

6.3. THE CENTRAL PLATEAU

by

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The block of land between the two rifts is relatively high but in the centre is the great, shallow depression that is the basin of Lake Victoria, the second largest area of freshwater in the world. Covering 66,250 km² this is the largest lake in Africa and, although it has a maximum depth of 93m the mean depth is only about 40m. From the ratio of its area to volume it could be regarded as a shallow lake but the fact that it has an annual cycle of stratification (Talling 1965), and thus behaves as a deep lake, has caused us to exclude it from consideration here. However, of the various shallow bays around its shoreline, the Nyanza Gulf (also known as the Kavironondo or Winam Gulf) is the only one sufficiently isolated from the main lake and likely to behave independantly. It has been studied in some detail and is therefore included here along with the complex of swampy lakes along the Victoria Nile, of which Lake Kyoga is the largest, the numerous smaller lakes in the NW part of the Lake Victoria catchment, and those of the Kagera River basin which lie mostly in Rwanda. Between 1961 and 1964 the level of Lake Victoria rose by more than 2m after 50 years of comparative stability. This totally unforeseen change and the ensuing problems for the surrounding countries stimulated a major hydrometeorological study of the catchments of Lakes Victoria, Kyoga and Mobutu Sese Seko by the World Meteorological Organisation (1974, 1982) referred to hereafter as the HYDROMET SURVEY. The reports of this survey contain a wealth of hydrological and meteorological data on the catchments of these three lakes which between them cover a large portion of Uganda, western Kenya and northern Tanzania plus most of Rwanda and Burundi and a small slice of eastern Zaire.

Geology: The whole of the Upper Nile Basin is underlain by the "Basement complex" of mostly Archean and Precambrian, igneous and metamorphic rocks which are some of the oldest in the world (formed more than 3,000 million years ago).

6.3.a. NYANZA GULF

1. Climate

The climatic diagram for Kisumu (Fig. 6.8) indicates a bimodal pattern of rainfall with two relatively dry seasons in January-February and July-October. There is very little variation in the mean monthly temperature.

Type: Afa Köppen

Winds: primarily from the SW in all months of the year: monthly mean wind speeds (1939-62) range from 5.5-7.4km/h at 0900h and 14.8-24.0km/h at 1500h, with maxima in January-March and minima in April-June.

Insolation: Monthly mean insolation at Kisumu during the HYDROMET survey was 529 cal/cm²/day in 1969 and 468.8 in 1970. The range

of daily insolation in Kisumu during 1973 was 703-250cal/cm². Hours of bright sunshine (1939-62): 2842 per year (range 2333-3118): monthly averages per day range from 6.9h in July and August to 8.78 in February. In January the highest radiation values (>290 watts/m²) are found in western Kenya, primarily due to reduced cloudiness, in July values >242 watts/m² are only found in western Kenya (Okoola 1982).

Air temperature: monthly means range from 21.9-24.3°C; the maximum temperatures are recorded in February and March; the lowest in December and January.

Rainfall: Rainfall in the catchment is plentiful, between 1250 and 1550mm/y. There are two maxima in March-May and October-November.

Evaporation: Nyenzi (1980) estimated potential (Ep) and actual (Ea) evapotranspiration from climatic data. For Kisumu he obtained values of Ea = 1150mm, Ep = 2173mm: over the Gulf itself he estimated 1250 and c2000mm per year respectively.

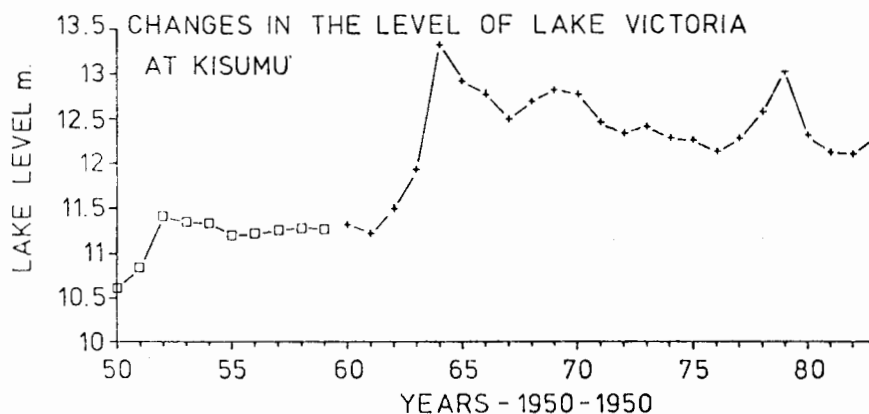


Fig 6.11 Changes in the level of Lake Victoria at Kisumu since 1950. The different symbols indicate the use of levels at the beginning of each year from 1950 - 59 (taken from Kite 1981) and of annual mean levels thereafter (calculated from monthly means supplied by the Kenya Ministry of Water).

2. Geography and Morphology

The Nyanza Gulf lies in the heavily populated Nyanza Province of Kenya: 0°15'S, 34°40'E. It is thought to have originated as a separate basin which became connected to the main lake in the mid-Pleistocene. The narrow channel (0.6km wide) between Mbita Point and Rusinga Island has now been closed off by a causeway. This has disrupted the once fast currents through this channel with detrimental impact on the fishery. The Gulf is, however, connected to the main lake by the 5km wide Rusinga Channel through which there is limited exchange of water with the main lake.

Altitude: 1136m asl

Area: 1400km² (Melack 1979). The Gulf is approximately 30km wide and 70km long from Rusinga Island to the Kisumu Gulf.

Depth: Mean depth <4m; maximum 35m in the channel off the lighthouse near Uyoma Point; most of the area of the Gulf is 2-6m deep (Rinne and Wanjala 1982). This depth must vary with that of the main lake which has undergone a number of cyclical fluctuations since the turn of the century (Fig. 6.11).

Landscapes: the north shore of the Gulf is generally rocky while the S. shore is flat and swampy. The south shore is bounded by volcanic hills which rise to 1750-2000m asl and descend to the lowland plain of tertiary lacustrine deposits near the lake.

3. Hydrography and Hydrology

The main inflows to the Gulf include the Nyando and the Sondu Rivers, which drain the western slopes of the Mau range, and the Kibos, all of which are gauged. The Nyando catchment was selected for special study by the HYDROMET survey because of its importance to two major development projects, the possible irrigation of the Kano Plain and the reclamation of the Miruka swamp for irrigated agriculture. This catchment contributes 0.4 milliard m³ to L. Victoria and empties via the Miruka Swamp into Nyakach Bay at the eastern end of Nyanza Gulf.

Discharge of the main rivers into Nyanza Gulf during 1969 and 1970: (from HYDROMET survey)

| River | Catchment area km ² | Month of max. millions m ³ | Month of min. millions m ³ | Annual total milliards m ³ |
|--------|--------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|
| Kibos | 1969 490 | May 13.9 | Jan. 2.7 | 0.068 |
| | 1970 | May 13.39 | Feb. 2.66 | 0.068 |
| Nyando | 1969 2650 | Feb. 36.3 | Dec. 8.0 | 0.247 |
| | 1970 | Aug. 103.1 | Dec. 15.4 | 0.594 |
| Sondu | 1969 3230 | Feb. 122.0 | Dec. 21.0 | 0.845 |
| | 1970 | Apr. 310.0 | Jan. 43.0 | 1.961 |

Many smaller rivers drain into the Gulf from the Nandi and Kisii Highlands.

Streams flowing into Nyanza Gulf (HYDROMET Survey 1974)

| | Catchment area km ² | Maximum alt. m | Approximate runoff 000 m ³ /y | (assuming runoff= 18% of rainfall) |
|--------------|--------------------------------|----------------|--|------------------------------------|
| North shore | | | | |
| Kisyan | 50.0 | 1615 | 13,806 | |
| Muguruk | 93.75 | 1768 | 25,095 | |
| Luanda | 84.4 | 1463 | 19,750 | |
| Awach Seme | 140.6 | 1494 | 38,190 | |
| Nyandiwa | 62.5 | 1372 | 14,074 | |
| Obera | 37.5 | 1359 | 7,877 | |
| Awach-Kibos | 109.4 | 1798 | 34,855 | |
| South shore | | | | |
| Awach-Kaboun | 575.0 | 2,033 | 146,245 | |
| Awach-Tende | 609.4 | 1,920 | 153,569 | |
| Olando | 84.4 | 1,341 | 19,750 | |

Of these streams the Awach-Kaboun and Awach-Tende are clearly the largest. The former was an intensively studied "index catchment" for the HYDROMET survey. The catchment area is productive agricultural land entirely rural, more densely populated in the East than to the West (average population density c250 people/km² (Atlas of Kenya)) but with the maximum density of cattle in Kenya (c250 heads/km²). The mean monthly discharges observed between April 1969 and December 1971 ranged from 0.93 cumecs in February to 16.23 cumecs in May and an average for the whole period of 5.45 m³/sec.

4. Physico-chemical characteristics of the water

pH: 6.8 - 9.2 (June 1984)

Conductivity: 170 - 179x10⁻⁶S/cm (Melack 1976); 110 - 160x10⁻⁶S/cm (June 1984)

Temperature: 23.8 - 26.0°C between August and December 1973 (Melack 1979); the highest temperature recorded was 29°C; June 1984 (surface) min. 24.8, max. 29.0°C.

Transparency: Secchi disc depths 75 - 150cm August to December 1973 (Melack 1979); June 1984 35 - 155cm.

Surface incident irradiance: 246 kerg/cm²/s at 1600h on 5.11.60 (Talling 1965). Light penetration in the Gulf is reduced compared with the off-shore waters of L. Victoria and the 1% level is at about 2.5m.

Major ions:

| meq/l | date | 11.8.73 | 12.10.73 | 22.12.73 |
|-----------------------|------|---------|----------|----------|
| Na | | 0.84 | 0.84 | 0.88 |
| K | | 0.42 | 0.42 | 0.42 |
| Ca | | 0.41 | 0.41 | 0.57 |
| Mg | | 0.17 | 0.26 | 0.26 |
| HCO ₃ | | 1.62 | 1.57 | 1.86 |
| SO ₄ | | 0.16 | 0.18 | 0.18 |
| Cl | | 0.2 | 0.2 | 0.19 |
| F | | 0.05 | 0.04 | 0.04 |
| SiO ₂ mg/l | | 4.0 | 7.0 | 2.0 |

June 1984 Alkalinity 40 - 72 mg/l as CaCO₃
Turbidity 3.3 - 28.5 NTU

Nutrients: July-August 1984: Total N 444-523x10⁻⁶g/l; Total P 23-27x10⁻⁶g/l.

Oxygen: Normally well oxygenated throughout the water column; the lowest concentrations recorded 6mg/l (68% saturated) and maximal concentration 6.5 - 7.7mg/l (94 - 108% saturated) (Melack 1979). June 1984: 4.6 - 9.45 mg/l (all depths included) and 5.8-8.1 mg/l in February 1985. At a deep water site off the lighthouse (near Uyoma Point) taken at 11.30h dissolved oxygen varied from 5.7 at surface to 4.6mg/l at 30m and 8.9 at the surface to 6.0mg/l at 25m in February 1985.

Mixing: occurs every night with temporary stratification set up during calm days for a few hours, before being broken down by SE winds in the afternoon. This is confirmed by the well oxygenated water throughout the depth of the water column.

5. Macrophytes

Papyrus islands detach themselves from the swampy regions of the shore. Pistia stratiotes is present but not plentiful; also Ceratophyllum demersum and Potamogeton pectinatus.

6. Phytoplankton

The phytoplankton is dominated by small cyanobacteria including Lyngbya limnetica, L.circumcreta, Aphanocapsa spp., Anabaenopsis tanganyikae, and Merismopedia spp. (Talling 1965). Talling measured a maximum photosynthetic rate of about 500 mg/m³/h (presumably O₂) and estimated integral photosynthesis to be about 1g O₂/m²/h; this was on 5 November 1960. In the top 5m of the water column the rate of photosynthesis was fairly even, with an average of about 24 mg/m³, and a maximum at 3m. The limit of measurable photosynthesis was about 6m.

Melack (1979) recorded a concentration of chlorophyll a of 17mg/m³ on 22 December 1973 and between August and December of that year obtained values of maximal photosynthesis of 230 - 640 mg O₂/m³/h (400-910 mgO₂/m²/h) and 4.3-9.8 g O₂/m²/d. Values were highest in October during this five month period. In July-August 1984 Chlorophyll a concentration ranged from 127-136mg/m³.

7. Invertebrates

Rzoska (1957) recorded 16 species in the zooplankton of Lake Victoria as a whole. Of these 10 occurred in the samples he took at a station off Kisumu. Juvenile copepods occupied 79-89% by numbers. In the Kisumu Bay area during June 1984 samples contained c72% Copepoda (mainly Thermocyclops sp especially nauplii, plus a few Tropodiatomus), c25% Rotifera (including 4 species of Brachionus, especially B. caudatus and B. calyciflorus, Polyarthra sp., and Keratella tropica), and 3% Cladocera (Moina sp., Diaphanosoma sp., Macrothricidae and Bosmina sp.). The medusa Limnocooida and juvenile notonectids and corixids were also present. Caridina nilotica occurs plentifully in offshore waters. Off-shore benthic samples, also taken in June 1984, were dominated by Bellamyia sp., Mellamyia sp. and Pila ovata (Gastropoda), Aspatharia/Mutela (Bivalvia), Povilla adusta (Ephemeroptera) and Brachythenius sp. (Odonata). In addition high densities of Oligocheata, particularly Alma sp., and chironomid larvae occur abundantly in the open water benthos.

8. Fish and Fisheries

The fish fauna is primarily nilotic but includes many endemic species, particularly among the smaller cichlids (Greenwood 1980).

Between 1951 and 1962 several non-native fish were introduced to the main lake, Oreochromis niloticus (= Tilapia nilotica = Sarotherodon niloticus), T.leucosticta, T.zillii, and Lates albertianus; all these eventually arrived in the Nyanza Gulf. Benda (1979) reported that the consensus of opinion seemed to be that up to 1969 fish stocks were lower in the Gulf than outside and that T.esculenta, Oreochromis niloticus, T.variabilis, Labeo victorianus, Barbus altianalis, Mormyrus kannume and Schilbe mystus had nearly disappeared from the Gulf. The only species to increase was Lates niloticus whose population had been building up ever since its introduction in the 1960s.

The fishery involved beach seines and hooks, the use of which has declined, plus gill nets and mosquito nets. The increasing use of the latter has been detrimental since they catch smaller fish. The impression that the inner Gulf was overfished was supported by Benda's (1979) analysis of fish catches from nine landings (inside and outside the Gulf) in the Kenya waters of L. Victoria which indicated a steady decline in total catch from 1968-76. This does not quite agree with the official statistics which show an almost continuous increase in total catch from 1971 through to 1982. The only significant drop was in 1979-80 (30.6 - 26.9 x10³ metric tonnes); otherwise yield has risen from 14918 t in 1971 to 60958 t in 1982. Data for the Kenya waters of L. Victoria in 1982 show % by weight of Lates 54%, Engraulicypris 17%, Oreochromis niloticus 4%, Mormyrus 4%, Bagrus 4% and Haplochromis 4%. Recent trawling in the Gulf caught only Lates and Oreochromis niloticus of which the former constituted more than 90% of the catch in a survey of 14 stations during 1979-81 (Okemwa 1984). Lates is increasingly becoming a food acceptable to the locals and Okemwa estimates a potential yield of 11,000 t/y for this species. The landings of Lates from the Kenya waters of L. Victoria reported by the Kenya Department of Fisheries for 1981-82 are 22834 and 33134 t respectively: most of this is caught within the Gulf.

For an extensive discussion of trawling in Lake Victoria see papers by Bergstrand and Cordone and Kudhongania and Cordone, and in the Gulf see Muller et al (1982).

9. Human activities and management

Kisumu is one of the largest towns in Kenya with expanding industrial activity. It is also a major port for the steamer services on Lake Victoria between Kenya and Tanzania.

6.3.b. LAKE KYOGA AND ASSOCIATED LAKES

Lake Kyoga is a very extensive, dendritic swamp lake in the heart of Uganda (Fig.6.12). The Victoria Nile flows through the western end and many tributaries join the river via the lake. Upstream on one of these tributaries is Lake Bisina (formerly L.Salisbury) and further downstream on the Kyoga Nile is Lake Kwania. These are the largest areas of open water in the drainage basin but there are innumerable smaller areas of open water sometimes dignified with separate lake names. The structure

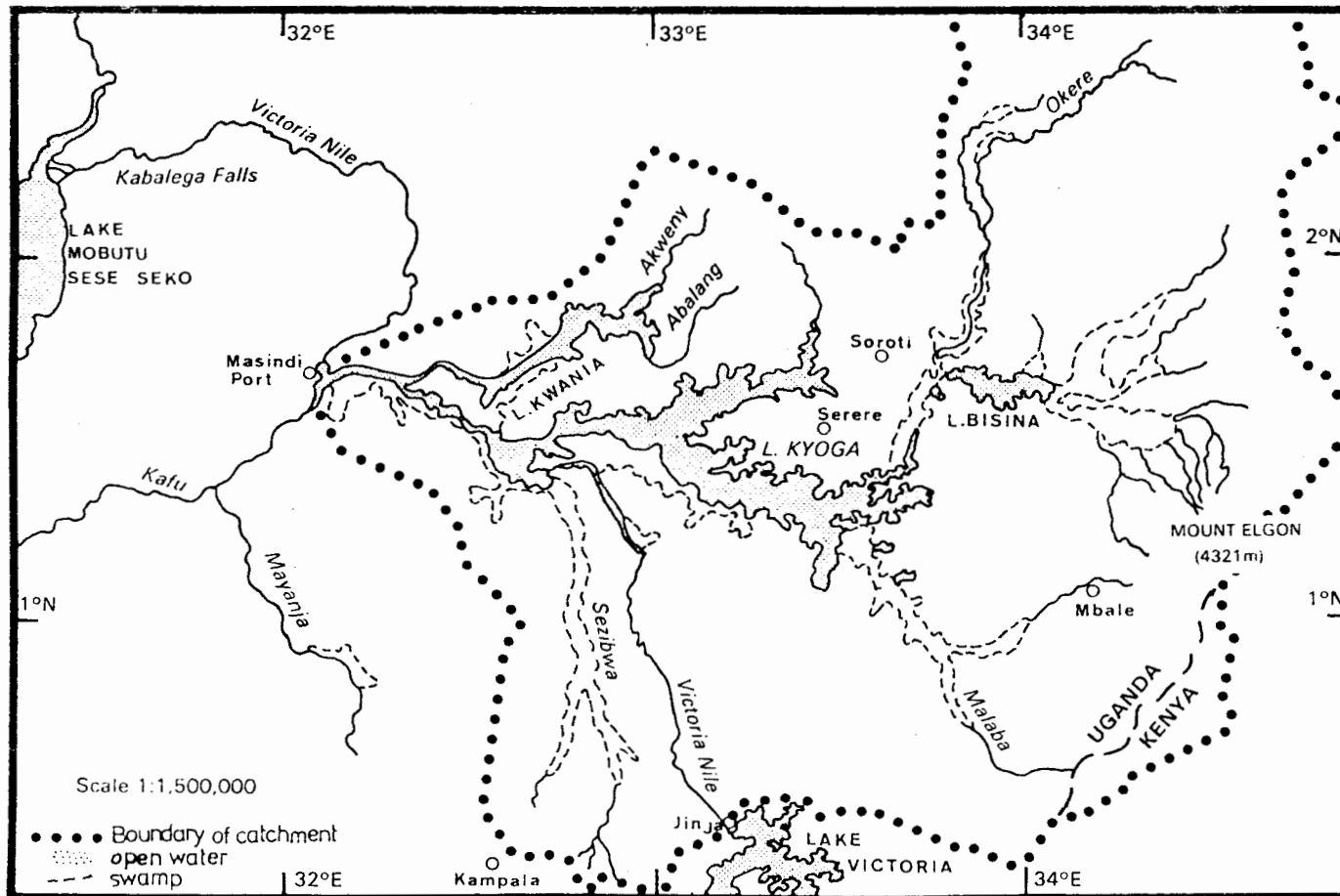


Fig. 6.12 Map of the Lake Kyoga catchment.

and hydrology of the whole complex was studied in some detail by the HYDROMET Survey (World Meteorological Organization 1974, 1982) and the fisheries are currently the subject of investigations by the Uganda Freshwater Fisheries Research Organization.

1. Geography and Morphology

Location: 01°20'S - 01°56'N; 32°20' - 33°40'E

Altitude: L. Kyoga 1034m at maximum water level
L. Kwanja 1033m

Area: (HYDROMET Survey 1974) The total area of the L. Kyoga land catchment is 74,713 km² including the lake itself. Of this 11,315.6 km² does not actually contribute to the inflow to L. Kyoga because of topography, low rainfall etc. This includes areas such as that of the Victoria Nile catchment, the area between Sezibwa and the Kafu River, the areas between the Abalang and Lakes Kojweri and Kwanja, and the area draining the swamps of L. Bisina. The Lake Bisina catchment area is 24,027 km² and the entire outflow from the lake passes under the Kapiri road bridge as inflow to L. Kyoga.

4735 km² of the L. Kyoga catchment consists of swamps and lakes made up as follows:

| | | | |
|----------------------|----------------------|---|----------------------|
| | km ² area | | km ² area |
| L.Kwanja | 508.1 | Sezibwa swamps | 467.5 |
| L.Kyoga | 1821.6 | Naigombwa, Umpologoma and Manafwa swamps | 528.8 |
| L.Nakwa | 93.1 | Lwere swamp | 29.4 |
| other small lakes | 200.0 | small lakes & swamps | 404.4 |
| total | 2622.9 | swamps of L.Kwanja and L.Kyoga | 386.3 |
| | | swamps between Olya and L.Kwanja | 136.9 |
| | | swamps of the L. Victoria catchment | 141.3 |
| | | total | 2094.6 |

After very detailed measurement of areas on the 1:50,000 maps of Uganda, plus levelling of the surrounding land and sounding in the lake, the HYDROMET Survey made a final calculation of the area below the 3400ft (=1036.32m) contour, which is the first to completely surround the lake. They arrived at the following areas for Lake Kyoga:

| | | | |
|--------------------|----------------|------------------------|----------------------|
| water: | open water | 2636 km ²) | |
| | swamp | 1260 km ²) | 3896 km ² |
| land below 3400ft: | swamp | 350 km ²) | |
| | seasonal swamp | 437 km ²) | 1564 km ² |
| | other land | 477 km ²) | |
| | Total | | 5460 km ² |

It is not clear how the categories and areas listed in this table correspond to those in the preceding table but the water area of 3896 km² is said to have a standard error of $\pm 2.5\text{km}^2$ if only the calculation is considered but taking other difficulties and sources of error into account the overall estimate is given as 3896 $\pm 40\text{km}^2$.

Morphometry: On the hydrological map in the Atlas of Uganda (1962) the open water area of L. Kyoga is shown to be in the region of 105km along the northern arm to its junction with the Victoria Nile, and about 90km along the southern arm from its confluence with the northern arm. The width of these arms is extremely variable and ranges from <1 - >16km.

Lake Bisina appears more regular in outline and is about 32km long by 6km wide.

Lake Kwania is about 69km long and varies from about 5 - 8km in width.

Depth: L. Kyoga - the lowest bottom point sounded during the HYDROMET Survey has an altitude of 1023.4m ie 10.73m below maximum and 6.9m below minimum water level; this was near Kikondo. These deepest parts are only a small area along the N. coastline of L. Kyoga and the main lake has a mean depth of about 3m.

L. Kwania: the deepest part is W. of Abeja with a height of 1027m, which is 5.3m below a water level of 1033m. The mean depth of the main lake is about 4m.

2. Climate

The climatic diagram for Serere (Fig. 6.8) is illustrative of the region as a whole with the exception of the much drier portions of the catchment to the NE.

Type: Afa Köppen; of the twenty-two hydrometeorological stations within the Lake Kyoga basin listed by the HYDROMET Survey (1974) 6 are described as C2 moist sub-humid, 11 C1 dry sub-humid and 5 D semi-arid using the indices of Thornthwaite (1948)

Insolation: at Soroti (1939-62) hours of bright sunshine

Mean annual total 2810 h; Range 2908 - 2704 h

Highest monthly mean 8.48h per day in October

Lowest monthly mean 6.19h per day in July

Evaporation: calculated by the Kohler, Penman, and from water balance (WB) methods, for 1969 and 1970, and by the latter two methods for the Normal Year (ie mean for 1946 - 70) by the HYDROMET Survey (1982):

| | 1969 | 1970 | Normal year |
|-------------------|-----------------|----------------|---------------|
| total mm per year | 1420 - 1867 | 1377 - 1751 | 1516 - 1623 |
| lowest month WB | July 72mm | November 22mm | July 91mm |
| Penman | July 140mm | September 133 | July 113mm |
| highest month WB | December 164mm | January 186mm | April 161mm |
| Penman | Oct & Dec 167mm | December 161mm | January 161mm |

3. Hydrography and Hydrology

The reports of the HYDROMET Survey (1974, 1982) give a detailed analysis of the hydrology of the Lake Kyoga basin. The main inflow to the lake is the Victoria Nile from the South which flows through the western portion of the lake and leaves as the Kyoga Nile from where it proceeds NW towards the Kabalega (=Murchison) Falls and Lake Mobutu Sese Seko (=L.Albert). The measured outflow from L. Kyoga includes the contribution from the River Kafu which joins the Nile just upstream of Masindi Port. This is the biggest tributary of the Victoria Nile with a catchment area of 15,492 km², 14.6% of which is covered by swamps, to the west of the Nile.

Many rivers drain the southern and eastern flanks of Mount Elgon and the mountains further north on the Uganda - Kenya border and flow into L. Kyoga. Among the largest are the Umpologoma with a catchment area of 3613.8 km² and mean annual discharge of 608.78 x 10⁶m³ which feeds the S. arm of L. Kyoga and the Omunyal (catchment area 695.6km², mean annual discharge 39.44 x10⁶m³) which feeds the N. arm. The mean annual discharge from L. Bisina to L. Kyoga is 372.97 x10⁶m³. All the contributions from this enormous area are, however, small beside that of the Nile. It should be noted that rainfall over the lake is less than the rainfall over the land catchment (c87% in a normal year) and that rainfall over the lake is less than evaporation from it (c 87% in a normal year). Water balance of L. Kyoga in a "normal year"

| | mm | 10 ⁹ m ³ per year |
|-----------------------------|------|---|
| Precipitation over the lake | 1220 | 5.55 |
| Inflow from land catchment | 639 | 2.91 |
| Inflow from L. Victoria | 5622 | 25.58 |
| Outflow | 5897 | 26.83 |
| Evaporation | 1516 | 6.9 |

The dominant influence on the hydrology of the whole basin is the inflow from Lake Victoria which in a normal year is 11 times the inflow from the the land catchment and in a wet year may be as much as 20 times greater. Nevertheless the outflow in the Kyoga Nile is greater than the inflow to L. Kyoga. Much of the difference is accounted for by the contributions of the Sezibwa (total mean annual flow 216.98 x 10⁶m³) and the Kafu (mean annual flow 682.9 x10⁶m³) both of which join the Nile on the opposite side to Lake Kyoga.

4. Physico-chemical characteristics of the water

Temperature: c28°C

pH: 7.6 - 9.0

Conductivity: Lake Kyoga 212x10⁻⁶S/cm at 20°C (Kilham & Hecky 1973)
245 - 300x10⁻⁶S/cm (various authors in
Talling and Talling 1965)

similar values were obtained by the HYDROMET Suvey
Lake Bisina 365 (Talling and Talling 1965)

Major ions and nutrients:

| Source | Livingstone 1963 | Talling and Talling 1965 1960 | Van Meel 1954 2.6.53 | Kilham and Hecky 1973 10.10.69 | HYDROMET 1974 |
|--------------------|---------------------|-------------------------------------|----------------------------|--------------------------------------|------------------|
| depth | | | 0m 1.5m 2.5m | | |
| mg/l | | | | | |
| Na | 1.78 | | | 27.5 | 26.3 |
| Cl | 1.2 | 1.5 | 1.5 1.5 2.7 | 7.1 | 8.7 |
| K | 7.8 | | | 6.5 | 6.6 |
| Ca | 2.0 | | | 13.7 | 14.1 |
| Mg | | 1.95 | 1.95 1.65 2.0 | 7.2 | 7.5 |
| Fe | | | | | 0.14 |
| SO ₄ | 3.85 | 10.0 | | 4.7 | 2.9 |
| NO ₃ | 0.87 | | | | |
| NO ₃ -N | | 0.008 | | | |
| NH ₃ | 0.41 | | | | |
| PO ₄ | | | trace | 0.025 | |
| PO ₄ -P | | 0.033 | | | |
| SiO ₂ | | 6 | | 30.0 | |

Alkalinity: Lake Kyoga 1.42 - 3.21 meq/l
Lake Bisina 2.35 meq/l (Talling and Talling 1965)

Oxygen: Van Meel(1954) gives oxygen at three depths about 1.5km off Bugondo in June 1953; they ranged from 50% at the surface to 38% at 2.5m.

5. **Macrophytes**

The open water of these lakes is surrounded by a fringe of papyrus (Cyperus papyrus) of variable width and floating islands of papyrus frequently appear in the open water (Worthington 1929). Shallow inshore areas landward of the papyrus are overgrown with floating macrophytes.

6. **Phytoplankton**

Van Meel (1954) lists the planktonic algae found in samples from Lake Kyoga; these include representatives of at least thirteen genera, among them several blue-greens of which Lyngbya was dominant. The diatom assemblage was dominated by Melosira and is typical of shallow warm-water, eutrophic lakes (Gasse et al 1983).

7. **Invertebrates**

Green (1967) recorded 24 species of Rotifera from seven stations in L. Kyoga. They had a mean density of 1524/m³ and 7732/m² of which the most abundant species were Lecane bulla, Keratella tropica and Brachionus caudatus.

From the same samples Green (1971) recorded a total of 13 species of Cladocera. At seven stations which ranged in depth from 3.5m -6m the

numbers under 1m^2 ranged from 962 - 8567 with a mean of 3743, and their density ranged from 241 - 1713 with a mean of 750 per m^3 . The most numerous species were Moina micrura and Diaphanosoma excisum; Ceriodaphnia cornuta and Chydorus barroisi were also abundant. Since the Cladocera only comprise 4% of the total zooplankton numbers, and Rotifera are only about twice as abundant, the zooplankton community is presumably dominated by copepods. If so they must be cyclopoids because Verheye and Dumont (1984) found no calanoid species recorded for L. Kyoga.

8. Fish

The fauna of L. Kyoga is essentially similar to that of the inshore waters of L. Victoria. Until the building of the Owen Falls Dam (commissioned in 1954) at the outlet from L. Victoria there was no effective barrier to interchange between the two lakes. The Kabalega (Murchison) Falls are, however, a barrier between Lake Kyoga and Lake Mobutu Sese Seko (L. Albert). Tilapia variabilis, which is endemic to Lakes Victoria and Kyoga, occurs with T. esculenta in Lake Kyoga (Lowe-McConnell 1956). T. zillii, T. nilotica and T. leucosticta were stocked into both Lakes Kyoga and Bisina during 1954 (Uganda Protectorate, Annual Report of the Game and Fisheries Department 1954-55).

The Nile perch (Lates niloticus) a large piscivore was also introduced in 1954 and 1955 and first appeared in catches in 1958 (Arunga 1981). By 1970 it comprised 60% of the total catch from Lake Kyoga and the catch of other species has declined since then.

9. Other Vertebrates

Crocodiles (Crocodylus niloticus) were once abundant in L. Kyoga despite the lack of sand banks and other firm shores for hauling out. They were extensively hunted between 1950 and 1965 but their decline in numbers is also due to an extermination campaign as the human population around the lake increased (Watson and Parker 1969). current data are not available to the author. Worthington (1929) also reported the presence of abundant fish-eating birds, including pelicans, the otter Lutra maculicolis, sitatunga and hippopotamus. The current status of these species in this area is unknown to the author.

10. Human activities and management

This complex of lakes is among the most important fish producing waters in Uganda and is the subject of investigation by the Uganda Freshwater Fisheries Research Organisation (Twongo and Ogutu-Ohwayo 1979) but no current information is available to the author. Until 1950 L. Bisina was fished only by the local people using long lines and baskets. At the end of 1950 a gill-net fishery was started for Tilapia esculenta and T. variabilis (Annual Report of the Uganda Game and Fisheries Department 1952). No Barbus or Bagrus were caught and they were, therefore, thought not to have been able to cross the swamp from L. Kyoga.

A fishery survey of L. Opeta reported in the same year listed T. variabilis, T. esculenta, Mormyrus macrocephalus, Schilbe mystus, Labeo victorinus, Protopterus, Clarias and Haplochromis spp. among the species caught.

In 1953 a crocodile skin industry was flourishing on animals trapped and shot on Lakes Kyoga and Bisina. This was thought to benefit the fishing industry but by now the crocodile stock was much reduced (Annual Report of the Game and Fisheries Department 1953). This industry was still considered profitable in the Annual Reports of 1957-58.

6.3.c NORTH-WESTERN CATCHMENT OF LAKE VICTORIA

Between the NW shores of L. Victoria and the Western Rift lies undulating plateau country with many shallow swampy valleys and occasional lakes.

Lake Wamala

Lake Wamala lies in the NE corner of the Katonga River basin but, with its outflow, the Kibimba, forms a separate drainage sub-basin of 2654 km² area. Sixty percent of this area is covered in swamp and in the Uganda Atlas no open water is indicated; thus the area of open water varies. It is fed by several swampy streams and although the River Kibimba leaves the lake the HYDROMET Survey (1982) reports that no flow has ever been recorded at the outlet and its contribution to the Katonga must be minimal. Sometimes the Kibimba is completely dry. The only inflow gauged is the Mmamujugu whose average annual inflow to L. Wamala (97 x 10⁶m³) plus 1200mm of rainfall must be lost through evapotranspiration.

Nevertheless the fishery is of importance to the local people and its decline in both catch per unit effort and size of fish caught, led the Uganda Freshwater Fisheries Research Organisation to carry out a fisheries resources survey there in May and July 1975 (Okaronen 1975). The lake was about 240km² in area and had 25 major fish landings at that time. There were 250 canoes licensed for fishing and a maximum permitted mesh size of 127mm still theoretically in force. No outboard motors were permitted on the lake. The survey caught Tilapia nilotica (which was introduced in 1953 and 1956), T. leucosticta, T. zillii, Clarias, and Protopterus. The first of these formed the bulk of the catch and were lighter in relation to their length than would be expected.

Lakes Kijanebalola, Kachira, Nakivali, Mbuho

There seems to be very little information on this group of lakes which lie west and south-west of Mbarara in the shallow valleys of various tributaries of the Kagera River (Fig. 6.13). They were visited by the Cambridge Expedition in 1931 and are mentioned briefly in early reports of the Uganda Game Department. Some have more recently been the subject of fishery resource surveys (Okaronen 1975b).

All these lakes are areas of open water in an extensive papyrus swamp.

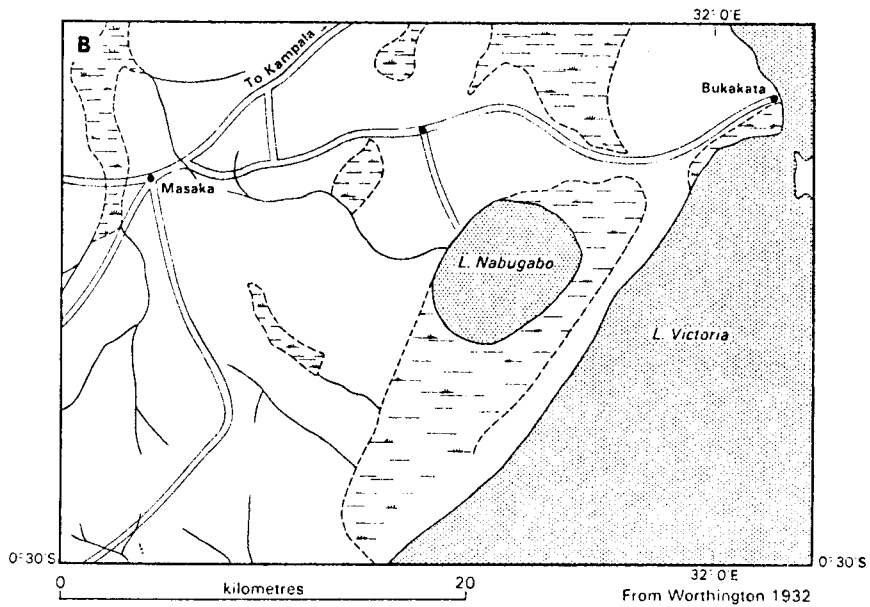
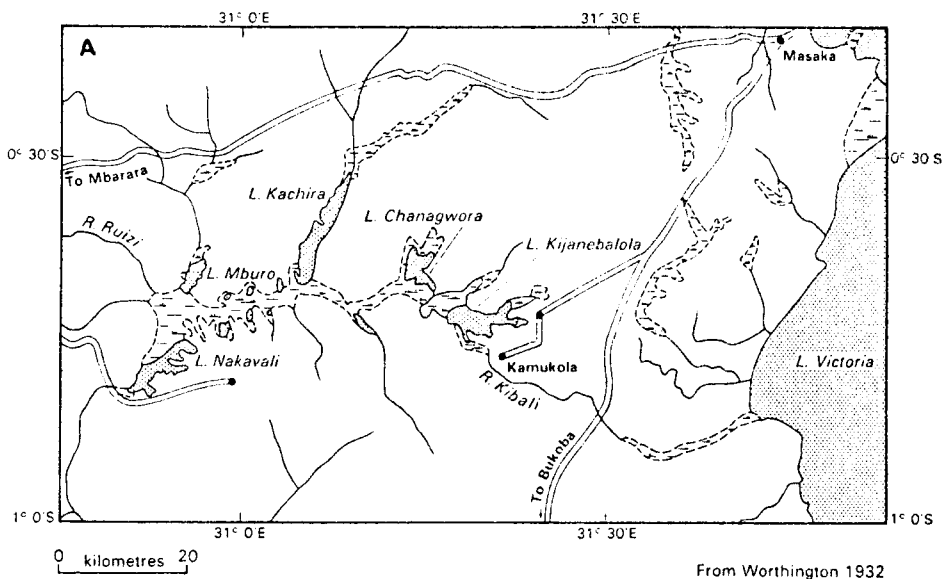


Fig. 6.13 Maps of lakes in the NW of the L. Victoria catchment; (a) Lakes Nakavali, Kijanebalola, Chanagwora, Kichira and Mbuoro; (b) Lake Nabugabo. Swamp areas associated with these lakes are also indicated.

The chief inflow is the Ruizi River from the west, which has a common headwater swamp with the River Ntungwe which flows to Lake Edward. Their main outflow is the River Kibali which flows, via the Kagera, into Lake Victoria. The HYDROMET Survey (1974) excludes them from the Kagera River catchment but in the Hydrological map of the Uganda Atlas they certainly appear to flow into this river. The complex is surrounded by savanna grasslands but inter-connected by aquatic grass and herb swamp (Uganda Atlas). The size and shape of the lakes themselves varies from year to year (Worthington 1932).

Physical data from Worthington (1932)

Some characteristics of the lakes in the NW catchment of L. Victoria

| | Alt. m | Area km ² | max. m | Temp. °C | pH | Secchi m |
|--------------|-----------|-------------------------|-----------|-------------|---------|-------------|
| Nakavali | | 26 | 3.5 | 24.8-25.9 | 7.7-8.5 | 0.5 |
| Mburo | | 10.4 | | | | |
| Kachira | 1230 | 36.3 | 4.1 | 25-26 | 8-8.4 | 0.5 |
| Chanagwora | |) | | | | |
| Kijanebalola | 1226 |)70 | 4.8 | 23.3-24.8 | 8.3 | 0.4 |

Invertebrates: Lowndes (1936) records Crustacea from three of these lakes:

| | Nakivali | Kijanebalola | Kachira |
|-----------------------------|----------|--------------|---------|
| <u>Ceriodaphnia rigaudi</u> | + | + | |
| <u>Moina dubia</u> | + | | + |
| <u>Cyclops leuckarti</u> | + | + | |
| <u>Cyclops hyalinus</u> | | | + |

Fish & fisheries: When Worthington (1932) visited these lakes he found Clarias mossambicus, C. werneri and Haplochromis spp in all the lakes but no Tilapia. He recommended the introduction of Tilapia from Lake Victoria. A number of introductions of various species of Tilapia, from various places, were subsequently made by the Game Department and are recorded in their Annual Reports.

Lake Kijanebalola

This is a finger-like lake about 30x2km, in South Buganda Province. Its major outlet is the Kibale River. It is much the same depth all over and when the water level is high it overflows in to the Kibale. This happens about every twelve years (Worthington 1932) and in between such times it has no outlet. Catches of fish seemed to be declining after 1971 and a fishery resource survey was carried out in May and July 1975 (Okaronen 1975) during which the majority of the catch was Haplochromis spp. but Clarias, Protopterus, Tilapia nilotica, T. esculenta and T. variabilis were also caught. About 465 canoes were reported to be fishing on the lake in 1974.

Lake Mburo

The Lake Mburo Game Reserve has recently been gazetted as a National Park (Oryx April 1983) with an area of 530km².

Lake Nabugabo

This small lake is primarily known to limnologists and zoologists for the very low conductivity of its water and the evolution of its endemic species of fish. The information given here is taken from Worthington (1932) and Beadle (1981).

The lake is 25 - 30km² in area and has a maximum depth of c5m. It is separated from Lake Victoria only by a sand bar (c1.2km wide at its narrowest point) which has been formed by wind induced currents in the main lake. Most of the lake is surrounded by swamp but there is forest along the NW shore and a sandy beach (Fig.6.13).

From dates established for contemporary raised beaches at the same level, it seems that L. Nabugabo has only been isolated for about 3700 years. There are 9 species of Haplochromis of which four have been described by Greenwood (1965) as endemic and must have evolved during that time. The other five are still found in L. Victoria and the four are clearly derived from stock common to closely related species in the main lake. The two species of Tilapia which occur in Nabugabo also occur in the main lake. The lake was stocked with T.nilotica, T. leucosticta and T. zillii in 1954, 56 and 58. In 1932 Worthington suggested that L. Nabugabo would be suitable for the experimental introduction of the highly predatory Nile perch before introducing it to L. Victoria. The introduction was strongly opposed particularly when the true interest of the fish fauna became known. Other fish species recorded include Protopterus aethiopicus, Alestes nurse, Clarias mossambicus, Bagrus docmac, Schilbe mystus, and Synodontis afro-fischeri. Gnathonemus longibarbis and Clarias wernerii are restricted to the swamps.

The inflow water to L. Nabugabo passes over very insoluble rocks and is of extremely low salinity (0.015 g/l) and about 20% of that in the main lake. On its E. shore the lake merges with an extensive area of Sphagnum dominated swamp which has water of very low pH (3.5 - 4) underneath. The water in the lake has a pH of 7 - 8.2. There are no molluscs in the lake and thus no vectors of bilharzia. The snails are presumably limited by the low concentration of calcium which may also explain the absence of crabs although they are abundant in L. Victoria.

The water from L. Nabugabo drains through the sand bar into the main lake.

Chemical composition of the water June 1967.

| | |
|-----------------------------------|--|
| Conductivity | 25.10 ⁻⁶ S.cm ⁻¹ |
| Na | 0.090 meq/l |
| K | 0.028 meq/l |
| Ca | 0.060 meq/l |
| Mg | 0.020 meq/l |
| CO ₃ +HCO ₃ | 0.140 meq/l |
| Cl | 0.040 meq/l |
| SO ₄ | 0.019 meq/l |

The water is opaque due to the suspension of organic detritus and abundant phytoplankton dominated by Melosira sp.

6.3.d BASSIN DE L'AKAGERA / AKAGERA BASIN

1. Géographie et géologie

Situation: Le bassin de l'Akagera (1°30'-2°30'S, 30°-31°E) est étudié ici en raison de la présence d'une zone inondée intégrée au Parc National de l'Akagera (Rwanda). La zone amont, dite du Bugesera, est en partie aussi au Burundi; un lac est en Tanzanie.

La morphologie de l'Est du Rwanda et des régions de Tanzanie et d'Uganda comprises entre le lac Victoria et l'Akagera dérive d'une ou de plusieurs surfaces d'érosion tertiaire et quaternaire. Celles-ci se sont établies sur le socle précambrien qui forme l'armature de toute l'Afrique Orientale. Ces surfaces ont été rajeunies à la suite des soulèvements qui ont formé les Rifts et les montagnes qui les bordent mais l'Est du Rwanda, proche de la cuvette du Victoria et éloigné des parties les plus relevées de l'ensemble, n'a été que faiblement repris par l'érosion.

Au niveau de l'Akagera, les roches du socle appartiennent au système du Burundien-Précambrien, appelé Karagwe-Ankole en Uganda et en Tanzanie. Elles sont formées de plusieurs séries sédimentaires distinctes, mais celles-ci n'interviennent pas dans la morphologie de la dépression de l'Akagera qui suit, du Nord au Sud, une zone anticlinale du socle où les granites apparaissent; les climats tropicaux favorisant l'altération superficielle des granites, ceux-ci forment une dépression par rapport aux roches environnantes.

L'Akagera suit cette dépression et le ralentissement de son cours a entraîné un alluvionnement important et, par suite, la formation des différents lacs qui occupent la dépression. Plus au Nord, l'Akagera traverse des roches non magmatiques dans lesquelles son cours se précise mieux.

Toute la région septentrionale du lac Ihema jusqu'au Iwapibari est entourée d'une vaste vallée à fond d'alluvions appartenant d'une part à l'Holocène et d'autre part au Pléistocène.

Les régions côtières occidentales, au Sud du Lac Ihema, sont formées par des assises pélitiques de séricitoschistes et phyllades.

Le bassin de l'Akagera, fait partie du bassin du Nil (Nil-Akagera), prenant naissance au Sud de la crête Zaïre-Nil à l'une des sources de la rivière Nyabarongo appelée Mwogo. Elle reçoit un affluent: l'AKanyaru et draine les eaux du haut Nil vers le lac Victoria en franchissant les chutes de Rusumo et en pénétrant dans une plaine couverte d'une papyraie qui comporte un grand nombre de lacs (tableau 6.11 et fig. 6.14 et 6.15)

Il faut distinguer deux sortes de lacs. Les premiers ont une communication directe avec l'Akagera: il s'agit des lacs Mihindi, Ihema, Rwehikama et Rwamapanga; les autres sont séparés du fleuve, souvent par des distances de 1 à 10 km: ce sont les lacs Rwanye-Kizinga, Hago, Kivumba et Nasho. Malgré les prairies flottantes et l'étendue de papyrus dont la superficie est parfois

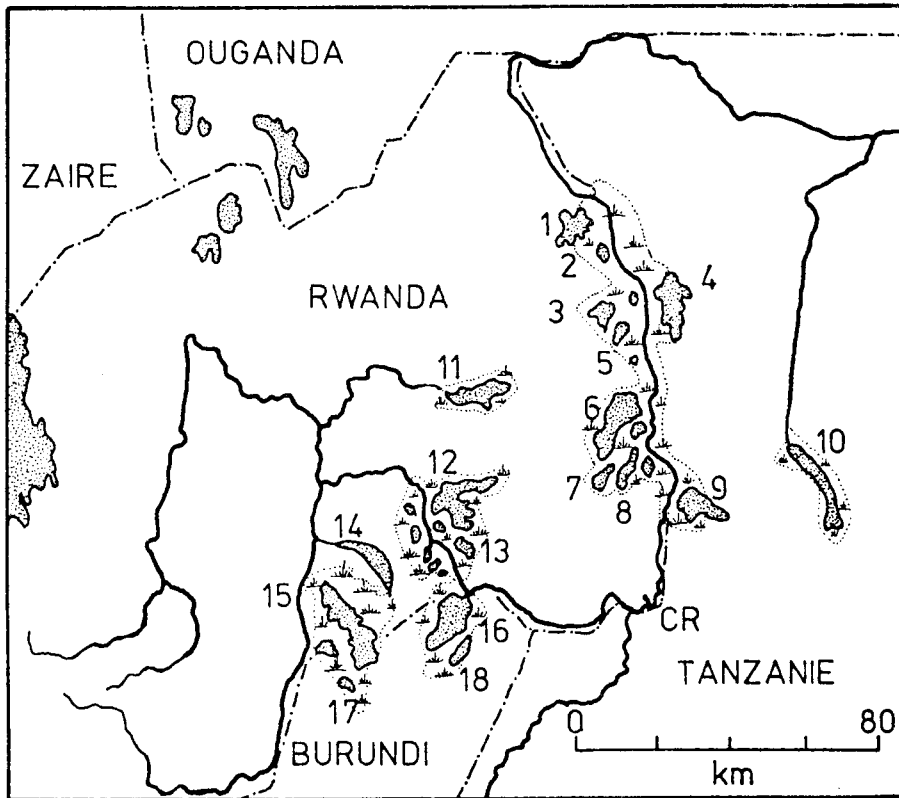


Fig. 6.14 Carte générale du bassin de l'Akagera / General map of the Akagera Basin.

- | | |
|----------------------|----------------------|
| 1: Lac Rwanyakizinga | 10: Lac Burigi |
| 2: Lac Mihindi | 11: Lac Muhazi |
| 3: Lac Hago | 12: Lac Mugesera |
| 4: Lac Mujunju | 13: Lac Sake |
| 5: Lac Kivumba | 14: Lac Cyohoha Nord |
| 6: Lac Ihema | 15: Lac Cyohoha Sud |
| 7: Lac Nasho | 16: Lac Rugwero |
| 8: Lac Rwehikama | 17: Lac Lirwihinda |
| 9: Lac Bisongo | 18: Lac Kanzigiri |

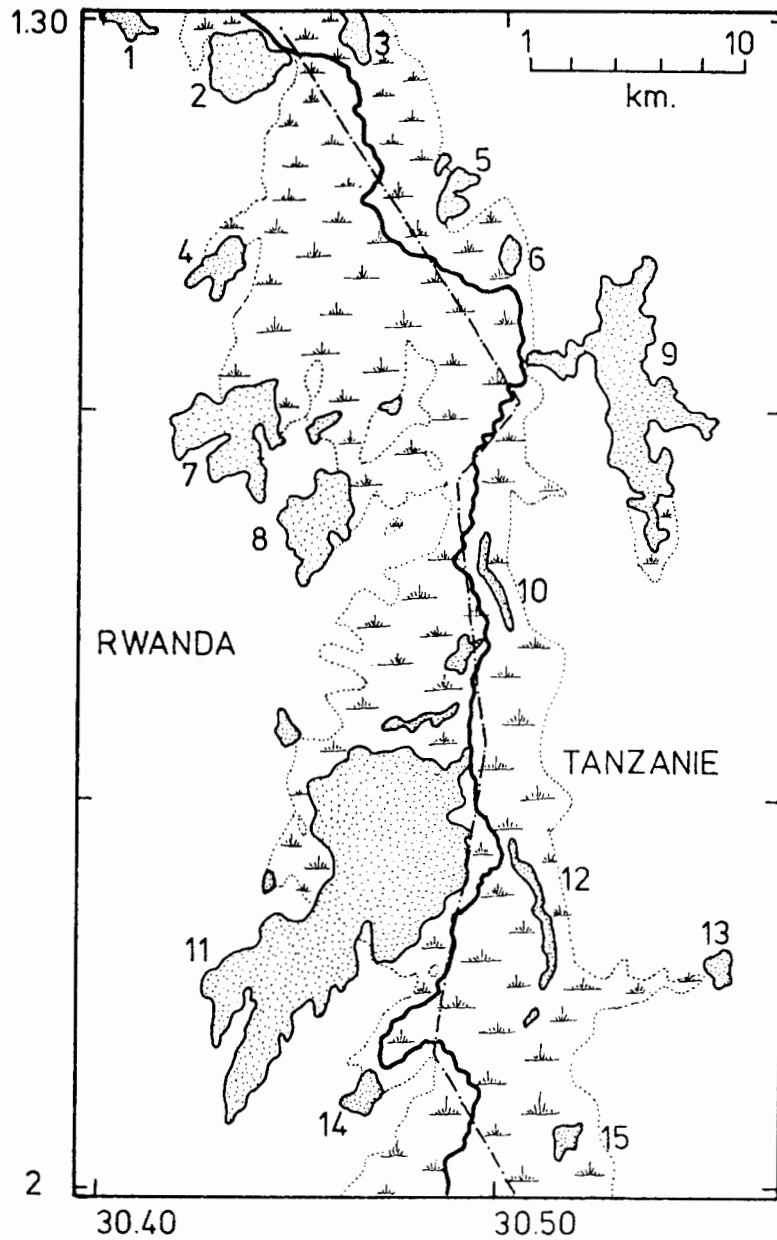


Fig. 6.15 Bassin de l'Akagera: zone incluse dans le Parc National/
The Akagera Basin: area included in the Akagera National Park

- | | |
|-------------------------|---------------------------|
| 1: Lac Rwanyanyakizinga | 9: Lac Mujunju |
| 2: Lac Mihindi | 10: Lac Sekena |
| 3: Lac Ouko | 11: Lac Ihema |
| 4: Lac Kisanju | 12: Lac Kasanga |
| 5: Lac Kasahi | 13: Lac Mubanza |
| 6: Lac Twawala | 14: Lac Rwakibale |
| 7: Lac Hago | 15: Lac Lweru kwa Kalambi |
| 8: Lac Kivumba | |

importante, ces lacs communiquent également avec l'Akagera soit par des chenaux naturels creusés par les courants, soit par ceux que les pêcheurs banyembo ont créés. D'autre part, ces lacs peuvent communiquer indirectement avec l'Akagera par infiltration lente sous les prairies flottantes, sous l'action des hautes eaux et des étiages du fleuve.

Même les lacs communiquant directement avec le fleuve en sont parfois isolés à la fin de la saison sèche et au début de la saison des pluies, lorsque le passage Akagera-lac devient insignifiant ou même inexistant.

Tous ces lacs, communiquant ou non avec l'Akagera directement ou indirectement, subissent une variation importante de l'étendue de leurs eaux libres, des zones d'inondation proprement dites et de leur profondeur suivant la hausse ou la baisse du niveau de l'Akagera. Chaque année le niveau varie de 1,0 à 1,5 m (deux fois par an) suite aux différentes saisons sèches ou pluvieuses. Le lac Mihindi communique avec l'Akagera par un large passage ouvert durant toute l'année. Seules, une partie de sa rive occidentale et les rives Nord-Ouest, Nord et Nord-Est, au contact de l'Akagera, sont bordées de marais permanents. Au sud du lac Mihindi, s'étale la plus grande étendue de marais permanents de l'Inghézi, qui est la zone d'inondation de l'Akagera sur sa rive gauche. Sur la bordure Ouest de ce tapis végétal flottant, sillonné de nombreux chenaux et interrompu par des eaux libres de surface fort variable, on trouve les lacs Kishandju, Hago et Kivumba.

L'altitude de l'ensemble des lacs est comprise entre 1100 et 1900 m.

2. Climat BS a₅ (Köppen) (fig. 6.8, Lulama)

4 saisons principales: 2 saisons sèches chaudes, 2 saisons pluvieuses chaudes.

Insolation: Moy. ann.: 2200 - 2250 h année⁻¹; max. en juillet (env. 235 h), min. en janvier (env. 110 h).

Pluviométrie: Moy. ann.: 650 mm; max. en janvier (env. 110 mm) et mai (100 mm); durée moyenne de la saison sèche la plus longue: 90 jours.

Température de l'air: Moy. ann.: 22,5°C; max. en septembre (moy. vraie env. 23,5°C; moy. max. journ. 29,5°C; moy. min. journ. 17,5°C); min. en mars (moy. vraie 21,5, moy. max. journ. 27,5, moy. min. journ. 14,5°C).

Kiss (1976) signale que la température de l'air varie entre 14,4°C (minimum) et 32,8°C (maximum absolu). C'est généralement entre 14 et 16 heures que la température journalière atteint son maximum et entre 5 et 6 heures son minimum quelle que soit la saison.

La région du bassin de l'Akagera est faiblement arrosée (650 à 900 mm), la saison des pluies dure environ huit mois. La région connaît un rythme climatique à quatre saisons assez semblable à lui-même sur toute l'étendue du bassin. Les variations thermiques

annuelles étant faibles, c'est essentiellement la pluie qui définit les saisons.

- De la mi-septembre à la mi-décembre: les averses sont assez fréquentes et assez fortes; c'est la petite saison des pluies. Il tombe alors, pendant ces trois mois, environ 27% des précipitations annuelles. L'humidité atmosphérique est forte, de telle sorte que lorsque le ciel s'est dégagé après une forte pluie de soirée, ce qui permet à la terre de se refroidir pendant la nuit, des brouillards se forment le matin, particulièrement au-dessus des vallées où l'humidité atmosphérique est maximale.
- Dès la fin du mois de décembre: les averses deviennent plus rares, elles ne disparaissent pas en janvier et reprennent vite dès février. Cette "petite saison sèche" n'est, en fait, qu'une rémission des pluies. Elle est marquée dans le bassin de l'Akagera.
- La grande saison des pluies: elle commence dans la deuxième quinzaine de février et se prolonge jusqu'à la fin de mai ou le début de juin selon les régions et les années. En mars, avril et mai tombent, en général, 40% des précipitations annuelles. Les pluies sont alors particulièrement fortes sur les reliefs; ce sont des averses orageuses, souvent au milieu de la journée et qui durent alors pendant quelques heures.
- La grande saison sèche règne en juin, juillet et août: elle gagne progressivement d'Est en Ouest l'ensemble du pays mais elle s'interrompt à peu près partout en même temps avec la petite "pluie des vaches" de la fin du mois d'août. La durée peut varier considérablement (de même que pour les autres saisons) d'une année à l'autre; l'air est alors très sec. L'humidité relative vers midi n'est que de 20%.

Vents: Le régime des vents est assez régulier sur les lacs du bassin de l'Akagera. Pendant la saison sèche, les vents viennent du NNE; ceux de l'ESE amènent les pluies pendant la saison des pluies, tandis que les vents soufflant du Sud et du Sud-Ouest sont à l'origine de violents orages.

Les vents soufflent toujours à faible vitesse, le plus souvent 3 à 6 km/heure, exceptionnellement 10 km/h;

La nuit, pendant les saisons des pluies, les lacs sont légèrement agités. Le matin, ils se calment et, vers le milieu de la journée, ils s'agitent à nouveau pour s'apaiser en fin d'après-midi.

Pendant les saisons sèches, les phénomènes sont inversés: Les nuits sont calmes après une agitation matinale; le milieu du jour est calme également mais on observe une agitation avant le coucher du soleil.

3. Morphométrie et hydrologie (Voir tableau 6.11)

4. Les Facteurs physico-chimiques (Voir tableau 6.12 et 6.13)

Température: La température de l'eau de surface varie, au cours de l'année entre 22 et 27,00°C et, au fond de 21,22 à 24,40°C.

Tableau 6.11 Localisation et données morphométriques et hydrologiques pour quelques lacs de L'Akagera

| Lac | Pays | Superficie km ² | Développement côtier km | Profondeur maximum m | Profondeur moyenne m | Volume d'eau 10 ⁶ m ³ | Long. max. km | Larg. max. km | Communi- cation avec l'Akagera | Parc National |
|-------------------------|------|-------------------------------|-------------------------------|----------------------------|----------------------------|---|---------------------|---------------------|---|------------------|
| Basse Akagera | | | | | | | | | | |
| Rwanya-Kizinga | R | 19,6 | 43,7 | 4,3 | 2,6 | 42,3 | 10,3 | 4,3 | N.P. | + |
| Mihindi | R | 10,9 | 14,5 | 6,8 | 4,4 | 41,8 | 4,2 | 3,9 | P. | + |
| Hago | R | 16,1 | 33,5 | 5,8 | 4,5 | 45,2 | 6,0 | 5,8 | N.P. | + |
| Kivumba | R | 8,7 | 18,2 | 5,6 | 4,2 | 30,3 | 5,2 | 3,5 | N.P. | + |
| Ihema | R | 86,4 | 77,8 | 7,0 | 4,8 | 512,6 | 22,0 | 7,8 | P. | + |
| Rwakibare | R | 3,6 | 9,5 | 6,0 | 4,3 | 13,6 | 4,0 | 1,8 | P. | + |
| Rwehikama | R | 19,2 | 36,3 | 6,7 | 4,1 | 51,4 | 14,0 | 3,1 | P. | Non |
| Rwamapanga | R | 9,5 | 17,5 | 7,0 | 5,2 | 32,6 | 7,0 | 2,2 | P. | Non |
| Nasho | R | 13,7 | 27,8 | 6,3 | 4,2 | 43,0 | 8,- | 2,1 | N.P. | Non |
| Ngoma (Bisongo) | T | 50,0 | 48,6 | 8,6 | 5,3 | 98,0 | 14,5 | 4,8 | P. | Non |
| Mujunju (Rwakajunju) | T | 80,0 | 57,0 | 11,0 | 5,9 | 182,0 | 14,9 | 6,1 | P. | Non |
| Rushwa | R | 5,0 | NC | 5,0 | NC | NC | NC | NC | P. | + |
| Burigi | T | 186,0 | 227,0 | 7,8 | 4,6 | 930,0 | 42,0 | 7,0 | P. | Non |
| Haute Akagera | | | | | | | | | | |
| Rugwero | R+B | 100,0 | 76 | 3,9 | 2,1 | 210,0 | 18,0 | 14,5 | N.P.* | Non |
| Cyohoha Sud | R+B | 76,0 | 227 | 11,0 | 5,2 | 395,0 | 32,0 | 2,0 | N.P.* | Non |
| Cyohoha Nord | R | 36,0 | NC | NC | NC | NC | NC | NC | N.P.* | Non |
| Tkimba | R | 35,3 | 27 | 4,0 | 2,8 | 99,0 | 6,1 | 6,1 | N.P.* | Non |
| Lirwihinda | B | 4,0 | NC | NC | NC | NC | NC | NC | N.P.* | Non |
| Kanzigiri | B | 12,0 | NC | NC | NC | NC | NC | NC | N.P.* | Non |
| Birira | R | 5,4 | NC | NC | NC | NC | NC | NC | N.* | Non |
| Gaharwa | R | 26,3 | NC | NC | NC | NC | NC | NC | N.P.* | Non |
| Gashanga | R | 2,3 | NC | NC | NC | NC | NC | NC | N.P.* | Non |
| Kirimbi | R | 2,3 | NC | NC | NC | NC | NC | NC | P.* | Non |
| Mugesera | R | 39,2 | NC | NC | NC | NC | NC | NC | P.* | Non |
| Sake | R | 14,3 | NC | NC | NC | NC | NC | NC | P.* | Non |

Pays: R = Rwanda; B = Burundi; T = Tanzanie

Communication avec l'Akagera: P = Permanent; N.P. = Non permanent; * = communication avec affluent et non l'Akagera elle-même. Parc National: + = inclus dans le Parc; Non = Non inclus.

Tableau 6.12 Données physico-chimiques disponibles sur les lacs de la Haute Akagera en amont des chutes de Rusumo (d'après Kiss 1976).
Available physico-chemical data on lakes of upper Akagera, above the Rusumo Falls (quoted from Kiss 1976).

| Lac | Temp. (°C) (Surf.) | pH | Conduct. 10 ⁻⁶ < S.cm ⁻¹ | Alcal. meq/l | Dur. tot. (CaCO ₃) mg/l | Ca (mg/l) | Mg (mg/l) | Na (mg/l) | K (mg/l) | Cl (mg/l) | CO ₃ HCO ₃ (mg/l) | CO ₂ libre (mg/l) | Prof. (m) | Transp. (m) |
|-------------|--------------------------|-------------|--|-----------------|---|--------------|--------------|--------------|-------------|--------------|---|------------------------------------|--------------|----------------|
| Mugesera | 25 | 9 | 236 | --- | 85 | --- | --- | --- | --- | --- | | Tr | 3 | |
| Rugwero | S 26 | 8,5- 8,8 | 155 à 156 | 1,5 | 68 | 4,40 | 6,07 | 13,40 | 6,35 | 5,40 | 91,51 | 5 | 5-6 | 0,3-0,4 |
| | F | 7,5-9 | 158 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sake | 26 | 8 | 182 | --- | 68 | --- | --- | --- | --- | --- | --- | 0 | 4,5 | |
| Cyohoha | S 23- 25 | 8,5- 9,5 | 250 à 256 | 2,5 2,9 | 102 --- | 9,00 --- | 10,85 --- | 25,75 --- | 9,55 --- | 4,30 --- | 152,52 170,82 | 0 --- | 7 --- | 0,7-0,8 --- |
| Cyohoha (N) | 21,5 -26 | 9 | 460 à 510 | --- | 153 | --- | --- | --- | --- | --- | --- | 0 | 2-2,5 | |
| Birira | 25 | 8 | 157 | --- | 68 | --- | --- | --- | --- | --- | --- | 0 | 6 | |
| Gaharwa | 25 | 0 | 192 | --- | 85 | --- | --- | --- | --- | --- | --- | --- | 2 | |
| Gashanga | 26 | 7 | 134 | --- | 70 | --- | --- | --- | --- | --- | --- | 10 | 3 | |
| Kirimbi | 24 | 8 | 204 | --- | 95 | --- | --- | --- | --- | --- | --- | 10 | 2,5 | |
| Mirayi | 25,5 | 7 | 144 | --- | 68 | --- | --- | --- | --- | --- | --- | 20 | 3,5 | |
| Kodogo | 24 | 6,5-7 | 129 | --- | 81,6 | --- | --- | --- | --- | --- | --- | 15 | 3 | |
| Murago | 25 | 8,5-9 | 141 | --- | 74,5 | --- | --- | --- | --- | --- | --- | 5 | 3 | |

TABLEAU 6.13. (1^{ère} partie). — Données physico-chimiques disponibles sur les lacs de l'Akagera, en aval des chutes de Rusumo (Kiss 1976, Karangwa 1982)
Available physico-chemical data on Akagera Lakes, downstream from the Rusumo Falls (Kiss 1976, Karangwa 1982)

| | Temp. (°C) | pH | Conduct $\mu\text{s. cm}^{-1}$ | Res. Sec (mg/l) | Alcal. (mécq/l) | Dur. tot. (°F) | Ca (mg/l) | Mg (mg/l) | Na (mg/l) | K (mg/l) | Cl (mg/l) |
|---------------------------|--------------------------------------|---------------------------|-----------------------------------|-------------------------|--------------------------|---------------------------|----------------------------|----------------------------|------------------------|------------------------|---------------------------|
| Rivière Akagera | 22,8 | 7 | 111 | 9,2 | 0,7 | 3,22 | 4,60 | 4,9 | 4,1 | 1,0 | 7,4 |
| Lac Ihema | Surf Fond 24,6 à 26,7 23,5 | 8,8 à 7,1 6 à 6,3 | 110 100 | 9,5 à 8,3 12,8 à 100 | 0,65 à 1 0,80 à 1,6 | 2,58 à 2,9 2,70 à 4,1 | 2,4 à 5 3,9 à 6,9 | 3,6 à 3,9 4,2 à 5,4 | 5,4 à 5,9 3,9 à 6,3 | 0 à 3,2 0 à 2,9 | 4,9 à 8,8 3,9 à 7,8 |
| Lac Mujunju | S F — | 8,5 7,4 | 97 98 | — — | 0,75 0,80 | 3,13 — | 5,35 — | 4,34 — | 6,5 — | 4,6 — | 9,23 10,29 |
| Lac Ngoma (Bisongo) | S F — | 8,4 7,2 | 101 97 | 10,01 — | 0,90 — | 3,03 — | 4,22 — | 4,65 — | — — | — — | 8,20 — |
| Lac Rwanya-Kizinga | — | 7,45 | 83 | — | 0,85 | 2,85 | — | — | — | — | — |
| Lac Rwehikama | S F — | 7,81 à 8,92 7,0 à 7,65 | 94 à 105 98 | 8,1 à 9,8 9,1 | 0,90 à 1,25 1,25 | 32,6 à 9,89 — | 5,07 à 5,15 — | 3,94 à 4,82 — | 4,8 4,95 | 2,1 — | 4,97 à 7,95 — |
| Lac Hago | S F — | 6,92 à 8,92 7,82 | 97 99 | 10,4 12 | 1 0,9 | 2,86 2,90 | 4,78 à 9,5 4,64 à 9 | 3 à 4,03 2,4 à 4,03 | 5,5 5,4 | 0 5,4 | 5,66 4,95 |
| Lac Mihindi | 22,6 à 24 | 6,1 à 7,1 | 97 | 10,8 | 0,35 à 0,65 | 2,99 | 4,34 | 4,5 | 3,6 | 0 à 0,9 | 6,4 |
| Lac Rwamapanga | S F 22 à 25 22,7 à 23,15 | 7,5 à 7,8 6,6 à 6,8 | 100 à 110 102 à 107 | 9,2 à 73 10 à 80 | 0,8 à 0,9 0,65 à 1,10 | 2,85 à 3,13 2,6 à 3,09 | 5,12 à 5,21 4,34 à 5,43 | 4 à 5,16 3,4 à 3,99 | 5,2 à 5,5 4,5 à 5,1 | 2,6 à 3,6 1,6 à 3,3 | 6,35 à 7,9 5,68 à 8,10 |
| Lac Kivumba | S F — | 9,15 6,7 | 103 100 | 10,5 12,2 | 1,00 | 2,92 2,81 | 4,64 à 9 4,28 à 8 | 2,70 à 4,25 3,30 à 4,03 | 5,4 5,2 | 0 | 6,01 à 6,3 6,37 |
| Lac Rwakibare | S F 23,7 à 26,8 22,7 à 23,6 | 6,8 à 7,2 6 à 6,4 | 93 à 107 102 à 107 | 10,2 à 60 10 à 90 | 0,75 à 0,9 0,65 à 1,5 | 2,94 à 3,09 2,6 à 2,77 | 5,12 à 5,35 3,64 à 5 | 3,8 à 3,86 3,25 à 3,3 | 4,5 à 5,2 4,3 à 5,1 | 1,6 à 3 1,3 à 3 | 6,74 à 8,1 6,39 à 8,7 |
| Lac Rushwa | S F — | 7,35 6,48 | 95 92 | — | 0,70 | 2,65 | — | — | — | — | — |
| Lac Burigi | S F — | 8,85 8,35 | 430 | — | 4,90 4,75 | 11,8 11,6 | 20,70 20,0 | 16,70 16,10 | 40,0 | 19,5 | 9,45 14,08 |
| Lac Ikimba | S F — | 7,89 7,68 | 79 77 | — | 0,80 — | 2,24 — | 4,28 — | 2,82 — | 4,4 — | 2,3 — | 2,85 — |
| Marais Kagevo | 24,6 | 7,05 à 7,6 | 90 à 109 | 8 à 8,3 | 1,0 | 2,85 à 3,26 | 3,85 à 5 | 4,56 à 4,86 | — | — | 4,8 à 7,2 |

TABLEAU 6.13. (2^e partie). — Données physico-chimiques disponibles sur les lacs de l'Akagera, en aval des chutes de Rusumo (Kiss 1976, Karangwa 1982)
Available physico-chemical data on Akagera Lakes, downstream from the Rusumo Falls (Kiss 1976, Karangwa 1982)

| | | NO ₂ (mg/l) | NH ₄ (mg/l) | PO ₄ (mg/l) | Fe ⁺⁺ (mg/l) | SiO ₂ (mg/l) | O ₂ sat. % | CO ₂ libre (mg/l) | CO ₃ + HCO ₃ (mg/l) | Mat. org. | Transp. (m) | Prof. max (m) |
|-------------------------|--------------|---------------------------|---------------------------|---------------------------|----------------------------|----------------------------|--------------------------|---------------------------------|--|----------------------|----------------|------------------|
| Rivière Akagera | | 0 | 0 | 0 | 0,30 | — | — | — | 42,7 | — | 0,1 | 9,7 |
| Lac Ithema | Surf Fond | 0 0 à 0,3 | 0 0,03 à 0,5 | 0 0 à 0,03 | 0,1 à 0,7 1 à 1,6 | 6 à 9,2 6,7 à 9,2 | 105 8 | traces 8,8 | 42,7 | 0,3 à 0,8 1,2 à 2 | 0,6 à 1 | 6 |
| Lac Mujunju | S F | — — | — — | — — | 0,15 0,80 | — | — | — | 45,75 48,80 | — | 0,5 à 1 | — |
| Lac Ngoma Bisongo | S F | — — | — — | — — | 0,6 1,10 | — | — | — | 54,90 | — | 0,5 à 1 | — |
| Lac Rwanya-Kizinga | | — | — | — | — | — | — | — | 51,85 | — | 0,5 à 0,7 | — |
| Lac Rwchikama | S F | — — | — — | — — | 0,56 0,95 | 5,8 6,5 | — | — | 54,9 | 0,4 1,3 | 0,6 à 0,8 | — |
| Lac Hago | S F | — — | — — | — — | 0,45 à 0,70 | 5,2 6 | — | — | — | 0,8 2,3 | 0,70 | — |
| Lac Mihindi | | 0 | 0 | 0 | 0,2 à 0,9 | — | — | — | 39,65 | — | 0,6 à 0,9 | 5,20 |
| Lac Rwamapanga | S F | 0 0 à 0,02 | 0 0,07 à 1,6 | 0 0 à 0,03 | 0,2 à 0,6 0,9 à 2,5 | 8,0 | 86 à 100 0 | 0 12,3 | 48,8 45,56 | 0,7 2,4 | 0,8 | — |
| Lac Kivumba | S F | — — | — — | — — | 0,55 à 0,95 0,80 | 8 8,5 | — | — | 61,01 | 0,9 2,1 | 0,49 | — |
| Lac Rwakibare | S F | 0 0 à 0,04 | 0 0, à 0,04 | 0 à trace | 0,3 à 0,4 0,8 à 2,1 | 8,4 8,4 | 56 — | 0 44 | 54,9 39,65 | 0,7 2,1 | 0,6 à 0,9 | 6 |
| Lac Rushwa | S F | — — | — — | — — | — — | — | — | — | 42,70 | — | 0,60 | — |
| Lac Burigi | S F | — — | — — | — — | — — | — | — | — | 289,30 | — | 0,5 à 1 | — |
| Lac Ikimba | S F | — — | — — | — — | 0,5 | — | — | — | 48,80 | — | 0,35 à 0,5 | — |
| Marais Kageyo | | — | — | — | 0,15 à 1,3 | 3,4 | — | — | — | 1,5 | 0,60 | 3,4 |

Les saisons sèches sont caractérisées par une tendance à la stratification pouvant souvent atteindre un écart de 2 à 4°C entre la surface et le fond, tandis que les saisons des pluies provoquent plutôt, en général, l'homogénéité de la masse d'eau.

Ces lacs peuvent donc être classés dans la catégories des lacs tropicaux de faible profondeur, holomictiques chauds.

pH: Le pH varie entre 7 et 9 en surface, entre 6 et 7,5 en profondeur, au cours de l'année. En général, pendant les saisons sèches, le pH baisse légèrement.

Ions dissous: Les cations alcalins et alcalino-terreux sont plus ou moins également partagés et leur quantité varie entre 2 et 10 mg/l suivant les différentes profondeurs et les saisons. Fe varie entre 0,1 et 1,4 mg en surface et de 0,5 et 9,0 mg/l au fond.

L'eau est relativement riche en hydrogénocarbonate (HCO₃), avec une variation de 30 à 85 mg/l. Les chlorures et la silice sont en faible concentration (3 à 20 mg/l), tandis que le SO₄ manque totalement.

Il semble qu'une carence en phosphate et en azote se manifeste car ces éléments sont consommés immédiatement après leur production.

Oxygène: La distribution d'O₂ correspond à celle des lacs tropicaux de faible profondeur. Les saisons de pluie sont caractérisées par une sursaturation et une quantité d'O₂ souvent assez importante jusqu'au fond. Pendant les saisons sèches, on note un déficit de saturation et les derniers mètres proches du fond sont parfois dépourvus d'O₂.

5. Macrophytes

Parmi les plantes submergées figurent Ceratophyllum demersum et Potamogeton pectinatus. Les plantes flottantes enracinées comportent essentiellement Ludwigia stolonifera et Nymphaea nouchalii. Les plantes flottantes libres dominantes sont Pistia stratiotes et Lemna paucicostata.

On note de nombreux hélrophytes dont Phragmites, Cyperus spp., Scirpus spp., Cladium.

Enfin figurent des arbustes: Aeschynomene elaphroxylon, Phoenix reclinata.

Deux communautés doivent retenir l'attention: la papyraie et sa frange en contact avec les eaux libres, dont les compositions floristiques sont données ci-dessous:

Papyraies
Cyperus papyrus
Ludwigia sp.
Melastomataceae sp.
Triumfetta sp.
Dryopteris gongylodes
Ipomoea sp.
Polygonum sp.

Frange devant papyraies
Vossia cuspidata
Echinochloa crus-pavonis
Leersia hexandra
Hydrocotyle ranunculoides
Utricularia inflexa
Ceratophyllum demersum
Echinochloa pyramidalis
Scirpus cubensis

Dans la région Sud, hors du parc national de l'Akagera, on assiste à un appauvrissement de la flore aquatique sous l'action de l'occupation par l'homme et notamment des défrichements dont certains sont liés au développement de la pêche.

6. Phytoplancton

La population phytoplanctonique est constituée par trois grandes familles: les Chlorophycées (5 genres et 6 espèces), les Cyanophycées, (3 genres et 6 espèces) et les Diatomophycées (un seul genre et deux espèces), (Kiss 1976). Toutes les espèces sont cosmopolites et leurs formes, variétés et sous-espèces, sont présentes dans de nombreuses autres eaux africaines.

Kiss (1976) a étudié le plancton du lac Ihema. Il a constaté, que la production primaire est comprise entre $1,51 \text{ g/m}^2/24 \text{ h}$ et $12,39 \text{ g/m}^2/24 \text{ h}$. Cette production primaire augmente en saison de pluies alors qu'elle diminue en saison sèche suivant la fluctuation saisonnière de la lumière.

7. Zooplancton

Trois groupes planctoniques sont présents: les Copépodes, les Cladocères, les Rotifères, avec un petit nombre d'espèces comme pour le phytoplancton. Cette pauvreté qualitative est compensée par une abondance quantitative.

D'après Kiss (1976), le plancton des lacs du bassin de l'Akagera est nettement celui de lacs eutrophes.

8. Poissons

L'ichtyo-faune est très diversifiée. 30 espèces ont été identifiées, appartenant à neuf familles; 22 d'entre elles sont communes au lac Victoria. Il convient de noter que la systématique des poissons du bassin de l'Akagera n'est pas parfaitement connue notamment pour les genres Clarias, Tilapia et Oreochromis et Alestes. Certaines espèces ont été introduites: T. rendalli, O. niloticus eduardianus (?), O. macrochir (?). On a signalé T. variabilis (?), O. esculentus (?)

9. Oiseaux

La liste systématique comprend 173 espèces réparties en 51 familles. L'avifaune est donc relativement plus riche que les autres groupes qui peuplent le bassin (Kiss 1976).

Une partie de cette avifaune joue un rôle très important dans la biologie du lac.

En effet, une trentaine d'espèces se nourrissent directement de poissons et d'insectes aquatiques. Elles peuvent donc être classées dans le régime ichthyo-et ichtyo-entomophage. On peut encore compter une quinzaine d'espèces entomo-malacophages qui consomment en outre des Batraciens.

Tableau 6.14: Lacs de la basse Akagera (Aval Chutes Rusumo):
Potentiel Piscicole (Dunn 1974)

| Lac | Superficie (km ²) | Nombre optimal de pêcheurs | Prises potentielles maximales équilibrées (t/an) |
|------------------------------|----------------------------------|----------------------------------|--|
| <u>Dans le Parc National</u> | | | |
| Chuju | 0.2 | 1 | * moins de 10t/an |
| Hago | 16.1 | 80 | 210 |
| Ihema | 71.9 | 360 | 900 |
| Kajumbura | 0.2 | 1 | * |
| Kisanji (N) | 0.4 | 2 | * |
| Kisanji (S) | 0.3 | 2 | * |
| Kivumba | 9.2 | 46 | 110 |
| Mihindi | 10.8 | 54 | 140 |
| Muhari | 0.6 | 3 | * |
| Ngarenke | 1.3 | 6 | 20 |
| Rukira | 0.5 | 2 | * |
| Rwakibare | 3.7 | 18 | 50 |
| Rwanyakizinga | 20.0 | 100 | 250 |
| Sekena (groupe) | 1.3 | 6 | 20 |
| Subtotal | 136.5 | 681 | 1730 |
| <u>Hors du Parc National</u> | | | |
| Nasho | 13.0 | 65 | 160 |
| Rwahikama | 21.1 | 105 | 260 |
| Rwampanga | 9.0 | 45 | 110 |
| Subtotal | 43.1 | 215 | 530 |
| Total pour tous les lacs | 179.6 | 896 | 2260 |

Tableau 6.15: Etat actuel de la pêche dans certains lacs du bassin de L'Akagera

| LAC | Nombre des pêcheurs en 1975-76 | Prises (tonnes) | Nombre optimal de pêcheurs (*) | Prises maximales les potentielles (tonnes) ** |
|----------------------|--------------------------------------|--------------------|--------------------------------------|---|
| <u>BASSE AKAGERA</u> | | | | |
| RWANYE-KIZINGA | 15 | 225 | 100 | 250 |
| MIHINDI | 8 | 120 | 54 | 140 |
| HAGO | 6 | 90 | 80 | 210 |
| KIVUMBA | 5 | 75 | 46 | 110 |
| IHEMA | 25 | 375 | 360 | 900 |
| RWAKIBABE | 4 | 42 | 18 | 50 |
| RWHIKAMA | 35 | 245 | 105 | 260 |
| RWAMAPANGA | 30 | 230 | 45 | 110 |
| NASHO | 28 | 150 | 65 | 160 |
| NGOMA - BISONGO | 26 | 182 | 250 | 550 |
| RWAKAJUNJU = MUJUNJU | 15 | 100 | 400 | 850 |
| RUSHWA | 10 | 90 | 25 | 55 |
| BURIGI | 20 | 25 | 900 | 2000 |
| <u>HAUTE AKAGERA</u> | | | | |
| BIRIRA | 6 | 70 | 27 | 54 |
| CYOHHA (N) | 55 | 40 | 130 | 420 |
| CYOHHA (S) | 65 | 40 | 31 | 770 |
| GAHARWA | 26 | 10 | 11 | 22 |
| GASHANGA | 13 | 30 | 11 | 22 |
| KIRIMBI | 15 | 20 | 11 | 25 |
| MIRAYI | 17 | 20 | 11 | 24 |
| MUGESERA | 325 | 300 | 196 | 390 |
| RUGWEIO | 150 | 280 | 100 | 220 |
| SAKE | 100 | 180 | 71 | 150 |
| TOTAL | 1050 | 2940 | 3045 | 6854 |

* D'après Dunn (1974); Blin (1977)

** D'après Henderson & Welcomme (1974).

Ces 173 espèces se subdivisent en différents groupes écologiques. Il y a des migrateurs d'Europe, tels Motacilla flava, Hippolais icterina, Sylvia borin, Phylloscopus trochilus, Riparia riparia, Hirundo rustica, qui passent ou hivernent avec quelques migrateurs africains, tels Creatophora cinerea ou enfin Quelea erythrops, qui passent en bandes de plusieurs milliers d'oiseaux.

Chaque année, également au mois d'août, les grues couronnées, Balearica regulorum, se rassemblent au bord des lacs; on peut en observer des groupes de 20 à 30 qui se livrent à leur célèbre danse nuptiale. C'est à la même époque qu'on peut voir aussi des oies de Gambie, Plectropterus gambensis, tout le long des rives.

Tous les ans, des colonies de Phalacrocorax africanus, Phalacrocorax carbo, Anhinga rufa, Ardeola ralloides, Pyrherhodia purpurea nichent sur certaines îles.

Il faut aussi mentionner les aigles-pêcheurs, Haliaeetus vocifer, qui vivent sur des territoires bien délimités. Souvent les couples perchent sur les Acacia du bord ou sur les Aeschynomene elaphroxylon ou même encore, sur des tiges de papyrus, courbées au-dessus de l'eau.

Les martins-pêcheurs pie, Ceryle rudis, sont très nombreux; ils partagent les territoires des aigles-pêcheurs. Le héron goliath, Ardea goliath, est souvent seul. Il vit sur les berges dans la ceinture de papyrus ou sur les plages. Il est assez fréquent et présent toute l'année.

10. Reptiles et Mammifères

La partie du bassin comprise dans le Parc National de l'Akagera comporte de nombreux mammifères de savane arbustive.

Dans les eaux elles-même il faut noter la présence des hippopotames, des crocodiles et des loutres, ces deux dernières espèces étant ichtyophages préférentiels.

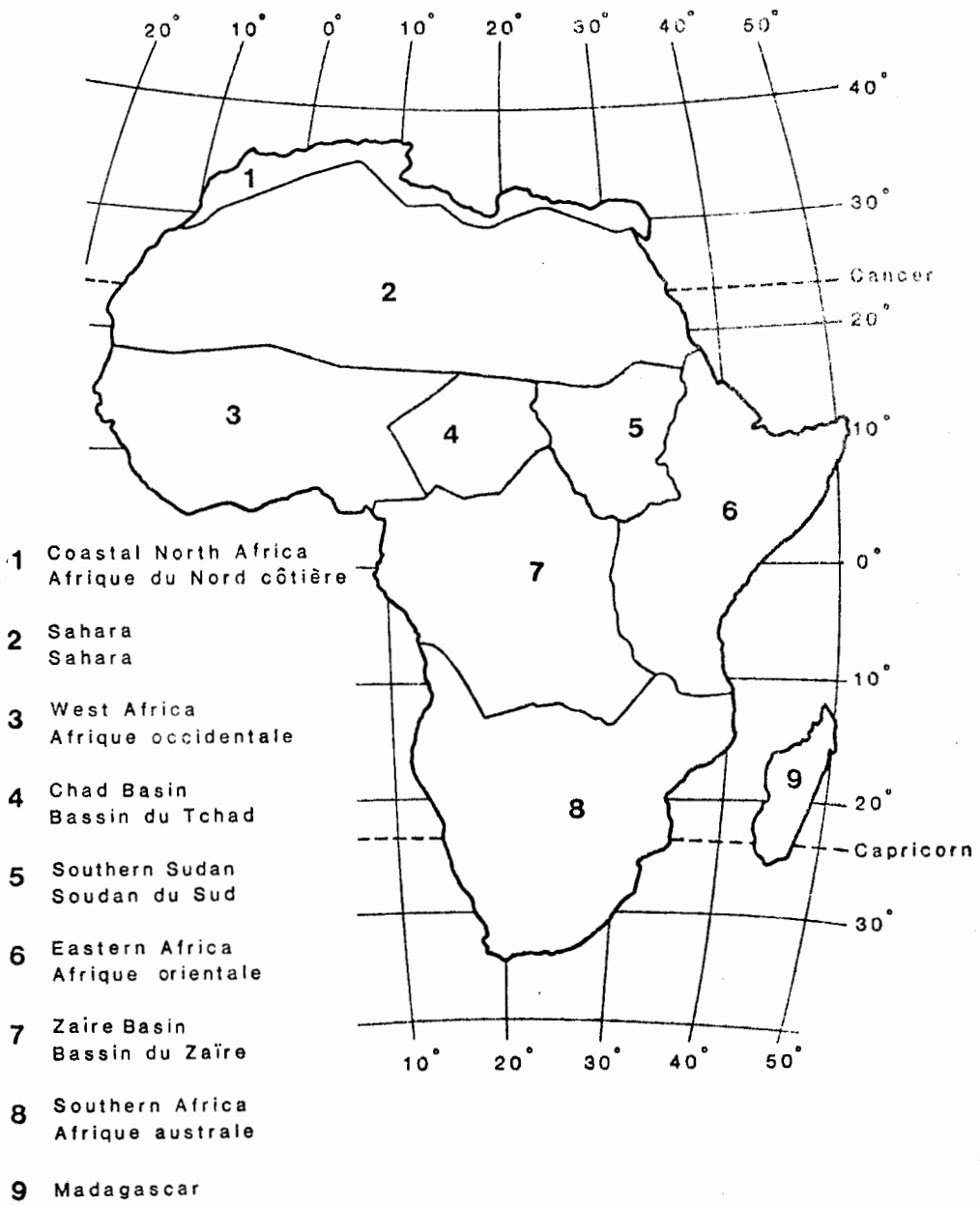
11. Activités humaines

La pêche (Voir tableaux 6.14 et 6.15)

La plupart des lacs peu profonds et très poissonneux, et dont les pêches semblent encore à une étape de développement très primitive sont, en fait, exploités d'une manière efficace et parfois même surexploités. Les captures comportent 20% de Clarias spp. et 60% de Tilapia spp.

Les estimations relatives à la production et à l'exploitation ont été faites au moyen d'une hypothèse fondée sur les données théoriques disponibles selon laquelle, pour assurer le maintien du rendement maximal possible dans les lacs du type considéré, cinq pêcheurs par km² et des prises de 125 kg/ha/an sont les maximums permis.

Théoriquement, on ne pêche pas dans les lacs qui se trouvent dans le Parc National, bien qu'un braconnage considérable se fasse à partir de la rive tanzanienne de la rivière. Les trois lacs au sud du parc sont pêchés mais les difficultés du terrain sont telles qu'il est impossible d'évaluer l'importance de ces pêches.



Regions of Africa treated in this Directory
Régions d'Afrique traitées dans le présent répertoire

DIRECTORY
REPERTOIRE



**African wetlands
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**Zones humides
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Edited by / Publié par les soins de

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Collection **TRAVAUX et DOCUMENTS** n° 211

PARIS 1987

This work was completed with financial assistance of :
Ce travail a pu être réalisé grâce au support financier de :

Council for Scientific and Industrial Research (South Africa)
Fonds de la Recherche Fondamentale Collective (Belgique)
Ministère de l'Environnement (France)
Royal Society (Great Britain)
IUCN and WWF



Funds and facilities for the preparation of camera ready text were made available by IUCN and WWF

L'IUCN et le WWF ont procuré les fonds et les facilités pour la préparation des manuscrits définitifs

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