

3.3 CHAD

Introduction

Chad is a landlocked country in the centre of North Africa being bounded by the Central African Republic in the south, by Cameroon, Nigeria and Niger in the west, by Libya in the north, and by Sudan in the east. It is the largest and least densely populated country in region 3. It has an area of 1 284 000 km², a population of 4 970 000 (1983) and a mean population density of only 3.8 persons/km². It stretches some 1750 km from north to south between latitudes 23°30' and 7°33'N, and 1250 km from east to west between longitudes 13°33' and 25°00'E.

Over 90% of the country drains to Lake Chad on the central western border. Only two small areas drain to other countries. Part of the Mayo Kebbi district in the extreme southwest drains to the Benue River in Cameroon and thence to the Niger River, and the northern section of the Tibesti Massif drains to Libya and Niger. Chad forms the eastern side of the huge endorheic basin in which Lake Chad occupies one of the lowest, but not the lowest, points. Most of the country is a sandy plain, 300-500 m asl, sloping down to lake Chad at an altitude of 280 m asl, but the great diamond shaped depression of Bode16 comprising 35 000 km² of land, 155-180 m asl (16°05'-17°38'N/15°50'-18°50'E), lies to the north of Lake Chad. Lake Chad is prevented from draining northeastwards into this depression by the dune barrage of the Erg du Kanem.

Highlands rise to 1163 m asl in the Monts de Lam in Logone Orientale Province in the far south, and the entire eastern part of the country along the border with Sudan is a high plateau rising above 500 m asl. There are peaks of 1320 m asl (14°22'N/21°37'E) and 1450 m asl (17°41'N/22°15'E) in the Ouaddai and Ennedi Massifs respectively. Other high points are 1506 m asl (12°07'N/18°56'E) and 1613 m asl (11°55'N/18°12'E) in the Guera Massif in the central south, but the highest land is in the Tibesti Massif in the far north of the country, where several peaks exceed 3000 m asl. Here Emi Kousi (19°53'N/18°34'E), at the southern end of the range, is the highest point in both Chad and the Sahara, reaching 3415 m asl.

The Tibesti Massif is triangular in plan, with sides approaching 400 km in length. It comprises about 50 000 km² of land with an average height in excess of 2000 m asl. At least 60% of its total area is situated above the 1500 m contour. The basement is Precambrian, overlaid with Palaeozoic sandstones, all capped by Tertiary and Pleistocene outpourings of basalt. Residual volcanic activity is still evident in numerous fumaroles, solfatari, mud pools and hot springs. There are a dozen or so hot springs in the Soborom district of the central Tibesti, where waters issue from the ground with temperatures between 22 and 88°C. Other warm springs (37°C) are situated on the eastern flank of Emi Koussi at an altitude of 850 m asl.

The Tibesti Mountains, which receive very little rainfall indeed, drain in radial fashion by

numerous intermittent watercourses which simply peter out in the surrounding desert. The waters draining from the massif do not spread away from the watercourses, and the water they carry is entirely lost by evaporation or infiltration to the soil, but the latter may be carried great distances by subterranean aquifers. Five major watercourses run northwards into Libya, the largest being the Bardage flowed at a rate of 425 m³/sec in 1954, but in the subsequent 9 years, was entirely dry for 4 years, had one short flow each year for 4 years (peaking at 5 m³/sec), and in the ninth year had three flows peaking at 4, 9 and 32 m³/sec.

The Tibesti Massif is roughly bisected along a N-S line by the great valleys of two fossil rivers or enneri. The Enneri Yebige, which drains to the north and peters out in a fossil floodplain on the plateau of Sarir Tibesti, and the Enneri Touaoul which drains south. The sources of the two streams are separated by the 1800 m high watershed stretching between the peaks of Tarso Tieroko in the west and Tarso Mohi in the east. The Enneri Touaoul joins the Enneri Ke and on some maps these are then shown as the Enneri Miski, which disappears in the Borkou plains.

The Ennedi Massif and the northern part of the Ouaddi Massif are also drained by a dendritic system of intermittent streams, and these too, peter out in central Chad. However, the Ouaddi south of the 14th parallel, receives over 400 mm rain/yr, and from here, and from the Guera Massif, streams discharge to the Ba Tha which empties into the seasonal wetlands around Lake Fitri, from where, in a wet year, water may travel via the Ba Tha de Leiri to the Bahr Erguig and thence to the Chari River and Lake Chad.

The Bahr el Ghazal is an intermittent watercourse running southwestwards across central Chad to the southeastern extremity of Lake Chad. The principal river system feeding this lake however is the Chari/Logone system. The Logone rises in Cameroon and flows NNE along the Chad/Cameroon border to the lake, receiving as its major affluent, the Chari River at N'Djamena (12°07'N/15°04'E). The Chari drains the northern part of the Central African Republic and part of southwestern Sudan, being formed by the amalgamation of the Bahr Aouk, Bahr Keita, Bahr Salamat and Bahr Sara Rivers.

Climate

The hot dry dusty Harmattan wind blows across Chad from the east or northeast throughout the year. In November the inter-tropical convergence zone is situated at a latitude close to 4°N, but from this time until August it moves steadily northwards over Chad, with humid monsoonal air penetrating under the Harmattan and bringing rain. The monsoon front usually reaches 20°N and the Tibesti Mountains, but in some years may retreat southwards before it has reached this latitude.

It is warmest in the south of Chad in April. The mean minima and maxima at Moundou (8°35'N/16°01'E) are 14.9°C and 34.0°C in January; 22.3° and 37.3°C in April; and 21.2° and 29.6°C in August. Comparable figures for Fianga (9°57'N/15°09'E) are 14.1° and 34.4°C in January; 24.8° and 38.7°C in April; and 22° and 30°C in August. At Bol (13°27'N/14°40'E) on the eastern shore of Lake Chad they are 13.8° and 31.1°C in

January; 24.1° and 38.6°C in April; and 24.2° and 34.1°C in August. By contrast, in the far north, August is the warmest month. The mean minima and maxima at Bardai (21°21'N/16°56'E) are 4.6° and 23.7°C for January; 14.4° and 34°C for April; and 19.4° and 36.7°C in August. Low temperatures of -10°C are not uncommon in the Tibesti, and readings of -5°C have been made on the Ennedi Massif. By contrast 50°C has also been recorded on the Ennedi. There is often a dust haze over the country in winter.

Precipitation decreases in passing north over the country. It exceeds 1100 mm along the southern border, being 1150 mm at Moundou and 1188 mm at Sarh (9°08'N/18°22'W). Both these places enjoy falls in excess of 300 mm in August, the wettest month, while the December-February period is rainless, and March and November are virtually rainless. A little farther north and east, Am Timan (10°59'N/20°18'E) still receives over 300 mm of rain in August, but has a mean annual total of only 902 mm. N'Djamena, on the Chari floodplain receives 582 mm/yr, with 240 mm in August and 6 rainless months, while Ab6che (13°49'N/20°49'E) receives 433 mm/yr, with 200 mm in August and 7 rainless months. At Faya-Largeau (17°58'N/19°06'E) in the central north, mean annual precipitation is 43 mm, with 20 mm in August, but reliable rainfall is not experienced north of the 16th parallel of latitude.

Bardai (21°05'N/17°00'E) at 1020 m on the northern flank of the Tibesti Massif recorded a mean annual rainfall of 12 mm for the eleven years 1957-1968. However, during this period some years were completely rainless while in others over 60 mm were recorded. Precipitation is often due to storms, but these are not connected with the SW Monsoon which does not penetrate this far north, rather they occur following the development of Sahara-Soudanian depressions. Precipitation is greater at higher altitudes, e.g. at 2250 m at Trou-au-Natron (21°10'N/16°06'E), the mean annual receipt is 126 mm, and Emi Koussi probably receives even more than this, and snow is not an unusual phenomenon on the high peaks.

Vegetation

A mosaic of open forest and woody savanna covers the southern part of the country, extending 100 km north of Moundou and 50 km north of Sarh, while a pure wooded savanna belt reaches northeast of Am Timan. Here in the south, leguminous and combretaceous trees are dominant. North of this, shrubby savanna covers the rest of the southern third of the country, except for the great wetland areas. Thin *Acacia* savannas cover the Ouaddi Massif, but much of the Ennedi Massif is a barren desert. However, the deep gorges which traverse it carry intermittent rivers lined by gallery forest with fringes of *Acacia* woodland. Xerophytic scrubland fringes the central western dune area, while on the northern side of this there are Sahelian steppes which finally peter out in true desert in the north. Other wooded vegetation occurs in some of the gorges in the Tibesti.

Wetlands

Despite the facts that Chad includes part of the Sahara and that its northern two thirds are extremely arid, with little reliable rainfall, it has a greater area of seasonal wetland than

any other country in the region. No less than 10 150 000 ha are subject to regular inundation, excluding land along the eastern shore of Lake Chad. There are several permanent lakes, in addition to Lake Chad, but no important artificial impoundments.

List of Wetlands Described

1. The Bahr Aouk & Bahr Salamat Floodplains
2. The Chari River Floodplain
3. The Logone Floodplain
4. Wetlands of the Mayo Kebbi System
5. Natural Lakes
 - (a) Lake Chad
 - (b) Djikare, Moilo & Rombou Lakes
 - (c) The Ounianga Lakes
 - (d) Rock Pools of the Ennedi Massif
 - (e) Lake Fitri
 - (f) Lake Iro
 - (g) Lake Fianga
 - (h) Lake Tikem
 - (i) Lake N'Gara
 - (j) The Lere Lakes
6. Wadis & Oases of the Tibesti Massif
 - (a) The Mare de Zoui
 - (b) The Oases of Borkou District
 - (c) Other Oases

1. Floodplains

General: There are approximately 4 995 000 ha of seasonally inundated land in the southeastern corner of Chad, flooded each year by waters derived from southern Sudan and the northeastern parts of the The Central African Republic, as well as from local rainfall. Direct precipitation over the floodplains varies from 1150 mm in the south to 800 mm north of Am Timan.

The Bahr Aouk flows southwestwards along the southern border of Chad all the way from Sudan in the east to the confluence with the Chari in the centre. A floodplain stretches north from the north bank of this river to the northern side of the Bahr Azrak, 228 km distant, and this includes the courses of several rivers, notably the Bahr Keita and Bahr Salamat which flow in parallel with the Bahr Aouk to join the Chari. During the dry season important ponds are left in the channels of some of the intermittent streams, e.g.

the Bahr Keita.

Hydrology: The flood begins to rise in all these streams in late August and peaks at the end of October. It declines rapidly in late November, and low water levels then persist from February to July. The Bahr Aouk does not carry a lot of water. Its mean year round discharge rate is 90 m³/sec, with a peak flow of 1200 m³/sec in October. The Bahr Keita carries more water at high flood, with flow rates approaching 1500 m³/sec in October. Farther north the Bahr Salamat, which has formed from the Bahr Azoum and Bahr Azrak, carries even more water. However, the Bahr Keita, Bahr Azoum and Bahr Azrak are all intermittent, as are all the minor affluents of the system. Only the Bahr Azouk, Bahr Salamat and Chari are perennial streams. Annual variations in peak flow are very great, as are the areas flooded. In a wet year the floods may last for 3-4 months.

Flora & Fauna: Typical floodplain grasses dominate the seasonally inundated land including species of *Andropogon*, *Cymbopogon* and *Hyparrhenia* on the fringes and *Echinochloa pyramidalis*, *E. stagnina* and *Oryza barthii* in deep water. *Acacia albida*, *A. scorpioides* and *A. sieberana* are common on levees and the floodplain margins

Human Impact & Utilisation: The rivers and their associated floodplains are fished quite intensively. The total catch from the system amounts to some 15 000 tonnes/yr. During the 1960s, the catch on the Bahr Salamat/Lake Iro system yielded 6000 tonnes/yr, while that on the Bahr Keita yielded 4000 tonnes/yr and that on the Bahr Aouk, just over 3000 tonnes/yr.

It is estimated that the number of cattle in the southern Ouaddi exceeds 700 000, and that in addition there are over 400 000 sheep and goats. Many of these animals are brought onto the floodplains to graze in the wake of the flood, and recession agriculture is widespread.

Conservation Status: The Zakouma National Park and the Bahr Salamat Faunal Reserve which encloses it are situated in the seasonally inundated area, and in total protect more than 2 000 000 ha including Lake Iro. Animals ostensibly protected here include *Cephalophus* spp., *Cercopithecus aethiops*, *Crocodylus niloticus*, *Kobus ellipsiprymnus*, *Leptailurus serval*, *Panthera pardus*, *Phacochoerus aethiopicus*, *Sylvicapra grimmia*, *Syncerus caffer* and *Tragelaphus scriptus*. The avifauna includes species such as *Balearica pavonina*, *Egretta* spp., *Leptoptilos crumeniferus* and *Pelecanus onocrotalus*. Fishing is permitted in the reserve, but poaching is a serious problem.

2. The Chari River Floodplain

Wetland Name: The Chari River Floodplain

Country: Chad

General: The Chari River has several sources in the northern highlands of the The Central African Republic, and derives principally from the waters of the Gribingui, Bamingui and Bangoran Rivers. It flows northwards into Chad receiving the waters of the Bahr Aouk and Bahr Keita above Sarh (Fort Archambault) and those of a major tributary, the Bahr Sara (Ouham River) just downstream from this place. The Bahr Sara also has several sources in the north of the The Central African Republic and carries more water than the Chari at the confluence. Some 30 km below the confluence the Chari receives the

Bahr Salamat on its east bank and then, a few kilometres farther downstream, the Batha de Lieri. This is an intermittent stream which drains the dry interior. Its course is parallel with that of the Chari for 200 km, just 5-10 km east of the Chari, but its direction of flow is opposite to that of the Chari. The Chari thereafter continues northwest towards Bousso (10°32'N/16°45'E), but some 80 km above this place it bifurcates, giving rise to an eastern branch known as the Bahr Erguig. Just below Bousso the main channel of the Chari receives the Ba Illi on the west bank. It then continues, with peak flows of 4000-5000 m³/sec, to its confluence with the Logone at N'Djamena and thereafter discharges into Lake Chad with peak flows of up to 6000 m³/sec.

Narrow floodplains occur on the Bahr Sara in Chad, but a major floodplain does not develop until just above the bifurcation which gives rise to the Bahr Erguig on the east bank. The floodplain is then 470 km long, reaching northwestwards along the Bahr Erguig and then across intervening lands to N'Djamena. It varies in width from 40 -165 km and covers some 1 557 500 ha. Another floodplain on the Ba Illi covers about 220 000 ha. It begins on one of the two intermittent headwater affluents of the Ba the Nam River, about 50 km above the point where the Nam and Dimlik Rivers meet to form the Ba Illi. From here it extends downstream for 130 km to the confluence of the Ba Illi and Chari, and has a maximum width of 35 km.

Yet another floodplain and permanent swamp complex occurs on the Batha de Lieri system which provides a further 1 137 500 ha of wetland. This includes floodplain and swamp land around Lake Fitri (12°16'-13°05 'N/16°27 '-17°59 'E), and another floodplain immediately to the east of the Guera Massif (11°33 '-12°08 'N/17°21'-18°00'E).

Hydrology: Just above its confluence with the Chari, the Bahr Sara has peak flows in excess of 2300 m³/sec, and flows in excess of 2000 m³/sec may be maintained from late August until late November. However, dry season (January-June) flows are in the order of 150 m³/sec. The peak flows in the Chari above the confluence are rather less than these and the annual volumes carried by the two streams are very different. Measured above the confluence, the Chari carries some 9.7 billion m³/yr, while the Bahr Sara carries 16.8 billion m³/yr. Thus below the confluence the Chari carries 26.5 billion m³/yr. Much of this is dissipated over the floodplains where high water is generally 1-1.5 m deep, although in depressions it may reach 3 m. Direct precipitation makes a substantial contribution to the flood, soaking the surface soil so that river water is not quickly lost by infiltration. Thus at N'Djamena, above the confluence with the Logone, the Chari still carries 26.1 billion m³/yr. Having received the contribution of the Logone, the mean annual flow of the Chari below N'Djamena is 38.7 billion m³, the mean contribution of the Logone being 12.6 billion m³/yr. At N'Djamena an absolute maximum rise in the river level, exceeding 7 m, was recorded in 1964, but the mean annual rise at this point is 5.3 m. Flow in the river below N'Djamena usually peaks in early November, with a mean maximum rate of 4450 m³/sec, while a rate of more than 4000 m³/sec is usually maintained throughout October and November. The flood subsides dramatically in late December and a mean minimum flow of 200 m³/yr is attained at the beginning of May. In the south the flood is maximal between late August and mid-October, and water remains high until the end of November, but the flood is later at N'Djamena, where high water is attained in late September and

persists until mid December.

Flora & Fauna: The flora and fauna of the floodplains is as described in the regional introduction for Soudanian and Sahelian regions. The upper reaches of the river and its southern affluents flow through densely wooded Soudanian/Guineo-Congolan savanna with *Isoberlinia* and *Monotes* spp., and species such as *Berlinia grandiflora*, *Cola laurifolia*, *Cynoinetra vogelii*, *Diospyros elliotii* and *Parinari congensis* in swampy spots along the river. The typical spectrum of gallery forest animals is associated with these. In the northern reaches the galleries are replaced by lower levee woodlands with species such as *Acacia albida*, *A. nilotica*, *A. seyal*, *Balanites aegyptiaca* etc., again as described in the regional introduction.

Human Impact & Utilisation: Some 17 000 tonnes of fish used to be landed each year from the lower Chari, between N'Djamena and the delta in Lake Chad. However, this figure fell dramatically after the drought of 1972-74 and has not yet fully recovered. The fisheries above N'Djamena have been less drastically affected. The catch upstream of N'Djamena, as far as the confluence of the Chari and Bahr Erguig, produces about 7000 tonnes fish/yr, while that on the Ba Illi produces just over 2000 tonnes/yr. The catch between the confluence of the Chari and Bali, as far upstream as Sarh, averages 4000 tonnes/yr. A large agro-industrial complex, producing and milling sugar cane, became operational at Banda in 1977.

Conservation Status: The Mandelia Faunal Reserve is situated on the floodplain between the Chari and Logone Rivers south of their confluence at N'Djamena, and is bounded by these two streams on the east and west. The park comprises 138 000 ha, and protected 660 elephants on its establishment in 1967. Other animals found in the park include *Gazella rufifrons*, *Kobus kob*, *Orycteropus afer*, *Phacochoerus aethiopicus* and *Tragelaphus scriptus*, and there is a rich avifauna along the rivers and around permanent waterholes.

The Manda National Park protects 114 000 ha on the west bank of the Chari, some way below the confluence of the Bahr Sara and Chari. The river bed is included in the park and forms the eastern boundary and there are numerous small swamps and pools in the park. Wetland species protected include *Hippopotamus amphibius*, *Kobus ellipsiprymnus*, *Kobus kob*, *Loxodonta africana* and *Syncerus caffer*. Again there is a rich avifauna associated with the wetland habitats.

3. The Logone Floodplain

Wetland Name: The Logone Floodplain

Country: Chad

General: The Logone has sources in Cameroon which rise as the Wind and Mbere Rivers on the Massif de l'Adoumaoua, from where it flows northeastwards into Chad. Here it is joined by the Pende River which rises in The Central African Republic. The Logone then flows northwestwards for about 80 km, where it divides to form a secondary channel on the

east bank. This is called the Marba, but sometimes also Ba Illi. At first it flows due north, away from the Logone which continues northwestwards, but after about 165 km it swings round and flows in parallel between the Logone and Chari Rivers, finally rejoining the Logone about 85 km above N'Djamena. A floodplain of 100 000 ha occurs on the Pende just below Doba (8°40'N/16°50'E), but the Logone does not overflow its banks until a point (9°03'N/16°33'E) just above the confluence with the Pende. Downstream from here the floodplain is continuous all the way to N'Djamena where the Logone and Chari Rivers meet. This floodplain is 400 km long. It begins at an altitude of 382 m asl and widens, some 80 km downstream, to occupy all the land between the Logone and Marba Rivers. Here, just above Bongor (10°18'N/15°20'E), it reaches a maximum width of 125 km, but then narrows abruptly to 25 km, before widening again to 40 km, a width it maintains to N'Djamena. The Logone/Marba floodplain comprises 2 100 000 ha of permanent swamp land and seasonally inundated land in Chad. The Logone forms the border with Cameroon for 275 km below N'Djamena, and its waters also inundate a substantial area in that country. In addition there may be a movement of water between the west bank of the Logone and Lake Fianga (10°02'N/14°20'E), and if conditions are right, water may pass from the Logone down the Mayo Kebbi system. Thus there is a connection between the Lake Chad and Niger Basins. At times of very high water, the Chari may overflow its west bank about 100 km below Bousso, and this flood may spread to meet that of the Marba, giving a common inundation zone between the Logone and Chari Rivers all the way to their confluence.

Hydrology: Flow in the Logone at Moundou rises sharply to a peak in late August, when it regularly exceeds 2000 m³/sec. In most years the flow rate then falls to about 1500 m³/sec by mid-October, but then rises to another peak in early November, when the flow again exceeds 2000 m³/sec. It falls sharply in December, to about 300 m³/sec, thereafter declining slowly to a minimum flow of less than 100 m³/sec in February. It then rises slowly to reach 500 m³/sec by late June and remains at this level until the end of August when the cycle starts again. Flow rate in the Pende is much lower than in the Logone, but the peaks and troughs occur in unison.

Immediately above the bifurcation of the stream to form the Marba, the Logone carries a mean annual volume of 17.2 billion m³ water. Here peak flow is bi-modal, reaching 3000 m³/sec in mid-August and again in mid-October, with a drop to 2000 m³/sec in mid-September. Having lost water to the Marba, flow in the Logone is reduced. At Bongor its flow approaches 2000 m³/sec in September and remains just below this level until the end of October, whereafter it declines sharply. Farther north at Logone-Birni (11°50'N/15°00'E), above the confluence with the Chari, the mean annual volume carried is 12.6 billion m³ and peak flows of 1000 m³/sec are reached in November.

Flora & Fauna: The rivers carry dense Soudanian gallery forest in their upper reaches, but this thins out to the north, and levee forest or scrub prevails along the rivers in the floodplain zones. The floodplains themselves carry grasses. The fauna is as described in the regional introduction.

Human Impact & Utilisation: The rivers and associated floodplains are fished over their entire lengths, with annual catches approaching 19 000 tonnes. The catch is concentrated in the lower region, between the confluence with the Chari at N'Djamena and the point where the Marba rejoins the Logone. Some 10 000 tonnes/yr come from this short stretch.

Rice is grown on 54 000 ha of empoldered land at Bongor, and large areas of floodplain are devoted to flooded rice culture in the vicinity of Lai (9°22'N/16°14'E), amounting to some 112 000 ha.

Conservation Status: The Mandelia Faunal Reserve protects an area between the Logone and Chari Rivers near N'Djamena, as discussed in the preceding section, 2. The Chari River Floodplain. Otherwise unprotected.

4. Wetlands of the Mayo Kebbi System

Wetland Name: Wetlands of the Mayo Kebbi System

Country: Chad

General: Between 14° and 16°E the Chad/Cameroon border runs close to the parallel 10°N, and just to the south of this the Mayo Kebbi flows west in a broad swampy bed to join the right bank of the Benue River in Cameroon. The Mayo Kebbi rises in Chad, in the wetlands of the Logone Floodplain, and prior to crossing the border into Cameroon, connects a series of lakes. These are, in passing downstream from east to west, Lake Fianga, which is largely situated in Cameroon, Lake Tikem and Lake N'Gara; then having descended the 45 m drop of the falls at Gauthiot, it flows through the two Lere Lakes. The rivers and lakes have areas of permanent swamp land on their banks, and in places there is a narrow floodplain along the rivers. The lakes are dealt with individually in the next section.

Hydrology: The Mayo Kebbi is fed principally by floodwaters from the lower Logone River as mentioned in the preceding section. The waters collect into the Kabia and Loka Rivers which merge above Lake Fianga. High water is from the beginning of August until late October.

Flora & Fauna: Galleries of Soudanian forest species occur along the rivers and there are typical aquatic floras in the lakes and on the floodplains, all as described in the regional introduction. Manatees survive in the system together with all the small aquatic animals. Large mammals are scarce but hunting still continues. Crocodiles are uncommon in the river.

Human Impact & Utilisation: The system is intensively fished and annual catches from the lakes and river in Chad are in the region of 10 000 tonnes. Rice is grown on the floodplains around all the lakes of the system.

Conservation Status: The Binder-Lere Faunal Reserve of 135 000 ha protects an area below Gauthiot Falls including Lakes Trene and Lère. The reserve is set in *Anogeissus-Boswellia* savanna, and forest galleries, river beds and marshes are included, in addition to the two large lakes. Animals protected in the reserve include *Cercopithecus aethiops*, *Genetta tigrina*, *Hippopotamus amphibius*, *Tragelaphus scriptus*, *T. strepticrosus* and *Viverra civetta*. There is a rich avifauna around the lakes. Poaching is severe and is locally attributed to people crossing the border from Cameroon and to military personnel.

5. Natural Lakes

Wetland Name: Lake Chad

Country: Chad

Coordinates: 12°29' -14°29' N/13°02' -15°21' E

Area: 2 500 000 ha at high water (c. 1 155 000 ha in Chad)

Altitude: 282 m asl (when lake surface covers 2 000 000 ha)

Nearest Towns: Bol (on E lakeshore); N'Djamena (100 km S)

General: Lake Chad lies just south of the Sahara and occupies a low point in one of the ancient drainage basins of Africa. The Bodele Depression, 350 km northeast, is lower than the lake with surfaces 155-180 m asl, but drainage of the lake in this direction is precluded by the dunes of the Erg Kanem. However, according to Beadle (1981), during the peak flood years of 1962 and 1964, water travelled 50 km from lake Chad along the Bahr el Ghazal towards the Bodelè Depression.

The Lake Chad Basin has been in existence since the Cretaceous and has suffered little physical deformation, although the size and distribution of water surfaces in it have changed dramatically as a consequence of climatic changes, especially during the Pleistocene. The lake was, for example, 5 times its present size only 6000 years ago (Servant & Servant, 1970; 1973). Connections were established more than once between the basin and the surrounding basins of the Niger, Nile and Zaire Rivers during the Pleistocene, but today, only the Niger basin is connected, and that only tenuously through the Mayo Kebbi system.

The drainage basin occupies more than 2 500 000 km² and is bounded by the highlands of the The Central African Republic, the Massif de l'Adoumaoua and the Mandara Mountains in the south, by the Jos-Funtua Plateau in the southwest, by the Mr Mountains in the northwest, the Tibesti Mountains in the north, and by the Ennedi and Ouaddi Massifs in the east.

Some 46% of the lake and its peripheral marshes are situated in Chad. Published accounts of the area of the lake vary between 1 379 200 ha (5325 square miles - Welcomme, 1972) and 2 500 000 ha (Beadle, 1981). According to Beadle the open water area has fluctuated between 1 000 000 ha and 2 500 000 ha this century. However, during the drought of 1972-1975 the area of open water fell below 250 000 ha and a similar state of affairs prevailed in 1908. During dry periods in the past, including the very recent past, when the lake has contracted greatly, parallel lines of wind blown dunes have developed along the eastern and northern shores. These are oriented NW-SE, and the fringes of these dune areas are flooded by the 'normal' lake producing lines of sandy islands along the eastern shore, often referred to as the 'archipelago zone'. The islands are particularly prominent in the southeastern sector. Farther into the lake, away from the eastern shore, in the northwestern part of the lake, lower dune ridges have been submerged, but they are so close to the surface that they are vegetated and form a series of reed covered areas, again oriented NW-SE. The 'normal' lake, such as persisted through the 1960s, is 235 km long, oriented NW-SE and some 100 km wide in the north. An arm, 100 km long and 50 km wide, extends due east from the southeastern corner. During the 1972-1975 drought the lake level fell from 282 m to 278 m, and the lake at first contracted to occupy three separate basins. By the beginning of November 1975 the northern basin was completely dry and little open water remained in the south basin. These events were accompanied by massive fish mortalities. At times during the Pleistocene, Lake Chad was vastly greater than it now is, and at one time extended to the Tibesti Mountains.

Hydrology & Water Quality: The lake is endorheic and both lake and lower basin are shallow, which is why the surface area of the lake is so variable. Of the total riverine inflow, 95% comes from the Logone/Chari system, the catchments of which, in the humid highlands of Cameroon, Chad and the The Central African Republic, represent about 25% of the total basin. The contribution of the El Beid River is minimal, possibly 2.5% of the total inflow, while the remainder is contributed by the Yobe, Yedseram and other intermittent streams. Precipitation over the lake probably averages 300 mm/yr, with variable and unreliable falls close to 250 mm/yr in the north, and more reliable, but still variable falls close to 460 mm/yr in the south. Potential evaporation over the lake is 2200-2300 mm/yr, and in excess of 2300 mm over the northern parts of the catchment. The maximum depth of the lake water, with a surface at 281 m, is 7 m in the northern basin and 4.5 m in the southern basin. The lake water is well mixed and well oxygenated, being shallow and subject to moderate winds. The southern part of the lake has salinities well below 1‰. However, a ridge crosses the middle of the lake from east to west, known as the Grande Barrière, and although in the 'normal' lake this is inundated, it restricts circulation. Thus the northern part of the lake is significantly more saline than the southern half, with readings of 2‰, although it is still well mixed. The saline waters extend south to the Grande Barrière during the dry season but are pushed back to the north when the Chari is in flood. It is remarkable that, since an estimated 90% of the incoming water evaporates each year, the salinity of the lake is so low. Carmouze (1970; 1976) estimates that a substantial proportion of the incoming ions are removed by chemical or biological processes, amounting to 60% of the calcium, 54% of the magnesium, 36% of the potassium, 44% of the carbonate and 84% of the silicate. However, it seems likely that a lot of dissolved minerals are lost by the seepage of dense saline water into a subterranean system (Roche, 1970). Certainly it has been demonstrated that ground water is moving outward from the lake in the vicinity of Bol (Dieleman & de Ridder, 1964). The salinity of the water seeping out of the lake is about ten times greater than that entering the lake.

Flora & Fauna: The seasonally flooded fringes of the lake are covered by typical floodplain vegetation as described in the regional introduction. The permanent swamps along the southern lake margins are dominated by *Cyperus papyrus*, with *Phragmites (mauritanus?)* and *Vossia cuspidata*. Islands of papyrus break away from the peripheral swamp and float into the lake during windy weather, but by contrast, the northern shores and islands are covered by *Phragmites australis* and *Typha domingensis*. *Papyrus* becomes less common in passing northwards, while *Typha* becomes less common in passing southwards. A swamp belt, intersected by many channels, crosses the lake over the Grande Barrière. In the north, *Cyperus laevigatus*, a species common on the margins of saline pools, occurs on the lakeshore. In the south *Cyperus articulatus*, *Leersia hexandra* and *Pycreus nzundtii* occur on the fringes of the lake, with *Hyphaene thebaica* at the limits of inundation.

Ceratophyllum denzersunz, *Potamogeton schweinfurthii*, *Vallisneria spiralis* and some other submerged aquatics occur in the lake and are especially well developed between the islands along the eastern shore. A vast expanse of aquatic vegetation, with *Nymphaea* spp., and the submerged species already mentioned, covers a shallow coastal area in the southeast. More than 1000 species of algae have been identified in the lake. The dune island zone of the eastern side of the lake is the most productive part of the lake.

During the severe drought of 1972-75, the exposed parts of the southern basin developed a luxuriant vegetation, described by Fotius & Lemoalle (1976), but the dry areas of the northern basin did not. Among the most important species in this explosive colonisation were *Aeschynomene elaphroxylon*, *Cyperus papyrus* and *Vossia cuspidata*. The vegetation on the Grande Barrière became a serious impediment to the re-flooding of the northern basin when a 'normal' influx from the Chari occurred at the end of 1974 and again in 1975.

The invertebrate faunas of the north and south basins in a 'normal' lake are distinct from each other, and from that in the waters of the archipelago of sand islands along the eastern shore. Molluscs dominate the benthic fauna, contributing 75-90% of the benthic biomass in the southern basin. Molluscs are however, relatively scarce in the northern basin, although there are extensive fossil mollusc beds at the north end of the lake. The reasons for the differences in both flora and fauna between the northern and southern basins is not known, though numerous hypotheses have been advanced and an introduction to recent thought and research is given by Beadle (1981).

Lake Chad is in the Soudanian ichthyological province but it has been the meeting place of species from the Nile, Niger and Zaire Basins. 179 species of fishes have been identified in the Lake Chad Basin, of which 84 occur in the lake itself. 106 species are common to the Chad and Niger Basins, with 8 species confined to the two basins. There are 105 species common to the Chad Basin and the Mayo Kebbi, and of these 21 are not found farther downstream in the Benue/Niger system. 85 species are common to the Chad and Nile Basins, with 7 species confined to the two basins, while 47 species are common to the Chad and Zaire Basins, with 13 species confined to the two basins. Of these 47 species, 18 are found only in the upper reaches of the Chari and Logone Rivers and their headwater affluents, suggesting that they are recent immigrants from the Zaire Basin. The possibility clearly exists that exchanges could occur across the flat watersheds in the The Central African Republic during times of exceptionally heavy rain. The fish fauna of the basin is discussed by both Beadle (1981) and Lowe-McConnell (1975) who give further references.

Many species of fish leave the lake and swim up the affluent rivers when water levels begin to rise. They then leave the rivers and move onto the great floodplains to spawn, returning to the lake with the recession of the flood, e.g. *Alestes baremose*, *A. dentex*, *Distichodus rostratus*, *Eutropius niloticus*, *Heteropisus bebe*, *Labeo senegalensis*, *Mormyrus rurne*, *Petrocephalus bane*, *Schilbe uranoscopus*, *Synodontis batensoda*, *S. membranaceus* and *S. schall*. Other fish are specialised for life on the peripheral floodplains, such as *Protopterus annectens*, while others are adapted to life in the peripheral swamps, e.g. *Brienomyrus niger*, *Clarias lazera* and *Polypterus* spp., but during the great drought of 1972-75 these latter species became abundant in the south basin. The balance of fish species and populations in the lake and lower affluents has changed following the Sahelian drought of the early 1970s, and this appears to have had moderately long term effects. These have been reflected in changing patterns of fish catches, and are discussed by Stauch (1977), Chouret (1978), Quensière (1976) and Benech *et al.* (1976). Rotting vegetation, after parts of the lake were re-flooded in 1975-76, led to local de-oxygenation and further fish losses.

Crocodylus niloticus is now very uncommon in the lake, but there are several species of semi-aquatic snakes on the banks. There is a rich avifauna. The lake is important to palearctic migrants, especially since the recent severe droughts in Senegal and Mali.

Large numbers of ducks are now seen on the lake. Most large mammals have been hunted out and have been replaced by domestic cattle. Species which remain include *Tragelaphus spekei*, in the reed beds, and there is a reduced *Hippopotamus* population. Small aquatic mammals, such as *Aonyx capensis* and *Lutra maculicollis* are common.

Human Impact & Utilisation: Salification of the soil surrounding the lake is increasing, partly due to irrigation, but in part naturally as a consequence of the seepage of water away from the lake and its subsequent evaporation at the surface. This may preclude the large scale expansion of irrigation agriculture. At present this is largely confined to the vicinity of Bol where land is empoldered, and used to produce maize, legumes and a variety of minor crops. Salt is produced to the north of Baga-Sola, a short way northwest of Bol. The lake is fished extensively from villages in Chad and in the 1960s the mean annual catch exceeded 26 000 tonnes, but this declined dramatically during the drought of 1972-75, and has not fully recovered. The floodplains around the southern end of the lake are grazed intensively by large numbers of domestic cattle. There were over 300 000 cattle and more than 100 000 sheep and goats in the vicinity of the lake in Chad before the drought in 1972-75, but we have no figures for recent years.

Conservation Status: Unprotected.

Wetland Name: Djikare, Moilo, & Rombou

Country: Chad

General: Several small permanent lakes occur immediately to the east of Lake Chad, in the Erg Kanem, where the water table reaches the surface in the troughs between dunes. In previous more pluvial times the area has been a part of Lake Chad and clays have been deposited in the inter-dune troughs where the lakes now occur. The three Djikare Lakes are situated closest to Lake Chad. The largest, Lake Bodou, is 71 km NW of Bol and 11 km inland from the shore of 'normal' lake Chad. It has an area of 40 ha and a maximum depth of 2 m. Its waters are saline.

The two Moilo Lakes are 31 km NE of Bol, and each have areas of about 60 ha and depths close to 2 m. Lake Rombou is 70 km NE of Bol. It has an area of 15 ha and is 1 m deep. Direct precipitation over the lakes is less than 300 mm/yr in all cases and insolation averages 3000 hrs/yr while potential evaporation exceeds 2200 mm/yr. All of these lakes are fringed by lush green vegetation. In those lakes with a low bicarbonate content in the water, *Phragmites australis* is dominant, with isolated stands of *Cyperus papyrus* and *Typha domingensis*. The aquatic vegetation is dense and includes all the typical species, but *Phragmites* may totally occlude shallow lakes. Other lakes with higher bicarbonate concentrations are less densely vegetated. Again *Phragmites* is present, though usually less tall, and *Cyperus laevigatus* often forms an outer landward zone.

The faunas of these lakes are improperly known. Among the fishes, *Henzichroznis bimaculatus*, *Paraphiocephalus obscurus* and *Tilapia* sp. have been recorded in the least saline lakes. Crocodiles are probably absent, birds are common and *Hippopotamus amphibius* has been recorded in several of the lakes.

Human Impact & Utilisation: Some salt, natron, containing sodium carbonate, sodium bicarbonate and sodium chloride is extracted locally, and nomadic people utilise the water resources of the area. Otherwise the lakes are undisturbed.

Conservation Status: Unprotected.

Wetland Name: The Ounianga Lakes

Country: Chad

General: Southeast of the Tibesti Massif the edge of the mega-Chad Basin abuts the 200 km Ounianga Escarpment, oriented NW-SE. This is a sandstone structure and at its feet there are a number of permanent saline lakes at altitudes close to 402 m asl. These lakes owe their existence to the fact that water in a subterranean aquifer reaches the surface in depressions between sand ridges west of the escarpment. The lakes are situated in NE Chad (18°44'-18°05'N/20°31'-21°51'E) equidistant from the Tibesti Mountains and the Ennedi Massif.

The principal lakes are at Ounianga Kebir (19°05' N/20°31' E) where Lake Jua (345 m asl) has an area of 370 ha and a maximum depth of 25 m, and there are 3 smaller lakes close by, known as Lakes Uma, Mioji and Forodom. A second group of lakes 50 km east occupies the Ounianga Serir (18°55'N/21 °51'E). Here ten lakes lie in rough parallel; these are Melekoui, Dierke, Ardiou, Teli, Abrome, Hogou, Diara, Tarem, Tibichei and Bokou. Lake Teli is the largest, covering 70 ha, with a maximum depth of 10 m and a high water surface at 360 m asl. The lakes are oriented NE-SW with their long axes parallel to the direction of the prevailing winds.

Flora & Fauna: Most of these lakes are fringed by narrow stands of *Cyperus laevigatus*, *Phragmites australis* and *Typha capensis*. *Lemna* spp. are common in the freshwater springs and *Nymphaea* and *Potamogeton* spp. grow in most of the lakes, while in some *Ruppia maritima* is present. Phytoplankton is abundant but not well studied. The surrounding moist ground once held stands of *Hyphaene*, but these have been removed and replaced by *Phoenix dactylifera*. No less than 25 000 date palms grow in the oasis of Ounianga Kebir. The fauna of these lakes has not been adequately studied. The invertebrates are also not well studied, but the area abounds with mosquitoes. Among fishes, two species have been collected in the ponds, *Haplochromis bimaculatus* and *Oreochromis galilaeus*.

Human Impact & Utilisation: There is intensive date growing in the area. However, many of the ponds are undisturbed and almost totally occluded by plants. Cattle are taken to the lakes for water and grazing. Salt (natron) *is* extracted from Lake Jua.

Conservation Status: Unprotected.

Wetland Name: Rock Pools of the Ennedi Massif

Country: Chad

General: The western edge of the Ennedi Massif is deeply gullied and its gorges are forested, by contrast with its bare desert surface. Rain falls chiefly as a result of thunderstorms in July and August and is often very intense. At these times flow in the oueds is torrential and erosion of the surface sandstone occurs freely with the production of canyons 10 - 100 m deep. Being narrow these tend to conserve surface water after the flood has passed. For example, at Archei (16°54'N/21°46'E) there is a north facing gorge 1.5 km long opening out of the escarpment, with 6 large ponds (gueltas) joined by swampy strips. These are all fed by permanent springs at the head of the gorge. At Beskere (16°30'N/22°15'E) a 2 km long gorge opens to the west out of the escarpment. A number

of springs at the head of the gorge fill a large guelta, several hectares in extent, and this overflows to a stream which then traverses a series of smaller ponds all the way down the canyon to a *Hyphaene thebaica* forest on the sands at the canyon mouth. Discharges from the springs at Archei have been measured as 600-700 m³/day, while those at Beskere produce upward of 1000 m³/day (Gillet 1957). There are many small pools with rocky bottoms along the other gorges of the lower, western part of the Ennedi Massif.

Flora & Fauna: The gorges contain dense riparian forest typical of areas farther south which receive at least 600 mm rain/yr. The pools are fringed by species of *Cyperus*, *Juncus*, *Phragmites*, *Scirpus* and *Typha*, and *Nymphaea* and *Potamogeton* spp. grow in them. The forest contains *Acacia nilotica*, *A. seyal*, *Adina microcephala*, *Balanites aegyptiaca*, *Boscia angustifolia*, *Ficus ingens*, *F. populifolia*, *F. sycomorus* and *Vitex doniana*. The algal flora appears to be transitional between that of Lake Chad and that of the Sahara (Compere, 1970). The invertebrate fauna is improperly known but it certainly includes mosquitoes and *Caradina africana*. Among the fishes, *Barbus apleurogramma* (also in Lakes Victoria & Tanganyika), *B. inacrops*, *Coptodon zillii*, *Labeo tibestii* (endemic to the Ennedi-Tibesti region) and *Oreochromis galilaeus* have been recorded and a species of *Clarias* is common. *Xenopus mulleri* (a tropical species) is common in the gueltas, and there are other unidentified amphibians. *Crocodylus niloticus* survives here in substantial numbers. Many migrating birds come to the gueltas, as do *Acinonyx jubatus*, *Hyaena hyaena*, *Panthera leo*, *P. pardus* and *Papio cynocephalus*.

Human Impact & Utilisation: Nomads utilise the water of the pools for domestic purposes, but the area is effectively uninhabited. There were permanent settlements here 6000 years BP.

Conservation Status: Extremely isolated and undisturbed. Several of these ponds are protected in the Fada Archei Faunal Reserve (16°35'-17°15'N/21°10'-21°32'E). Animals protected in the reserve include *Acinonyx jubatus*, *Addax nasomaculatus*, *Ammotragus lervia*, *Felis caracal*, *Gazella dorcas*, *Orycteropus afer* and *Struthio camelus*.

Wetland Name: Lake Fitri

Country: Chad

General: Lake Fitri (12°41' -13°00'N/17°24' -17°38'E) measures 35 km in length, oriented NW-SE, and has a maximum width of 20 km. It is 290 m asl at low water and has an open water surface which fluctuates markedly. Because the lake receives its water from northern, semi-arid catchments, where annual variations in rainfall are great, and because its basin is remarkably shallow, annual changes in its area may be very great. It has possibly covered an area of 130 000 ha in some very wet years, e.g. 1870, and it dried almost completely in 1901 and 1973, but its 'normal' area is about 50 000 ha at low water when it has a 150 km perimeter. There are a number of permanent swamps around its 'normal' margin, and it is set on a seasonally inundated plain fed by the Batha, which drains the central part of the Ouaddi Massif and flows for 3-4 months of the year. It also receives water from several short streams which flow north from the Guera Massif. The lake is endorheic, but at times of high water it overflows onto the floodplain, and during an exceptionally high flood its waters may be carried south by the Batha de Leiri into the inundated lands of the Bahr Erguig, a part of the Chari system. Annual variations

in water level are usually of the order of 1.5-2 m, peaking in October and falling to a minimum in May.

The lake water is fresh, with salinities below 0.8700, well mixed and well oxygenated, but generally rather turbid with Secchi depths of 20-65 cm. The permanent swamps on the lake fringes are dominated by *Phragmites mauritanus* and there are large stands of *Echinochloa stagnina* and *Vossia cuspidata* on the edges. *Aeschynomene elaphroxylon* and *Mimosa pigra* are common in less deeply inundated places, while *Ceratophyllum demersum*, *Nymphaea* and *Potamogeton* spp. are abundant in the water. Many fish species are adapted to survive the dry season in the swamps, e.g. *Clarias anguillaris*, *C. lazera*, *Gymnarchus niloticus* and *Protopterus annectens*. The avifauna is as described in the regional introduction for floodplains and swamps. *Pelecanus onocrotalus* is sometimes present in large numbers. Crocodiles have been hunted to extinction, but *Loxodonta africana* is still present and may browse on the marginal vegetation.

Human Impact & Utilisation: The lake is fished intensively yielding a mean annual catch in excess of 3000 tonnes. The surrounding floodplains are heavily grazed by domestic cattle, and are utilised for the recession cultivation of crops locally, but the lake itself is almost undisturbed. Bilharzia is common in the local population.

Wetland Name: Lake Firo

Country: Chad

General: This small lake, 15 km long and up to 7 km wide, is situated 10°05'N/19°25'E) some 5 km north of the Bahr Salamat, with which it is more or less continuous at high water. It is 387 m asl at low water and then has an area approaching 10 000 ha. A floodplain is continuous between the lake and the river, but the northern lakeshore is not extensively flooded. The lake is fringed by dense herbaceous vegetation.

Human Impact & Utilisation: It is an important fishing centre, yielding 1000 tonnes/yr, while a further 1000 tonnes/yr is caught on the floodplain immediately to the southwest of the lake.

Conservation Status: The lake is included in the Bahr Salamat Faunal Reserve.

Wetland Name: Lake Fianga

Country: Chad

Coordinates: 9°46'-10°10'N/15°11'E

Area: 11 900 ha (7140 ha in Chad)

Altitude: 323 m asl (high water)

Nearest Towns: Bongor (15 km NE); N'Djamena (225 km N)

General: Lake Fianga spans the border with Cameroon and is situated in permanent swamps of the Mayo Kebbi Depression. A channel connects the northern end of the lake with the Logone River and another connects the southern end with an affluent of the Mayo Kebbi. Water flow in the northern channel is reversible and thus the lake effectively lies on a watershed between the Lake Chad and Niger Basins, as the Logone flows down to Lake Chad and the Kebbi flows to the Benoue, a tributary of the Niger. The swamps, which lie to the east of the lake receive most of their flood water from the Logone and drain into Lake Fianga, the level of which varies

by about 3 m in the course of a normal year. Fianga is a shallow lake, with a maximum depth of 4 m during low water (June-July), but the mean low water level varies by as much as 2 m from year to year.

Human Impact & Utilisation: The lake is fished quite intensively, and manatees, which are now extremely scarce in the Mayo Kebbi, have been hunted to virtual extinction.

Conservation Status: Unprotected.

Wetland Name: Lake Tikem

Country: Chad

General: This lake is situated on the Mayo Kebbi (9°50'N/15°05'E). Its water surface fluctuates between 320-323 m asl during the course of a year, while its surface area ranges from 1500-6200 ha. The maximum recorded depth is 5 m at low water. Low water is from May to June inclusive and high water from September to October. The forests which occurred on the periphery of the floodplain have been very largely cleared, but the remnants include *Acacia albida*, *A. seyal* and some gallery forest species such as *Khaya senegalensis*.

Human Impact & Utilisation: Rice is grown in the seasonally inundated zone around the lake and the waters are fished intensively.

Conservation Status: Unprotected.

Wetland Name: Lake N'gara

Country: Chad

General: Lake N'Gara (9°55'N/14°44'E), part of the Mayo Kebbi system, has a water surface that fluctuates by about 4 m each year, from 319-323 m asl. Its area changes with these fluctuations from 4000 -14 200 ha, and maximum depth does not exceed 4 m at low water. Rice is grown on the seasonally inundated plain and the lake is fished intensively. Some open forests occur around the lake, with several species subject to inundation including *Acacia albida*, *A. seyal* and *Khaya senegalensis*.

Wetland Name: The Lere Lakes

Country: Chad

General: These two lakes are about 234 m asl at low water and are situated on the Mayo Kebbi on the Chad/Cameroon border. The two basins are situated one east and one west of the town of Lere (9°41'N/14°17'E). The western basin, known as Lake Lere, measures 14.5 km in length and has a maximum width approaching 4 km. It has a maximum depth of 8 m and a mean depth of 4.5 m at low water, when it covers 4100 ha. The eastern basin holds Lake Trenè, which is 6 km long and 2 km wide. Both lakes are oriented E-W and both expand considerably at high water. Flooding in both lakes is bi-modal; local precipitation leads to a peak in August and a second flood comes down the Mayo Kebbi in October.

Both lakes are isolated from Lakes N'Gara, Tikem and Fianga, situated upstream on the Mayo Kebbi, by the Gauthiot Falls. The fish fauna of the Lere Lakes reflects this, showing great affinity with that of the Niger, while the faunas of the upstream lakes have their greatest affinity with that of the Chad Basin. Species which frequent muddy bottoms in

the Lere Lakes include *Brienomyrus niger*, *Hyperopisus occidentalis*, *Mormyrus rume* and *Pollimyrus isidori*, while those that frequent rocky bottoms include *Labeo coubie*, *Mormyrops deliciosus* and *Petrocephalus simus*. *Crocodylus niloticus*, *Hippopotamus amphibius* and *Trichechus senegalensis* are present.

Human Impact & Utilisation: Rice is grown in the seasonal inundation zones on both lakes, and both are fished.

Conservation Status: Both lakes are included in the Binder-Lere Faunal Reserve.

6. Wadis & Oases of the Tibesti Massif

Wetland Name: Wadis & Oases of the Tibesti Massif

Country: Chad

General: Although much of the Tibesti Massif receives less than 20 mm rain/yr some spectacular canyons leading out from it carry intermittent rivers (enneris). Most of these support vegetation, and pools of water persist for long periods in their upper gorges. A number of oases lie along the course of the Enneri Yebige which drains north into the Libyan desert, and these are virtually unexplored. The longest enneri, the Enneri Tijitinga, extends almost 400 km south from the western end of the Tibesti before petering out in the sands north of the Bodele Depression. Immediately east of this the Enneri Miski is the major southern effluent. It *is* fed by several streams from the western flanks of the Emi Koussi and by others from the eastern flanks of Tarso Kobour including the Enneris Korom and Aouei. Its waters also flow beneath the sands towards the Bodale Depression. Several other watercourses drain the Emi Koussi in radial fashion, from southwest to southeast, and disappear in the Borkou, a sandy basin between the Tibesti and Ennedi Massifs. From them subterranean water finds its way to the Borkou Pools (discussed later). Above 2000 m the beds of most enneris contain strings of pools, often connected by flowing water, and most of these too, are unexplored. The water of the enneris is of low salinity. The gueltas are flushed by floods several times a year and never become very saline. Many of the pools are fringed by macrophytes, including *Cyperus laevigatus*, *Equisetum ramosissimum*, *Juncus fontanesii* and *Scirpus holoschoenus*, and most contain fish; *Barbus anema*, *B. apleurogramma*, *B. batesi*, *B. deserti*, *Barilius* sp., *Clarias gariepinus*, *Coptodon zillii*, *Labeo annectens*, *L. niloticus*, *L. tibestii* (endemic to Ennedi & Tibesti regions), *Oreochromis borkuanus* and *O. galilaeus* have been recorded from the Tibesti.

Wetland Name: The Mare De Zoui

Country: Chad

Coordinates: 21°20'N/17°05'E

Area: a few hectares

Altitude: c. 600 m asl

Nearest Towns: Bardai (10 km S); Faya-Largeau (420 km SE)

General: This permanent lake, on the northern flanks of the Tibesti, is situated in the valley of the Enneri Bardagè, which in its upper reaches, is often referred to as the Enneri Zoumeri. The narrow lake is supplied by springs at the head of the gorge. After rain it

overflows and a small stream cascades and trickles down the gorge through small marshy patches and pools.

Flora & Fauna: The lake is fringed by dense stands of *Phragmites* and *Typha*, possibly *P. australis* and *T. capensis*, and the open water supports *Potamogeton* spp. The phytoplankton appears rich but has not been properly described. On the fringes of the massif, farther down the enneri, where there is no surface flow and the water table may be 7-8 m deep, *Salvadora persica* and *Tamarix articulata* both grow. *Tamarix* is dominant, often forming a dense strip along the lowest part of the wadi. Higher up and farther into the massif, near the guelta, *Tamarix* is replaced by stands of *Acacia nilotica*. *Hyphaene thebaica* grows sporadically at the mouth of the gorge. Neither amphibians nor fish have been recorded in the gorge, but this does not mean that they are absent.

Human Impact & Utilisation: Little use is made of the guelta and it is seldom visited, although an oasis farther out onto the plateau is used for horticulture, date production and watering domestic animals.

Conservation Status: Unprotected.

Wetland Name: The Oases of Borkou District

Country: Chad

General: The plain of Borkou slopes gradually away from the feet of Emi Koussi, towards the south, in places descending by little scarps. Precipitation is negligible here and surface water is soon absorbed, despite which little ponds and springs arise at the feet of tiny scarps which are scattered over a wide region. These water sources all support small settlements, e.g. those at Medimi (19°04'N/18°28'E), Douki (18°50'N/18°56'E), Yarda (18°30'N/19°01'E), Tigui (18°38'N/18°47'E), Berchi-Guele (18°16'N/19°43'E), Faya Largeau (17°59'N/19°07'E) and Galakka (18°05'N/18°25'E). All these places are within 400 km of Emi Koussi, and it is believed that water from the southern Tibesti travels underground to these sites where it emerges at springs. In addition to these oases there are numerous areas of humid sand which have a high water table throughout the year.

Flora & Fauna: Open ponds are fringed by reeds and *Typha domingensis*, with *Juncus maritimus*, *Phragmites australis* and *Scirpus laevigatus* on saline areas that develop around the ponds as a consequence of seasonal water fluctuations. Other hydrophytes associated with the ponds, and patches of marshy soils are *Epilobium mirei*, *Heleocharis tibetica*, *Helosciadium mauritanum*, *Kosteletzkia borkuana* and *Lotus borkuanus*. Only two fishes have been identified in the pools, *Epiplatys senegalensis* and *Oreochromis borkuanus* (endemic).

Human Impact & Utilisation: The oases are exploited intensively throughout the Borkou region. The springs are augmented by many artificial wells and bores, and there is a deal of small scale irrigation gardening. Cattle, goats and camels are watered at the centres, of which only about half have been cited. There are comparatively large plantations of *Phoenix dactylifera* in the areas of moist sands, but *Hyphaene thebaica* and other native vegetation still survives.

Conservation Status: Unprotected.

Wetland Name: Other Oases

Country: Chad

General: There are numerous other oases around the Tibesti on both the western and northern sides, e.g. at Zouar (20°26'N/16°31'E). Where these oases are accessible, and not infested by mosquitoes, their natural vegetation of *Acacia*, *Ficus*, *Hyphaene* and *Tamarix*, tends to have been replaced by *Phoenix dactylifera*. Communities have developed at several sites, sustained by date production and small scale horticulture, using traditional methods of irrigation. Generally goats and camels are kept at these places, and occasionally sheep. In addition, the pools of the oases are fished.