Experience and Lessons Learned Brief for Lake Chad

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1. Introduction

The Lake Chad hydrological basin is located between latitudes 6 and 24 degrees north and longitudes 7 and 24 degrees east. The area extent of the basin is 2,500,000 km^2. Lake Chad, once one of Africa's largest freshwater lakes, has shrunk dramatically in the last 40 years. It is situated on the edge of the Sahara Desert providing a vital source of water to human and wildlife communities alike. The lake, once measuring as large as 25,000 km^2, has also been as small as about one-twentieth of that size during this century. The lake is freshwater, despite potential evaporation rates that are four times as high as rainfall in the region. It is an extremely shallow lake - rarely more than 7m deep. The lake supports a growing human population as well as millions of birds and a number of mammals, reptiles, and amphibians.

Figure 1: Lake Chad Basin

The Lake Chad basin has extensive floodplains. The World Conservation Union (IUCN) in 1987 reported that the Chad basin holds one of the largest areas of wetlands in the Sahelian region with over 10 million ha in Chad alone. The most significant of the basin's floodplains in terms of size and ecological values, are those on the Chari, Logone and Yobe rivers. The well-known floodplain sites include the Sategui-Deressia in Chad, the Yaeres in Cameroon and Chad and the Hadejia-Nguru in Nigeria. The fringes of the Lake Chad can also be regarded as floodplains in view of the alternating recession and flooding that occur on those fringes every year.

The back-to-back droughts of the 1970s and 1980s have left the basin and approach to its management completely, if not permanently changed. The degradational changes include: shrinkage of Lake Chad and decreased flows in the major rivers; falling of groundwater tables; disappearance of specific plant species and reduction of canopy cover; loss of wildlife populations; increased soil erosion and/or loss of fertility; reduction in rainfed or even irrigated crops; alteration of economic development parameters such as job opportunities, community organization of labour, terms of trade, and rules governing access to natural resources (LCBC 1990).

Figure 2: Africa's Shrinking Lake Chad (1963-2001)

As a result of the combined effects of climate fluctuations (droughts) and unsustainable water projects (large dams) significant reductions occurred in the flow of rivers, which feed Lake Chad. This in turn resulted in the shrinkage of the lake. Projects such as the South Chad Irrigation Project (SCIP) in Nigeria, which depended on water abstracted from the lake became stranded by the receding lake shore and had to be abandoned. Conflicts arose among various water users who had to compete for the increasingly scarce water resources.

Annual floods, which used to inundate large areas that served as breeding grounds for fish as well other wildlife (e.g. birds) and for traditional farming as well as groundwater recharge

became drastically reduced by droughts and regulation by poorly designed dams coupled with unsustainable reservoir operation. The disappearance of large annual floods also led to the degradation of river channels. This is most pronounced where change in topography is so dramatic (as in the Yobe basin) that siltation and growth of invasive weeds such as Typha are enhanced.

It is therefore not difficult to appreciate the disappearance of many valuable plant and fish species, and loss of wildlife species as well as reduction of canopy cover. Village communities in these formerly extensive wetlands frequently lament such permanent losses of biodiversity, previously thriving fish festivals and work opportunities.

Loss of canopy cover, a product of both natural and anthropogenic causes have exposed the land to erosion by water and wind over decades and has produced virtually sterile soils in many areas of the Chad basin. Poor irrigation practice and misuse of chemical fertilizers have aggravated the loss of soil fertility in the basin.

The increasing conflicts resulting from competition between different land and water users (upstream and downstream, crop farmers and the nomadic herdsmen, urban water and irrigation water, etc) has led to the breakdown of traditional rules governing peaceful relationships. In the absence of new guiding rules and regulations that are equitable and properly enforced, the breakdown of law and order is inevitable.

There is need to undertake a water allocation process in order to formalize existing water use rights and manage water demands within the basin. This implies the implementation of some other policy options including river channel improvement works. Water augmentation and conservation techniques need to be promoted. Sustainable management of agricultural practices as well as natural resources need to be encouraged within the basin.

The on-going GEF project on the reversal of land and water degradation trends in the Lake Chad basin need to reinforce the efforts of NGOs in replicating good practices within the basin.

2. Background

Before the colonial era, organised states like the Kanem-Borno, the Kingdoms of Bilala, Wadai and even Fezzan, tried with varying fortunes to impose their domination on the vast depression known as the Lake Chad. However, since the introduction of Islam into the Lake Chad area in the 9th Century A.D. and the emergence of Kanem-Borno Empire, the Lake Chad had been a unifying factor for the people living around it. The Kanem-Borno Empire was famous for its culture and learning and for its commercial and diplomatic links with North Africa and the Middle East, as testified by European explorers.

By the end of the 19th century there was a scramble for Africa by European colonial powers and the Lake Chad and its basin were no exceptions. Political boundaries were re-drawn and the traditional links amongst the people of Kanem, Baguirmi and other kingdoms around Lake Chad became broken and the areas kept in isolation for more than 10 years during the colonial occupation.

However, when the four countries sharing the Lake Chad (Chad, Nigeria, Cameroon and Niger) gained independence in 1960, there was a great surge for re-union and the then political leaders turned their attention to the development of the Lake Chad area. It was realised that the area forms one ecological unit and development activities in one country can have some effects in other countries. The initiative was taken by Chad in 1962 and by 22nd May. 1964, a convention and statute were formally drawn and signed by the four countries establishing the Lake Chad Basin Commission to coordinate the development and promote cooperation in the Lake Chad and its basin (Jauro, 1994). The Commission was joined by the Central African Republic in 1994 thus bringing the member countries to five. Sudan too has been admitted and only needs to ratify the Commissions instrument to become a full member.

2.1 Bio-physical features

The socio-economic context

The 1991 population census shows that the hydrological basin or region of Lake Chad housed about 22 million people, with an average density of 22 persons per square km, but ranging from 1.5 to 37 persons in the riparian countries. The current population in the conventional basin is more than 11 million, distributed as follows: Nigeria 6 million, Cameroon 2 million, Chad 3 million, and Niger 200,000. The projections for the year 2020 are 23-30 million. The average population growth within the basin is quite high, being 2.4-2,6%. The major cities in the basin include N'Djamena (400,000), Kano, Maiduguri, and Maroua.

The shallow lake is very important as it provides water to more than 20 million people living in the countries which immediately surround it - Chad, Cameroon, Niger and Nigeria. Moreover, the large drainage area is underlain by aquifers that provide the principal source of water to dug wells and boreholes for domestic, village and urban use.

The major contribution of the lake to the rural population of the remote area is the fishing activities – on the open lake and surrounding fishing areas and ponds. The annual fish catch in the Lake Chad was 130,000-141,000 tons up to the early seventies. The present level of production is close to that of 1977 and is in the region of 60,000-85,000 tons, being about 75% of the whole region. However quantifying fisheries in Lake Chad is challenging in view of very little time series data (Jolley et al 2001). There are many important fish species in the lakes and other numerous wetlands, including charachin *(Alestes baremoze), A. dentex*, and Nile Perch *(Lates niloticus)*.

Agriculture is the main activity of the population in 60% of the administartive units of the Lake Chad Basin. The Lake Chad provides the water and the agricultural springboard for the production of these and other commodities. Similarly, millions of other people in Niger, Chad and Cameroon republics also depend on the Lake for most of their economic activities and livelihood. The increasing pressure on the soil and the diminishing water sources, however, present serious sustainability problems for these activities.

At present, out of an irrigation potential of over 1.16 million hectares in the whole hydrological basin fewer than 115,000 ha are actually irrigated. However, due to the lowering of the level of Lake Chad and of the inflows of the main rivers in recent history, every new irrigation development has to be studied very carefully. In 1980 the maximum potential development was estimated at fewer than 400,000 ha by a UNDP-financed study. Taking into consideration the

above aspects, the total potential for the whole of the Lake Chad basin 1.16 million ha would require 16.53 km^3 of irrigation water, or 66% of the current total inflow to the lake.
Lake Chad is known for its yield of natural soda, which is related to the abundance of soda in Central African Republic (CAR), an activity that contributes to keeping the lake water fresh. Its extraction occupies hundreds of children particularly girls who easily dig it out in areas severely affected by dry season floods as in the Hadejia-Nguru Wetlands in Nigeria.

Lake Chad basin houses some of the poorest countries of the world. This is true of six of the countries listed in Table 1, five of which have less than US $350 per capita output and income per annum. Moreover, the populations of four of the countries earned less in 2001 than in 1995. The estimates of income (CFA) from various sources or activities are as follows in order of importance: fishing 26 billion, crops 15.5 billion, animal husbandry 8.6 billion, small irrigation scheme. The estimates of annual household income (CFA) from various sources or activities are as follows in order of importance: fishing 26 billion, crops 15.5 billion, animal husbandry 8.6 billion, small irrigation schemes 6.3 billion and large irrigated projects 5.5 billion. However, the World Resources Institute estimates the real value of ecosystem services to twice the gross national product of $33 trillion. The habitat thus needs to be protected in order to preserve the values of the ecosystem services.

Table 1 Lake Chad Region: Per capita Output and Income in 1995 and 2001.

Lake Chad and its drainage area: landscape and natural habitat

The Lake Chad basin was formed by the extension of the earth's crust due to tectonic forces dating back to the Cretaceous, with the geological and geomorphological development of the basin being attributed to the `cool´ rifting of the West and Central African Rift System (Burke, 1976 in Isiorho *et al.*, 1996). The Chad Artesian basin thus consists of the Lake Chad (Chad Syncline) and the Chari-Logone system (Chari-Logone Artesian basin). These sub-basins are underlain by basement complex in the upper source areas and by a progressively thick sequence of sedimentary deposits towards Lake Chad. It is believed that structural features control the locations of the present day rivers Chari, Logone and Komadougou-Yobe, as well as earlier streams.

Lake Chad's area is currently at its minimum of 1350 km^2. The lake reservoir's depth varies from 4-8m in the north pool to 2-4m in the south pool, with an average of about 1.5 m. The lake is situated on a plateau at an altitude of about 283 m above mean sea level (UNDP/FAO 1972, UNDP/DEWA 2003).

Annual rainfall averages 320 mm but ranges from nearly 1,600 mm in the southwest of the basin to less than 150 mm in the north. The rainfall, which is generally heaviest in August, is monsoonal. The 28-year mean rainfall at Bol Dune is 384 mm of which 342 mm (89%) falls during July-September. Annual temperature averages 21.4^oC. The climate of the hydrological Lake Chad basin can be divided into six zones (UNDP/FAO 1972, LCBC 1990): Guinea zone, Sudano-Guinea zone, Sudano-Sahelian zone, Sahelo-Sudanian zone, Sudano-Saharan zone and Saharan zone.

Because conditions in the region are so hot and dry, leading to high rates of evaporation (reaching 2300 mm per year), the lake would likely be saltwater if it were not for several factors.

One is that the heavier salts flow out through underground passages, preventing salt buildup in the lake. Another is that the lake receives large freshwater inputs from the nearby Adama Plateau. The ecoregion includes the Hadejia-Nguru wetlands to its west. Swamps occupy the margins of the lake, and dense floating vegetation covers the shallow waters. This shallow lake expands dramatically with seasonal floods, and as noted earlier, providing a vital refuge for migrant palearctic birds and other animals.

The landscape within the conventional basin is very diverse. First, there are three types of lakes: piedmont lakes in Cameroon and Chad; interdunal lakes in Chad and Nigeria; and hydrographic lakes such as Lake Chad. About fifteen landforms have been identified. These include active and relict deltas; sand barriers of present and past lake shorelines; ergs, sand dune islands, and other Aeolian landscapes; flatlands derived from Quaternary lagoons; pediments from eroded massifs; fossil valleys and wadis; and incised stream and river beds. Projects designed to protect soils and water supplies as well as the long-term productivity of the land surface in general must carefully tailor their technical and social interventions to the specific landscape.

2.1 Political and socio-economic features

The drainage area of Lake Chad covers about 2.4 million km^2. The bulk of this hydrological basin area lies in the republics of Chad and Niger where it also accounts for more than half of total area of each country. About 20% of the total area of the Lake Chad basin, or 427300 km^2, is called the Conventional Basin (with 42% in Chad, 28% in Niger, 21% in Nigeria and 9% in Cameroon. The New Convention area of LCBC has increased since 1994 to 966,955 km^2, and the newest to 1,035,000 km^2.

The conventional basin exhibits a socio-historical unity based on the history shared by the population groups, some of which straddle national boundaries. As noted earlier, the main languages used in the region reflect the political roles exercised during the pre-colonial period: Kanuri. The old states converted to Islam such as Kanem, Bornu, the Peul Empire of Sokoto, Wadai, and Baguirmi are largely responsible for the present distribution of populations in the conventional basin (LCBC, 1990).

The status of conservation and development is more dependent on the practices and policies in the member states than on the shared human and natural resources. Niger and Chad speak French. Nigeria speaks English while Cameroon is officially bilingual. All countries have opted for a state-led development and natural resources control policy.

2.3 Institutional and managerial features

The Lake Chad Basin Commission, an inter Governmental Agency was established by the Fort Lamy (now N'djamena) Convention and Statutes on May 22, 1964 by the heads of four countries that share the lake. It was not until March 1994 that Central African Republic was admitted as the fifth Member State. The Sudan indicated interest in joining the Commission and its membership was ratified during the tenth Summit of the Heads of States held on 28th July 2000. The admission of Sudan increased the conventional area to 1,035,000 km^2 in 2000. However, Sudan is yet to ratify the Convention establishing the Commission, a necessary precondition for partaking in the activities of LCBC.

According to LCBC, Convention and Statutes, the primary responsibilities of the Lake Chad Commission are to regulate and control the utilization of water and other natural resources in the

basin; to initiate, promote and coordinate natural resources development projects and research within the basin area; to examine complaints; and to promote the settlement of disputes, thereby promoting regional cooperation. In December 1977, the LCBC signed a protocol for harmonization of regulations relating to the fauna and flora in the four member States, and adopted plans for the multi-donor approach towards major integrated development for the Conventional Basin. In 1994, Member States approved a Master Plan for the Development and Environmentally Sound Management of the Natural Resources of the Lake Chad Conventional Basin. A strategic Action Plan with long-term vision (20 years) for the Chad Basin that was prepared by the Global Environmental Facility (GEF) was discussed and adopted by the Member States in 1998. In March 1999, a 3 - year inland fisheries project started in Lake Chad financed by the European Union. (GIWA, 2002). The LCBC's mandate covers the entire active basin (also referred to as the new conventional basin), which is now 966,955 km^2.

The LCBC steered diagnostic studies carried out in the 1980s and the resulting Lake Chad Master Plan which was finalised in 1992 (LCGC, UNEP & UNSO (1992) and ratified in 1994. The LCBC has also driven the GEF PDF-B work, which has achieved consensus on a "Strategic Plan" to address basin degradation. The Fort Lamy Convention recognises the sovereign rights of the member States over the water resources in the basin, but forbids any unilateral exploitation of the lake water, especially when such use has a negative effect on the interests of the other states. It also recognises *the right of the member States to plan projects*, provided that they consult the LCBC beforehand. However, the Member States were supposed to refrain from adopting any measures likely to alter the lake's water balance, its exploitation by other riparian states, the quality of its water and the biological characteristics of the fauna and flora in the basin. The Member States must inform the LCBC of all projects planned within the "conventional" basin.

After the I990 reform, the LCBC has been trimmed and now has an annual budget of USD 1,000,000, 50% of which is used for operational activities and 40% for development activities. The budget consists of contributions from the 5 member States at the time, and was broken down as follows: 20% from Cameroon, Central African Republic 4%, 7% from Niger, 52% from Nigeria and 11% from Chad. National, sectoral and environmental plans exist in each country. National institutions are officially in charge of co-ordinating the implementation of Action Programme 21 in Chad, Cameroon, Niger and Nigeria. At national level, the relevant environmental institutions are (UNEP/DEWA, 2003):

- Cameroon: the National Consultative Committee on the Environment and Sustainable Development (CCNEDD - 1997), which includes the Prime Minister, various ministers, professional associations and NGOs),
- Central African Republic
- Chad: The National High Committee on the Environment, which includes the Prime Minister and various ministers. (HCNE - 1995).
- Niger: the National Council for the Environment and Sustainable Development (CNEDD - 1997), which includes the Cabinet leader, ministers, civil society, university and NGOs),
- Nigeria: the Federal Environmental Protection Agency (co-ordination of ministers) backed by the National Advisory Council (governmental organisations, private sector, NGOs, community organisations, university) and by the National Council on the Environment (States). Almost all the States in the Federation have prepared a long-term Environmental Action Plan.

In addition, a Basin Committee for Strategic Planning (BCSP) has already been created through the LCBC to assist in the creation of the local initiatives. The BCSP comprises senior country officials, across key ministries such as environment, agriculture, and finance, to increase the likelihood that, where necessary, policy and administrative changes and funding priorities could be made to ensure replication of the most promising locally driven enterprises.

3. Biophysical Environment

The economies around Lake Chad are among those most chronically vulnerable to food insecurity in Africa. They deal with variability through mobility and through diversity of food sources. It has been noted that lake-related activities include fishing and soda-mining. Some people raise livestock, typically moving closer to the lake for grass in the dry season, then moving away in the rainy, mosquito season; some graze their animals up to 100 km away. After the 1970s droughts, many herders shifted from grazing animals (cattle and camels) to browsing animals (sheep and goats), which adversely affected the area's vegetation by consuming the woody plants.

3.1 Lake environments

Hydrology, hydrogeology and water resources

By virtue of its location and climate, Lake Chad drainage area has limited surface and groundwater resources. The water supply to the lake is primarily from the Chari-Logone (96%) and the Komadugu-Yobe Rivers (2%). The total annual mean river inflow decreased from the pre-drought value of 39.8 km^3 to the present value of 21.8 km^3 (-47% change) while the total lake input (including direct rainfall on the lake) decreased during the same time by 50%. These decreases in inflows reflect largely the dry conditions that affect all the river systems in the basin.

Table 2: Drainage areas, inflows into Lake Chad, and overall water balance of the lake

The surface of the lake is covered with a mixture of island archipelagos (23%), reed beds (39%), and open water (38%). The area of open water persists in the southern basin/pool, mostly near the Chari River inflow (Table 2).

According to Magnet (1996), the annual average temperature of the Lake Chad water varies between 25.5°C and 27.5°C. Transparency is clearest in the southern open waters in December to January (100cm) and most opaque in August (20cm). The pH levels in the Chari and in the southern pool of the lake are between 7 and 8, but can reach 9 in the northern pool. Conductivity averages $450x10^{-6}\mu Scm^{-1}$, but increases with distance from the Chari delta. Salinity varies between 40-70 mgl^{-1} in the Chari river, 60-120 mgl^{-1} in the open waters of the southern pool, with an average of 700 mgl^{-1} in the northern pool. Close to the Chari delta, the water is low in calcium and magnesium carbonates but there is considerable seasonal variation. The water has more minerals as one moves northwards, because of evaporation.

These patterns of water quality are clearly depicted in Fig. 3, which shows not only the surface temperature and the transparency of the lake water but also the regime of the dissolved oxygen.

Figure 3(a): Seasonal Trend of Surface Water temperature (^{o}C) Bol-ile, 1956-1960
Figure 3(b)Trend of Transparency, Southern Basin
Figure 3(c): Changes in DO percent saturation, Southern Basin

Groundwater resources of regional importance within the Lake Chad basin are represented by two aquifer systems (Olivry, 1996):

- The phreatic aquifer contained within the Quaternary sand or clayey-sand deposits. The aquifer can be found at depths ranging from a few metres to about fifty metres. Electrical conductivity varies from 50-5,000µS.cm^{-1}. The water quality has calcium bicarbonate with low mineralisation essentially similar to surface water quality. Important nitrate concentrations (up to 300mg/l) attributed to agricultural or faecal origin are reported.
- The confined and often artesian Pliocene aquifer, sometimes called the middle aquifer of the Chad formation, has been recognised only in the central part of the basin. It is encountered at a greater depth (sometimes between 250-400m.). It is well exploited in Nigeria and the extreme north of Cameroon where many boreholes constructed in the sixties and presently in poor states constitute permanent drains of this aquifer. The aquifer has a lesser geographic extent compared to the water table aquifer and its water is older and more mineralised (700-4,000µS.cm^{-1}). This water was classified as bicarbonate with TDS greater than 700mg/l.

The chances of a hydraulic continuity between the two aquifers are remote. Apart from these two aquifers, there are other artesian layers at great depths whose extent and capacities are not well known (Continental Terminal, Continental Hamadien and Continental Intercalaire). Except for the continental terminal aquifer, which outcrops south of Chad, these are probably highly mineralised fossil waters, used for limited purposes. It appears that these horizons have the same hydraulic head as the Pliocene aquifer but exchange with the latter is presumed to be non-existent or extremely small. The continental terminal aquifer is of the sodium bicarbonate type with associated deep waters having a TDS in the range 75-600mg/l. In the south of Chad where the aquifer outcrops, the water quality is fresher and characterized by TDS less than 200mg/l. In the Kousseri area, high temperatures (40°C-46°C) as well as high conductivity values are observed. This water may be geothermal in origin.

Flora, Fauna and Wildlife Resources

The major wetland plant communities present in the Lake fall into three broad categories: floating "sudd" communities, permanent reed swamps, and seasonal herbaceous swamps (edaphic grasslands). A swamp belt – the great barrier – separates the Lake into a north and south pool. Vegetation in the south pool consists of *Cyperus papyrus, Phragmites mauritianus, Vossia cuspidate*, and other wetland plants. *Phragmites australis* and *Typha australis*, grow in the more saline north pool. Occasionally, the floating plant Nile lettuce (*Pistia stratiotes*) covers large areas of open water. Vast expanses of dark, cracking Pleistocene clays line the southern shore of the Lake. Grassland communities dominate where flooding is extensive because most tree species cannot tolerate prolonged flooding. Woody communities dominated by *Acacia* species grow interspersed with grasslands. These woody communities vary in density, ranging from scattered trees and bush grasslands to woodlands and thickets. Xeric woodland species found around Lake Chad include baobabs, desert date palms, African myrrh, and Indian jujube (Mockrin and Thieme, *op. cit.*).

Sahelian large mammal species that used to be common in the Lake Chad ecoregion include red-fronted gazelle, dama gazelle, and dorcas gazelle (*Gazella rufifrons, G. dama, G. dorcas*), patas monkey (*Erythrocebus patas*), striped hyena (*Hyaena hyaena*), cheetah (*Acinonyx jubatus*), caracal (*Felis caracal*), and the endangered wild dog (*Lycaon pictus*). Other species found include the African elephant (*Loxodonta Africana*), two species of otter (*Lutra maculicollis, Aonyx capensis*), hippopotamus (*Hippopotamus amphibious*), sitatunga (*Tragelaphus spekei*), and kub (*Kobus kob*). Two near-endemic rodent species, *Mastomys verheyeni* and the Lake Chad gerbil *Taterillus lacustris*, are also found.

The sitatunga is now considered extinct in Niger while only a few declining populations remain in the Lake Chad region of Nigeria. A reduced hippo population is still present and otters remain common. Nile crocodiles are now uncommon in the Lake.

Up to a million wintering ducks congregate on Lake Chad each year, making it the third most important area for migratory water birds in West Africa. Some 49 of the 83 major Palaeoarctic species attracted to the Sahel depend on wetlands, and for another 10 species wetlands are preferred habitat. The actual numbers of birds vary year to year, depending on the size of the lake and on wetland conditions elsewhere in West Africa. The eco-region supports two near-endemic birds, the rusty lark and the river prinia. Other birds include the marbled teal, which is occasionally seen on Lake Chad and in northern Chad and is thought to be declining worldwide. Ruffs are common here, with over one million seen on the lake at one time. A few populations of elephant, kob, and red-fronted gazelle still live in sections of the Chad Basin. Although humans have hunted out other large mammals and crocodiles, smaller mammals (such as the endemic Lake Chad gerbil), smaller reptiles, and amphibians remain.

Table 3 depicts the number and distribution of birds as related to the extent of the surface water (wetlands) in the Hadejia Nguru wetlands of Nigeria between 1994 and 1997. Altogether the open-water bodies contain over 300 species of water-related birds, largely made up of palaeo arctic migrants, but also including Afro-tropical migrants as well as resident species. The number of birds and the extent of the flood are strongly correlated. The relationship is however not exact because in addition to flood extent, flow regime characteristics such as frequency, depth of water and duration of specified flows are important (Oyebande, 2001). However, as the table shows poor flooding results in low number of waterfowls.

Table 3 Number of water-related birds and flood extent in the Hadejia-Nguru wetlands, Nigeria

The conventional Lake Chad basin encloses one of the most productive regions of freshwater fish in Africa. Some 130 species are found within the lake basin. Significant biodiversity loss has been noticed in fish during the past decade or so. Fish species such as *Alestes* and *Shilbe spp.* whose pattern of migration and spawning is triggered by the rising flood are more severely affected by the change in the flood cycle, much more than *Claris* and *Tilapia*, for example. A comparison of flooding extents and fish catches in 1992, 1993, 1994 and 1996 (the last two years being regarded as good years) together with the information obtained on the fishermen's perception of the flood impact led to the conclusion that the minimum annual flooding extent required to sustain the fish ecosystem and fishing industry in the Hadejia-Nguru Wetlands is 800 km^2 (Oyebande, 2001).

As a result of climate variability and unsustainable water projects, five to eight species of fish have disappeared from different parts of the Lake Chad basin in Nigeria. The experience in the Logone valley south of the Semry Irrigation Project is similar: fish yields collapsed by 90% for lack of inundations. Together with collapse of the floating rice farming this has produced a battalion of unemployed Kotoko youths who need retraining and empowerment to work with other rice varieties and with the collapsible fish cages.

3.2 Degradational history

The lake nearly occupied the whole of its hydrological basin some 10,000 years ago, but has since experienced fluctuating fortunes, having completely dried out four times between 1400 and 1910. Lake Chad covered 25,000 km^2 in 1963, compared with 1,350 km^2 today (Fig. 2). In addition, the vegetation of the northern part of the Lake has disappeared and sand dunes have begun to form on the dry lakebed. The lake's shrinkage is attributed to the combination of a drier climate and growing human demand for water. But over the past few decades the region has experienced a series of devastating droughts.

The significant decrease in direct lake rainfall since the 1960s, which is largely due to a decrease in the number of large rainfall events and in river inflows (47%), have been largely responsible for the shrinkage of the lake. The lake being very shallow, responds rapidly to changes in rainfall and river inflows. At the same time, the need for water for irrigation in the four countries that share the lake has increased about fourfold, further draining the lake[1]. Nevertheless, the problem is expected to worsen in the coming years as population and irrigation demands continue to increase. The low water-use efficiency (about 11%) that characterizes the region's irrigation needs to be revisited and drastically improved.

If the trend of shrinking continues in the Lake, it is very possible that migration of some of the most active fishing and agricultural communities might occur, as these people may wish to seek for a better life elsewhere.

Gaston (*op cit.*) also studied the effects of the 1973 and the 1983-84 droughts on the Sahelian pasture lands in the Kanem region of Chad Republic. According to the author, the effects of the 1973 drought seen on the ground were spectacular. There were many dead trees and all woody species had disappeared, as had the perennials of the field layer. In many places, sand had been blown and heaped against the dead and fallen trees. A revised 1:500,000 map based on specially flown aerial photographs taken in 1974 showed only eight (out of twenty vegetation types represented on maps of the same scale prior to 1973) vegetation formations. The northern limit of the Sahel had moved 50 km to the south to 15°N. The movement resulted from the significant downward shifts of isohyets widely observed in the Sahel and the progressive desertification ushered in by the desiccation.

Available dry matter following the rains of 1975 varied from 250 kg/ha to 1000 kg/ha, but this was only on 78% of the pasture area of 1964-1965. The remaining 22% was completely devoid of vegetation. Calculations done by the author showed that the pasturelands have a carrying capacity limited to 66% of the livestock fed prior to the drought.

[1] The total water requirements by the potential irrigated areas are 16.5 km^3, but less than 10% of such areas currently under irrigation. In any case Nigeria, which accounts for the bulk of the present basin's irrigated area (73%) contributes less than 3% to Lake Chad.

Addressing the problems associated with the Lake Chad however requires enormous degree of commitment and regional cooperation. For the many years, countries in the commission have been taking steps to institute a process of water transfer so as to effectively recharge the Lake Chad, and revive it well enough to continue to benefit user-countries. The decrease in river flow has in places led to the degradation of the river channels and hydrology. Accelerated siltation and weed growth, particularly Typha australis have done great damage in the Hadejia-Jama'are-Yobe basin and elsewhere. Irrigation channels have been clogged and river channels blocked by siltation and Typha, so that water could not reach the lower parts of the catchments and Lake Chad. The twin pests of Typha, quela birds that flock in large numbers inflict additional loss of rice and other grains and aggravate the already unstable livelihoods in the basin.

The environmental impact of pollution is trans-boundary in nature, because nutrient loads from upstream developments (irrigated and urban discharges) impact on downstream populations and communities. Contamination by agricultural and industrial chemicals, solid wastes, and sedimentation has local as well as trans-boundary implications. Crop residues left after harvest in different parts of the basin also contribute to the pollution of water bodies to some extent (Oguntola, 2003). Fig. 3 shows the surface temperature, dissolved oxygen and the transparency of the lake water in the period between 1956 and 1976. More recent data series are required to assess the changes that had taken place during the past three decades.

3.3 Resource conflicts and their resolution

Inadequate approach to resource management is the most complex cause of environmental degradation and resource conflict in Lake Chad basin. Access to natural resources and their use are poorly managed, and the communities and groups could not be assured of a fair and stable set of management rules for access and use. Droughts, civil strife and population movements have placed further constraints on sustainable management of the vital resources of the region.

By the end of the 1960s, drought conditions had started to set in and the Lake Chad level began to fall until it reached a crisis position. Within a decade the Lake had shrunk to about one tenth of its normal size. The Lake water receded for more than 150 km from its northern and eastern shores, and by more than 80 kilometers from its western shoreline. Some of the natural fauna and flora disappeared and sand dunes appeared on the dry lake bed. All economic activities such as fishing, livestock rearing and farming, were adversely affected and the population had to migrate as environmental refugees. It was this phenomenon that started the major trans-border crisis of the Lake Chad basin. People whose economic activities were dependent on water such as fishermen, kept on following the receding water across boundaries without noticing the borders. By 1983, a crisis had started. Such migrants found themselves in other countries without fully realizing the change, as there were no boundary marks in the Lake Chad. Territorial disputes erupted between some member countries over emerging islands in the Lake (e.g. Darak).

This trans-boundary problem led the LCBC Member States to resort to their sub-regional organisation, which has a mandate for examining complaints and promoting the settlement of disputes. Under that forum, the Heads of State issued specific directives to the Commission to address security issues on the Lake Chad. The regional organization has provided a very vital forum for conflict resolution. Two committees were immediately constituted, one on security and the other on the border demarcation exercise. The Security Committee held a series of meetings and finally came out with a recommendation that "to ensure lasting peace and security in the zone, a joint patrol system should have to be introduced. This was adopted and every member

country contributed security agents who jointly patrolled specifically demarcated areas of the Lake Chad.

A major gap in the LCBC convention is its failure to prescribe any water allocation rule. FAO[2] was requested to assist the Commission in the formulation of common regulations for the apportioning of the surface water in the convention basin among member states. Following its review at the 13th Session, the draft agreement prepared by FAO's legal Office on water utilization and conservation was referred to the Legal departments of Member States for detailed study. The report is still in the cooler till today.

Adherence to a number of the past agreements between the riparian countries on the conservation and development of the basin's resources could not be enforced, but only voluntary in the absence of international monitoring or sanctioning bodies. Examples include the 1970 Moudou Agreement between Cameroon and Chad, specifying limits of water level changes in the Logone permissible with the creation of control structures. Another failed agreement, this time by the four LCBC member states is the 1977 Agreement on Common Regulation of Flora and Fauna.

Improperly designed dams and poor, uncordinated operation of the dam reservoirs have led to numerous conflicts within and between member countries. A very large dam (Kafin Zaki) under construction in the basin had to be suspended when the enormity of its negative potential impact on the basin's water balance became clearer. Communal uprisings (downstream versus upstream riparians) have become more frequent in recent times, but application of science and advocacy has helped to resolve some of the conflicts. For example, the dry season test releases in 1996 from Tiga and Challawa Dams (which control over 80% of the flow of the Hadejia River) were revealing. The results showed that virtually no water from the Hadejia River system leaves the Hadejia-Nguru wetlands into Komadugu Yobe due to weed blockages (Typha reed beds), and siltation of the riverbed in the zone of the wetlands. Yet the test releases flooded most of the floodplains along the Hadejia river system, simulating perfectly the wet season condition and proving that the dam outlets and Hadejia barrage are adequate to generate artificial flooding in most wetlands. The implication of this for downstream ecology had been grave and had earlier led to disputes between upstream and downstream communities (HNWCP, 1996).

Obviously, absence of an integrated river basin management strategy is partly responsible for the conflicts. Examples are the inefficient use of huge quantities of water in large irrigation projects (Kano River and the Hadejia River irrigation projects) to the neglect of the needs of the more productive downstream water projects and requirements. There is also the present inefficient way of meeting the water demands of the Kano City water supply through filling the pit of Kano City Water Supply intake with higher than optimal levels towards the end of the dry season at a time when there are not many other demands (Diyam Consultants, 1996). Feasible technical solutions are known but the River basin Authority in charge lacked the will to implement it (Oyebande, 2003).

On the main Komadougou-Yobe river around Mamouri area of Niger Republic, the conflict over the use of the river flow had reached crisis proportion. In the late 1980s, Niger authorities constructed a water intake structure on the left bank of the Komadougou-Yobe river, upstream of some existing irrigation schemes exploited by Nigeria on the right bank around Yau. This led to

[2] At the 9th Council meeting of LCBC at Yaounde in June 1969.

reduced water availability at the Nigerian Borno State irrigation schemes. The operators of the scheme in turn went some distance upstream of the Mamouri scheme intake structure and created a canal to get more water to their scheme in the spirit of the riparian doctrine that asserts, "prior in time is prior in right". The conflict was eventually resolved at the bilateral level by the Nigeria-Niger Joint Commission for Cooperation.

Resource Use Conflict between Nomads and Farmers

Inter-ethnic conflicts over the use of natural resources are a common occurrence in the Lake Chad basin. Many casualties have been recorded in most countries within the basin in recent years. The main cause of the conflict is due to lack of water for livestock as well as lack of agricultural land leading to the encroachment of farmers into pasture lands, and vice versa.

Large-scale versus small-scale (traditional) irrigation and water requirements

LCBC member States have developed large irrigated areas along the rivers that feed the lake with the intention of supplementing traditional rice growing. In Chad, the production of irrigated rice represents only 4% of national cereal production as opposed to traditional rice growing which represents 75 per cent. In Cameroon, irrigated production has been reduced for marketing reasons. On the whole, current irrigation projects are still very weak. Unfortunately analysis of water use in the Logone floodplain reveals huge losses in the traditional floodplain agricultural production in recent decades due to climate variability and human activity. The construction of both the Yagoua-Tekele dyke (on the Logone) and the Maga in 1979 has had severe negative impacts: recession rice cultivation dropped to 75% and cotton to 33% (Matt and MacDonald, 1999, Oyebande 2001).

In Nigeria, the planned irrigation under the existing water management works is estimated at 185,000 ha, of which only about 32,000 ha have been completed and irrigated. The total identified potential has been evaluated at 356,000 ha. However, even an attempt to complete the development of the first 185,000 ha has already created water shortages and conflicts. Nigeria also plans the development of 146,000 ha of fadamas (floodplains). Fortunately, the approved master plan for the Conventional Basin proposes to concentrate future developments on small-scale irrigation projects.

Unsustainable development of the fisheries resources

Lake Chad poses a unique challenge for fishing regulations because it lies within four different countries. Systems of regulating access to fishing were recently created. Regulations are very complicated and haphazardly enforced, with confusion among different administrative agencies over regulation and taxation (WWF, 2001). Some major issues contributing to dwindling fish catches, apart from rainfall and river inflow deficits driven by the back-to-back droughts of the past 4 decades, include:

- Over- exploitation: This is a major problem on lake. Being an international water body, the lake hosts many fishing vessels, some originating from other countries outside the riparian countries (e.g. Mali) who harvest fish there;
- Smaller mesh sizes and increased juvenile catch that contribute to significant resource waste and depletion;

- Destructive fishing practices;
- Decreased viability of stocks through contamination and disease;
- Impact on biological and genetic diversity.

4. Management Environment

4.1 Institutional Roles, Management Strategies

Protected Areas

Acquisition and development of grazing reserves began in the 1960s when the Northern Nigerian Government started placing emphasis on the nutritional disease control and water development aspects of livestock management. It was also to encourage the nomadic population to opt for gradual settlement. Areas acquired in Lake Chad basin include Borno Emirate (219,000 ha) and parts of Kano (42,485 ha).

The Lake Chad Game Reserve is currently the only protected area on Lake Chad. It occupies 7,044 km^2 along 150 km of the western lakeshore in Nigeria, more than half the Nigerian shoreline of the lake. However, this reserve is a conservation area only in theory and local communities have claimed the land for settlements, farms, and cattle grazing and as bases for fishing. A similar situation exists in the Hadejia-Nguru wetlands where there are some forest reserves and small areas that are under National Park status, but local populations also heavily use these areas. It is necessary to formulate and enforce access rules for adherence locally, nationally and regionally.

Regional initiatives for data monitoring and database creation and establishment of early warning systems are both imperative and urgent. Such systems need to be for surface and groundwater as well as invasive weeds and associated pests. The ongoing effort in the West and Central Africa in HYCOS provides lessons and opportunities for such challenging endeavours.

RAMSAR Sites

Within the framework of a strategy to save the Lake Chad, the LCBC Heads of State took note of the efforts being made by the Ramsar Convention Secretariat and the World

BOX 1. The Lake Chad Vision for 2025 and the Region's Principal Objectives

The Lake Chad Vision for 2025 highlighted a number of important issues deduced from the existing situation in the basin. These include problems associated with (a) climatic changes resulting from rainfall deficits, reduced runoff in the major rivers, considerable shrinkage of the Lake Chad, falling levels of groundwater table, decline in perennial vegetation and increase in the vulnerability to soil erosion; (b) poor decision-making, development policies focused on short-term solutions, as well as unsustainable development decisions, leading to construction of large dams upstream without adequate consideration for downstream users and ecosystems, abandonment of costly investment due to lack of water. etc; (c) lack of water and environmental policies (effective monitoring system water resources quantity and quality, facilities for early warning and preservation measures, management of water demand etc.); (d) weak co-ordination through low level of stakeholders participation and unsuitable institutions; and (e) weak economic situation of member states coupled with persistent rural economy and population growth responsible for increasing pressure on water, ecosystems and continued decline in biodiversity in the region.

The vision of the Lake Chad Region subsequently presented identified three objectives, namely (i) maintenance of the Lake Chad and other wetlands of the region at sustainable levels for economic security of the freshwater ecosystem resources, sustained biodiversity and aquatic resources of the basin and their equitable use and alleviation of poverty; (ii) acceptance of responsibilities for freshwater, ecosystem and biodiversity conservation and judicious integrated river basin management by regional and national authorities; and (iii) equitable access by member states to safe and adequate water resources to meet their needs and rights (Second World Water Forum 2000, UNEP/DEWA, 2003).

Wide Fund for Nature on Conservation and Restoration of the Lake. Thus at its July 2000, following the declaration of the Lake Chad (in Cameroon, CAR, Chad, Niger and Nigeria) a Trans-boundary Ramsar site of International Importance, LCBC urged all the member States that were yet to ratify the Ramsar convention to speed up action to accomplish the ratification. A Global Environmental Facility (GEF) project has been approved for Ramsar designation, including a management plan for the lake and the basin (WWF, *op. cit.*).

The Sum of US$10.08 million has been approved for the project, which was scheduled to take-off in 2003.

Box 2 Memorandum of Cooperation between Ramsar and LCBC

Memorandum of Cooperation between The Bureau of the Convention on Wetlands (in accordance with Ramsar Convention of 1971) and The Lake Chad Basin Commission (LCBC) in November 2002 spells our the following objectives among others:

- reinforcing the role of wetland ecosystems for sustainable development;
- reinforcing the institutional partnerships at basin level and national level between all stakeholders - governmental entities, Intergovernmental Organizations (IGOs), Non Governmental Organizations (NGOs), and other stakeholders concerned with the conservation and sustainable use of wetlands;
- establishment of a coherent national and regional network of Ramsar sites at the basin level, as the basis for their sustainable management;
- taking into account innovative approaches to transboundary wetland management in the Lake Chad Basin subregion, by promoting partnerships between the Partners, Conventions (such as CBD, UNCCD, UNFCCC, etc.), regional and subregional organizations, Governments, IGOs, NGOs, etc. as models for global replicability.

Announced at the then ongoing World Parks Congress in Durban, South Africa is the establishment of a giant transboundary protected area by Nigeria, Cameroon and Birdlife International. Elements of the ecosystem to be protected include:

- Mountain forests, grasslands and savannas of the Gashaka Gumti National Park in Nigeria (6,670 km^2), and Tchabal-Mbabo (300 km^2) in Cameroon Mountains;
- Both with endemic bird areas and important bird areas: 28 bird species of Afromontane ecosystem, 13 of which are found only in the area.
- Large mammals: endangered Chimpanzee species,

Gashaka Gumti is protected but suffers encroachment by cattle grazers and farmers, while Tchabal-Mbabo is not currently protected at all. The strategy is intended to provide effective and sustainable protection for the newly created areas.

Monitoring and assessment

Generally, there is insufficient knowledge of water resources, and specifically, how aquatic systems function. There is no systematic system for monitoring the quantity and quality of freshwater resources, nor are there effective water quality protection programs.
The available water quality data series date back to the sixties and seventies (Fig. 3). Lake Chad's River basin organizations established in member countries like Nigeria made substantial contributions in this area up to the late 1980s before lack of political will and funding problems resulted in the collapse of the monitoring networks. Nevertheless most of the available datasets have been captured.

4.2 Capacity Building and Stakeholder Participation for Reducing Stress

Lake bed farming

At the local level, people living near the lake, particularly in the northern areas of the basin developed strategies for taking advantage of the opportunities afforded by the lake. Basin farmers use both traditional and improved technologies to adapt to the changing water levels. Crop strategies include farming the lake bottom; the receding Lake Chad left behind an estimated 0.5 million ha of cultivable land, some of which was being cropped. Farming is also done on "recessional lands", where the lake water recedes every year, in the "polder" depressions between dunes. Rice, wheat, maize and vegetables are grown. In a traditional polder, one crop a year is grown as the lake water recedes. If 'dams' and pumps are used, up to three crops a year can be grown. Besides fewer fish, a low lake level also means shorter shoreline and thus fewer polders. It is estimated that only 10% of the lake's polder areas were being used.

In the past few years, river and lake levels have been rising slowly. If this trend continues, it will present new challenges and opportunities to the local people who depend on the lake and the surrounding lands for their livelihoods (Nami, 2002).

Stakeholder Participation in Transboundary Protected Area

The transboundary protected area in Gashaka Gumti Park (in Nigeria) and Tchabal-Mbabo (in Cameroon) has been noted above. A study to develop the capacity of the stakeholders to provide fully effective protection to the area has been designed.

Community Projects

UNEP/Belgium Mega-Chad Project is titled 'The Promotion of Renewable Energy Resources and Conservation of Threatened Flora Species in the Dryland of Mega-Chad of the West African Sub-Region'. This community-based project aims at promoting the use of renewable energy resources (Solar, Biogas), fuel-efficient wood stoves, and water-harvesting techniques as well as the conservation of threatened flora species.

The Mega-Chad project is based on replication of best practices in land degradation control. The 3-year project on land degradation control with a strong socio-economic component is under implementation since November 2001 in collaboration with the University of Maiduguri, Nigeria, and the LCBC. The project will address propagation of diminishing tree species for biodiversity conservation, training and implementation of renewable energy technologies (solar energy for cooking and extraction of underground water, water harvesting and promotion of youth clubs for environment conservation.

4.3 Financial Investment for management programmes

Given the very limited financial resources of the region described in section 2.1, it is certain that much political will and commitment would be required to raise substantial funds for the much needed regional development. Even then, enormous financial inflow from external support agencies would be indispensable. LCBC Members realizing this challenge as far back as 1977 adopted plans for multi-donor approach towards major integrated programmes in the basin.

Thus in the final communiqué issued at the end of the Tenth Summit of the Heads of State and Government of the Lake Chad Basin Commission held on 28th July, 2000 in N'djamena the Heads of State urged the international community and all donors and assistant agencies to team up with GEF and the Implementation agencies of the project to save the Lake Chad and its teeming population from the adverse effects of drought and desertification. The Heads of State

unanimously mandated President Olusegun Obasanjo of Nigeria to assist in making contacts with potential donors and mobilize them for the planned donors conference.

Some of the donor and LCBC ongoing and planned investments and their status, real and potential impacts are outlined in the following sub-sections.

Reversal of Land and Water Degradation Trends in the Lake Chad Basin Ecosystem: Environmental and Social Impact Assessment.

The objectives of the LCBC/GEF Project, Environmental and Social Assessment (EAISA, October/November 2001) were to identify, qualify, and to the extent possible, qualify the likely negative and positive environmental and social impacts of the project as presently designed, and to propose the mitigating measures to avoid negative impacts. The study showed that there were no significant negative environmental or social impacts expected. However, many of the pilot proposals focused on further community planning initiatives, with few on-the ground interventions, The study recommended initiating community based development interventions as a high priority component of the pilot projects (The Natural Resources Group 2001).

The Heads of States of LCBC countries in a recent meeting noted with satisfaction the progress on the LCBC/GEF project, expressed appreciation to GEF, and urged the implementation agencies, i.e. the UNDP and the World Bank, to expedite action on the technical design of the pilot projects recently approved.

Survey of Lake Chad, Wetlands and their Conservation.

The WWF Living Waters Campaign's ongoing work with the governments of Chad, Cameroon, Nigeria, Niger and the Central African Republic is to carry out a survey of Lake Chad and other wetlands as well as promoting their national conservation efforts and wise use of wetlands.

With similar objectives, IUCN West African Regional Office is also supporting an ongoing survey of wetlands in the region. Lake Chad basin in Nigeria, Niger and Chad are covered by the survey. In particular, the project plans to apply the conclusions of the World Commissions on Dams to lift the threat on wetlands in the region.

Hadejia-Nguru Wetlands Conservation Project (HNWCP) in Nigeria

The HNWCP project was established in 1987. IUCN managed Phases II and III of the project, from 1992 to 2000 before handing it over to the Nigerian Conservation Foundation (NCF). It is therefore right now in a state of abeyance, with DFID-JEWEL Project, based on a MoU with NCF, keeping the Information Centre at the Project Office in Nguru open for all users. While it lasted HNWCP promoted the integrated management of the water resources of the Komadugu Yobe Basin (KYB), in which the Hadejia-Nguru Wetlands (HNWs) are situated, as a means of safeguarding the ecological, hydrological and economic integrity of the wetlands. It also promoted public awareness and education, preparation of management plans and guidelines, advocacy and the wise use of the wetlands' natural resources.

IUCN has another project, which is likely to kick off in late 2003 on Water Governance in the whole of Komadugu-Yobe Basin. It is an aspect of IUCN's Water and Nature Initiative (WANI),

a global programme. The project will be implemented in partnership with NCF and the Federal Ministry of Water Resources FMWR). Its ultimate objective is to assist the FMWR to develop and implement an integrated water resources management plan for this part of Lake Chad Basin in Nigeria (Oyebande *et al*, 2003).

DFID-JEWEL's livelihoods project supported by the UK DFID is also working in the basin. Its ultimate objective is to contribute to poverty reduction in the HNWs through the improved management and utilisation of the common property natural resources of the HNWs. It has just completed a 10 months inception phase (end of July), and is looking forward to starting a 3 years and 3 months implementation phase by the first October 2003 (Oyebande *et al*., op. cit).

Inter-basin water transfer Project

The forty-ninth session of the Council of Ministers of LCBC held in Yaounde, Cameroon, from 8 to 18 January 2002 emphasized the need to speed up the feasibility study of the Lake Chad replenishment project. The project seeks to feed the lake with water from the Congo basin. The invitation to this conference of delegates from the International Committee of the Congo-Oubangui-Sangha Basin, demonstrates the commitment of member countries to safeguard the Lake Chad basin. The erstwhile chair of LCBC and President of the CAR had headed a team made up of ministers from Cameroon, Niger and the CAR to obtain the non-objection of the two Congos for the implementation of this project. Sources said the Congo DR and the Republic of Congo have already approved it. The LCBC has submitted requests for funds to donor countries, both directly and through the New Partnership on African Development (NEPAD). It plans to start feasibility studies soon to examine the social, economic and environmental impact of the proposed project. The Members of the LCBC are reported to have put together one million US dollars in counterpart funds and are waiting for donors to contribute the remaining US $5 million that the studies will require.

This proposed project, still in the conceptual stage, proposes to move 100 x 10^9 m^3 of water annually from the Zaire River in a navigable canal 2,400 km in length. This project involves constructing dams at the donor and receiving basins, which would then be used to produce about 30 to *35* GWh of electricity. This supply, along with the oil to be produced in Chad (see also Box 3), would contribute towards meeting the sub-region's energy requirements.
The canal to be used to transfer water from the Oubangui is also expected to facilitate the transport of goods and services within the region. And when there is enough water, irrigation will boost agricultural production, fishing as well as reforestation (UN's IRIN, 2003). In fact an area of between 50,000 to 70,000km^2 in the Lake Chad Basin would be put under extensive irrigation development as a result. Finally, an area of between 5 and 7 million hectares could be put under intensive irrigation development in the receiving basin (Jauro undated). On the whole, it will provide an opportunity to rebuild the ecosystem, rehabilitate the lake, reconstitute its biodiversity and safeguard it as the people, if properly educated, informed and empowered, would no longer see the need to cut wood for energy.

Box 3 Future Oil Production and Wetland Ecosystems

Chad has proven recoverable oil reserves estimated at approximately one billion barrels. The Exxon-Mobil Chad Cameroon Petroleum Development and Pipeline Project involve the development of oilfields in southern Chad and the construction of a 1070km pipeline to offshore oil-loading facilities in Cameroon's Atlantic coast. A refinery will be developed in N'djamena.

Petroleum exploitation within the basin would give rise to increased urbanization, mining activities in CAR would continue, large-scale agricultural projects would continue to be operated, the Chari-Logone Integrated Rural Development Project would come on-stream, there may be further reduction or complete disappearance of wetlands or lakes. However, the experience of the Niger Delta suggests that oil spills and related hazards could cause severe contamination of the water bodies and deplete the biodiversity of flora and fauna.

The Mega Chad Project and the Transboundary Protected Area Between Nigeria and Cameroon

Already described in section 4.2 are the Mega Chad Project and the Transboundary Protected Area straddling Nigeria and Cameroon. The former is supported by UNEP and the Belgium Government while the latter (the transboundary protected area) is being supported by UNDP/GEF fund with US$390,000 and will take 15 months to complete. In both cases the goal is to reduce environmental and ecosystem degradation and promote sustainable resource utilization through provision of necessary investment fund which has constituted a severe constraint.

5. Lessons learned and Recommended Initiatives

5.1 Political Will and Commitment

The LCBC is the most relevant international organization because it defines the conventional basin. Until recently, evidence of the Commission's presence has been virtually invisible in the conventional basin apart from some scattered infrastructure. Member States need to vest the Commission with more power to enable it resolve water and land disputes and conflicts. Lack of strong evidence of supranationality is a basic weakness in all river basin organizations and regional economic communities in Africa. One finds that a key factor of the success achieved by similar organizations in developed countries is the preparedness of members to be bound by decisions made by the regional institutions (ECA, 2001). It is not just a matter of getting a protocol or convention ratified that makes it work, but the degree to which it is binding on member States. Such a step depends on the political will and commitment of the member countries to the regional organization and its goals.

The compelling evidence of the degradation of Lake Chad and its basin, and the urgency of the need for restoration has stimulated LCBC member countries to muster some political will to cooperate with the Commission. Moreover, within their limited resources, there is evidence of improved commitment by member states to their financial obligations.

5.2 Need For sustainable institutions and effective stakeholder participation

Most of the policies and institutions required to prevent environmental degradation and promote sustainable development are similar throughout the basin (section 2.3).

Stakeholder participation is gradually being encouraged. A number of community projects are ongoing or planned in which stakeholders are involved at various stages (section 4.2). A good example is the rehabilitation of the Logone wetland in Cameroon in 1993[3]. The embankments of the barrage along the river were modified over eight years. Stakeholders and local community members were involved in the planning and design of the project. Small-scale fishing has recommenced and potable water from groundwater sources has been supplied to 33 villages.

The World Bank aided Agricultural Development Projects (ADPs) in the Yobe basin (Nigeria) facilitate wetland (fadama) farming through promotion of fadama users associations (FUA), each consisting of 25 fadama farmers. There were 276 such associations registered in Yobe State by 1996. The FUAs facilitate securing and recovery of loans and other service charges. They also facilitate training of members in bookkeeping, agronomic practices, as well as pump repairs and maintenance. In addition, there were also 46 water users associations (WUAs), which managed rural water supplies in the State and maintained the facilities while the Local Government assisted with major breakdowns (Oyebande, 1997). Similar WUAs have also recently emerged belatedly in Kano River Irrigation Project and the Hadejia River Barrage Project to facilitate recovery of charges and fees and for taking over some functions such as clearing the troublesome invasive Typha reeds and desilting of irrigation canals.

The advocacy brokered by IUCN in the Komadugu Yobe basin, which led to broad-based stakeholder participation in the resolution of upstream-downstream conflicts, is a good example. It led to the dry season test water releases from Tiga and Challawa Gorge dams among others (section 3.3). There is need to involve both domestic and international NGOs to be involved effectively at all crucial stages of water management practices.

LCBC and member countries need to streamline and replicate such user associations for activities such as fisheries, livestock farming, crop farming, etc. in other parts of the basin.

5.3 Legislative Frameworks and Financing Strategies

Integrated river basin management requires appropriate and effective legal framework in order to achieve the desired goals. LCBC is yet to accomplish this prerequisite. The LCBC member countries need enabling legislation to guide integrated and sustainable water utilization and management. LCBC will do well to assist members in achieving such a water code. Nigeria's National Water Decree 101 of August 1993 as water law is fairly detailed but the mechanism for its implementation as well as the political will to enforce it is yet to be demonstrated. There are also other policies approved by the National Water Resources Council, which are currently in use. These include charges for water from dams and irrigation infrastructure provided by the River Basin Development Authorities (RBDAs).

Recently, a draft policy for reservoir operation presented to the National Water Resources

[3] A barrage was constructed across the floodplain in 1979 to create Lake Maga. And supplied irrigation water to some farms. It has had severe negative environmental and social impact on the wetlands and the people.

Council in Nigeria was discussed but could not be agreed on as upstream and downstream stakeholders' views could not be reconciled. A Committee set up to handle the matter was inaugurated in early 2003 to apply the policy to all water infrastructures. This should be finalized not only in Nigeria, but also in all member countries and adopted as a regional policy to solve the problem of water allocation.

Also, the a draft agreement prepared by FAO's Legal Office on water utilization and conservation which was referred to the Legal departments of LCBC Member States for detailed study at its 13th Session should be taken out the cooler for updating and implementation.

The financing strategy has been discussed in details (section 4.3). LCBC member countries are more financially committed to basin programmes as demonstrated in the case of the inter-basin water transfer to replenish Lake Chad. External support Agencies and Donors such as World Bank, UNDP/GEF, IUCN, WWF, DFID, ADB, and some National Funding Agencies are already actively involved in the basin. The LCBC should continue to reach out directly and also through NEPAD and the African Union to the various donors including the EU, the Islamic Development Bank, FAO, World Food Programme and UNEP. It should mobilise them within a wider framework of multilateral support to member states and LCBC in restoring Lake Chad's water resources and ecosystems of global importance, an undertaking that is beyond the means of the chronically poor countries inhabiting the region.

5.4 Broadening The Lake Basin Management: Linking Local, National, Regional And International Entities

Poor coordination is perhaps the most critical managerial problem confronting Lake Chad basin and its national components and it manifests in various forms. The sub-basins are sometimes granted autonomy, which produces artificial divisions and precludes basin-wide planning. Consequently, project approach to development in which schemes are developed in isolation has prevailed.

Since the Abuja Summit of LCBC held in 1994, each member country has been trying to apply the main recommendations of the Summit in relation to the Master Plan: preparing medium and long-term database for planning and setting up early warning systems for rational water use and the environment, including environmental impact assessment for large projects within the basin; promotion of integrated multi-purpose projects; integration of the environment in all education systems as a training, information and awareness tool.

The LCBC/GEF Project on the integrated development of Lake Chad has lofty objectives, and has achieved a measure of success in some of the fundamental areas. It has set up a Programme Coordination Unit (PCU), which involves lead agencies in member countries. Some of the plans and achievements include (UNEP/DEWA, 2003):

- 15 completed community-endorsed plans for access to and sustainable use of resources;
- A completed trans-boundary diagnostic analysis (TDA) and established monitoring systems and models of the hydroecological functions within the basin;
- Six pilot projects implemented with feedback from implementation supporting the development of the TDA and Strategic Action Program (SAP). These include five important wetlands distributed in all member countries and registration of Lake Chad as a Ramsar site.

- The formulation of a GEF SAP that includes necessary baseline and additional actions to address the priority trans-boundary issues and provision of monitoring and evaluation tool for implementation; design of a set of sub-programmes and identification of resources for their implementation.

These are sure steps to a higher level of integrated basin management and development similar to what the South African Development community (SADC) has attained. No effort should be spared in carrying them to a logical conclusion.

Some of the actions that need to receive urgent attention as part of the integrated water/basin development and management are:

- Improvement of dam design, coordination and efficient operation of the reservoirs. LCBC might look into the possibility of promoting adaptation of the draft policy for reservoir operation being processed by the National Water Resources Council in Nigeria by other member States.
- Reversing of the channel degradation owing to blockages by silt and invasive weeds is a major cause of water scarcity in downstream areas and hence of disputes and conflicts. The solutions identified in the Yobe basin include strategies to remove/clear the weeds (a regional endeavour is required here), improved reservoir operation, water-apportioning structure at crucial location (an option that has been stalled). Typha grows to full cycle within three weeks of its clearance, thus frustrating such efforts. A non-structural approach such as using reservoir operation for attacking the weed holds greater promise. It is known that Typha cannot survive where pronounced dry season spell exists. This is the case in the Jama'are basin; dam regulation is lacking and pronounced dry season period occurs annually.
- Promotion of water resources augmentation through inter-basin water transfer (section 4.3) and rainwater harvesting. The LCBC is already seriously committed to recharging the water of Lake Chad through transfer from The Congo. Also in parts of the basin rainwater harvesting for animals and crops is being practiced at informal scale. The communities could be empowered to apply the technique more scientifically. Rational exploitation of groundwater need to be similarly promoted.
- Management policies and legislation which would articulate water quality and effluent standards, protection zones, necessary buffer capacity, approved method of waste treatment and discharge, etc. need to be developed and enforced at national and regional levels to forestall pollution within the basin in the future. Nigeria and most of its 36 states have established elaborate standards; effective strategy for enforcement remains the main bottleneck.

5.5 **Role of scientific research, data and capacity building**

The survival of Lake Chad depends on multi-sectoral, integrated water resources management based on good scientific data and local knowledge. The status of monitoring and data /information system has been summarized in section 4.1 with a strong recommendation for implementation of regional initiatives for data monitoring and database creation and multi-purpose early warning system with lessons from the ongoing effort in the West and Central Africa HYCOS (hydrological cycle observing system).

The two associated research institutions in the basin are Lake Chad Research Institutes at Maiduguri (Nigeria) and N'Djamena (Chad). The Institute in Maiduguri had established some 10 stations/experimental sites, but in 1987 had to downsize its ambitious mandate to become a crop-based research institute with three programmes: wheat-barley programme, millet programme and farming systems programme with extension feedbacks to end-users on farming practices, soils, integration of livestock, agroforestry, etc through on-farm extension linkage project. It had a breakthrough in1980-90 in developing some high-yielding and early maturing varieties of wheat. These and other research institutions need to be partners in progress and properly equipped to deliver results that will lead to breakthroughs in knowledge and management practices.

Although it is not a research institute, North East Arid Zone Development Programme (NEAZDP) was established (by the European Development Fund of the Lome Convention) to promote integrated rural development in the area north of Latitude 12^{o}N in northeast Nigeria. It has achieved a lot and with its EU funding fully restored could be effectively used as a member of LCBC PCU. The Programme's accomplishments include a semi-detailed natural resources inventory, with easily updatable database, 15 specialised socio-economic surveys to produce indicators that facilitate sustainable rural development interventions, feasibility studies to enhance agricultural productivity, intensification of small scale irrigation, awareness raising and improved water supply.

The LCBC and member countries should strengthen such good examples, replicate them, and use them to link local level development to national and regional integration.

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Table 1 Lake Chad Region: Per capita Output and Income in 1995 and 2001.

Country	Per Capita GDP ($)		Per Capita GNI ($)	
	1995	2001	1995	2001
Algeria	1 510	1 773	1 590	1 630
Cameroon	600	567	660	570
Central African Republic	335	250	340	270
Chad	214	197	210	200
Niger	206	174	190	170
Nigeria	283	365	210	290
Sudan	257	380	290	330

Source: ADB (2003), Table 14.

Table 2: Drainage areas, inflows into Lake Chad, and overall water balance of the lake

S/	River Sub-system	Catchment area (km^2)	Area of lake and wetlands (km^2)	Inflows & Outflows (km^2 yr^{-1})	
				Long-term mean (pre-	Mean of 1971-90
Inflows					
1	Chari-Logone	590000	8000	39.8 (93%)	21.8 (96%)
2	Komadugu-Yobe	147840	6000	1.0 (2%)	0.45 (2%)
3	Yedseram-Ngadda-Ebeji	53720	80-120	0.89	0.12
4	Others			1.2	0.2
5	Total river inflows		18,000[4]	42.89	22.57
6	Rainfall on open water surface			6.0	2.1
7	Total input			**48.89**	**24.68**
Outflows					
8	Evapotranspiration			43.0	21.3
9	Infiltration			3.0	1.4
10	Total Outflow			**46.0**	**24.5**
11	Bottom leakage & discrepancy			**2.89**	**0.18**

Sources: Oyebande (1997), UNEP/DEWA (2003).

[4] Long-term average is 18,000 km^2, but the mean for the 1971-90 is only 9,400 $km.^2$

Table 3 Number of water-related birds and flood extent in the Hadejia-Nguru wetlands, Nigeria

Hydrological unit	1994	1995	1996	1997
Hadejia River	n.a	n.a	n.a.	n.a
Marma Channel & Nguru Lake (Birds)	45,715 (61%)	120,709 (47%)	61,853 (32%)	202,440 (64%)
Flood (km^2)	106	349	334	335
Old Hadejia & Burum Gana R.	n.a.	n.a.	n.a.	n.a.
Kafin Hausa (Birds)	9,378 (13%)	49,452 (19%)	113,754 (60%)	67, 995 (21%)
Flood (km^2)	17	78	74	135
Total (Birds)	55,093 100%)	170,161 100%)	175,607 100%)	270,435 (100%)
Flood (km^2)	123	427	408	470

Source: Polet *et al* (1997), Oyebande (2001).

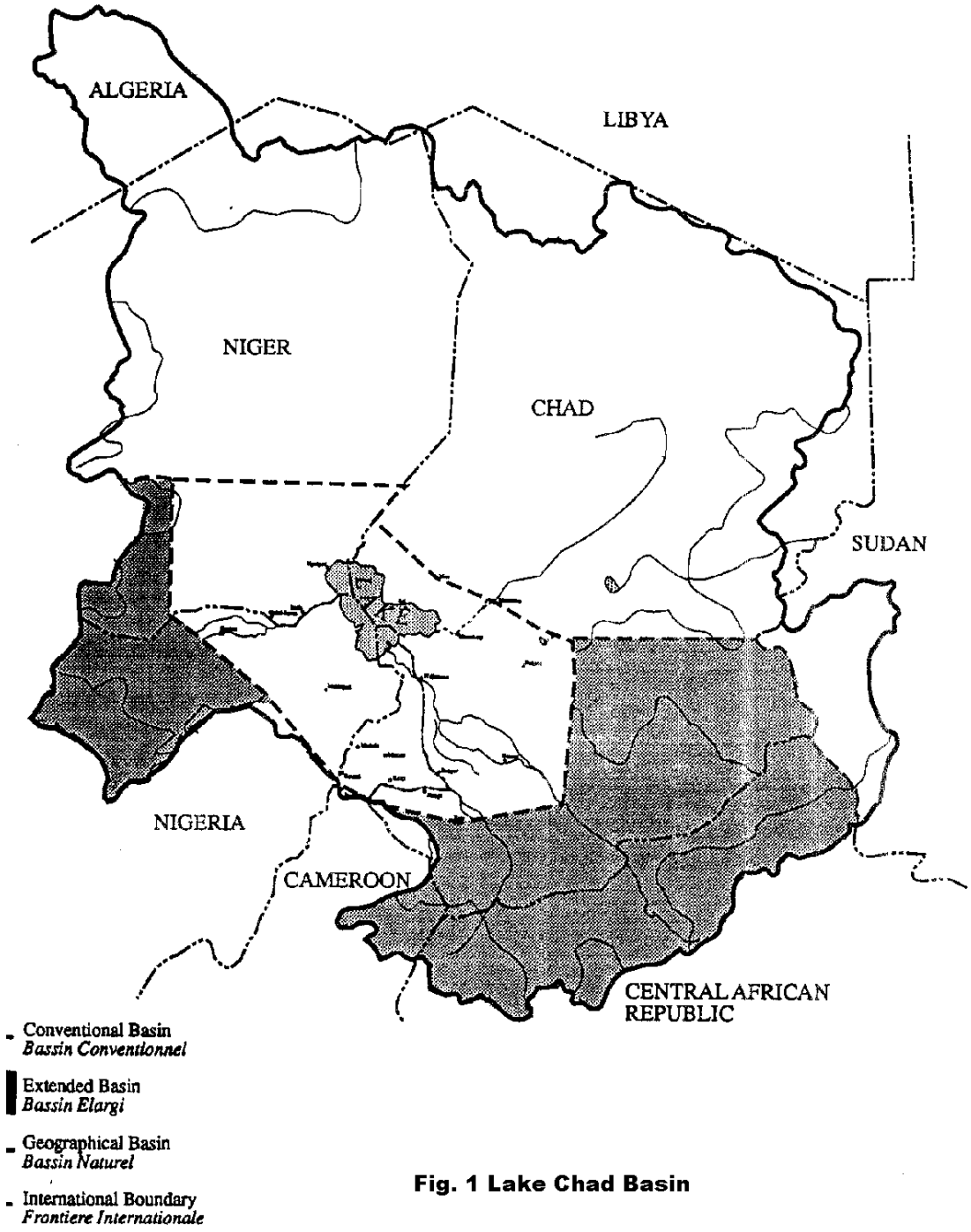

Fig. 1 Lake Chad Basin

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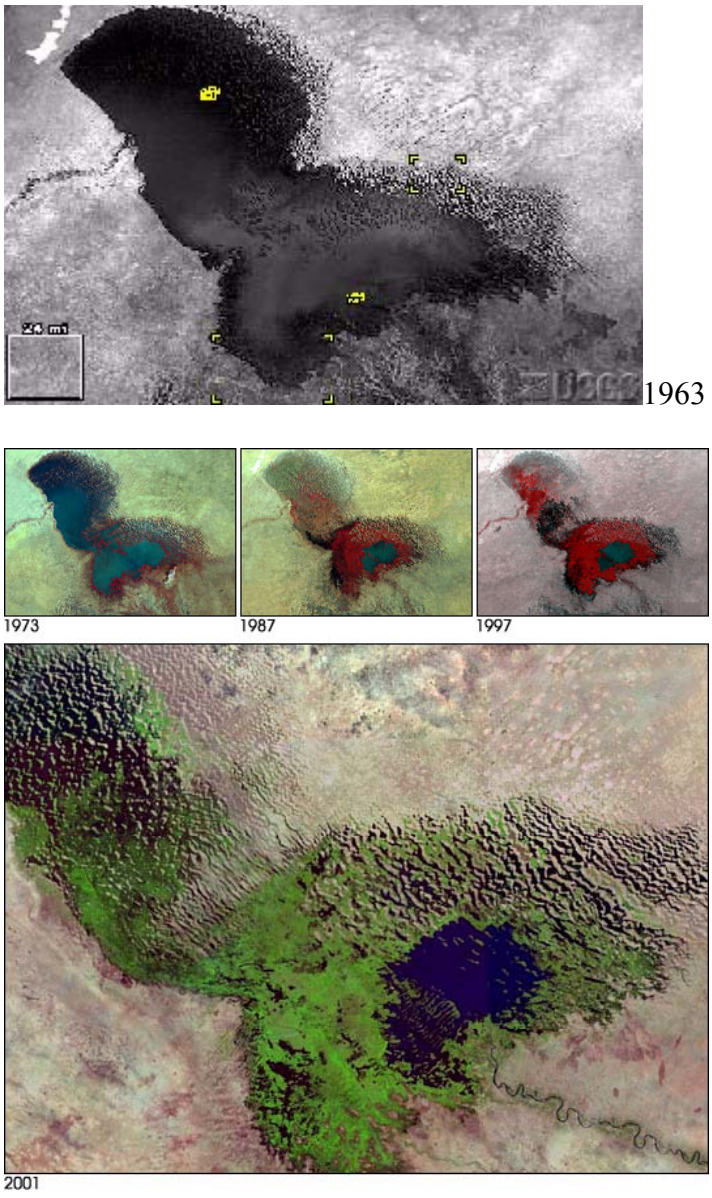

Figure 2 A**frica's Shrinking Lake Chad (1963-2001)**

Sources: Argon low-resolution satellite photograph, 31 October 1963, Landsat 5 MSS scenes, 1973, 1987, NOAA 14 AVHRR, 2 January 1997; USGS (2001).

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2
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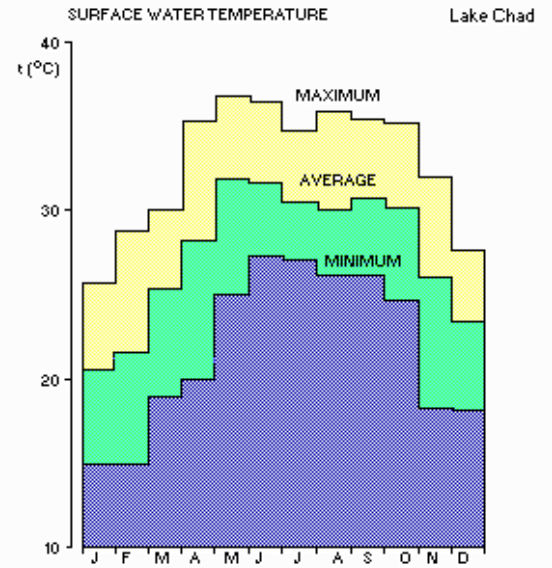

Fig-3a Seasonal trend of surface water temperature [°C], Bol-Île,1956-1960

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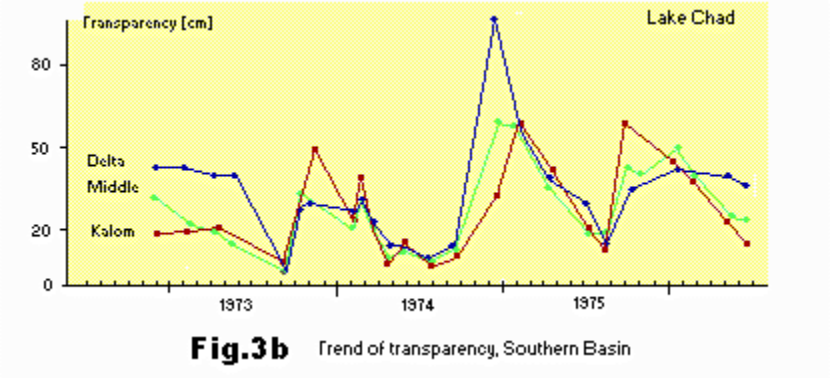

Fig.3b Trend of transparency, Southern Basin

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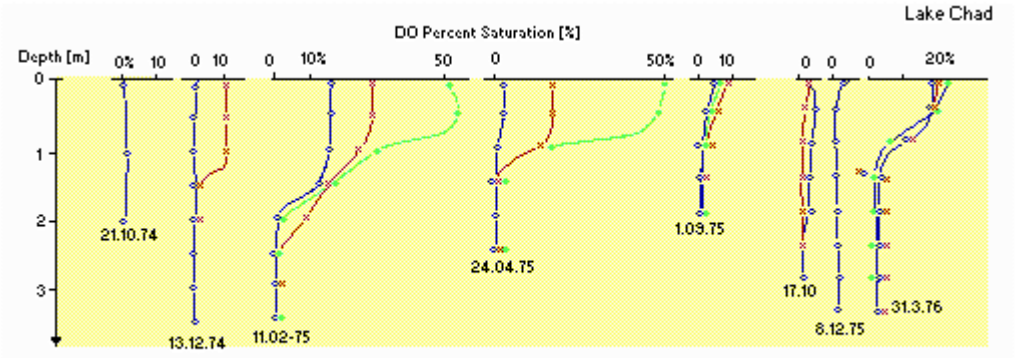

Fig-3c Changes in DO percent saturation, Southern Basin
Source: http://www.ilec.or.jp/database/afr/afr-02.html

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