Over the last two decades the annual population growth in the region has ranged between 2.5 and 3.0% (World Bank 2002c). The current population within the region is estimated to be approximately 37.2 million people (based on ORNL 2003). The total population has increased by about 11.7 million since 1990 (population estimates for 1990 was 25.5 million people (UNEP 1999). Figure 19 shows how the Basin's population is unevenly distributed between the countries. Nigeria, Africa's most populous country hosts an estimated 22 million people (about 59%) of the total population living in the region. Whereas the northern and eastern peripheral countries, Algeria, Libya and Sudan, only have approximately 2.7 million inhabitants in the Basin (about 7%), as it only represents just over 6% of the land area of the Basin (EROS Data Center 2002). Population densities are greatest in Nigeria and surrounding Lake Chad and decreases in the more arid northern provinces. For example in the Tibesti Highlands the people are primarily nomadic pastoralists, and population densities are as low

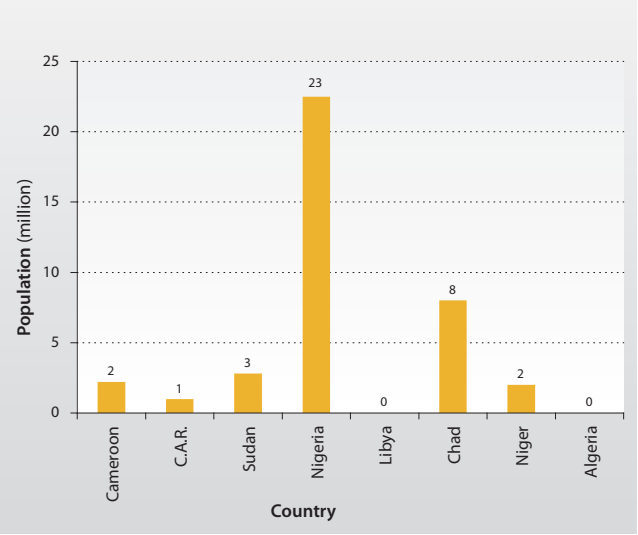


Figure 19 Estimated population in Lake Chad Basin (2002).
(Source: Based on ORNL 2003)

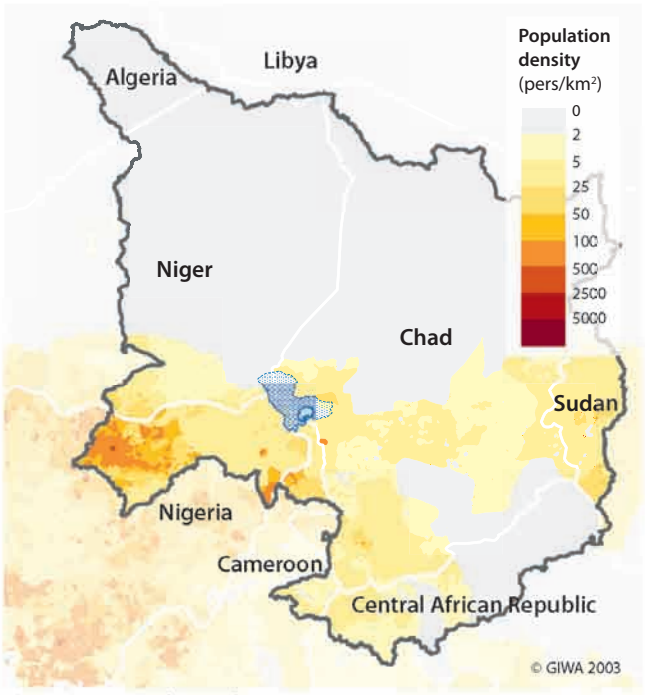


Figure 20 Population density.
(Source: Data from ORNL 2003)

as 0-1 people/km^2. Figure 20 shows the population density distribution in the region. The region is also experiencing rapid urbanisation, as destitute rural communities search for an improved standard of living in the swelling southern cities such as Kano (Nigeria), Maiduguri (Nigeria) and N'Djamena (Chad). In Cameroon the population of the northern city of Garoua has more than doubled from 122 600 to 287 000 between 1987 and 2003 (World Gazetteer 2003).

Population structure

The Basin's population is characterised by a young age structure, particularly in the southern riparian countries. In Niger for example nearly 50% of the population is under 15 and only 2% is over 65 (World Bank 2002c). The riparian countries of Sudan, Libya and Algeria, located on the periphery of the northern, northwest and northeast borders of the Basin have a larger proportion of over 65 year olds and their population structure is less skewed towards the young. Figure 21 shows the population age structures for the countries of the Basin.

The Basin's population is also predominately rural. In Chad (46% of the Basin's surface area) approximately 80% of the population is rural (IMF 2003).

Economic activities

In the Lake Chad Basin production activities are dominated by the primary sector and tertiary sectors in which technical progress is slow,

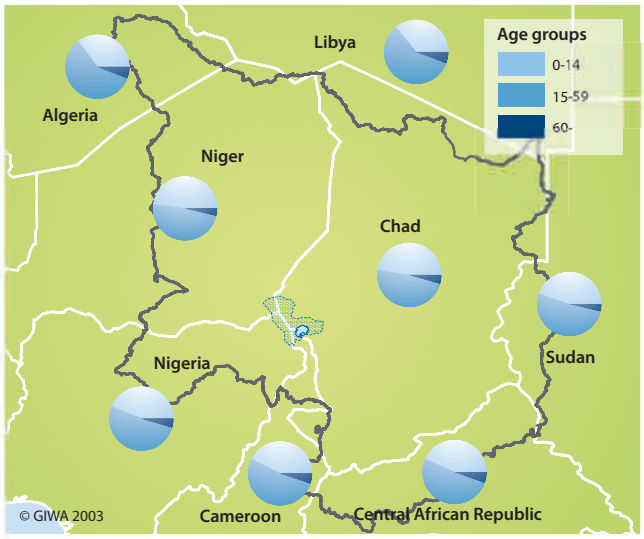


Figure 21 Population structure in the Lake Chad region.
(Source: ESRI 2000)

with a predominance of informal, low productivity activities. In Chad and Niger those working in the primary sector head the poorest households because they make up 78% and 80% respectively of the population but account for only 39% of the GDP (World Bank 2002c, IMF 2003). The primary sector employs more than 80% of the population and comprises primarily of agriculture and livestock rearing (Government of Niger 2002). Table 2 shows the regions sources of income.

Table 2 The region's household sources of income.

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

** CFA=Franc de la Communauté financière africaine.*
(Source: Nami 2002)

The economic activities in the Basin include:

- Mining: e.g. Gold mining in Central African Republic.
- Oil: Exploration and exploitation.
- Agriculture: Cotton, groundnuts, cassava, millet, sorghum, rice, onions. Mixed cropping is widely practiced.
- Fisheries: In dams, rivers, floodplains and the Lake Chad.
- Manufacturing: Cotton ginning, brewing, leather industry, machinery, milling and food industry.

Generally, the Lake Chad region is relatively less industrialised, however the commencement of oil exploitation in southern Chad may trigger industrial development. The number and sizes of industries also differ per country, but generally, there are few industries compared for example with the rest of West Africa. Agro-industries, textiles and tanneries dominate, whereas heavy industries are relatively few (World Bank 2002b). The majority of industry is focused in the urban areas that are disproportionately distributed with the highest concentrations in northern Nigeria and Cameroon, whilst the lowest are in Chad, CAR and Niger.

Mining

Although the Basin contains many minerals they are poorly utilised. Chad's minerals for example, have been relatively unexplored, although it is believed to have many mineral deposits. The principal mineral resource is natron (a complex sodium carbonate), which is dug up in the Lake Chad area and is used as salt and in the preparation of soap and medicines. Annual production is a few thousand tonnes. There is gold mining development in the Logone River Basin in southern Chad and CAR.

Oil exploitation

In Chad, oil extraction began in July 2003 and is expected to account for 45-50% of Chad's national budget. The project is exploiting the oil fields at Doba in southern Chad (at a cost of 1.5 billion USD) and has constructed a 1 070 km pipeline to offshore oil-loading facilities on Cameroon's Atlantic coast (at a cost of 2.2 billion USD). Figure 22 shows the Doba oil field in Chad and the pipeline in Cameroon. The sponsors are ExxonMobil of the U.S. (the operator, with 40% of the private equity), Petronas of Malaysia (35%), and ChevronTexaco of the U.S. (25%). The project could result in nearly 2 billion USD in revenues for Chad (averaging 80 million USD per year) and 500 million USD for Cameroon (averaging 20 million USD per year) over the 25-year production period (World Bank 2003b).

Agriculture

Agriculture is the main activity in 60 % of the administrative units of the Lake Chad Basin. The most commonly grown crops are cotton, groundnuts, cassava, millet, sorghum, rice and onions. Most farming in the Basin is rain-fed, cultivated and harvested by hand, and grown without the use of fertilisers and other agro-chemicals. Mixed cropping is widely practiced and rice is grown by both traditional and modern methods. Cotton is the most important cash crop in the region and is grown in southern Chad, northern Cameroon and Nigeria. Flood recession cropping is a major production system in the Lake Chad Basin (Box 2). Sorghum and berbere are the principal crops produced under this system.

Box 2 Resources available to the Lake Chad Basin's population.

Lake Chad
The Lake is very important to the communities living in the region. It serves as the political barrier between the neighbouring countries of Cameroon, Chad, Niger and Nigeria. It is an important source of potable water (AEO 2002) in a drought prone region and is a source of employment for a variety of professions. Its fisheries resource is particularly significant to the rural populations. The seasonal fluctuations provide excellent feeding grounds for fish through the exposing and submerging of the lake shore (Neiland & Béné 2003). Fish is a major source of protein for the region particularly for the land-locked countries of Chad and Niger. The recessional lake waters also provide very fertile agricultural and pasture land which has been capitalised upon during recent lake retreats. Fertility is then restored during periods of lake expansion. A significant amount of water is stored beneath Lake Chad and is very important for the recharge of the groundwater system (Isiorho et al. 1996), which may be available for future use (Isiorho et al. 2000). The Kanem Lakes (northeast of Lake Chad) contain the blue-green algae *Arthrospira*, which is sun-dried by the local Kanembu tribe to make the cake Dihé.

Rivers and floodplains/wetlands
The floodplains support a significant proportion of the Basin's population. They provide essential income and nutrition benefits in the form of agriculture, grazing lands, non-timber products, fuel wood, drought fall back security, tourism potential and fishing. Ramsar estimated the economic value of the wetlands to be 34 to 51 USD per ha (Barbier et al. 1997), the total economic value of the Hadejia-Nguru wetlands (Nigeria) is estimated to be 15.9 million USD (Schuijt 2002). The table shows the economic values of wetland goods and services in the Hadejia-Nguru wetlands. Like the communities surrounding the Lake Chad, fishing is also a fundamental activity of the floodplains and is practised within a strongly seasonal and flexible matrix of various activities.

Economic values of the Hadejia-Nguru wetlands, valued using market pricing.

Wetland goods or services	Economic value per year (converted to 2002 million USD)
Agriculture	10.7
Fishing	3.5
Fuel wood	1.6
Doum palm	0.1
Potash	<0.1
Total economic value	15.9

(Source: Schuijt 2002)

Mineral resources
The Lake Chad Basin is very rich in mineral resources although mining activity is poorly developed. Mineral resources contained within the Lake Chad Basin include kaolin, natron (soda ash), gravel, diamond, gold and petroleum.

Land and soil resources
Tectonic activity and the fluctuating lake levels over geological time have resulted in the Lake Chad Basin having exceptionally diverse soils and landforms. There are three types of lakes and over 15 landforms ranging from fossil valleys and wadis to active and relict wadis. There is a diverse range of soils numbering over 20. Farmers utilise a variety of soils with different water capacity (dry, drought, wet, very wet) holding properties that allow farmers to ensure some crop production in all types of year. These soils can be found within 10 m of each other and act as a famine prevention technique (LCBC 1992). In general, soil water limits production throughout the Basin. In wet years or, in the southern basin regions, when water is more abundant, nitrogen becomes the limiting factor.

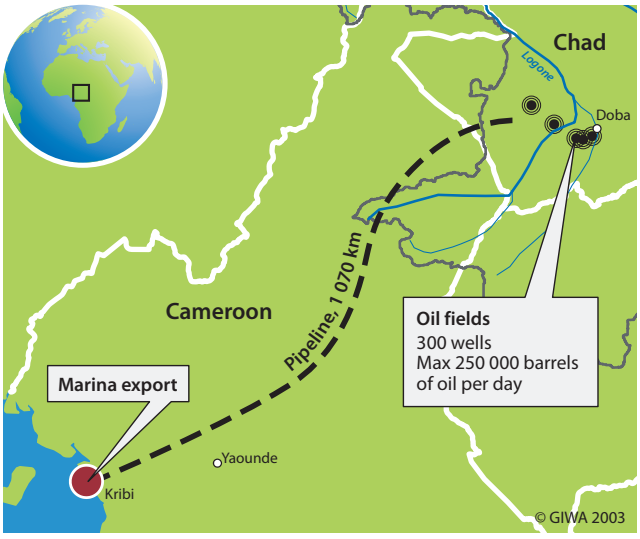


Figure 22 Doba oil field (Chad) and Cameroon pipeline.
(Source: World Bank 2003b)

Farmers are sedentary and the pressure that they put on the quality of the soil grows as their numbers grow (Nami 2002). In Niger, recurrent grain shortages (2 out of 3 years) despite increased overall agricultural production in the last 10 years (1990-1999) and strong demographic growth, has resulted in food production trailing behind actual consumption needs. This has led to food dependence, especially in rural areas, and frequent appeals to foreign aid in emergencies or when facing famine (Government of Niger 2002).

In the 1970s, the irrigated agriculture was seen as a solution to food insecurity in the region and was given priority funding. But the agricultural projects did not yield the results expected, at a time when member States saw it as the appropriate solution to increase agricultural production and improve food security for the people (Nami 2002). However, in Chad irrigated rice accounts for only 4% of national cereal production whereas traditional rice farming accounts for 75%. Figure 23 shows the distribution of irrigation areas, that are mostly located in Nigeria. The reason for growing rice is that it constitutes a cash crop, whereas the market for sorghum is limited (King 1993). However, there are high technical and financial inputs required for the irrigation schemes and net revenues are reported as being negative (King 1993). Furthermore, freshwater shortages have prevented the schemes from functioning. In contrast, traditional flood-recession farming has low inputs, and the scale of outputs compared with other systems has demonstrated the importance of this farming sector (King 1993).

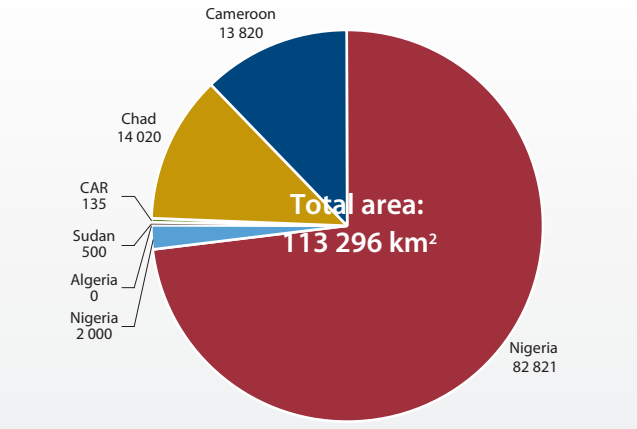


Figure 23 Distribution of irrigated areas.
(Source: FAO 1997)

Animal husbandry

This is an economic activity also very important in the region, particularly for the migrant cattle herders, who undertake large seasonal transhumant migrations. The meat from livestock makes a major contribution to the dietary needs of the population (King 1993). In Chad, 83% of the working population is engaged in the production of crops and livestock, primarily for domestic consumption. Only 25% of Chad's land is cultivated, but about 50% is grazed (Stuart & Adams 1990 in Keith & Plowes 1997). Borno state in Nigeria is the largest livestock centre in West Africa (Everything Nigeria 2002). Figure 24 shows typical Zebru cattle that have been sold to the slaughter house for production of dried meat. Cattle exports mainly to Nigeria are very important to the Chad and Cameroonian economies (King 1993).

Figure 24 Typical Zebru cattle that have been sold to slaughter-house for production of dried meat.
(Photo: FAO R. Faidutti 1987)

Fisheries of the Lake Chad Basin

The inland fisheries of the Lake Chad Basin, and in particular Lake Chad are among the largest and most productive in the whole of Africa. It is estimated that from 1969 to present, an estimated 1.7 million tonnes of fish have been landed, resulting almost entirely from skilled, native fishing operations using relatively unsophisticated techniques (mainly gill nets or longlines from canoes) (Stauch 1977, Durand 1980, Sagua 1986 in Neiland & Béné 2003).

The fishing activities within the Lake Chad Basin are a fundamental element of the livelihoods of over 10 million people living in and around the basin area (Box 2). The system creates a new set of aquatic environments each year, which dictate the local farming and herding production systems. The sustainability of these systems is a key factor of the economic and social stability of the region. Fish from the Lake Chad Basin is traded within all riparian countries and makes an important contribution to the food security of urban centres (Neiland & Béné 2003).

Current research suggests that fish demand is evidently attractive enough to encourage large numbers of fishers (full and part-time), estimated to be more than 170 000, and that the combined trade of riparian countries is worth upwards of 23.5 million USD per year (Neiland & Béné 2003).

Eight different types of fishing grounds are exploited across the Lake Chad Basin. Seasonal ponds and receding channels are the most common type of water bodies used, followed by rivers (Logone and Chari), the open waters of the Lake and the permanent ponds and oxbows. A comparison between areas shows that the Yaéré floodplains offers the largest diversity of exploitable water bodies, followed by the Chari delta and the western shores of the Lake (Neiland & Béné 2003).

The fisheries is largely dictated by the intra-annual flood regime of the Chari-Logone and Komadugu-Yobe sub-systems. Flooding influences the extent of the Lake Chad and its fringing floodplains, as well as the river floodplains. Fish move into the floodplains to feed and to breed, and then retreat with the floods to the main channels and open lake, along well-defined channels and outlets. The seasonal fluctuations in Lake Chad's water level provides excellent feeding grounds for fish through the exposing and submerging of the lake shore. The flooding regime represents an important natural asset, which most households at Lake Chad exploit in one way or another. As the flood peaks and begins to subside, fishers have the option to either fish the area of open water remaining at the centre of the Lake or to fish the pools and channels of residual flood water which remain around the villages (Sarch 2001). Considerable intra- and inter-annual variation in the flooding of the lake shore means that the supply, i.e. the timing, location and amount of resources such as fishing grounds is important determinant of both the productivity of these resources and which groups are able to access them at a given point in time (Sarch 2001). The main fishing season is from October until March (i.e. from the end of the rainy season until halfway into the dry season) while there is a secondary peak in fishing activity at the very end of the dry season when the open water bodies are at their smallest in size and fish are easily caught.

There are six key livelihood groups associated with the fisheries, namely: fishers, fish mongers/processors, fish wholesalers, fish retailers, fish gear dealers and boat builders. A total of 20 different types of fishing gear are used in the Basin (Neiland & Béné 2003). Apart from the seine net (taurow) which is owned almost exclusively by the richer families but operate collectively, all wealth groups, disregarding the area, use the same set of traditional fishing gears, i.e. essentially gill nets, traps (Mali traps or goura), hook-lines, cane trap (ndurutu), cast nets, and dip nets (sakama). The diversity and number of each fishing gear used by households declines with poverty. Investments in fishing inputs such as new fishing gears can generate instantaneous surplus, in contrast to farming activities where several months would have to pass before eventual benefits might be returned from the investment (Béné & Neiland 2003).

Figure 25 *Alestes baremoze* (Silversides).
(Drawing: Robbie Cada)

Figure 26 *Lates niloticus* (Nile perch).
(Drawing: Robbie Cada)

The inland waters of the Lake Chad Basin harbour a relatively high fish biodiversity and have at times had abundant quantities of fish. Common fish market species include *Alestes baremoze* (Silversides), *Clarias* (catfish), *Tilapiine cichlids*, *Petrochephalus* and the *Lates niloticus* (Nile perch) (Béné & Neiland 2003). Figure 25 and 26 show the *Alestes baremoze* and *Lates niloticus* respectively.

There have been 21 species of fish identified from Lake Chad that migrate 100 to 150 km up the El Beid and Chari-Logone rivers to the Logomatia marshes to spawn (Bénech & Quensière 1989). Several species, such as *Alestes baremoze*, are known to migrate for breeding over distances up to 650 km from the Lake Chad into the Chari-Logone River as far as Cameroon (Durand 1978).

Fisheries production for the year 2001 in the Lake Chad Basin was estimated at 68 784 tonnes (wet weight) (Jolley et al. 2002 in Neiland & Béné 2003). Fish are an important part of the diet of most people in the Lake Chad Basin, providing an essential supply of protein. The commercial trade of fish originating from the Lake Chad Basin is also very important in the whole of West Africa (Neiland & Béné 2003).

The largest fish market in the Lake Chad Basin is Baga-Kawa in Nigeria, near the lake shore, followed by the much smaller markets of Kinassaram and N´Djamena in Chad and Maroua in Cameroon. The majority of all

Table 3 Market characteristics of fish passing through the three main markets of Lake Chad Basin, June 2000 to May 2001.

Country market	Total volume (tonnes/dry weight) (wet weight conversion factor 4.5)	Total wholesale price		Unit price per kg of fish products (USD)
		Local currency (million)	USD (million)	
Nigeria (Baga Kawa)	10 876 (48 942)	2 487 (NGN)	20.8	0.52
Chad (Kinasserom)	343 (1 546)	551 (XAF)	0.8	0.45
Cameroon (Maroua)	1 518 (6 831)	1 402 (XAF)	1.9	0.79
Total	12 737 (57 319)	-	23.5	0.54

(Source: Neiland & Béné 2003)

Lake Chad Basin fish regardless of country or origin is directed into Nigeria, although some fish is retained and traded locally within the Lake Chad Basin. Table 3 shows the market characteristics of fish passing through the three main markets.

Economic growth

The countries within the region are among the poorest countries in the world. Chad was ranked 155th out of 162 countries on the United Nations' 2001 Human Development Index (HDI), with an annual per capita income of only 200 USD. The Gross National Incomes (GNI) of the countries are extremely low with the exception being Algeria (no data for Libya). Out of 206 countries ranked by the World Bank in terms of GNI per capita; Chad, Niger, CAR and Nigeria are amongst the 23 poorest countries in the world (World Bank 2002c). Figure 27 shows the disparities in GNI between the riparian countries.

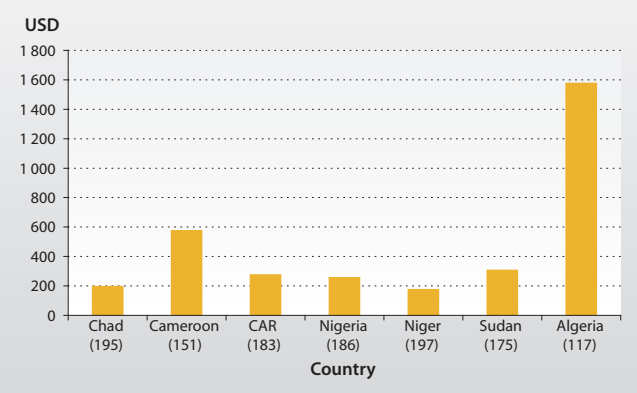


Figure 27 Gross National Income per capita of riparian countries.
Note: No data for Libya. Within parenthesis: GNI ranking by the World Bank.
(Source: World Bank 2002c)

Economic growth is very slow and variable in the region. Overall in the 1980s and 1990s, Chad and Niger's economies are characterised by a practically stagnant standard of living for the populations, with GDP growing in Chad by barely 1.4% per year over 20 years (IMF 2003) and in Niger by 1.9% per year over the decade 1990 to 2000 (Government of Niger 2002). In CAR and Sudan growth rates have declined steadily since 1997. The low growth rates of the Basin's economies are considered as being insufficient to sustain long-term reductions in poverty and bring improvements in the standards of living in the region. In Nigeria, despite vast oil reserves, GDP growth averaged 1.6% between 1980 and 1990, 2.4% between 1990 and 1998, but just 1% in 1999 (Narayan & Petesch 2002).

The economies of the Basin's countries generally suffer from a very low productivity, insufficient infrastructure, poor governance, a lack of a dynamic private sector, an oversized informal sector and a vulnerability to domestic and external shocks. In Sudan and Chad economic progress has also been inhibited by the series of civil war and associated military expenditures, infrastructure deterioration and discouragement of foreign aid and investment (World Bank 2001). The AIDS pandemic has directly impaired economic growth because it mainly affects the economically active population. In Chad, 56% of detected cases are in the 14-49 year old population (IMF 2003).

Poverty

The Lake Chad region is trying to cope with mass poverty. Figure 28 shows how an especially high proportion of the Basin's country populations falls below both the 1 USD and 2 USD international poverty line. The World Development Indicators (World Bank 2002c) does not have data regarding the percentage of Chad's population that is under the international poverty line, and data that is available appears to underestimate the pervasiveness of the problem. The percentage of poor households in the region is likely to be 60% or more (IMF 2003). Nigeria's poverty has steadily grown worse since the 1980s and according to World Bank Development Indicators (World Bank 2002c) in 1997, 90.8% of the population was below the 2 USD per day international poverty line. Based on the poverty line set by the Poverty Profile for Niger prepared in 1994, 63% of the population is poor, and 34% is extremely poor. The extent of poverty in Algeria is not as severe as in the southern region's of the Basin but in recent decades due to economic stagnation the percentage of the population under the poverty line has increased from around 8% to 14% (World Bank 1999).

The burden of poverty is spread unevenly across regional and socio-economic groups.

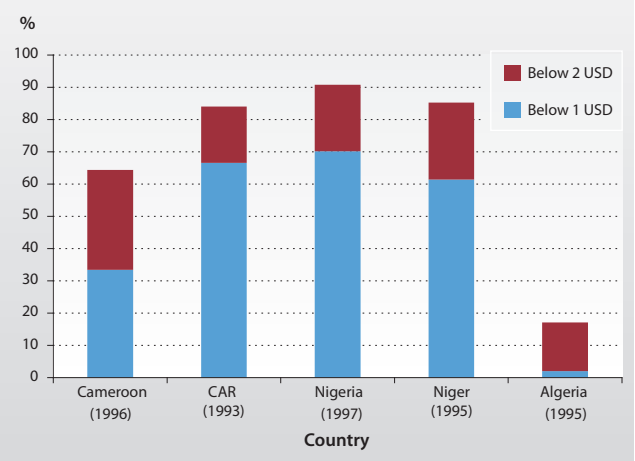


Figure 28 Population below international poverty line.
Note: No data for Chad, Libya and Sudan.
(Source: World Bank 2002c)

Regional inequalities within countries

The severity of poverty in the actual basin is hidden by national figures, as it is often severest in the sector of the country lying within the Lake Chad Basin boundaries. For example, a survey in 1996 estimated 67 million people in Nigeria to be affected by poverty of which the northern region which lies in the Lake Chad Basin accounts for the largest share (40%) of the country's poor people (World Bank 2002c). In Cameroon the situation is similar; in northern and extreme provinces, located in the Lake Chad Basin, there is a particularly significant number of people living in extreme poverty as compared with the rest of the country (World Bank 1999). Surveys have indicated that the poorest segment of the Yaéré floodplains (north Cameroon) is not food self-sufficient (Béné et al. 2000).

Rural-urban inequalities

Poverty is generally more acute and widespread in rural areas. In Niger, 86% of poor people (36% of whom are considered extremely poor) live in the countryside (Government of Niger 2002). In Chad, in both percentage and absolute terms, the problem is also worse in rural areas, since the population of Chad is largely rural (approximately 80%) (IMF 2003). In Algeria 70% of the poor lived in rural areas in 1995 but the share of urban poor is increasing (World Bank 1999).

Gender

Single women and widows are identified as among the most vulnerable and impoverished groups and poverty is more severe in female-headed families than in male-headed families. For example, in Chad households headed by a woman are more prone to poverty than those in which the head of household is a man (54% and 34% respectively). This is partly explained by the fact that most women heads of household are widows or divorcees with dependent children and scant resources (IMF 2003).

Vulnerable groups

Certain socio-economic groups that are at high risk are above all, women and children needing special protection, the disabled, demobilised military personnel, senior citizens, and persons living with HIV (IMF 2003).

Health

Standards of health in the region are overall very poor. However there is a great disparity between the northern countries of Algeria and Libya, which have far higher standards of health than the sub-Saharan nations. Niger, Chad and CAR have the lowest standards of health. The health of the rural populations is inferior to that of the urban populations and it is often the case that these areas of the country are located in the Lake Chad Basin. For example in Niger, child malnutrition is most severe in the regions of Diffa and Zinder contained in the Lake Chad Basin as well as Maradi (Government of Niger 2002). Table 4 shows national statistics for health.

Life expectancy

In Algeria and Libya life expectancy at birth is 71 years and is comparable to the Europe EMU life expectancy of 74 years. However, the life expectancy of the rest and majority of the region reveals a dismal situation, ranging from only 43 in CAR to 56 years in Sudan (World Bank 2002c).

Mortality

Infant mortality is very common in the region. In particular infant mortality in Chad, Niger and CAR is higher than the sub-Saharan average with over 9% of children dying before the age of one. In Niger one out of four children die before their fifth birthday and the country has one of the highest maternal death rates in the world (700 deaths per 100 000 live births) (Government of Niger 2002).

Table 4 Health and education indicators.

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

Note: ND = No Data.

(Source: World Bank 2002c)

Malnutrition

Excluding Algeria where undernourishment is minimal and Libya (no data), in the rest of the countries of the region, 28% of the population are undernourished. In Cameroon vulnerability to malnutrition is greatest in the northwest and northern provinces that are located in the Lake Chad Basin. Acute malnutrition is experienced by 8% of the people living in these predominantly rural provinces (Amin & Dubois 1999). In Niger, 43% of children under five suffer from malnutrition. The nutritional status in Niger has also been deteriorating; the percentage of children exhibiting stunted growth has risen from 32% in 1992 to 40% in 2000 and is most severe in the regions of Diffa and Zinder located in the Lake Chad Basin (Government of Niger 2002). However, in Nigeria despite there being a low life expectancy (47 years), 92% of the population have sufficient nourishment (World Bank 2002c).

Diseases

Diseases are widespread across the region. The high child mortality can in part be attributable to several diseases, including malaria, various forms of diarrhoea, acute respiratory infections, measles, tetanus, yellow fever, diphtheria and chicken pox (Government of Niger 2002). Tuberculosis incidence in 1999 was greatest in CAR and Cameroon (415 and 335 per 100 000 people). However, vaccination coverage is low (15% in Niger). The highest infant mortality rates are in the region where vaccination coverage is lowest, in Niger this is Zinder (on the fringes of the Lake Chad Basin) and Maradi (Government of Niger 2002). The prevalence rate of the AIDS pandemic continues to increase in the Lake Chad Basin countries. In Chad the number of confirmed cases of AIDS has grown from 10 in 1989 to 1 010 in 1993, to 1 343 in 1996 to over 12 000 cases in 2000 (IMF 2003) and the zero prevalence rate is now between 5 and 10% among adults. In Niger, this rate is over 5% among adults, whereas in Nigeria, Cameroon and CAR the epidemic is from 5% to 14% of zero prevalence among adults (UNAIDS 2001). The AIDS pandemic is far less severe in Algeria, Libya and Sudan. Schistosomiasis (Bilharziasis) is endemic in the Basin and is particularly focused in the Chari-Logone and Komadugu-Yobe river basins and tributaries. Malaria transmission is very high in the region due to the intensity of African mosquito vectors of malaria (ESSO 1999).

Healthcare facilities

The health facilities available to the Basin's population are very poor. The average percentage of GNP spent in the sub-Saharan region is 4.9%; except for Cameroon, all of the Basin's countries spend a smaller percentage of their GNP than this average (World Bank 2002c). In Niger between 1994 and 2000, on average, the government earmarked only 6% of its budget for health, far below the 10% recommended by the WHO (Government of Niger 2002). In Niger, Chad and CAR there is only one physician for more than 20 000 people and only in Algeria and Libya is there one or more physicians per 1 000 people. Nigeria, despite rapid population growth, has doubled the number of physicians it has per 20 000 people from two in 1980 to four in 2000 (World Bank 2002c). In Chad, very few (less than 5%) women from poor households give birth at a health centre primarily due to a shortage of such facilities but also because of the cost of services (IMF 2003).

Education

Illiteracy is a hindrance to development in the region and remains particularly high in Chad, Niger, CAR and Sudan. Niger's primary school enrolment rate is very low (31%) and the literacy rate is the lowest in the world (Table 4). There is a sharp disparity between girls and boys. In Niger, less than one fifth of girls attend school and 92% of females were illiterate in 2000. In CAR net enrolment of girls dropped from 50% in 1995 to 37% in 1998 (Government of CAR 2000). The greatest proportional inequality is found in Libya where only 9% of men are illiterate compared to 32% of women (World Bank 2002c). On a regional scale the Sudan sector of the Lake Chad Basin consists primarily of the region of West Darfur, where literacy in 1993 for the male population stood at 68.4% but for women only 20.2% (World Bank 2003).

Factors that discourage enrolment are the long distances to school, low quality of education, and a low probability of being hired in the modern sector. The children who do attend school have to cope with very little resources. In some of the countries, standards of education are falling. In CAR for example from 1995 to 1998, the net primary enrolment rate fell from 60% to 44% (Government of CAR 2000). However, despite continued economic hardship, in some countries improvements have been made. Nigeria for example has experienced a decline in economic living standards yet illiteracy rates have fallen by almost 30% for both males and females between 1990 and 2000 (World Bank 2002c).

Being poorly educated, many communities are therefore unable to liaise or negotiate effectively with local administrations, central government, NGOs and donors. Another consequence is that farmer organisations, cooperatives, and professional associations are very weak.

Water supply and use

Water uses in the Lake Chad Basin include domestic, industrial, agricultural (flood cropping and small-scale irrigation), large irrigation projects (e.g. Kano River Irrigation Project), livestock, fisheries and ecological. The majority of freshwater consumed in the region is used for agriculture followed by domestic use. The unindustrialised nature of the region results in very little water being used for industrial

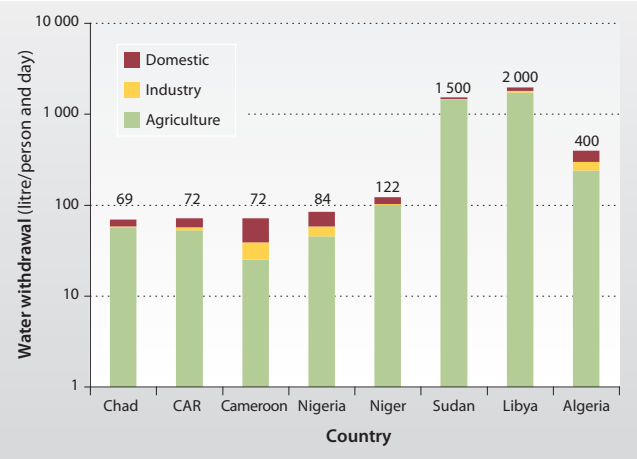


Figure 29 Freshwater withdrawal per person per day by economic sector.
(Source: World Bank 2002c)

processes. In Africa, Nigeria is the sixth largest user of water by volume (4 billion m^3 year) (Revenga & Cassar 2002). Figure 29 shows the percentage water consumption by sector.

Water for domestic use is mainly obtained using traditional methods. In the Sudan sector of the Basin (West Darfur) over 50 % of water is obtained from dug wells with bucket collection (World Bank 2003a). Women have to travel great distances in order to gather water for drinking, cooking and other everyday activities. The Tiga and Challawa Gorge dams through the Kano City Water Supply (KCWS) supply the large Nigerian urban centre of Kano City for domestic and industrial purposes.

Access to safe drinking water in the Basin is very limited. The percentage of people living in rural areas with access to an improved source of water in 2000 ranges from 26% in Chad to 56 % in Niger, excluding Algeria Libya and Sudan (access is above 68%) (World Bank 2002c). In the Niger sector of the Lake Chad Basin (Agadez, Diffa and Zinder Departments), modern water points only cover 53 % of the population's needs. Water shortages are a regular occurrence in this sector of Niger, because of lack of available supplies and the condition of infrastructure (Government of Niger 2002).

Traditional agriculture in the Basin is predominantly rain-fed. The rivers in the Chari-Logone and Komadugu-Yobe sub-systems support flood farming and recessional farming. Farmers in downstream areas therefore depend largely on river flow because rainfall is low and variable. The many large irrigation projects are located predominantly in the Komadugu-Yobe Basin.

Sanitation

Sanitary conditions for rural dwellers are particularly poor with severely limited waste disposal facilities. For example in Niger, the rural sanitation rate was barely 5% in 1996 and has been steadily declining, with the development of disease vectors in swamps and irrigation facilities and the deterioration of drinking water quality as a result of improper transportation and conservation (Government of Niger 2002).

In Chad no town has a functioning wastewater treatment system and collection networks are dilapidated. Less than 2% of the inhabitants of towns and cities have lavatories with running water while lavatories are practically nonexistent in rural areas. As a result, the poor are frequently exposed to chronic diseases related to poor living conditions and lack of access to water and sanitation. Moreover, water-related chores (which take up to four to five hours a day in certain areas) may, among other things, shorten the time spent on more productive and fulfilling activities (IMF 2003). In the Sudan sector of the Basin (West Darfur), over 50% of the population do not have access to any type of toilet facility, and 42% use a traditional pit. There are no sewage systems (World Bank 2003).

Infrastructure related to water

In the last 40 years there has been considerable development of dam infrastructure in the region which have impounded a large proportion of the Lake Chad Basin's water resources. In northern Cameroon, the 30 km earthen Maga Dam was constructed on the upper part of the Waza-Logone floodplain in 1979 to provide water for the SEMRY irrigated rice scheme and for fish farming (LCBC 1998). The Lake Chad supplied freshwater to Nigeria's South Chad Irrigation Project (SCIP), which had a goal of irrigating 67 000 ha of cultivated land, and Baga Polder Project, which had a goal of 20 000 ha. However, by 1996 only 2 200 ha and 1 000 ha were under irrigation respectively and presently they are both not functioning. The Kano River Irrigation project (KRIP), fed by the Tiga Dam (Komadugu-Yobe) was completed in 1974, water is also released from the dam to supply Kano City (northern Nigeria). The Challawa Gorge Dam on the Challawa River (Komadugu-Yobe sub-system) was constructed in 1992 to supply water for the Hadejia Valley Irrigation Project and to provide water for Kano City. Work on the Kafin Zaki Dam on the Jama'are River has been stopped and started many times, and its future is presently unclear. Table 5 shows technical details of the major dams in the Lake Chad Basin. Figure 46 shows a map depicting Lake Maga in the Chari-Logone sub-system and Figure 49 shows those dams located in the Komadugu-Yobe sub-system. The Alau Dam (162 million m^3 reservoir) is located on the Ngadda River system and supplies the city of Maiduguri (Nigeria) to the southeast with 72 million m^3 of water. The irrigation component consisted of 22 km

Table 5 Technical details on major dams in the Lake Chad Basin.

Details of major dams and reservoirs		Tiga Dam 1974-1991	Tiga Dam 1992	Challawa Gorge Dam 1992	Maga Dam
Storage capacity (million m^3)		1 989	1 429	972	680
Active capacity (million m^3)		1 843	1 283	904	ND
Dead storage (million m^3)		ND	146	68	280
Maximum release capacity (m^3/s)		ND	25[1] / 60[2]	86	50
Catchment area (km^2)		ND	6 641	3 859	6 000
Average annual evaporation (m)		ND	2.14	2.31	ND
Average (1964-1985) annual inflow (million m^3)		ND	914	476	ND
Surface area (km^2)	At 100% storage	180	145	100	400
	At 75% storage	ND	117	80	ND
	At 50% storage	ND	85	60	ND
	At 25% storage	ND	52	35	ND
Annual evaporation losses (million m^3)	At 100% storage	385	310	231	ND
	At 75% storage	ND	250	185	ND
	At 50% storage	ND	182	139	ND
	At 25% storage	ND	111	81	ND
Evaporation losses/ average inflow (%)	At 100% storage	42	34	49	ND
	At 75% storage	ND	27	39	ND

Note: ND=No data. [1]Actual maximum capacity of the canal valve is 35 m^3/s. [2]Kano River release gate not provided with control valve and therefore blocked; two smaller release gates not included.

(Source: IUCN 1998, Attewill & Lawerence 2002)

of conveyance canal from Alau Dam to Jere Bowl for development of 2 000 ha of rice cultivation. However this scheme was not completed.

Institutional arrangements - The Lake Chad Basin Commission

The Lake Chad Basin Commission (LCBC), an Inter Governmental Agency was established by the Fort Lamy (now N'Djamena) Convention and Statutes on May 22 1964 by the heads of four countries that share the Lake. This Old Conventional Basin did not include the Central African Republic and excluded the large desert expanses of Algeria, northern Niger, northern Chad and Sudan and, in particular, excluded the upstream part of the active basins of the Chari-Logone and Komadugu-Yobe. In March 1994, Central African Republic was admitted as the fifth member State during the 8th Summit of Heads of State (held in Abuja, Nigeria) leading to the New Conventional Basin thus increasing the conventional area to approximately 987 000 km^2. This has enlarged the conventional basin to include the upper basins of the Chari-Logone and Komadugu-Yobe systems. The New Conventional Basin includes five countries; Chad, Nigeria, Cameroon, Central African Republic and Niger. Sudan was admitted into LCBC in June 2000, but is yet to ratify the Convention establishing the Commission, a necessary precondition for partaking in the activities of LCBC. The admission of Sudan has now increased the conventional area from 427 000 km^2 in 1964 to 1 035 000 km^2 in 2000. This new definition of the conventional Lake Chad Basin thus takes into account almost all the water resources that supply the Lake, the floodplains and the aquifers in the lake area (World Bank 2002b).

The functional system boundary for water, land, forest and wildlife comprise much smaller sub-sets of the Lake Chad Basin Commission's geographic limit. This is because the hydrologically active area of the Basin is much smaller (966 955 km^2) than the topographic limits of the Basin (2 434 000 km^2) which cover a large part of desert areas in Niger and Chad and are hydrologically de-coupled from the Lake (World Bank 2002b).

The primary responsibilities of the LCBC are: to regulate and control the utilisation of water and other natural resources in the Basin; to initiate, promote and coordinate natural resources development projects and research within the basin area; to examine complaints; and to promote the settlement of disputes, thereby promoting regional cooperation and integration. The Fort Lamy Convention recognises the sovereign rights of the member States over the water resources in the Basin, but forbids any unilateral exploitation of the lake water, especially when such use has a negative effect on the interests of the other states. It also recognises the right of the member States to plan projects, provided that they consult the LCBC beforehand. The member States were also supposed to refrain from adopting any measures likely to alter the Lake's water balance, its exploitation by other riparian states, the quality of its water and the biological characteristics of the fauna and flora in the Basin. Lastly, the member States must inform the LCBC of all projects planned within the Conventional Basin. National, sectoral and environmental plans exist in each country. National institutions are officially in charge of coordinating the implementation of Action Programme 21 in Chad, Cameroon, Niger and Nigeria.

At national level, the relevant environmental institutions are:

- Cameroon: National Consultative Committee on the Environment and Sustainable Development (CCNEDD), which includes the Prime Minister, various ministers, professional associations and NGOs.
- Central African Republic: Ministry of Meterorology and Ministry of Mines and Energy.
- Chad: National High Committee on the Environment (HCNE) which includes the Prime Minister and various ministers.
- Niger: National Council for the Environment and Sustainable Development (CNEDD) which includes the Cabinet leader, ministers, civil society, university and NGOs.
- Nigeria: Federal Environmental Protection Agency (coordination of ministries) backed by the National Advisory Council (governmental

organisations, private sector, NGOs, community organisations, university) and by the National Council on the Environment (States). Almost all the States in the Federation have prepared a long-term Environmental Action Plan.

Chronology of recent projects executed in the Lake Chad Basin

Diagnostic Study of Environmental Degradation in the Lake Chad Conventional Basin 1989

The study was undertaken by specialist consultants in cooperation with LCBC member States with funding and support from UNEP. The study gave a synopsis of environmental degradation in the diagnostic basins of the Lake Chad Basin. The goals of the report were to identify the symptoms, causes, and also to set priorities for strategic action. In November 1989, a report was submitted to the Environmental Ministers of the LCBC member States with a number of recommendations (see Kindler et al. 1990). The diagnostic study identified causes of environmental degradation and recognised defining "type years" according to rainfall, channel flow, lake levels and flooding as a necessity for a flexible development policy which can adjust rapidly to water supply changes. The study recommended: (i) integration of irrigated cropping with food storage and famine prevention programmes; (ii) improving water and soil conservation through incorporation of tree regeneration, forage production and other agro-forestry techniques in irrigated agriculture; (iii) imposing a moratorium on large-scale water projects; (iv) undertaking a review of existing water projects; (v) correcting the environmental impact of specific projects to downstream and floodplain users; and (vi) according priorities to downstream users (fishery, recession agriculture, pasture, groundwater recharge) and to multiple use of wetlands (wildlife, tourism and economic production).

Master Plan for the Development and Environmentally Sound Management of the Natural Resources of the Lake Chad Conventional Basin 1992

The Master Plan, compiled in cooperation with UNEP, UNSO, National Experts, the LCBC Secretariat and Consultants, was drawn up on the basis of the recommendations of the Diagnostic Study. The Master Plan supplemented by a programme of action for sustainable agricultural development was prepared with the assistance of the FAO. A prioritised Master Plan was produced from these two documents, for the environmentally sound management and development of the conventional basin. The document consists of 36 projects relating to water resources, agriculture, forestry, biodiversity management, and livestock and fishery development within the Lake Chad Basin (see LCBC 1992).

Decision Support System Project

The Decision Support System Project (DSS) funded by UNEP with contributions from the LCBC in 1995 was intended to support the implementation of the Master Plan. Expected outputs were a DSS and a donors' conference. The donor conference was not undertaken as the Planning Committee decided on first preparing a Strategic Action Plan (see below).

Planning and Management of Water Resources of the Lake Chad RAF/88/029, 1990-1993

A project financed by UNDP. Objectives included the evaluation of water resources, strengthening of data collection and management, model simulations, formulation and evaluation of development strategies. The outcomes from this project were incorporated in the Master Plan and eventually the Strategic Action Plan (see below).

Monitoring and Management of Groundwater Resources in the Lake Chad Basin 1992-1993

Financed by the French Cooperation under convention No98/C88/ITE and executed by the consultancy firm BRGM. The objective of the project was to provide the LCBC with a groundwater resource management model. Insufficient funds resulted in the development of only a pre-model. The project provided remarks and recommendations for the groundwater resources in the Lake Chad Basin, and also identified gaps in knowledge.

Lake Chad Basin PDF-B Strategic Action Plan 1998

Integrated and sustainable management of the international waters of the Lake Chad Basin: A Strategic Action Plan (SAP) was initiated in 1996 following a request from the LCBC made to the GEF (LCBC 1998). The preparation of the SAP facilitated by the United Nations Department responsible for Economic and Social Affairs (UNO-DESA) was supervised, corrected and validated by member States and by LCBC specialists. The objective of the SAP was to prepare a regional framework for protecting the environment and for the sustainable use of the various resources throughout the Lake Chad Basin.

UNESCO-BMZ Management of ground-water resources for sustainable development of the Lake Chad Basin

Within the framework of UNESCO International Hydrological Programme (IHP) particularly its project on "Humid Tropical Zones" and the implementation of LCBC's Master Plan for the Development and Environmentally Sound Management of the Conventional Lake Chad Basin, implementation of the above project commenced in 1997. UNESCO implements the project which is funded by the German Ministry for Economic Co-operation and Development (BMZ). It has the

following objectives (UNESCO 1997): (i) knowledge and quantification of the recharge and reserve of the underlying aquifers under three different climatic scenarios of humid, medium and dry years; (ii) evaluation of aquifer recharge from floodplains and surface water; (iii) proposal of regulatory issues for aquifer protection; (iv) proposal of management systems for the quaternary and continental terminal aquifers through the development of a flow simulation model for the three different climatic scenarios; (v) improvement of the efficiency of national agencies for coordinating the development actions through purchased equipment, trained staff, data base and computer simulation; and (vi) contribution to the implementation of the LCBC Master Plan.

The project prepared a hydro-geological synthesis report at the end of 1997 that highlighted data gaps and information that would need to be updated during the project execution. The final hydro-geologic report incorporating all data and analysis done by the project, including the groundwater model developed, is being awaited.

GEF/UNDP and World Bank Project: Reversal of Land and Water Degradation Trends in the Lake Chad Basin Ecosystem

GEF initiated a project brief, as well as the SAP. On the basis of the brief 10 million USD was designated for this project. "The development objective is to build capacity within the Lake Chad Basin Commission (LCBC) and its national committees so that it can better achieve its mandate of managing land and water resources in the greater conventional basin of Lake Chad". A Transboundary Diagnostic Analysis and Strategic Action Programme are currently being initiated. See the World Bank Project Appraisal Document (2002a).

Sustainable development of Continental fisheries - A regional study of policy options and policy formulation mechanisms for the Lake Chad Basin EU-INCO Project 1999-2003

Funded by the European Union, the EU-INCO project is a collaboration of both African and European research teams. The project was operated over three years and included a full range of research, knowledge dissemination and capacity-building activities (see Fisheries of the Lake Chad Basin: Using Policy as a basis for future development action) (Neiland & Béne 2003).

Promotion of the Use of Renewable Energy Resources and Conservation of Flora Species in the Drylands of Mega Chad of the West African sub-Region, 2001-2004

The community-based project covers four countries namely Chad, Cameroon, Niger and Nigeria. The project focuses on measures to address loss of biodiversity due to habitat loss as a result of uncontrolled exploitation of vegetal resources, with its negative implications on climate change; and, increasing rate of land degradation, which exacerbates the poverty condition of the inhabitants. Pilot projects include: training and implementation of renewable energy and water conservation technologies, establishment of woodlots of threatened species of community value, and youth and environmental clubs.

Figure 30 Protected wetland in Chad Basin National Park, Nigeria.
(Photo: WWF-2001, canon/Meg GAWLER)

Protection status within the region

Current national protected areas include the Lake Chad Game Reserve on the western shore of Lake Chad in Nigeria (Figure 30), the Manda National Park on the west bank of the Chari in Chad, and the Mandelia Faunal Reserve on the floodplain between the Chari and Logone in Chad. The Hadejia-Nguru Wetlands Conservation Project was started in 1985, as a joint undertaking by the IUCN, BirdLife International and the Nigerian Conservation Foundation (Thieme et al. In preparation). The Aïr and Ténéré National Nature Reserve in Niger and the Ouadi Rimé-Ouadi Achim Faunal Reserve in Chad are the two most important protected areas in the Sahelian sub-desert zone of Africa. They contain many of the last viable populations of many of the larger ungulates of the South Saharan Steppe and Woodlands ecoregion (Burgess et al. In press).

Lake Chad poses a unique challenge for fishing regulations because it lies within four different countries. Systems of regulating access to fishing were recently created. Taking Nigeria as an example, Sarch (2000) shows that regulations are very complicated and haphazardly enforced, with confusion among different administrative agencies over regulation and taxation.

In July 2000, the Lake Chad Basin Commission (LCBC) declared all of Lake Chad a transboundary Ramsar site of international importance. However, only the national governments of Niger and Chad have designated their sections so far, although both Nigeria and Cameroon have promised that they too will designate their sections as Ramsar sites. Currently there are the following Ramsar sites: Nguru Lake (and Marma Channel) complex (Hadejia-Nguru Wetlands, Nigeria); Lake Chad (Chad site); Lake Chad (Niger Site); and Lake Fitri (Chad) (Ramsar 2003). The GEF/World Bank Project has allocated substantial funding for the improved management of the existing and planned Ramsar sites (LCBC 2002). All Lake Chad Basin riparian countries have ratified the Convention on Biodiversity (CBD).