CHAD

Area: 1,284,000 km^2

Population: 4.79 million (United Nations estimate, 1983)

I. BACKGROUND

Natural regions

The territory of Chad covers the eastern half of the Chad basin. Viewed as a whole, the Chad basin has two parts of unequal size. The larger, northern part extends over several countries. It lies between the Jos plateau (Nigeria) and the Air (Niger) in the west, the Tibesti in the north, the Ennedi and the Ouaddai in the east, and the Mandata mountains (Cameroon) and the Guéra massif in the south.

The southern part lies almost entirely in Chad between the Mandata mountains and the Pala plateaus in the west, the Oubangui ridge in the south (from the Yade mountains to the Jabal Mela), and the Birao ledge and the Guéra massif in the east and north.

The lowest part of the whole basin is in the north-east sector in the Djourab and Bodelé country (155 to 180 m in altitude). The present Lake Chad occupies a higher position (about 280 m). It is held at this altitude by the dune dam of the Kanem erg. The bed of the Bahr El Ghazal or Soro, which formerly ran from the lake as far as Djourab, no longer contains water in the present climate. The relief in Kanem, Eguey, Toro and Djourab consists mainly of dune formations. The alternating dunes and depressions create a monotonous landscape with differences of altitude of only 30 at the most. The mountain massif of the Tibesti has volcanic peaks which provide the highest points (Emi Koussi - 3,415 m, Toussi - 3,315 m) and the high plateaus of Tarso at 2,000 to 3,000 m.

The eastern edge of the basin rises steadily in gentle glacis to the crystalline massifs of Ouaddai. The depositional glacis in the centre of the basin have varying degrees of induration or are covered with dune formations; further east they merge gradually into erosional glacis, at first thinly covered but then bare at the edge of the massifs. The crystalline formations rise sharply above the glacis in inselbergs. The Guéra massif (central Chad massif), where Mt. Guédi in the Abou-Telfane rises to 1,508 m, presents the same aspect of mountains raised above the surrounding heavily cuirassed glacis and running towards Lake Fitri in the north-west, the Chari plains in the west, and the Salamat plains in the south and south-east. In the south the area of the Chari and Logone basins consists of low sandclay plateaus (the Koros) and depositional flood plains. There is no apparent variation in the relief except in the rainy season when it is easy to distinguish the flooded from the unflooded land.

The Koros rise slowly to the southern edge of the crystalline rock. A wide rock pediment stands out 500 to 600 m higher, with residual relief of the inselberg type. The spurs of the Yade massif (Lam mountains) rise sharply from these erosional glacis.

The southern, central and eastern glacis are often covered with ferruginous crusts which protect the relief and prevent the reestablishment of the vegetation.

The plains of the lower Chari and lower Logone slope imperceptibly down to Lake Chad. The only inhabitable spots are small bluffs on the banks of the watercourses at the top of which are perched villages which escape the annual floods.

The lake itself is held back in the north by the Kanem dunes; it works its way between the dunes and forms a large number of oblong islands at its north-eastern edge.

Climate

Chad has a very varied climate. There are three main climatic zones, from south to north:

Sudanese zone

This zone extends roughly from 7°5' to 10° n; it has heavy rainfall with an annual average of 1,000 to 1,400 mm. The population is sedentary and agriculture well developed, with food and cash crops: millet, sorghum, groundnuts and cotton.

The heavy rainfall produces the following annual variations in temperature:

- In January the maximum temperature is about 30°C, while the minimum varies from 15°C to 20°C, producing an average of about 25°C;
- In March the zone is slightly hotter with an average of around 35°C;
- July the weather becomes very rainy and the air quite humid; the minimum temperature is about 20°C;
- In November, the last month of the rainy season, the temperatures rise to a maximum of 35°C, with a minimum of 18°C, while the daily averages range from 20.5°C to 20°C. Owing to the heavy rainfall the evaporation is less heavy in this zone that in the rest of the country. It is in the order of 1,900 mm/year.

Sudano-Sahelian zone

This zone extends roughly from 10° to 11°50' N; it receives less rainfall that the Sudanese zone. The annual rainfall of 700 to 1,000 mm makes it suitable for certain food crops, mainly millet, sorghum and groundnuts. Livestock is also fairly well developed. The population thus consists of herdsmen and farmers.

The annual temperature variations are roughly the same as in the Sudanese zone.

- In January the maximum temperature is about 30°C and the minimum between 15°C and 20°C, producing an average daily temperature of about 25°C;

- In March the weather becomes hotter. The maximum temperature is about 38°C and the minimum about 20°C, with a daily average of around 30°C.

- In July the weather is fairly mild owing to the atmospheric humidity and the rainfall. The maximum temperature varies between 25°C and 30°C, while the minimum remains above or at 20°C; the average temperature is around 25°C;

- In November the weather is slightly milder than in July. The maximum temperature is about 35°C and the minimum between 15.5°C and 18.5°C, with an average daily temperature of between 20°C and 15°C. The evaporation is about 2,100 mm/year.

Sahelian zone

The Sahelian zone extends roughly from 11°5 to 14° N and the rainfall is only 200-700 mm. In the north, in the Borkou-Ennedi-Tibesti desert (BET), the total annual rainfall is below 500 mm. The Sahelian zone has more herdsmen than farmers. Only early crops are grown here. The people are mainly herdsmen, in constant search of watering places and pasture for their livestock. The annual temperature variations are almost the same as in the Sudano-Sahelian zone. The great heat causes considerable evaporation of surface water and transpiration from plants. The annual evaporation in this zone is around 2,200 to 2,300 mm.

The BET desert region in the far north has very great temperature variations during the year. For example, in January the maximum temperature ranges from 17.5°C to 27°C, while the minimum temperatures are below or at 13°C - 15°C, with daily average of 10°C to 20°C.

In contrast, it is very hot in July. The maximum is above 40°C and the minimum about 25.5°C.

In November the weather is cooler with a maximum temperature of 22.5°C to 27.5°C and a minimum of about 17.5°C; the daily averages range from about 17.5°C to 22.5°C.

The po;ulation of this zone consists mainly of nomadic camel herdsmen.

II. SURFACE WATER

Permanent watercourses

The Republic of Chad is drained by two main rivers, the Chari and the Logone, which are fed mainly by tributaries outside the country.

The Chari, upstream of its confluence with the Logone, receives the following tributaries:

Right Bank	Left Bank
Bahr Salamat	Bahr Illi (Padjouek)
Bahr Keita	Bahr Sara
Bahr Aouk	

The Bahr Sara, just above the Manda bridge (on the Bahr Sara) receives a largeish tributary, the Maudoul, and on its right bank, a few kilometres before it joins the Chari, the Bahr Ko.

The flows, the highest levels and the area of the catchment basin for the various hydrometric stations, from upstream to downstream on the Chari, are as follows:

Station	Catchment basin (km^2)	Annual flow (m^3/s)	Year	Highest level (cm)	Crest flow (m^3/s)
Saha	193,000	326	1961	725	2,090
Heli-Bongo	217,000	243	1962	710	-
Bousso	450,000	945	1961	610	3,980
Mailao	500,000	946	1961	750	4,220
D'Djamene	600,000	1,280	1961	910	5,160

Source: Monographie du Tchad and Annuaire hydrologique de la Republique du Tchad 1977-1978.

Tributaries of the Chari

Station	Watercourse	Catchment basin (km^2)	Year	Highest level (cm)	Crest flow (m^3/s)
Baibokoum	Logone	21,360	1956	785	
Moundou	Logone	34,900	1956	630	3,640
Lai	Logone	56,700	1955	605	3,730
Tarangara	Bahr Salamat	135,000	1961	560	93
Kyabe	Bahr Keita	14,000	1964	740	545
Golonoosso	Bahr Aouk	96,000	1962	580	968
Manda	Bahr Sara	79,600	1955	750	3,670

Source: Annuaire hydrologique de Tchad 1977-1978.

The Logone is the largest tributary of the Chari; above its confluence with the Chari (at N'Djamena) it receives the following tributaries:

Right bank	Left bank
Ba - Illi	Tangilé
Pendé	Nya
Lim	

During the high-water period at Bryor and Ere the water of the Logone is captured by the rivers of the Benoue basin - Mayo Kebi and the Kabia.

Tributaries of the Logone

Station	Watercourse	Catchment basin (km^2)	Year	Highest level (cm)	Crest flow (m^3/s)
Bologo	Tandjilé	-	1969	780	210
Argao	Nya	-	1970	620	415
Moulkou	Ba-Illi	-	1970	545	-
Gore	Pendé	-	1970	670	1,060

Source: Annuaire hydrologique du Tchad 1977-1978.

Lake Chad

Lake Chad is the country's main water resource. Its basin is one of the best known in Africa, for it has been the subject of many studies.

Lake Chad is situated in the Sahelian zone and is fed by three rivers, two of which are not in Chad (Komadougou Yobé in Nigeria and El-Beid in Cameroon) and have much smaller flows than the Chari. In an average year the total recharge is about 50 billion cubic metres. In a normal year the hydrological balance of Lake Chad is as follows:

Recharge from the Chari-Logone system;	43.25×10^9 m^3
Recharge from other rivers;	1.92×10^9 m^3
Rainfall on the lake;	7.25×10^9 m^3
Total	52.42×10^9 m^3
Evaporation from the lake	49.95×10^9 m^3
Losses through infiltration	2.47×10^9 m^3

In the period of mean flow the Chari-Logone system delivers 40×10^9 m^3. After the severe drought in 1972-1973 the total recharge was only about 25×10^9 m^3 (Annuaire hydrologique 1977-1978 .

After the highest water level observed at the N'Djamena measuring station (Public Works station) in 1961, the following flow characteristics were recorded:

- Water level 9.10 m
- Flow 5,160 m^3/s
- Mean annual flow 170 m^3/s
- Flow volume 53.7×10^9 m^3
- Total stocks 10.5×10^9 m3

The area of the lake under water is 23,500 km^2.

The sediment discharge in the lake varies between 2 and 2.6 million tons a year.

In addition to Lake Chad there are six other less important lakes:

- Lake Fitri (Batha prefecture) which has a catchment basin of 1,300 km^2 and is fed by the River Batha;
- Lake Iro in Moyen-Chari which has a catchment basin of 455 km^2 fed by the crest waters of the Bahr Asoum;
- The lakes (Tikem, Fiangat and Léré) in Mayo Kebbi which are fed by the Kabia (Tikem-Sianga) and Mayo Kebbi (Léré).
- Lake Ounianga in Borkou-Ennedi-Tibesti.

Seasonal watercourses

In the north of the country, especially in Ouaddai, all the watercourses (wadis) flow for only a few hours after heavy rain. The main wadis are the Rimé, Karmé and Enné. The Bertha and its tributary the Nelmele flow only from July to October.

III. GEOLOGY

The most ancient Precambrian rocks, with an average age of about 1,000 million years, are found around the edges of the country; these are the granitic and crystallophyllitic rocks of the Tibesti and the Ouaddai and the Lam mountains in the south. They also emerge as more recent sediments in some places in the middle of the basin. It is thought that the Chad basin is broken up into a series of small parallel basins which can be identified from the general orientation of the crystalline ridges (north-north-east/south-south-west and west/north-west).

Soundings and aeromagnetic prospecting indicate that the basement rock is regular and slopes gently towards the south-west to the western frontier of Chad. The Tibesti sandstones which form the Tarsos in the interior of the massif also belong to the Precambrian period.

The Paleozoic series (Cambrian-Ordovician, Devonian and Carboniferous) appear only in the north of the country in Borkou and Ennedi where they form

large sandstone tables. The deposits are contemporary with the first manifestations of life, witness the fossils of animal and vegetable organisms (bilobates and harlania of the Tassilian sandstones, fish of the Carboniferous period).

The Mesozoic period is little represented in Chad. In northern Ennedi the Erdi sandstones are probably contemporary with the Nubian sandstones. In the Mayo Kebbi region the Lame series marks the most eastern extension of the marine transgression through the Benoue trench (Cenomanian).

Apart from the Eocene marine deposits in northern Tibesti, the Tertiary formations in Chad are mainly continental terminal. The continental terminal has been thoroughly studied in southern Chad where it covers a large part of the basins of the Logone and Moyen-Chari; it includes:

- A middle series of red sands;

- An upper series with varying degrees of crust.

The continental terminal series are well preserved only in the regions where they were protected by indurated formations. The interfluvial areas known as Koras became cuirassed during the Quaternary period.

The main layer of this cuirass runs from the southern crystalline rock to the Mayo Kebbi region. It is also found around the central massif of Chad as far as the Ouaddai.

Quaternary formations occupy most of the Chad basin. The studies carried out by ORSTOM and BRGM have dated these formations fairly accurately. The chronology of their deposits is identical with the variations in the level of Lake Chad resulting from climatic changes over the past million years. The wet periods favoured the deposition of diatomites and clays, the periods of alternating seasons produced more sandy deltaic deposits, while the dry periods led to the formation of sand dunes.

The most ancient lacustral extension of the Quaternary period reached Borkou in the north, Ouaddai and the central massif in the east, and in the south the region of the Koros and the crystalline shelf of Mayo Kebbi across which the waters of Paleo-Chad were repeatedly poured towards the Atlantic in the Bénoué. The deposits corresponding to this extension form a clay-sand series with limestone concretions. A shift to a dryer climate caused the lake to retreat and produced the first delta of the Chari and the deposition of sand dunes which is most visible in Cameroon and Nigeria.

The second extension of the lake (wet period) is marked by the line of the lacustral belt at the 320 m contour. During this period the direction of discharge of the Benoue was reestablished through the Toubouri lakes, and the Recent clay series was deposited. The second delta of the Chari was formed after the retreat of the lake.

The last transgression is delimited by the sand belt at an altitude of 278-290 m.

The present delta of the Chari is the result of the retreat of the waters of the lake to their present limits.

IV. HYDROGEOLOGY

The Quaternary formations are of complex and varied composition, and they can range from pure sand to sand with a very marked clay content; they can also be of a clearly kaoline type (for example, the Koro de Lai aquifer, where the water circulates through tiny channels).

These abrupt variations in the clay or sand content are very common, and the Quaternary sediments usually take the form of overlapping lenticular units.

The three main groups of aquifers in Chad are:

- The "sanies" aquifer in northern Bastra;

- The Chari-Baguirmi aquifer;

- The shallow "Oudian" aquifer in Kanem.

In addition to these three large aquifers, there are two other types of aquifers:

- The aquifers of the Koros and the southern region;

- The fragmentary aquifers, usually underflows of the granitic regions.

The "Koros" aquifers in the south

The recharge of the sanies aquifer comes partly from the underflows of the alluvial valleys of the Ouaddai and Batha massifs and their ancient beds. Most of the water probably comes from rainfall, which infiltrates swiftly in these very sandy regions.

Chari-Baguirmi aquifer

This region has a succession of compact and very flat clay-sand formations dotted with small higher areas of dunes or with clay depressions which are flooded in the rainy season and which increase in size further south. The average depth of the Chari-Baguirmi aquifer is 35 to 40 m. In the north-west and west the aquifer rises to a depth of about 20 m as it draws closer to Lake Chad, the Chari and its tributaries (Bahr Ligua).

In the south-west and south lie the flood areas of the Chari and its eastern tributaries. In view of the abundance of surface water in this area, the inhabitants have never had to dig wells.

Kanem aquifer

The recharge of this aquifer is fairly complex: most of the recharge is contributed by Lake Chad through its spreading grounds at the southern edge of Kanem; the rainfall must also supply very large quantities of water, for it infiltrates very easily in these sandy formations.

In the northern part of Kanem a study of the chemical properties of the water seems to indicate a very large recharge from the southern slopes of the Tibesti (rainwater and condensation) and from the north-west slopes of the Ennedi.

A feature of the water of the Kanem aquifer is its heavy concentration of sodium salts (carbonates and sulphates), but these salts do not occur everywhere.

At the edge of the Batha and Kanem regions, in Harr and Guetty, there is an aquifer which lies no more than 10 m deep.

Aquifer of the Koros and southern region

The region of Chad south of the 11th parallel N is well watered by a sufficiently dense hydrographic system and the problem of water does not arise; most of the villages take their supplies directly from the Chari and the Logone or their tributaries. Very productive underflow aquifers are found at shallow depths in the valleys of these watercourses.

On the borders of the Koros the aquifer is clearly larger, for its storage rock consists of beige sands separated by an episodic stratum of lateritic cuirass.

Aquifers of the granitic regions

These are local underflow aquifers in the deep valleys of the granitic massifs; the ground water flows very easily through the coarse granitic sands, from which good yields can be obtained.

To sum up, there exists throughout Chad a number of large aquifers which should make it possible to develop the areas which are at present virtually uninhabited and uncultivated.

V. GROUND-WATER RESOURCES

The main technical services for water resources are the Hydrological Service and the Water Office, both under the authority of the Department of Water Resources and Meteorology (Ministry of State for Agriculture and Rural Development). The Water Office has specific responsibility for the study and evaluation of ground water and it performs the following functions:

- Compilation of ground-water files;
- Direction of ground-water research and exploitation;
- Planning of water resources development;
- Preparation of ground-water research and exploitation projects and market studies for the water-supply works for towns, villages, industries and suburban districts;
- Control of drilling and digging operations for ground-water reconnaissance and exploitation;

- General study of the country's ground-water aquifers to obtain better knowledge of the available resources and their exploitability;

- Participation in urban sanitation studies;

- Briefing of visitors interested in ground-water problems.

From 1950 to 1979 the Water Office carried out several hydrogeological studies financed by FAC and EDF. This produced a better overall picture of the country's situation with respect to ground water and its exploitability. However, these studies were not always taken as far as necessary. They were conducted by expatriates, usually furnished by French technical co-operation as the country had almost no national specialized staff. A policy for training national staff was established to cope with this problem.

Most of the prospecting was by electrical sounding.

The ground-water resources consist essentially of the resources of the large area of shallow groundwater known as the Chad basin and of the stocks of the subsurface aquifers.

The aquifer of the Chad basin is the most heavily exploited. All the wells and 80 per cent of the boreholes tap the water of this aquifer, which has a fairly good recharge and extends over almost all the country, except for the mountain regions of BET, Ouaddai and Guéra and other areas where the basement rock outcrops. There are two hydrogeological units: one in the north, the Lowlands of Chad, drains the waters of the Kanem, the Niger aquifer and the BET aquifer; the other, in the south, is recharged by the waters of Lake Chad, the Chari and the Logone and the Chari-Baguirmi horizon.

The two units are separated by the ground-water watershed which starts from Chittati, passes close to Ati and ends at Abéché.

The southern unit can be subdivided into smaller units, including the Koros and Logone horizons.

The Chad basin has two recharge zones: internal and external.

The external zone consists of the mountainous regions of the Hoggar, Ouaddai, Dargour, etc.

The internal zone consists of the Lake Chad synclines where the rainfall is heavy. It has a good recharge from surface water: lakes, the Chari and the Logone and other watercourses. However, apart from the Bahr Azoum, the watercourses of southern Chad drain the aquifer; this phenomenon ceases below Kim in the case of the Logone which begins to recharge the aquifer, and below Niellim for the Chari. The reason for this in the case of the Chari is that after Bousso the river flows only over clay alluviums; from N'Djamena to the lake the two watercourses recharge the aquifer. The Batha recharges the aquifer as far as Ati. The waters of the lake itself seem to feed the neighbouring regions, in particular the Chihati aquifer and the Batoum-Ammak depression. The water of the basin is mostly calcium bicarbonate or calcium and sodium bicarbonate, sometimes with heavy sodium concentrations

in areas of heavy evaporation. The mineral content of the water is 1-3 g/l, sometimes as high at 6 g/l.

The basin has a series of aquifers with different hydrogeological properties formed by the following geological formations, which may contain confined aquifers:

- The Pliocene-Quaternary formation in the central part of the basin where several aquifers can be distinguished: a Pliocene aquifer in the Koro region with alternate strata of fluvial-lacustral sedimentations and dunes, and an Early Quaternary lacustral aquifer in Moji.

The water-bearing rocks of the Pliocene-Quaternary formation are up to 500 m thick and they have good permeability. In the lower levels of this series, which also consist of sands, a confined aquifer known as the "middle pressured aquifer of the Chad formations" offers excellent resources around the lake, where it is artesian.

The depth of the top of the aquifer varies from 250 to 350 m.

The water of this aquifer has a low mineral content; yields of 2 1/2 are obtained from the wells.

- The continental terminal contains argillaceous sandstones and sands covering vast areas:

- In the north from the Lowlands to Batha, where the traditional wells (sanies) sometimes have to be 80 m deep to reach the aquifer;

- In the south of the country, where this formation includes a ferruginous cuirass altered by erosion.

This aquifer is 100 to 200 m deep. The water has a low mineral content which increases from the south towards the Lowlands. The average yield of the wells is 27.7 l/s.

- The third aquifer consists of arkosic sandstones, micro-conglomerates and calcareous micro-breccias of the lagoonal-lacustral Upper Cretaceous period, which are found only in Mayo Kebbi and have poor permeability. There may be a confined aquifer under the thick surface layer of marls and schists.

These aquifers have so far received little attention owing to the availability of surface water and shallow local aquifers which are more easily exploited.

The external recharge zone contains hardly any water. For example, the Carboniferous marine limestones and the Cambrian kaoline sandstones which form a continuous aquifer in BET have poor permeability. A large part of this area (where the basement rock outcrops) consists of Precambrian fissured granitic rocks of poor permeability. The fissures are less than 50 m in depth.

The boreholes which reach this aquifer at Largeau have yields of about 1,000 m^3/day. However, the traditional method of obtaining water is by means of wells which usually tap the resources of the alluvial horizons.

A large amount of fresh water is contained in these alluvial horizons. In the Saharan zone the ground water is usually found in lenses. In addition to the fresh water resources suitable for domestic use, the country's subsoil contains fairly large stocks of thermal and mineral water.

Although these resources are located far from the big centres, they can be exploited as sources of energy for the neighbouring settlements.

The shallow aquifer is subject to fluctuations depending on the region, the rainfall and the flood waters of the rivers. The results of recent deep soundings (Conoco) seem very promising.

However, the data needed for a reliable estimate of deep resources can be provided only by additional deep reconnaissance soundings.

VI. EXPLOITATION OF GROUND WATER

Government bodies

Ground water is of vital importance for the country's economic and social development. Ground water is extensively used both for drinking water (100 per cent of the urban water supply comes from wells and boreholes) and for pastoral water supplies.

In order to ensure rational and fair utilization of water, the Government established by decree the National Pastoral and Village Water Supply Office (ONHPV) under the authority of the Ministry of Livestock and Pastoral Water Supply.

This body is responsible for the maintenance and replacement of rural water supply installations and the construction and equipment of new installations.

The Office is run by national technicians backed up by expatriates and it is administered by an administrative council chaired by the Director-General of the Ministry of Livestock and Pastoral Water Supply.

As it was established only recently, the Office is still at the stage of internal organization and equipment. It is not therefore possible at present to give an accurate picture of its human and material resources, although they do seem clearly insufficient.

The country's largest drilling company was SOTRAHY, but it departed Chad after the events of 1979.

Utilization of ground water

With almost 6,000 waterpoints, including some 2,000 cement wells and more than 400 wells equipped with pumps, Chad is in a good position compared with other African countries with respect to programmes for the utilization of ground water.

The waterpoints give the following yields:

- 20 m^3/day from a traditional well or a cement well in granitic areas;

- 40 m^3/day from a cement well in sedimentary areas;

- 400 m^3/day from a borehole.

Urban uses

In Chad the urban water supply comes almost exclusively from ground water. However, N'Djamena had developed to such an extent before the events of 1979 that it was planned to take part of the water from the Chari and to treat it for distribution to the consumer; it was thought that in the long term ground water alone would not be sufficient to meet the needs.

With respect to the use of ground water for urban supplies, it must be pointed out that there are only 21 boreholes or wells supplying drinking water for 11 urban centres (N'Djamena, Sahr, Moundou, Abéché, Kelo, Koumra, Doba, Pala, Moussoro, Mao and Fianga). In future years about 10 other urban centres ought to be quipped with a water-supply system. In 1974 8.4 million cubic metres of drinking water were supplied for an urban population of 600,000, i.e. 40 litres a day per inhabitant.

Rural uses

The use of ground water in rural areas depends on the region. In the regions which are sufficiently well-watered, the wells supply water for human consumption, as the animals can be watered directly from pools, lakes and waterholes.

In some regions, particularly north of the 13th parallel N where there is almost no surface water, there are many wells of mixed use. The water points can also be used to supply water to small-scale farming operations. It is common to find small irrigated areas around the wells and it is possible to envisage at the national level the establishment of a system of village irrigation using ground water. For example, a borehole discharging 400 m^3/day can easily irrigate a minimum area of 6 ha. The multiplication of such irrigated areas throughout the country could make a substantial contribution to the efforts to achieve food self-sufficiency.

Industrial uses

The biggest consumers of industrial water are the Sahr textile factory, the Banda sugar mill, the Logone breweries at Moundou, and the 22 mills of Cotton Tchad.

The 1975 water requirement was estimated at 13,000 m^3/day, i.e. about five million cubic metres a year.

Agricultural uses

The current annual requirement for irrigation water for rural development is estimated at about 552 million cubic metres, which would be sufficient for all the irrigated land, i.e. 19,090 ha.

The types of crops envisaged are rice, wheat and sugar cane.

Future needs

An estimate of the future needs for 2000 is given below. This forecast takes into account the growth rates of the population, livestock and irrigated areas.

Domestic needs

The World Bank estimates that by 2000 the population will be seven million and the urbanization rate 6.7 per cent a year. The country's population will be distributed as follows:

Population	1983	2000
Urban	900,000	2,700,000
Rural	4,100,000	4,300,000
Total	5,000,000	7,000,000

According to a document prepared by the Inter-African Committee for Hydraulic Studies (CIEH) entitled "Utilization of water resources and land in the savannah regions", the daily consumption of water in Chad in 2000 will be as follows:

- Rural areas: 50 litres a day per inhabitant;
- Urban areas: 200 litres a day per inhabitant.

The total annual consumption will be as follows:

- Rural areas: about 80 million cubic metres;
- Urban areas: about 200 million cubic metres.

The total domestic requirement will therefore be 280 million cubic metres a year.

Livestock needs

The same CIEH document envisages that the cattle population will stabilize at five million head and the sheep and goats at 10 million head, with 600,000 camels. The average daily consumption of water by livestock is estimated as follows:

20 litres a day per head of cattle;

5 litres a day per sheep or goat;

35 litres a day per camel.

The total quantity of water consumed each year by each category of animal is as follows:

- Cattle: about 40 million cubic metres;

- Sheep and goats: about 20 million cubic metres;

- Camels: about 8 million cubic metres.

This makes a total of about 70 million cubic metres.

Irrigation

The areas suitable for irrigation are distributed by region roughly as follows:

Lac	60,000 ha
Kanem	5,000 ha
Assalé	13,000 ha
Ouaddai (geographical)	1,000 ha
Batha	20,000 ha
Bahr Azoum	200,000 ha
Chari	163,000 ha
Logone	200,000 ha
Total	662,000 ha

The 19,090 ha irrigated at present represents barely three per cent of this total.

The CIEH document envisages that 72,000 ha will be irrigated in 2000 in Chad, i.e. barely 11 per cent of the total area suitable for irrigation and less than four times the area irrigated at present. If this figure is accepted and if 24,000 m^3 is taken as the annual amount needed to irrigate a hectare of land, the total amount of water needed will be about 1.7×10^9 m^3.

On the basis of the estimates given above for population, livestock and irrigation, the water requirement for 2000 can be established at more than 2,000 million cubic metres a year.

VII. PROBLEMS

Shallow ground water is virtually unused south of the 13th parallel N, except in large urban settlements. North of this line, larger quantities of water are drawn off owing to the temporary nature of the waterholes created in the rainy season. In contrast, the degree of exploitation is very worrying on the Kanem and Bathagar plateaus where measurements show the aquifer to be remarkably stable. Recharge by infiltration of meteoric water is very problematical, and the exploitable aquifer must be monitored closely.

Surface and ground water is used for the permanent crops which occupy a total area of 1,652,000 ha and which also make direct use of rainwater; in addition to the 19,090 ha officially inventoried, the irrigation system

also supplies water to a large number of small plots, with the water taken directly from watercourses, waterholes and lakes.

VIII. CONCLUSIONS

Ground water is of vital importance for the country's economic and social development. Ground water is extensively used both for drinking water (100 per cent of the water requirement of the urban centres comes from wells and boreholes) and for pastoral water supplies.

The problem of water is all the more important as Chad is a Sahelian country. The Government is therefore determined to solve it. In the years to come the implementation of a rational water-supply policy will reduce the cost of water, especially in the urban centres, where it is sold at the following rates:

- 0 to 4 m^3: CFAF 77/m^3;
- 5 to 1,000 m^3: CFAF 168/m^3;
- 1,000 to 1,300 m^3 and above: CFAF 77/m^3.

Number of waterpoints inventoried, September 1977

Prefecture	Boreholes	Soundings	Large-diameter wells	Other traditional	Total
Batha	7	56	340	246	649
BET	4	0	18	14	36
Biltine	47	51	93	660	851
Chari-Baguirmi	139	90	389	519	1,137
Guéra	1	14	65	118	198
Kanem	12	0	410	615	1,037
Lac	49	0	0	54	103
Logone occidental	10	13	45	43	111
Logone oriental	2	17	49	116	184
Mayo Kebbi	11	16	216	89	332
Moyen-Chari	69	16	195	278	558
Ouaddai	1	52	97	831	981

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