TRANSBOUNDARY GROUNDWATER FACT SHEET

The Lake Chad Basin Aquifer System

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The fact sheet is a result of Fanny Bontemps research work during her internship at GWPO Secretariat

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1. Context

The Lake Chad Basin is a terminal depression with eight countries grouped around it, four of which are in direct contact with the lake: Nigeria, Niger, Chad and Cameroon.

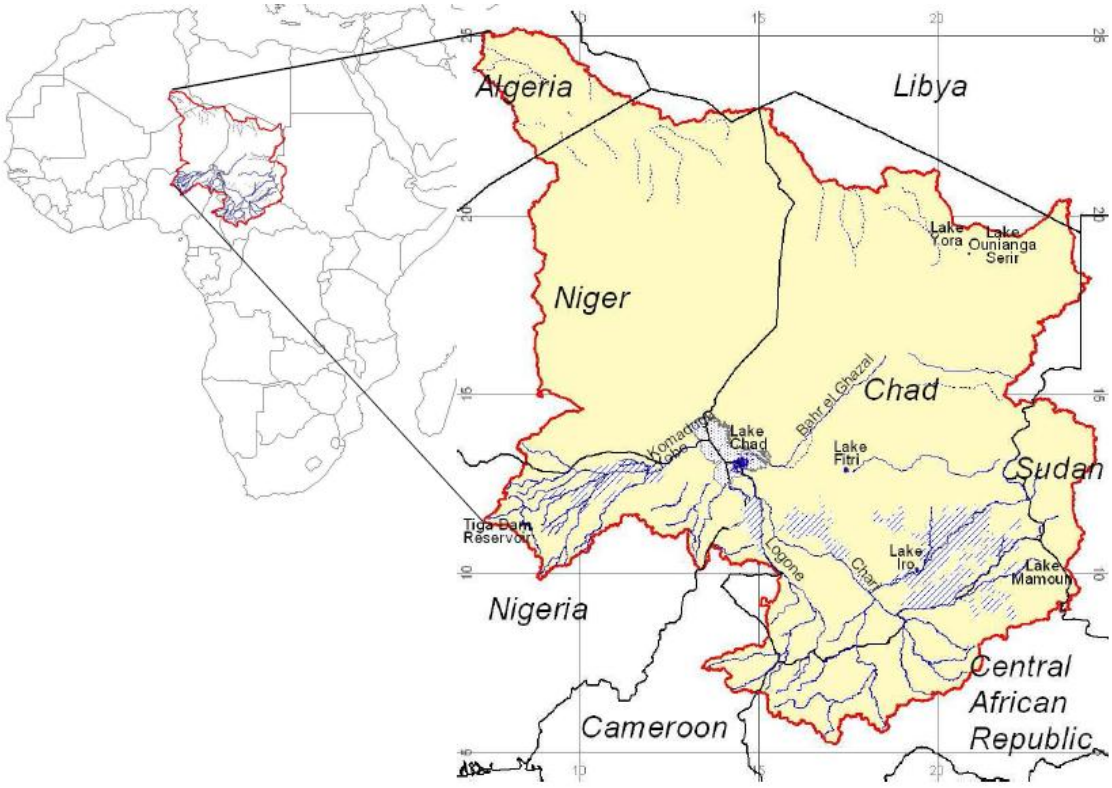
Geographical and climatic context

The basin is an extended plain with an altitude varying from about 3,000 meters in the north, north-west and south-west (respectively in the Tibesti Mountains, in the Ahaggar Mountains and in the Adamawa Plateau) to 180 meters in the Pays Bas, in the basin center.

Because of the Chad lake shallowness, most of the southern ponds and all of the northern ones can be considered as swamps.

Depending on precipitation rates, which vary from an average of 1,400 mm/year in the south to one of 10 mm/year in the north, four climatic zones can be identified in the Lake Chad basin:

- The humid zone in the basin southern part (Cameroon´s and CAR´s territory)
- The dry sub-humid zone on CAR´s and Chad´s territory
- The semiarid zone in the basin central part, in Nigeria, Chad and Niger
- The Northern arid and hyper arid zone in Niger and Chad.



Socio-economic context

About 30 million people are settled in the Lake Chad Basin and belong to some of the poorest countries in the word. Agriculture, and primarily rain-feds in the south and in flooded areas, is the main basin

activity. However, in the last thirty years, water demand for irrigation has quickly increased. For instance, between 1983 and 1994, irrigation demand has grown by 200%, leading to water resource overexploitation. This growth is mainly due to irregular precipitations and the low efficiency of irrigation systems.

Moreover, sanitarian coverage is nearly absent in all countries and water-linked infections such as hepatitis, typhus, cholera or malaria, spread over populations except in northern countries (Algeria and Libya). The drinking water coverage is also inadequate and in rural areas, most people obtain water directly from ponds in the rainy season or from hand-dug well in the dry period. In cities, groundwater is the main supply for the drinking water coverage but this coverage, mainly due to the cost, is still inadequate and does not reach rural areas.

Environmental context

Over the last forty years, The Lake Chad Basin has suffered the largest documented decline in biodiversity, and despite efforts to manage threats and pressures, it is still declining.

Before, flora was mainly characterized by sparse vegetation cover such as savannahs, steppes, deserts… Nowadays, vegetation is highly modified by human activities which weaken ecosystems, such as agriculture, grazing or fuel wood collection.

Concerning fauna, the Lake Chad Basin hosts diversified species including ones of great international interest (elephant, lion, and migratory birds). However, several species have almost disappeared from the basin like the Addax, the Oryx or the black rhinoceros.

As explained before, the basin is home to a rich biodiversity but high human pressure causes flora depletion, deforestation and soil degradation, especially in areas where environmental and climatic conditions favor agriculture. Moreover, poaching, stray animal and fishing channels multiplication worsen this pressure. However, human activities could also contribute to the biological diversification by setting up an agro-forestry system and creating protected areas.

Invasive species development is another issue caused by human activities. This phenomenon is mostly seen in the komadougou-Yobe sub basin, Chari Logone sub system and the lake itself. In the KYB sub-system, there are two prominent invasive species, typha grass and quelea birds. The Chari-Logone system was colonized by water Hyacinth and the lake itself has been invaded by Typha and water Hyacinth. Related impacts are crops destructions by birds and channels blockage by weed. Both lower incomes, increase poverty and enhance conflicts between different uses of resources.

In order to protect basin biodiversity, a Strategic Action Program called “Reversal of Land and Water Degradation Trends in the Lake Chad Basin Ecosystem” was set up by the Lake Chad Bain Commission.

2. Groundwater characteristics

Generalities

The Lake Chad Basin covers 2,434,000 km^2, which is approximately 8% of total Africa surface[1]. The basin is shared by the following riparian countries: Chad (45%), Niger (28%), the Central African Republic (CAR) (9%), Nigeria (7%), Algeria (4%), Sudan (4%), Cameroon (2%) and Libya (0.5%). Chad and Niger are those with the largest shared territory but three quarters of the lake water come from the CAR and Cameroon.

Geological characteristics

The Lake Chad Basin is one of the largest sedimentary groundwater basins in Africa. It is composed of three main aquifers: the upper Quaternary with the Lower Pliocene, the Continental Terminal and the Cretaceous lower aquifer. Since the main source of water recharge to these aquifers is from surface waters (e.g. Lake Chad), the aquifer system is highly sensitive to climatic changes.

- **The upper quaternary aquifer** is composed of two secondary aquifers supposedly connected.
    - The Phreatic aquifer, in quaternary sand deposits, located between a few meters to a 50 meters depth. The water is suitable for domestic uses and livestock watering through dug wells and boreholes. However, there are high nitrate concentrations due to agriculture discharges and fecal contamination. This aquifer is directly linked to Lake Chad.
    - The artesian Pliocene Aquifer is deeper as it can be found between a 250m depth and a 400m one with a more mineralized water. This water is used mainly in Nigeria and the Cameroon extreme North regions. The artesian pressure is currently lowering possibly due to over pumping and as this aquifer is only replenished in limited areas and not connected with the lake.
- **The middle aquifer** is composed of Continental Terminal formations which are alternating sandstone and clay layers, 450-620 m from the surface. This water is also suitable for domestic uses but extraction costs are considerable. However, this aquifer supplies important urban centers like Maiduguri in Nigeria.
- **The Cretaceous lower aquifer** is not well known yet. It is composed of the Hamadien Continental and the Intercalary Continental, two fossil and highly mineralized groundwater tables.

See the geological cross section in appendix.

Hydrological characteristics

The Lake Chad Basin could be subdivided into two main hydrological sub basins:

- The Chari-Logone subsystem, which covers approximately 650,000 km^2 and hosts the Chari River and the Waza-Logone floodplains.

[1] UNEP, 2004

- The komadugu-Yobe sudsystem, which covers 148,000 km^2 but contributes only to 2.5% of the total riverine inflow into Lake Chad.

Isotopic studies suggest that groundwater in the Middle and the Lower Aquifers is 20,000 or more years old and is not replenished by modern recharge.

Concerning the upper aquifer recharge, isotopic studies have highlighted recharges zones in higher areas (Mandara Mountains, Guera and Batha massifs) and in exposed sand dunes areas. Leakages from three rivers (Yaéré, Massénya and Logone Rivers), the Lake Chad and wetlands also contribute to aquifer recharge.

However, these latest groundwater recharges have decreased in recent years, mainly due to drought conditions and management decisions in the upstream regions. Indeed, river flows have dropped by 47% since the late sixties and, summing lower precipitations, the total input volume inflowing into the Lake has decreased by 50%.

The water quality is high on the average although a salinization phenomenon in the North. However, water quality investigations in the three aquifers have shown high fluoride concentrations. High concentrations of trace elements were also found in several Nigerian samples (barium, boron, chromium, nickel, molybdenum, lead and uranium).

3. Uses

Since agriculture remains the most important activity for over 60% of the basin population, irrigated agriculture is the first water user. Indeed, groundwater is used increasingly for irrigation especially for dry-season irrigation of seasonal grazing grounds.

Sectoral groundwater use in Chad and Niger		
	Chad	Niger
Industrial use	0 %	4%
Agricultural use	79%	39%
Domestic use	21%	58%

From Marianne Alker, German development Institute

The FAO has estimated current and potential water volumes used for irrigation in each riparian country.

Country	Area under irrigation (ha)	Irrigation potential within the whole basin (ha)	Gross irrigation water requirement (km3/year)	
			Per ha (m3/ha.year)	Total (km3/year)
Nigeria	82,821	304,000	1,000	3,040
Niger	2,000	11,000	0.215	2,000
Algeria	0	18,000	0.000	0
Sudan	500	4,000	7,500	0.030
Central Africa	135	16,500	16,500	8.250
Chad	14,020	277,500	15,500	4.163
Cameroon	13,820	66,700	12,500	0.834

4. Groundwater management

The Lake Chad Basin Commission

The Lake Chad Basin Commission, based on the "Convention Relating to the Development of the Chad Basin" signed in 1964, was created in order to regulate the management of transboundary natural resources. Cameroon, Niger, Nigeria, Chad and The CAR are members of the LCBC and Sudan was granted membership in 2000 but has not yet ratified the convention.

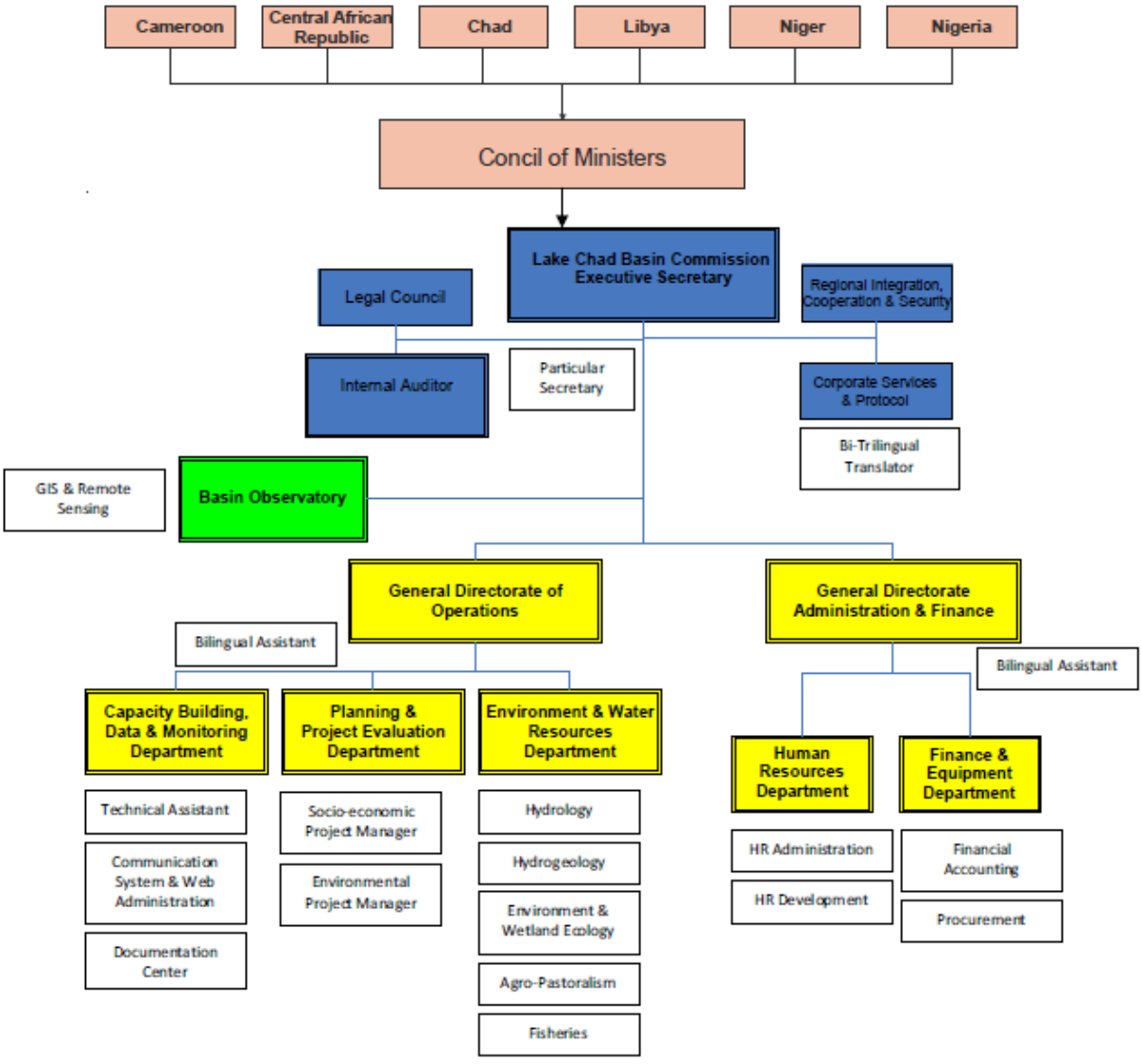


Diagram of Lake Chad Basin Commission organisation

This commission is in charge of:

- Regulating and controlling water and natural resources uses in the basin
- Initiating, promoting and coordinating natural resources development projects and research within the area.

- Examining complaints, promoting conflicts settlements and promoting regional cooperation.

The LCBC is also in charge of groundwater management and even if only few groundwater programs are currently being implemented, the LCBC has recognized groundwater importance and has made effort to fully include groundwater in its activities.

The LCBC budget is provided by member countries with the following participation rates: Nigeria 52%, Cameroon 20%, Chad 1%, Niger 7% and CAR 4%. However, not all countries pay their entire duty so LCBC has to cope with constantly lowering founds.

In general, the LCBC is weakened by political and financial issues and suffers a lack of effective institutional capacity and technical knowledge to tackle transboundary aquifers challenges. For these reasons, LCBC is often bypassed, even when problems fall under its mandate.

The Nigeria-Niger Joint Commission

This commission was created in 1998 and concerns the equitable sharing as well as the development, conservation and use of common water resources between Nigeria and Niger. The commission area covers the Maggia/Lamido River Basin, the Gada/Goulbi of Maradi River Basin, the Tagwa/El Fadama River Basin and the lower section of the Komadougou-Yobe River Basin. Groundwater is explicitly included in the agreement which recognized the hydrological link between surface and groundwater.

The Chad-Cameroon Joint Commission

This commission was created in August 1970, but is inactive and without permanent secretary.

The Cameroon-Nigeria-Mixed Commission

This commission was created in 2002, out of the LCBC, in order to solve border-related conflicts between Cameroon and Nigeria.

5. Challenges

Knowledge lack and management issues

In general, knowledge and management of groundwater in riparian countries is far from being adequate. This is the reason why governments do not consider water issues as they should and do not transfer the matter to the LCBC.

Indeed, despite the LCBC existence, groundwater management is not yet a concerted issue in the basin. All member countries decide on large water investments and constructions (dams, deep wells) without taking into consideration the possibility of affecting riparian countries. International donors always finance these projects under the condition of a LCBC non-objection, which is easy to get due to a lack of experts able to decide on the contrary.

However, countries share common issues and interests. Countries motivation levels for cooperation depend on their own climate conditions and water dependency:

- Downstream **Nigeria** may have a strong motivation for cooperation as its water demand is high and its surface water availability has been considerably reduced by water development projects in upstream Nigerian countries. In contrast to the other riparian countries,

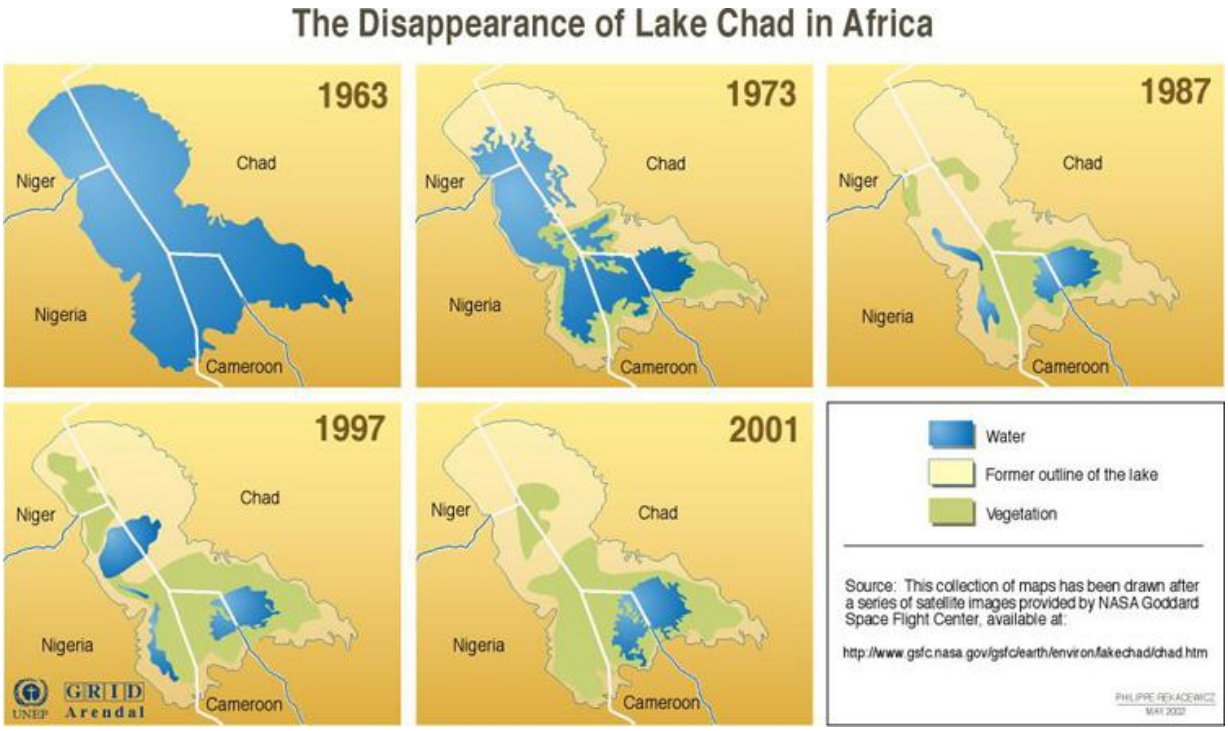
groundwater extraction from all aquifers, including the lower one, is technically and financially feasible in Nigeria, giving it a clear advantage in groundwater development.

- **Cameroon** may have little motivation for cooperation as it shares only wetlands in the Lake Chad Basin and does not depend on exploitation of the lower aquifers.
- **Chad** motivation for cooperation is also low since the north of Chad is sparsely populated, and the Lower Aquifer exploitation will probably be impeded by technical and financial lacks.
- **Niger** is very dry and depends heavily on access to groundwater. Thus, Niger has a strong motivation to cooperate, especially since it faces technical and economic issues in groundwater exploitation development.
- **The Central African Republic** is presumably independent of groundwater resources and therefore is supposed to have little motivation to cooperate.

In addition to this motivation shortage, members do not necessarily need the agreement of the others before carrying out projects which alter regional water resource. In the past, this has led to various dams and irrigation projects with negative impacts on downstream riparian countries.

Water resource decrease

Groundwater abstraction rates have been increasing since the middle of the 20th century, both for domestic and agricultural needs. The Lake has also shrunk by 90% since that time and water flow has declined both due to drier climatic conditions and water overexploitation. At the same time, water demand has increased with population growth. Therefore, as surface water is lacking, populations are more and more groundwater dependent and extractions have increased to overexploitation.



Nowadays, both because of overexploitation and reduced recharge flows, groundwater level is declining, threatening the economy of riparian countries. Indeed, Niger water dependency rate is about 90%, Chad´s one about 65% and Nigeria´s about 23%. A high dependency rate is closely linked to drier climate and agriculture-based economy. In the most densely populated part of the basin, and

since most of the population is Nigerian, about 50% of drinking and agriculture water demand is provided by groundwater.

Water quality degradation[2]

Regarding wells and pumps, groundwater contamination could be attributed to inflows and infiltrations of human and animal feces, wastewater and germs. Indeed, wells are both used by local populations and cattle. Apart from populations using drinking water network, most people consume contaminated water from wells and rivers, which causes diseases such as hepatitis, typhus or cholera. Thus, groundwater pollution is both due to animals and a lack of measures against water soiling.

Lake Chad groundwater is naturally strongly charged in cations and others elements like sodium, sulphates, iron and manganese. All have an impact on water organoleptic properties (taste, smell and flavor) but none on health, except the sulphates laxative effect.

However, the nitrogenous rate is worrying as the nitrate rate exceeds the 50 mg/l threshold in 42 wells and the nitrite one presents a 0.2 mg/l excess in 72 wells. These rates are both unhealthy in case of frequent and long–term consumption. Nitrogen degradation mainly comes from animal fecal matters in open wells.

In cities, in terms of bacteriology, no water samples of the Chadian Utilities Company contain coliforms and fecal streptococcus, which means that treatments are effective.

Lake Chad Basin industrialization

Oil industry development in Chad could bring negative impacts on groundwater resources and ecosystems. Nowadays, the basin is not much industrialized, but the oil exploitation beginning in Chad will increase industrialization. Indeed, this could lead to increasing urbanization, mining activities in the CAR and large-scale agricultural projects. All of which damage wetlands and lakes. Moreover, oil spills might cause water resource contamination, including groundwater aquifers.

6. Supporting programs

LCBC programs

While transboundary surface water has been more or less extensively studied, knowledge on transboundary groundwater is quite poor and only four projects have been carried out since the LCBC creation:

- **Survey of groundwater resources in the Lake Chad Basin** which was carried out between May 1967 and 1972 with assistance from UNDP and FAO. It has investigated for the first time transboundary groundwater within the basin, through an extensive drilling program.

[2]Information available on groundwater quality mainly come from the BGR/LCBC Project data base which come from about 300 wells or boreholes and the thesis of Edith Kadjangaba about the city of N'Djamena.

- **Monitoring and management of groundwater resources in the Lake Chad Basin**. This project was funded by the ''Fond d'Aide et de Coopération de la Réparation de la République Française'' between 1991 and 1993, and was carried out with BGRM assistance. This project has proposed new technical tools for a rational water management such as the first regional groundwater model including Quaternary sands, Lower Pliocene and Continental Terminal.
- **Management of groundwater resources for the sustainable development of the Lake Chad Basin.** This project was carried out between July 1997 and December 2007, by UNESCO/LCBC, with the BMZ financial support. Its objectives were to contribute to the better management and planning of water resources by developing a manpower infrastructure and a simulation model, in order to characterize the upper aquifer behavior.
- **BGR ongoing project**
    - **Supraregional Africa: Groundwater Management of Lake Chad Basin** (2012-2017)

  The project intends to strengthen the LCBC so that it is able to coordinate the groundwater data exchange between member countries, integrate them in a management system and elaborate water resources strategies of sustainable character.

  On-going activities:

  - Collecting and quality analysis of available data.
  - Training of experts on collection, diagnostic and analysis of groundwater data.
  - Developing a database for groundwater information.
  - Compiling a hydrogeological map for the Chad Basin area.
  - Establishing a unit responsible for evaluating and analyzing data within the LCBC. The unit will be in charge of developing integrated water management strategies within the Basin area

GWP program

- Strengthening Institutions for Transboundary Water resources management in Africa (SITWA):

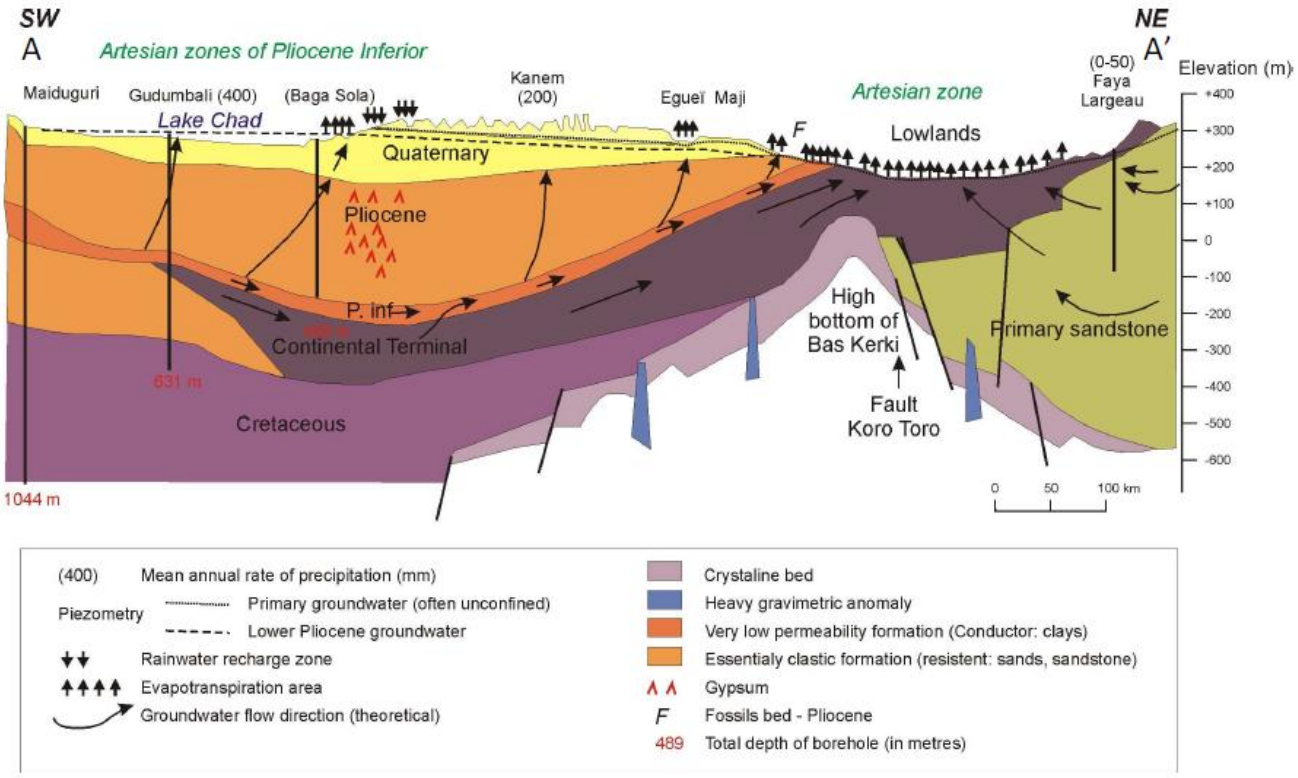
Objectives: The overall objective is to strengthen regional cooperation at the political, economic and stakeholder level for sustainable management of transboundary water resources in Africa and contributing to peace and security, stability and poverty alleviation, relying on African knowledge.

Specifics objectives are to provide a technical (pragmatic and institutional) assistance to ANBO aiming to transform it into a sustainable and influential organization and then improving water governance for transboundary water resources in Africa.

Activities: supporting the LCBC

Appendix

Cross-section with the geology in depth, drawn between Maiduguri to the SW and Fay Largeau to the NE of the Lake Chad Basin (after Schneider & Wolff, 1992).



From Groundwater need assessment, Lake Chad Bain, by Sara Vassolo, Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), 2012.

References

Bibliography

Vassolo. (2012). “Groundwater needs assessment Lake Chad Basin”. Bundesanstalt für Geowissenschaften und Rohstoffe (BGR).
M. Alker. (2008).”A Case Study for the Research Project: Transboundary Groundwater Management in Africa”. Conceptualizing Cooperation on Africa’s Transboundary Groundwater Resources. German Development Institute.
C. Adkins. (2007).”Groundwater recharge history and modern recharge in the Lake Chad Basin: source of salinity and fluid flow in a disappearing lake, Lake Chad, Africa”.
B. Ngounou Ngatcha, J. Mudry, C. Leduc. ”The state or understanding on groundwater recharge for the sustainable management of transboundary aquifer in the Lake Chad Basin”.
M. Sani Adamu. (2007).”Groundwater as part of the work of Lake Chad Basin Commission (LCBC)”. Lake Chad Basin Commission.

Websites

Bundesanstalt für Geowissenschaften und Rohstoffe (BGR)

http://www.bgr.bund.de/EN/

Lake Chad Basin Commission (LCBC)

http://www.lcbc.disk-world.net/
http://lakechad.iwlearn.org/

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