**CHAD**


Source: esri

## General

Chad - officially the Republic of Chad - is a landlocked country in Central Africa. It is bordered by Libya in the North, Sudan in the East, the Central African Republic in the South, Cameroon and Nigeria in the Southwest and Niger in the West. The area of the country is 128 Mha (million hectares) with, in 2022, a population of 18.9 million, or 0.15 persons per ha (Wikipedia and United Nations, 2022)

## Climate and geography

Most of the country has a desert climate. Each year a tropical weather system known as the intertropical front crosses Chad from South to North, bringing a wet season that lasts from May to October in the South, and from June to September in the Sahel. Variations in local rainfall create three major geographical zones. The Sahara lies in the country's northern third. Annual precipitation throughout this belt is under 50 millimetres. The Sahara gives way to a Sahelian belt in the centre of Chad with precipitation from 300 to 600 mm per year. In the Sahel, a steppe of thorny bushes (mostly acacias) gradually gives way to the South to East Sudanian savanna in Chad's Sudanese zone, with annual rainfall of over 900 mm (source: Wikipedia).

The dominant physical structure of the country is a wide basin bounded in the North and East by the Ennedi Plateau and Tibesti Mountains. Lake Chad in the South-west zone of the country, after which the country is named (and which in turn takes its name from the Kanuri word for lake), consists of the remains of an immense lake that covered 330,000 km$^2$ of the Chad Basin 7,000 years ago. Although in the 21$^{st}$ century it covers only 17,806 km$^2$, and its surface area is subject to significant seasonal fluctuations, the lake is Africa's second largest wetland. The lake is shared by Chad with Cameroon, Niger and Nigeria. Chad is home to six terrestrial ecoregions: East Sudanian savanna, Sahelian Acacia savanna, Lake Chad flooded savanna, East Saharan woodlands, South Saharan steppe and woodlands, and montane woodlands. Chad's major rivers – the Chari, Logone and their tributaries - flow through the southern savannas from the southeast into Lake Chad (source: Wikipedia).

Lemoalle and Magrin (2014) described the situation around Lake Chad. They also showed the irrigation schemes in the Lake Chad Basin (Figure 1). Part of these schemes in the flood prone areas and around Lake Chad are polders.

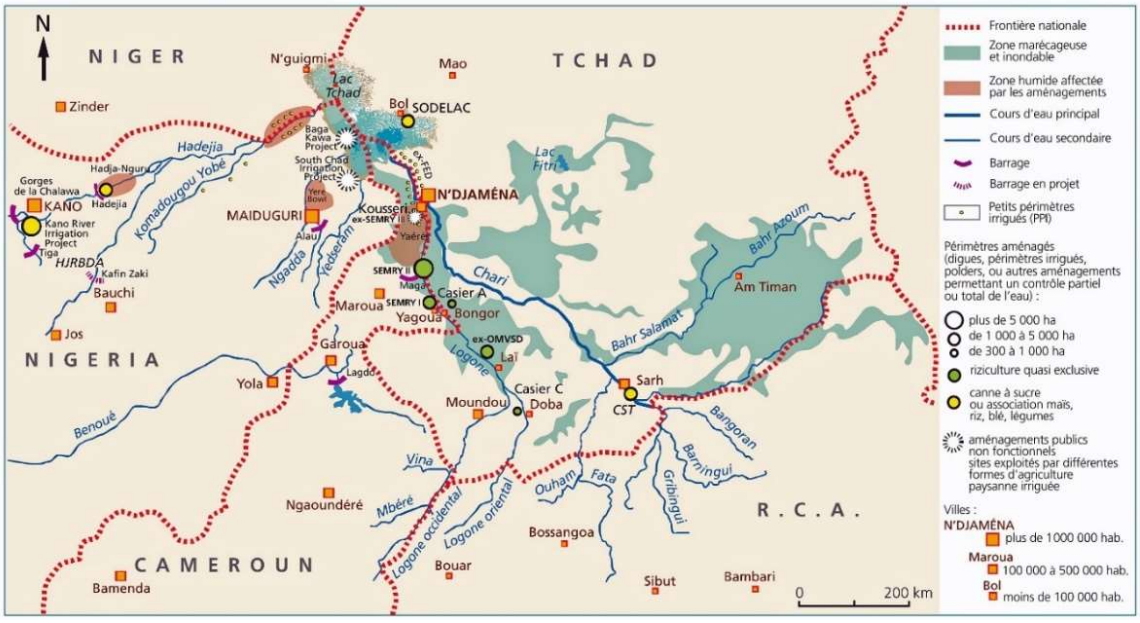


*Figure 1. Irrigation schemes in the Lake Chad Basin (Lemoalle and Magrin, 2014)*

In Chad polders have existed and are still existing along the east coast of Lake Chad (Figure 2) (Dieleman and De Ridder, 1963; Batello *et al*., 2004). This lake has no outlet. In some publications reference is made that crop strategies in areas bordering lake Chad include farming of cultivable lands on the lake bottom, some of which were being cropped. Farming is also done on *recessional lands*, where the lake water recedes every year and in *polder* depressions between *dunes*. Rice, wheat, maize, and vegetables are grown. In a traditional polder, one crop per year was grown as the lake water receded. If dams and pumps are applied, up to three crops per year can be grown. Besides fewer fish, a low lake level also means a shorter shoreline and thus fewer polders. Around 1970 Chad's Lac Prefecture estimated that only 10% of its polder areas were being used.

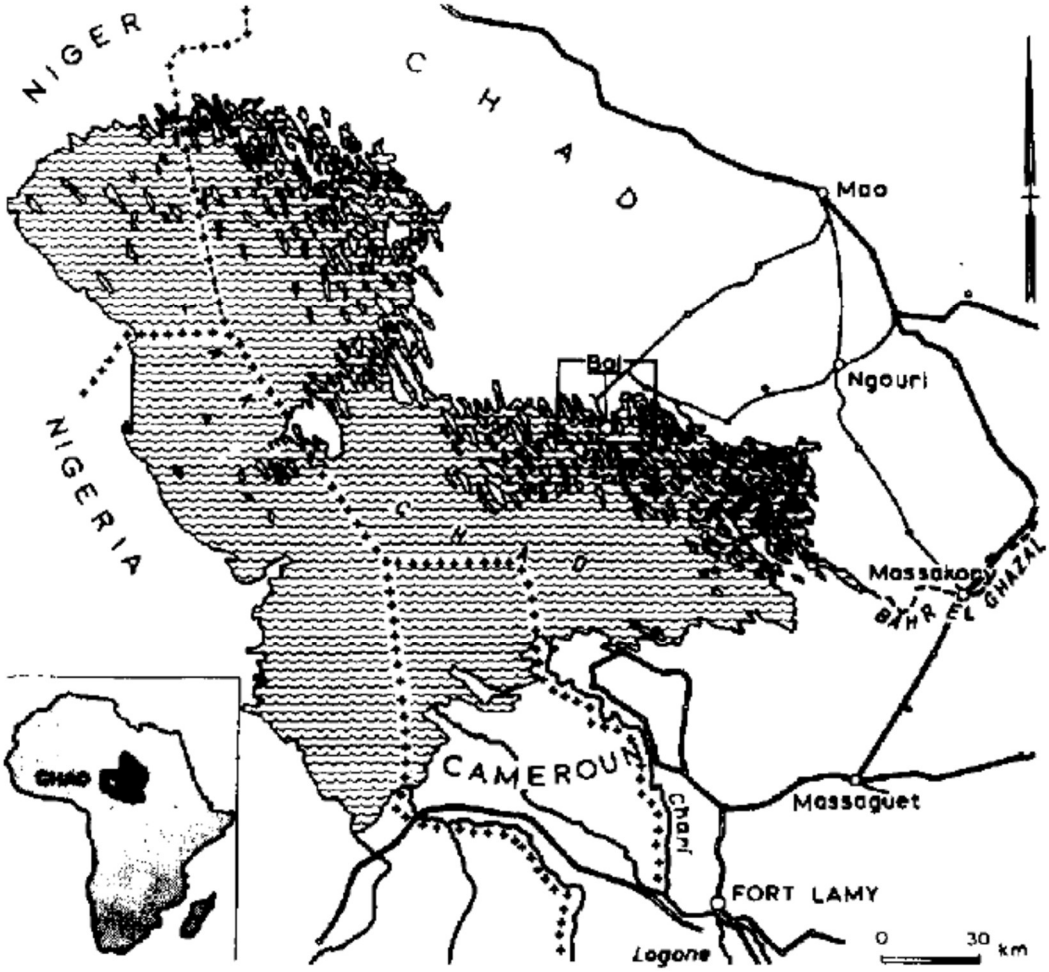


*Figure 2. Lake Chad and its surroundings (Dieleman and De Ridder, 1963)*

The paper by Dieleman and De Ridder (1963), the report by Kindler *et al*. (1989) and the paper by Visentini and Linoli (1990) (Figure 3) show bed and water levels of lake Chad that are relevant in relation to polder development. They gave the following data:

- bed of the lake about 277 m+MSL (mean sea level);
- high water 283 - 284 m+MSL;
- all time minimum lake level at Bol Dune from 1907 – 1972 is 279.93 m+MSL;
- minimum water level in 1973: 278.12 m+MSL and in 1974: 278.23 m+MSL.

The National Aeronautics and Space Administration (NASA) has published on its web site maps with the area of Lake Chad from 1963 – 2007 (Figure 4). From these maps it can be derived that in that period on average there has been a continues decline in the lake level.

A little more detailed map for the situation in 2010 has been given by Magrin *et al*. (2015) (Figure 5).

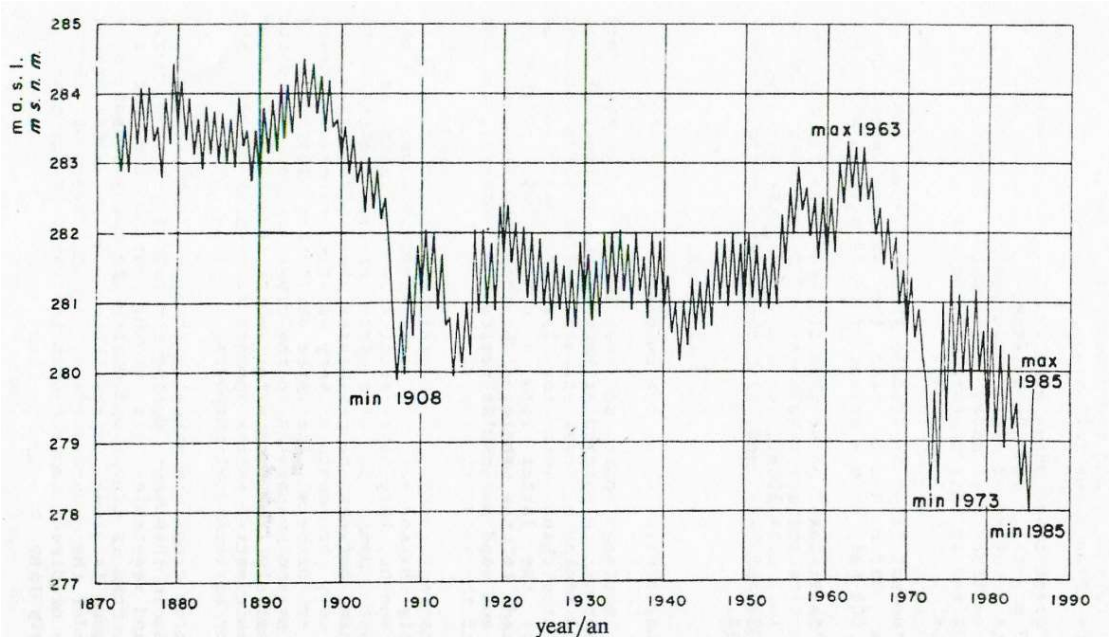


*Figure 3. Annual variation of the water level of Lake Chad at Bol (Visentini and Linoli, 1990)*

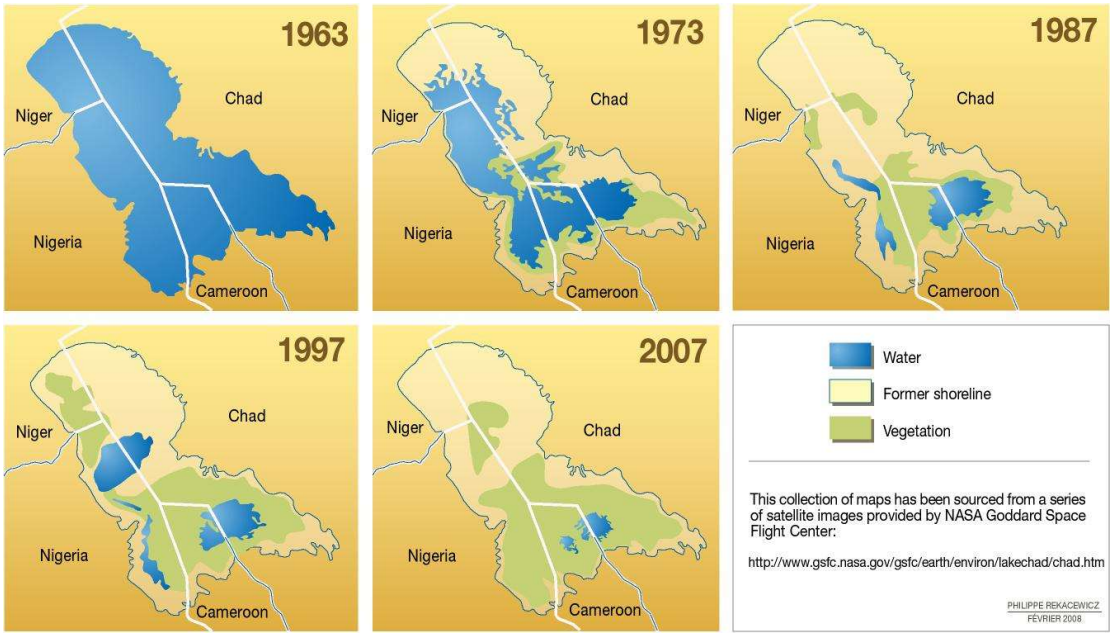


*Figure 4. Declining of the area of Lake Chad from 1963 – 2007 (NASA web site).*

Magrin *et al*. (2015) showed the minimum and maximum area of Lake Chad, as well as the river basins that discharge in the lake (Figure 6).

Based on local and satellite observations, combined with simulations Pham-Duc *et al*. (2020) presented the fluctuations in the water level of Lake Chad (Figure 7). From Figure 7 it can be derived that since 1980 the lake level has more or less stabilised.

Kindler *et al*. (1989) mentioned that the northeast border of Lake Chad contained small interdunal valleys that flooded seasonally as Lake Chad did rise. Others became moist from rising groundwater, corresponding to the rise in the lake level. When Lake Chad receded or trapped water infiltrated and evaporated, these 'polders' became fields for the cultivation of wheat, maize, cotton and potatoes. They stated that a complex series of events might occur with polder development. On one hand, the lake surface is restricted and marginal salt deposit areas reduced. On the other hand, any localized increase in salt concentrations will limit crop production and long-term soil fertility. At this point polder development may not be large enough to impact salinity in wet years.

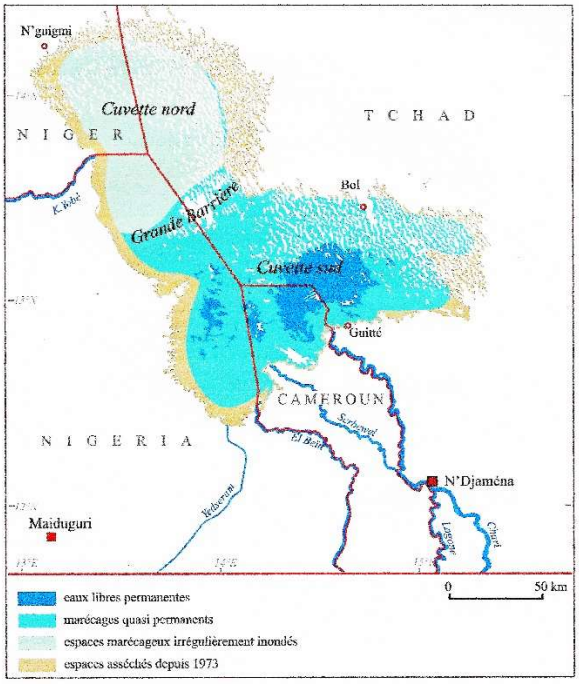


*Figure 5. Situation of Lake Chad around 2010 (Magrin et al., 2015)*

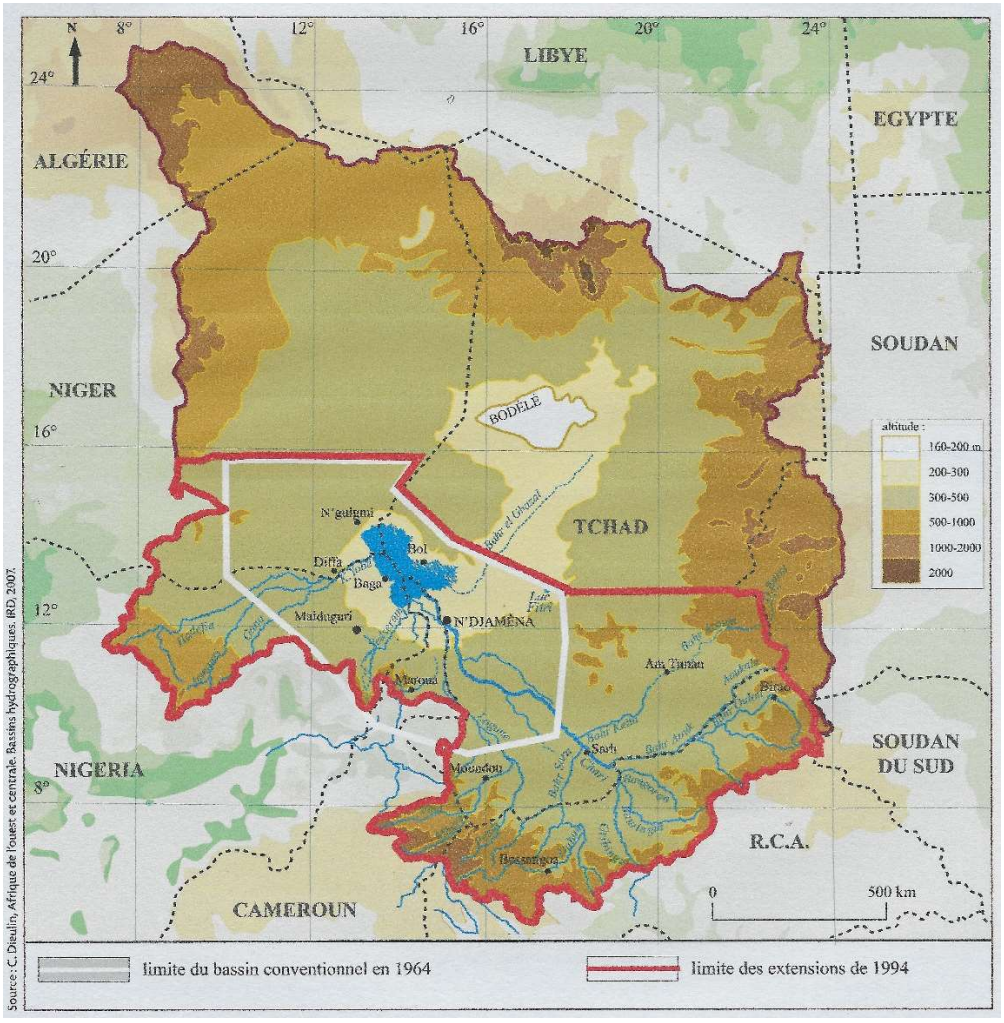


*Figure 6. Lake Chad and its river basin*
*(source: United States Geological Survey (USGS); Magrin et al., 2015)*

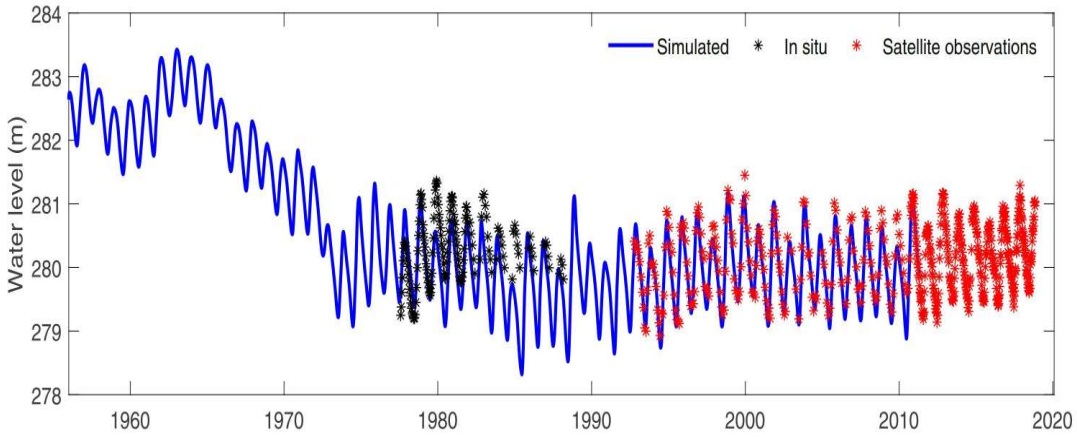


*Figure 7. Water level in Lake Chad from 1955 till 2020, based on local and satellite observations combined with simulations (Pham-Duc et al., 2020)*

According to Visentini and Linoli (1990) the traditional polders were located along the Chad shoreline, in particular between the villages of Baga Sola and Konlodin, where a series of islets and sand dunes stretch into Lake Chad. In the driest months the local population created polders by constructing sand dams between the peninsulas. They also described that every 2 to 4 years the farmers broke the sand dams when the water level in the lake was high, to leach the accumulated salts through the soil and letting in water from the lake. Three types of polders were distinguished:

- *lowest polders*. The groundwater table either appears to the ground surface or the water is raised by capillary forces just until the surface;
- *slightly higher polders*. The capillary rise goes as far as the rootzone of the crops but never reaches the surface;
- *highest polders*. The surface level is so high that the roots of the crops are not reached by the capillary rise.

On Google Earth it can be observed that there are still several polder areas in the east coast of Lake Chad.

In order to promote agriculture in the polder areas in 1967 the *Société de Development du Lac Tchad* (SODELAC) has been established.

**Existing polders**

Lemoalle and Magrin (2014) mentioned that after 1929, many rudimentary dams have emerged on the north-eastern shores of Lake Chad between Baga-Sola and Kouloudia and that, until 1949, this sector had 23 polders covering 1,500 ha.

Halfway the 20$^{th}$ century two *modern* polders were created by constructing dikes between the peninsulas (Figure 8) (Dieleman and De Ridder, 1963; Visentini and Linoli, 1990; Batello *et al*., 2004). The first one was the *Bol Guini Polder,* 500 ha. The construction of this polder started in 1951, when the main part of the area was surrounded by dikes. In 1954 the water in the endiked area evaporated and the lake bottom emerged. The soils are clayey, rich in organic matter and minerals. The land use is agriculture with wheat and maize as main crops. A typical cross-section of the polder is shown in Figure 9 (Group Polder Development, 1982). The other polder was the *Bol Berim Polder,* 1,000 ha. This polder was reclaimed in 1954. It is rather similar to the Bol Guini Polder (Group Polder Development, 1982).

There has been the Lake Chad Polders Project, consisting of: i) rehabilitation and completion of the irrigation and drainage networks of the *Bol Guini Polder* (370 ha net area); ii) construction of the irrigation and drainage networks for *Bol Berim polder* (800 ha net area); iii) establishment of a commercial agricultural development section, which would have to prepare the way for farmer settlement, and be responsible for the first year of operation on all newly developed land; iv) provision of a package of services (resettlement assistance, training extension, credit, and marketing) to the farmers who would take up cultivation of the polders; v) construction of necessary service centres and

houses for project staff; vi) expansion of adaptive agricultural research at the Matafo Research Station; vii) provision of consultant services to reorganize the SODELAC. The project appraisal report by the World Bank (1975) described the envisaged improvement of the Bol Guini, Bol Berim and Mamdi polders. Schematic representations of these polders are shown in Figure 10. In the project evaluation report by the World Bank (1987) it is shown that the project indeed started in 1975, but was stopped in 1979. The report stated that most of the project works were not completed and that those that were completed were destroyed during the civil war.

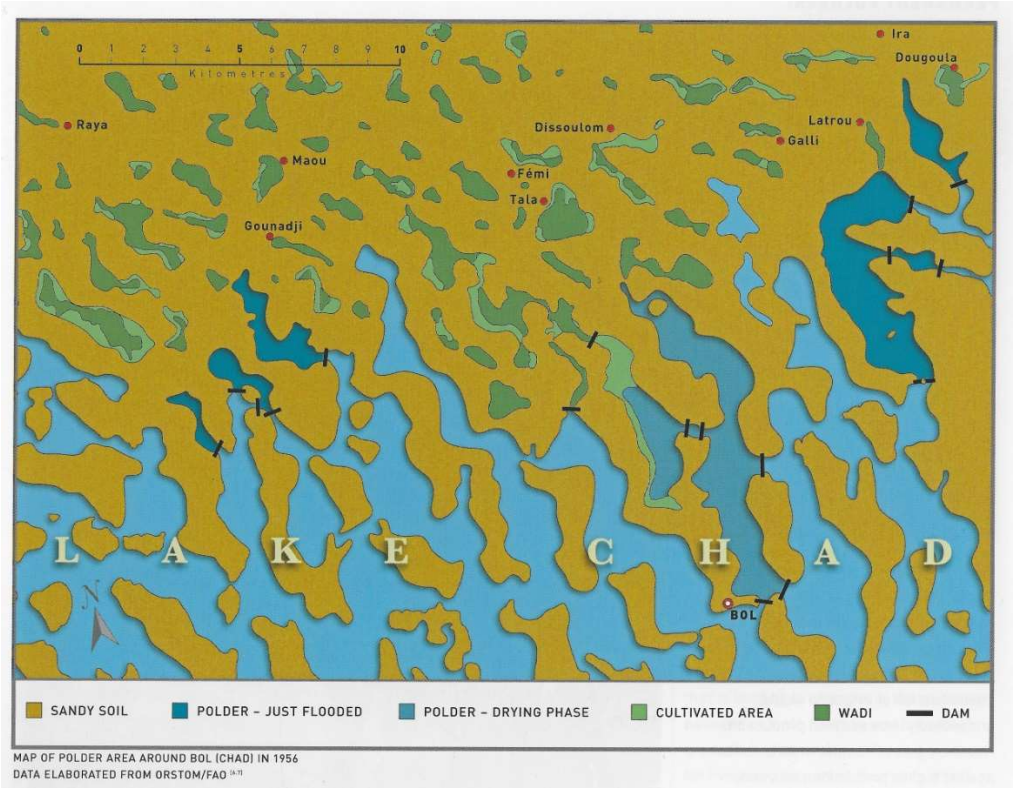


*Figure 8. Map with polders along Lake Chad (Dieleman and De Ridder, 1963; Batello et al., 2004)*

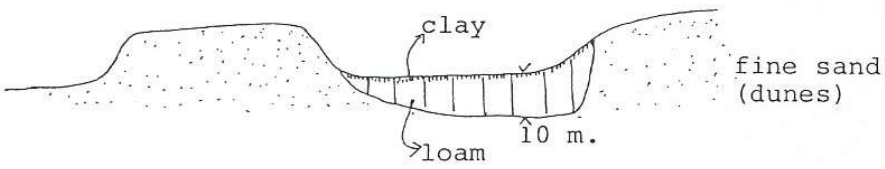


*Figure 9. Typical cross-section of the Bol Guini Polder (Group Polder Development, 1982)*

Visentini and Linoli (1990) described that they identified 44 traditional polders with a total area of about 19,000 ha, of which in 1986 only 15 with a total area of about 7,700 ha were still cultivated. They also described that under the Italy - Chad Rehabilitation and Development Programme, among others, 11 polders with an area of 4,800 ha were selected for rehabilitation and enlarging to in total about 7,800 ha. Most of the surface in these polders is below 279.80 m+MSL.

In addition to the work on the Bol Guini and Bol Berim polders, as mentioned above, there has also been the intention of the development of the Mamdi Polder (1,600 ha) that is adjacent to these polders (World Bank, 1975). However, in the framework of this project no activity has taken place with respect to the Mamdi Polder (World Bank, 1987). Nevertheless, this polder is shown on Google Earth. It is not clear when it has been made. It could have been in the framework of the project supported by Italy (Visentini and Linoli, 1990).

In addition on Google Earth several other small polders in the area can be identified.

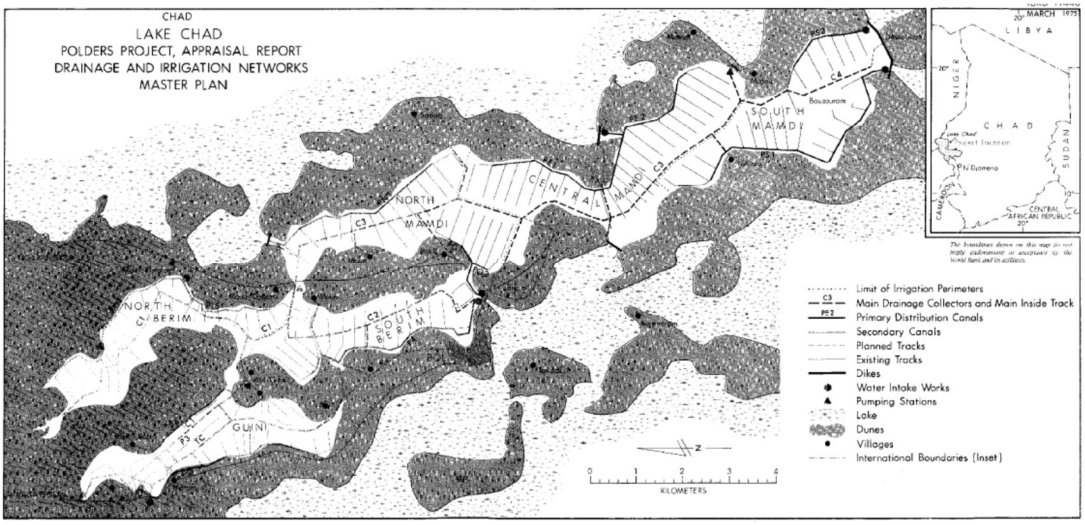


*Figure 10. Envisaged lay out of the Bol Guini, Bol Berim and Mamdi polders (World bank, 1975)*

General characteristics of the polders in Chad are shown in Table I. Characteristics of the water management and flood protection systems are shown in Table II.

**Proposed polders**

No proposed polders have been identified.

**Various**

In order to compensate for the drop down in the water level of Lake Chad there have been serious plans to transfer water from the Congo River to Lake Chad, called the *Transaqua Project*. An overview of these plans was given by Vichi (2011). In addition there has been a feasibility study on the transfer of water from Oubangui River to Lake Chad (Cima International, 2011). In this study it was concluded that there was a technical feasibility of an average transfer of about 5.4 $km^3$/year. As far as it is known, so far the plans have not been implemented.

**Location of the polders in Chad as shown on the World polder map**

The location of the polders in Chad is shown in Figure 11.

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*Figure 11. Location of the polders in Chad (source: esri – Batavialand)*

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*July 2024*

Table I. General characteristics of the polders in Chad

| Name | Reclamation | Area in ha | Type *) | Latitudes | Longitudes | Elevation in m+MSL | Land use |
|---|---|---|---|---|---|---|---|
| *Existing polders* | | | | | | | |
| Bol Guini Polder | 1951-1954 | 500 | RLL | 13º 30' N | 14º 41' E | 270 | Agriculture |
| Bol Berim Polder | 1954-1956 | 1,000 | RLL | 13º 29' N | 14º 42' E | 270 | Agriculture |
| Mamdi Polder | 2005 | 1,600 | RLL | 13º 25' N | 14º 44' E | 277 | Agriculture |
| Bibi Polder | | 600 | RLL | 13º 31' N | 14º 23' E | 284 | Agriculture |
| Bol Baga Sola Polder | | 345 | RLL | 13º 32' N | 14º 18' E | 278 | Agriculture |
| Broumtchouloum 1 Polder | | 280 | RLL | | | 285 | Agriculture |
| Broumtchouloum 2 Polder | | 715 | RLL | | | 285 | Agriculture |
| Diboulboul Polder | | 510 | RLL | 13º 29' N | 14º 48' E | 278 | Agriculture |
| Goumatcherom Polder | | 230 | RLL | | | | Agriculture |
| Kagou Polder | | 120 | RLL | | | | Agriculture |
| Kala-Kola Polder | | 350 | RLL | | | | Agriculture |
| Kindjiria Polder | | 600 | RLL | 13º 31' N | 14º 30' E | 285 | Agriculture |
| Melea Polder | | 975 | RLL | 13º 16' N | 14º 58' E | 284 | Agriculture |
| Midi-Koura Polder | | 510 | RLL | | | | Agriculture |
| Tchingam Polder | | 315 | RLL | 13º 30' N | 14º 25' E | 283 | Agriculture |
| Woleirom Polder | | 485 | RLL | | | | Agriculture |
| Italy-Chad Rehabilitation and Development Programme | | 7,800 | RLL | 13º 31' N | 14º 23' E | Below 279.80 | Agriculture |
| Total | | 16,935 | | | | | |

*) RLL = reclaimed low-lying land; LGS = land gained on the sea; DL = drained lake

Table II. Characteristics of the water management and flood protection system of the polders in Chad

| Name | Design criteria in chance of occurrence/year | | | | | | |
|---|---|---|---|---|---|---|---|
| | Water management | | | | | | Flood protection |
| | Drainage | | | | | Irrigation | Rural |
| | Type | Design criterion | Percentage of open water | Discharge capacity | | | |
| | | | | $m^3/s$ | mm/day | | |
| Bol Guini Polder | RLL | | | 1.2 | 20.7 | yes | |
| Bol Berim Polder | RLL | | | 1.25 | 10.8 | yes | |
| Mamdi Polder | RLL | | | | | | |
| Bibi Polder | RLL | | | | | | |
| Bol Bagassola Polder | RLL | | | | | | |
| Broumtchouloum 1 Polder | RLL | | | | | | |
| Broumtchouloum 2 Polder | RLL | | | | | | |
| Djiboulboul Polder | RLL | | | | | | |
| Goumatcherom Polder | RLL | | | | | | |
| Kagou Polder | RLL | | | | | | |
| Kala-Kola Polder | RLL | | | | | | |
| Kindjiria Polder | RLL | | | | | | |
| Melea Polder | RLL | | | | | | |
| Midi-Koura Polder | RLL | | | | | | |
| Tchingam Polder | RLL | | | | | | |
| Woleirom Polder | RLL | | | | | | |
| Italy-Chad Rehabilitation and Development Programme | RLL | | | | | | |