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Lake Chad: Recent Shrinkage and Research Priorities

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Lake Chad is a shallow endoreic lake formed in a depression in the central part of the Sahara-Sahel contact in North Africa. During the late Quaternary, the Chad has experienced drastic changes in response to climate changes in its catchment area which extends from the hyperarid center of the Sahara to the north to humid savanna woodlands to the south (Fig. 1). Lake-level changes of the Chad in the last 20,000 years, such as the complete drying up during the Last Glacial Maximum and the greater extension of its area during the periods of both post-glacial warming and the northern hemisphere hypsithermal, have been well documented (e.g., Maley, 1981; Servant, 1983; Schneider, 1994; Table 1) and were used as a benchmark for the reconstruction of the environmental history not only of the Sahara-Sahel but also the regions of equatorial Africa (e.g., Kodomura, 1995).

Parallel with the Aral Sea, recent dramatic shrinkage of the Chad has attracted attention of the international community (Kindler et al., 1990) as a phenomenon symbolizing widespread environmental degradation of the south side of the Sahara due to the "desertification" caused by "the spreading of the Sahara". However, little scientific data as to inform the recent changes taken place in the lake itself and its catchment area are hitherto available. This paper is intending to overview the recent changes in lake level and area, land use/cover and precipitation changes in the catchment area, based on a reconnaissance and data collection in the Republic of Chad during February-March 1996. Mention is also made of research gaps and priorities for this problematic international waters.

Recent Changes in Lake Level and Area

According to the obervation at Bol (Fig. 1), the annual mean lake level dropped from ca. 282m in the early 1960s to ca. 279m in the 1990s (Fig. 2). The lake area has shrunk from 25,000 −20,000km^2 to 1,500−1,000km^2 in the last 30 years (Table 1).

Since the early 1970s the open water areas have almost been restricted to the south lake and the north lake was only filled with water in the good rainfall year.

The lowering of lake level and the shrinkage of lake area have been caused by the decrease in the influx from the Chari which rises to the southern humid areas and shares now more

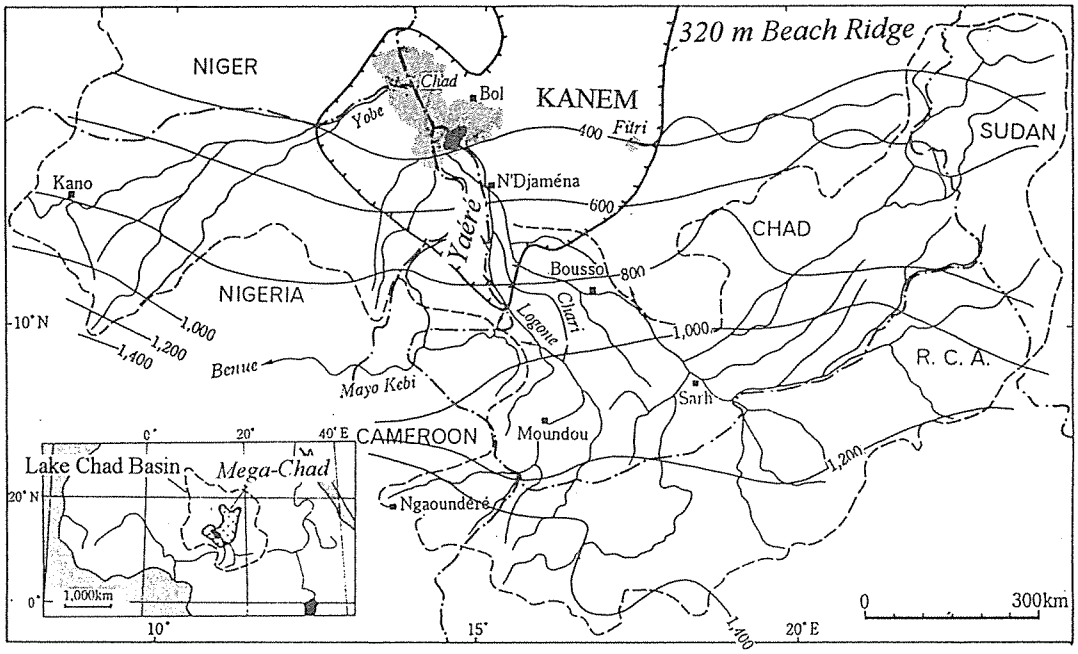

Fig. 1 Lake Chad: its past and recent changes. *Maga-Chad* (WL=ca. 320m asl; 7-5 ka BP), *Grand Tchad* (WL=284m; dotted area; 1850-1879), and recent open water area (WL=ca. 279m, black area; 1990s), with the distribution of mean annual rainfall over the southern Chad Basin.

Table 1 Lake area and level changes of the Chad

Period/ Date	Area km²	Level m	Depth m	Nickname	Reference
18-13 ka BP	0				Maley, 1981
7-5 ka BP	c. 330,000	>320	>40	*Mega-Tchad*	Schneider, 1994
1850-1870	20,000-25,000	284	c.4	*Grand Tchad*	Thilo, 1928
1904-1915	12,000-13,000	281	c.1.5	*Petit Tchad*	Tilho, 1928
1917-1919	15,000-20,000	282	c.3	*Tchad normal*	Tilho, 1928
1962	22,600	283.5	4.05	*Tchad normal*	Carmouze, 1967
1972	18,000	280.4	2.35		Carmouze, 1967
1982.3.21	1,600*	279.5			Nakayama et al., 1994
1985.5.1	1,570#	<279			Bauvilain, 1986
1991.3.13	1,200*	279.0			Nakayama et al., 1994
1995.5.24	1,356*	279.7			MSSL-WCMC-UNEP, 1996
1995.9.2	1,355*	278.4			MSSL-WCMC-UNEP, 1996
1995.10.8	1,408*	279.1			MSSL-WCMC-UNEP, 1996

Landsat data, * NOAA data. MSSL-WCMC-UNEP: Global Lake & Catchment Conservation Database.

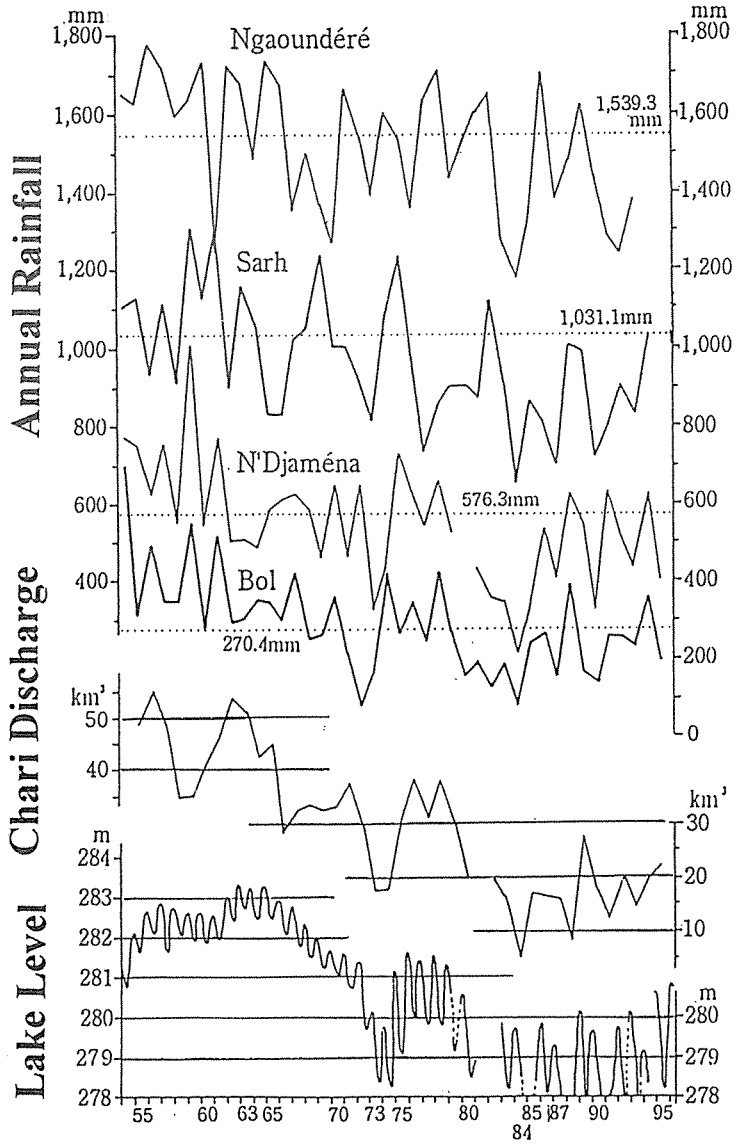

Fig. 2 Fluctuations in annual rainfall at selected stations in the Chari-Logone catchment (1954–94: Bauvilain, 1995; 1995: data from DREMN), Chari River discharge at N'Djaména (data from DREMN), and lake level at Bol (1954–64: Carmouze, 1967; 1965–95: data from DREMN) during 1954–95. DREMN: Direction des Ressources en Eau et de Météorologie Nationale/Tchad.

than 90% of the annual water influx to the lake. The influx of the Chari measured at N'Djaména decreased from 40–50km^3 in the early 1960s to 10–20km^3 in the 1990s (Fig. 2). This decrease in the influx from the Chari has undoubtedly resulted from long-lasting drought conditions in its catchment area, particularly in the middle to upper reaches, i. e., the Sudanic and Sudano-Guinean Zones (Fig. 3). It is worthy of note that the annual rainfall in these subhumid zones during the 1990s is 10–20% less than that during the 1960s.

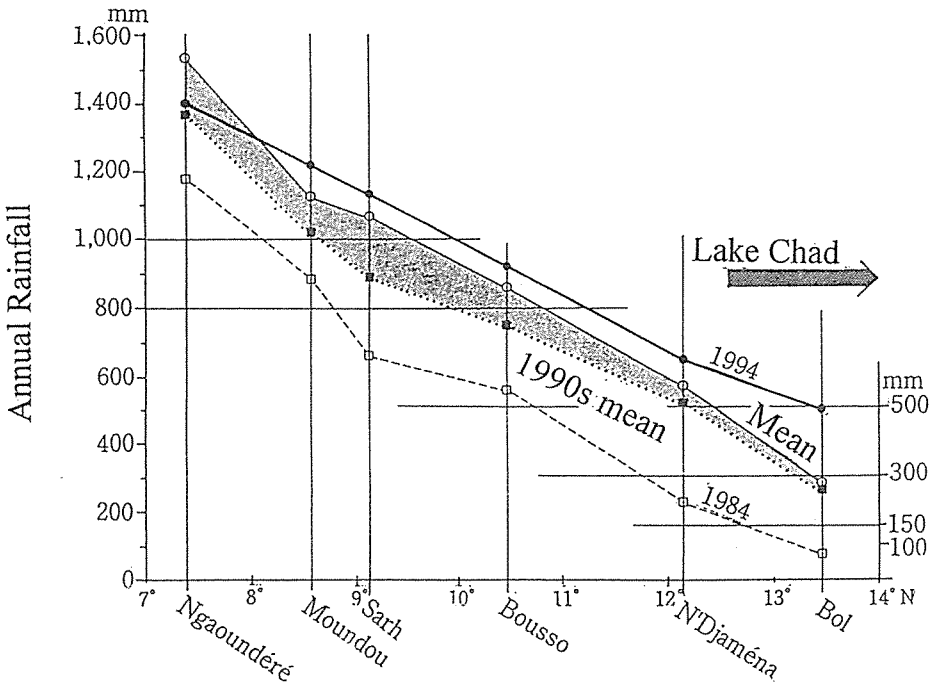

Fig. 3 South-North cross section showing rainfall variations over the Chari-Logone catchment area: Long-term mean, 1990s mean, and recent wettest (1994) and driest (1984) years (data from Bauvilain, 1995). Note greater deficit in the 1990s from long-term mean in the middle to upper reaches under the subhumid climate.

In contrast, although the contribution to water budget of the lake is negligibly small, the annual rainfall in the Sahel Zone, including the greater part of the lake area, has shown a slight recovery from the "Grand Sécheresse" of 1984 toward the long-term mean (Figs. 2 and 3).

The annual discharge of the Chari at N'Djaména in the 1990s is less than 70% of that in the early 1960s. This decrease is too great to account for the decrease only in the catchment precipitation. Possible effect of such large-scale paddy rice field irrigation projects as SEMRY I and II in North Cameroon, OMVSD in southern Chad, etc. on the Lake Chad water balance should be noted (Kindler et al., 1990; Cherel-Geffard et Pieyns, 1996). Among others drastic drying up of the Yaéré (seasonally flooded wetland) of the Logone plain due to the effect of SEMRY II with Maga Dam construction should deserve special attention (e. g., Kadomura, 1994). Unfortunately, however, no quantitative data are so far available for this question.

It is clear that the recent dramatic shrinkage of Lake Chad has been caused not by the spreading of the Sahara, i. e., sand dune encroachment from the north, but caused by the decrease in the river discharge originating from the southern catchment area under subhumid and even humid climates. After drying up, the former lake bed has inevitably been subjected to wind action; blowing out, sand dune formation and encroachment.

Spatial Pattern of Land Degradation in the Sahel Zone

In spite of persistent drought conditions in

the last 30 years in the Sahel Zone of Chad to the east of the lake, no overall remobilization of sand dunes could be observed. The spatial pattern of land degradation has occurred in close relation with landform and superficial deposits as exemplified as follows:

1) Among various land surfaces, reg-like areas with stony deposits are most vulnerable to vegetation degradation because the recovery from the damage of the 1984 drought has been minimum. Widespread bare surface over such areas has provided a favorable condition for the formation of nebkha dunes within the steppe landscape. In contrast, most of wadis and depressions are well colonized by thorn bushes with *Hyphaene thebaica* (doum palm).

2) As reported for the other parts of the Sahel (e. g., Kadomura, 1994) in the Sahel Zone within the domain of the Republic of Chad, there is also no evidence indicating the overall southward march of the Sahara and/or sand dune remobilization, although patchy areas of creeping sand are found everywhere.

3) This is also true even in the Kanem sand dune (semifixed) area to the north of the 13th parallel. Aged, big trees of *Acacia raddiana* still exist over the dune crest with *Leptadenia pyrotechnica,* and the thickets of *Acacia nilotica, Capparis* spp., *Hyphaene thebaica,* etc. grow on the interdune depressions.

4) These observations should have significant implications in the detailed reconstruction of palaeoenvironmental changes at the desert margins and in a better understanding of the patterns and processes of dryland degradation, particularly "desertification".

Research Priorities

As outlined above, Lake Chad is now in a critical situation due to coupled effect of persistent drought and increased human impacts on land and water resources, particularly in the southern catchment areas. Assessment of human activities such as paddy rice field irrigation projects on Lake Chad water budget and rational management of land and water resources in the catchment areas call for thorough scientific data, but so far available data are very limited. The establishment of a comprehensive observation network system for monitoring and assessing the water budget changes and also land use/cover changes in the basin, particularly in the Chari-Logone catchment, should be cruicial for promoting a better understanding of biogeophysical processes that have resulted in severe environmental degradation, and planning integrated programmes for the management and sustainable use of freshwater resources while controlling land degradation in this transboundary watershed.

Detailed, integrated field studies by a multidisciplinary team should be an urgent and essential prerequisite to realize this important task. Review of the recommended actions for conservation and development described in "Lake Chad Convention Basin Diagnostic Report" (Kindler et al., 1990) may give a baseline for planning research programmes. Close linkages with such international action plans as Long-Term Ecological Monitoring Observatories Network (ROSELT) of Observatoire du Sahara et du Sahel (OSS) and sub-regional anti-desertification activities in the framework of United Nations Convention to Combat Desertification (CCD) should also be considered.

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DIWPA (The International Network for DIVERSITAS in Western Pacific and Asia) Activities in 1993–1996

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The DIVERSITAS programme was organized by IUBS-SCOPE-UNESCO in 1990 to promote and catalyse knowledge about biodiversity, including its origin, composition, ecosystem function, maintenance, and conservation. Based on collaborate research and communication that are international in scope, DIVERSITAS is entering a new phase of organization and activity. In 1996 the programme is incorporating new sponsoring organizations, including ICSU, IGBP-GCTE and IUMS in addition to three organizations which established DIVERSITAS. The main purposes of DIVERSITAS are:

1) Study of ecological function of biodiversity;
2) Study of mechanisms of origin, maintenance and extinction; and
3) Inventory and monitoring of biodiversity.

DIWPA was established to cover these purposes in the region of Western Pacific and Asia where the continuous green belt of forests covers from Siberia to New Zealand. The continuous green belt along latitude is only found in this region. The total number of members is 310 from 36 areas: Australia (10), Brunei (1), Canada (1), Beijing/China (29), Cook Islands (1), DRP Korea (1), Fiji (13), Finland (1), France (9), French Polynesia (7), Germany (1), Guam (3), India (5), Indonesia (9), Japan (56), Korea (14), Laos (1), Malaysia (32), Micronesia (2), Mongolia (3), Myanmar (1), New Caledonia (2), New Zealand (1), Palau (1), Papua New Guinea (1), Philippines (4), Russia (31), Singapore (18), Sri Lanka (2), Taipei/China (15), Thailand (7), Netherlands (1), U. K. (3), U. S. A. (11), Vietnam (8) and Western Samoa (5).

The 5th Planning Meeting of DIWPA was held on May 7, 1996 in Beijing, China, during "International Symposium on Transect Studies on Global Change and Biodiversity" (May 6-8), which was cosponsored by DIWPA. The chairperson Prof. H. Kawanabe proposed ten scientists from various areas in Western Pacific and Asia as members of the steering committee, and the proposal was accepted by all the participants. Prof. T. Nakashizuka and Prof. T. Yumoto joined in the secretary board, being responsible for the publication of newsletters and the international field biology course, respectively.

Purposes of DIWPA

The purposes of DIWPA are:

1) Networking of biodiversity field stations,
2) Promotion of international research projects,
3) Civilian interchange, and
4) Voluntary conservation activities.

Main future plans are Biodiversity Observation Year 2001 and Biodiversity Sumit in Western Pacific and Asia in 2005.

Organization of DIWPA

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Steering Committee:

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Prof. Zhang Xinshi, Director of Institute of Botany, Beijing, China

Prof. Zhao Shidong, Commission for Integrated Survey of Natural Resources, CAS, Beijing, China
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Prof. Takakazu Yumoto, Center for Ecological Research, Kyoto Univ., Japan

Assistant Secretary:
Ms Sanae Nakajima, Center for Ecological Research, Kyoto Univ., Japan

Activities of DIWPA

Planning Meetings held:
1st, December 1993, Kyoto, Japan
2nd, September 1994, Paris, France
3rd, June 1995, Beijing, China
4th, December 1995, Singapore
5th, May 1996, Beijing, China

Workshops and Symposia:
1st, DIWPA International Workshop "Biodiversity and the Dynamics of Ecosystems"

International Field Biology Course:
1st, August 1995, Sarawak, Malaysia
2nd, August 1996, Lake Baikal, Russia
3rd, August 1997, Thailand

Publicatons:
Newsletters Nos. 1–4 (April and November 1995 and April and July 1996)
DIWPA Series No. 1 "Biodiversity and the Dynamics of Ecosystems" (November 1996)
IFBC Seriens No. 1 "Bornean Tropical Rainforest" (March 1996)

(Center for Ecological Research, Kyoto University)