Lake Tanganyika

Experience and Lessons Learned Brief

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1. Introduction

Lake Tanganyika has the largest volume of the three African Great Rift Valley lakes. It also is the second deepest, and the second largest lake in the world by volume, containing almost 19,000 km^3 of water—only Lake Baikal is larger. The lake contains almost as much freshwater as the five North American Great Lakes combined. It contains a volume of water seven times more than that of Lake Victoria, which is the largest lake by area in Africa. It has a length of more than 670 km and an average width of 48 km. The length of the shoreline is about 1,900 km, of which 43% is rocky, 21% is mixed rock and sand, 31% is sand, and 10% is marshes. Figure 1 depicts the lake and its basin.

Figure 1. The Lake Tanganyika Basin.

2. Background

The main economic activity of the 10 million people living in the lake's drainage basin is agriculture. The main agricultural products include maize, tobacco, rice, sugarcane, coffee, beans, groundnuts, cassava, cattle and goats. The socio-economic statistics for the riparian nations of Lake Tanganyika are given in Table 1. Tanzania, Burundi, Zambia and the Democratic Republic of Congo (DR Congo) all have low levels of economic development, with gross national incomes

(GNIs) per capital respectively of US$250, 140, 320 and 110. However dependence on the lake varies significantly between the riparian countries. Agriculture, livestock raising and the processing of these products, as well as mining, are the main industries in the drainage basin of Lake Tanganyika.

The lake has a crucial travel and trading role in regard to the neighboring countries of Tanzania, Burundi, DR Congo, and Zambia. Bujumbura, Kigoma and Mpulungu serve as shipping centers for commercial trade between the riparian countries. Ship lines connect Kigoma (Tanzania), Kalemie (DR Congo) and other coastal towns as an essential part of the inland traffic system of East Africa.

Although landlocked, Zambia has water resorts on the shores of Lake Tanganyika in the north part of the country. The Nsumbu National Park provides world-class game fishing. Goliath Tiger fish of over 35 kg and giant catfish of over 50 kg have been caught at the three lodges; namely, Kasaba Bay, Nkamba Bay Beach and Ndole Bay. The lake also serves as a base for boating expeditions. In February or March of every year, a national fishing competition attended by fisherman from around the world is held at Kasaba Bay.

Tanzania earns some income generated from tourist activities at Mahale Mountain and Gombe Stream National Parks. The park's forested mountain slopes, which help define the Great Rift Valley, are home to chimpanzees, which are accustomed to humans and, therefore, somewhat approachable. Mahale is rich in plant species that have a major influence on the life of chimpanzees, which utilize 328 food items from 198 plant species. Some of these plants are used by chimpanzees as medicine and appetizers.

Burundi's capital, Bujumbura, with a population of 400,000, is the largest city at the northeastern end of Lake Tanganyika, and hosts many tourist hotels. The Rusizi Delta National Reserve, the "Musee Vivant" in Bujumbura and Reptile Park are some of the interesting places to be seen. Uvira and Kalemie in DR Congo also provide tourist attractions.

In recent years, Lake Tanganyika, like many other biologically sensitive areas, has begun to feel the environmental and socio-economic effects of increased population pressures. Fishing practices, for example, have become much more efficient and, consequently, more destructive. For example, commercial fishing, began in the mid-1950s, has had an extremely heavy impact of the fish stocks and the majority of fish species.

The fisheries of Lake Tanganyika are by far the most important source of animal protein for human consumption in this region of Central Africa. Lake Tanganyika has traditionally supplied between 25-40% of the protein needs of the local population in the four riparian countries. About 45,000 people are directly involved in the lake fisheries, operating from almost 800 sites. The main fishery product, the "Tanganyika sardine" (*Stolothrissa tanganikae*, Herring family), also is very important for the local economy. It constitutes 55-90% of the commercial fishery and 80-99% of the traditional artisinal fishery (Rufli 2001). A major increase in the number of fishermen has been observed throughout large parts of the lakeshore. Many people are now exploiting the more accessible coastal waters, which are richest in fish biodiversity and the nursery for most of the pelagic fish.

In spite of the need for maintenance of sustainable fisheries essential for the livelihoods of riparian populations, traditional approaches to enforcement have had little success, often being constrained by limited resources. Ornamental fishery is a particularly serious problem because it is a major threat to the lake's biodiversity. Reasonable management of this exportable resource could provide sustainable economic benefits.

The most damaging threat to the lake's biodiversity, however, appears to be an increased rate of sediment influx, especially from the heavily-impacted smaller watersheds of northern Lake Tanganyika, where large-scale deforestation and farming practices have caused a dramatic increase in the soil erosion rates. It is noted that Lake Tanganyika is a source of fish, a means of transportation, a water supply for drinking and washing, and a receptacle for effluents. Unfortunately, however, traditional attitudes and responses to land and water

Table 1. Socio-economic Statistics for Lake Tanganyika's Riparian Nations.

Item	Burundi	DR Congo	Tanzania	Zambia
Population growth rate (%)	2.0	3.2	2.4	2.2
Population density (persons/km^2)	250	21	36	13
Adult literacy (%)	46	59	74	76
Per capita GNP (US$)	120	110	240	320
School enrolment (% of school age population)	51	78	67	89
Life expectancy (yr)	42	51	47	43
Percent of population without access to:				
Safe water	48	32	34	62
Health service	20	NA	7	25
Sanitation	49	NA	14	29

Source: Adapted from Odada et al. (2004).

resource management, as well as waste disposal practices, are no longer sustainable because they cannot keep pace with the rapid increase in the human population density.

Pollution will inevitably lead to increased threats to human health associated directly with declining water quality. In addition, the associated loss of the lake's fishery, the traditional protein source, will increase the vulnerability of the people living in the region. The population of the region is expected to grow annually by an average of 2-3% over the next twenty years. This will inevitably increase the pressures on the aquatic environment, by increasing the fishery and water demands, as well as higher land development pressures, with increased erosion from farms causing more sediment transport to the lake.

3. Biophysical Environment

3.1 The Ecosystem

Some basic information about the lake is summarized in Table 2. As shown in Figure 1, major towns around the lake include Bujumbura (Burundi), Uvira and Kalemie (DR Congo), Mpulungu (Zambia) and Kigoma (Tanzania). Lake Tanganyika is located between latitude 3°20' and 8°48' S and between longitude 29°03' and 31°12' E. The lake is estimated to be about 12 million years old and is of tectonic origin. The maximum depth is in the southern part of the lake, while almost the same depth (1,250 m) is found in the north central part of the lake.

The four riparian countries that share the lake, in terms of surface area, are Burundi (8%), DR Congo (45%), Tanzania (41%), and Zambia (6%). The lake is an important source of drinking and domestic water source, as well as an international transportation route, among other uses. It is bordered by four national parks or nature reserves, as follows:

- Rusizi River Nature Reserve (Burundi);
- Gombe River National Park (Tanzania);
- Mahale Mountains National Park (Tanzania); and,
- Nsumbu National Park (Zambia)

The lake could serve as an example for managing lakes in other developing countries. Because prevention is much more cost effective than abatement, it is important to establish a management plan at this stage to maintain the lake in an oligotrophic state. Its residence time is 440 years, which implies that, if the lake's water quality deteriorates it will take a very long time for the lake to recover. Many rivers enter the lake, but only the Lukuga River flows out. The lake volume is 18,880 km^3, giving the lake an enormous buffer capacity, but also making it extremely difficult for the lake to recover if it is polluted. Thus, it is of utmost importance to prevent pollution and general over-exploitation of the lake in the first place.

Fortunately, the lake has received relatively less human impact than many other African lakes, including Lake Victoria. However, the drainage basin population of 10 million is growing very rapidly (about 2.5% per annum), and the anthropogenic impact on the lake's water quality is expected to increase in the coming years. On a lake-wide basis, the lake is still not polluted; is in an oligotrophic state, and has not yet suffered from eutrophication. The chlorophyll-*a* concentration in the southern lake is approximately 1 µg/L, while it is about 2 µg/L in the northern lake, and even about 5 µg/L in the central lake. The concentration of reactive inorganic nitrogen (mainly nitrate) is 50-90 µg/L, and the reactive inorganic phosphorus concentration is 5-10 µg/L.

Limited, but very sensitive, areas (Bujumbura Bay in Burundi; Kigoma Bay in Tanzania), currently show evidence of unfavorable water quality changes, due mainly to urban and industrial runoff. It is a high priority that these places remain unpolluted, since drinking water for more than 400,000 people in Bujumbura and 80,000 in Kigoma is withdrawn from the lake. It would be a major catastrophe if the lake, for one reason or another, became unsuitable as a drinking water source, and its fish unfit for human consumption.

The primary production derived from chlorophyll estimates in 1995 is on the order of 0.80-0.86 g C m^{-2} d^{-1} in April to May, and more than three times as much in October to November (2.8 g C m^{-2} d^{-1}); with an annual production of 662 g C m^{-2} a^{-1}. The same estimates obtained from radiocarbon measurements indicate an overall average for the whole lake of 1.2 g C m^{-2} d^{-1}, or 426 g C m^{-2} a^{-1}. The annual production of herbivorous copepods (secondary production) is estimated to be 23 g C m^{-2} a^{-1} (Sarvala et al. 1999).

Table 2. Basic Information about Lake Tanganika and its Drainage Basin.

Riparian countries	Burundi, Congo, Tanzania and Zambia
Altitude (surface)	773 m
Surface area	32,600 km^2
Volume	18,880 km^3
Maximum depth	1,470 m
Average depth	570 m
Residence time	440 years
Drainage area	223,000 km^2
Population in drainage area	10 million
Population density in drainage area	45/km^2
Length of lake	670 km
Length of shoreline	1,900 km
pH	8.6-9.2

Source: Adapted from Odada et al. (2004).

The lake contains around 500 endemic species out of the total of 2,156 species (Coulter et al. 1991). The number of species inhabiting the lake is 325 fish, 759 algae, 81 aquatic plants, 219 crustaceans, and 171 birds. This includes about 200 species of cichlids. The lake has 8 species of crab, 15 species of shrimp and about 60 species of snails. Although the lake has a uniquely high biodiversity, it is endangered. As previously noted, the lake is important for its fishery (commercial, subsistence and ornamental fishing). The estimated fish harvest in Lake Tanganyika is 165,000-200,000 tons/year (Mölsä et al. 1999), comprising a primary protein source.

The lake's ecosystem is sensitive to climatic conditions. There are two main weather seasons. The wet season, usually from September to May, is characterized by high humidity, considerable precipitation and frequent thunderstorms. Heating of the lake takes place mainly during the beginning of this season (i.e., from September to November). As a result, thermal stratification establishes all over the lake, with the temperature difference between the surface and bottom water layers within 4°C. The dry season from May to August has dry weather and strong southern and southeastern winds. The lake loses heat by evaporation caused by strong winds. The cooling is strongest in the southern basin, from May to September (Coulter et al. 1991).

Southeastern winds drive warm epilimnion surface water towards the north end of the lake, while water flows south as a deep current, causing upwelling along the southern coast. This results in a tilting of the epilimnion (Lewis 1995). Thermocline depths at Bujumbura and Kigoma were 74-83 m in the dry season of 1993, while the epilimnion in the south end was reduced in May and disappeared in June during the upwelling (Lewis 1995). The productivity of the lake is highly dependent on these hydrodynamic states and climatic conditions, particularly wind and temperature. As mentioned above, the monsoon wind from the southeast causes the accumulation of water in the epilimnion, thereby deepening the thermocline in the north, while deep, rich waters upwell in the southern end (Plisnier and Coenen 2001).

After the dry season, when the wind force weakens, oscillations of the metalimnion form waves. These waves influence the thermocline depth. Consequently, a regular pulse of production is induced when the deep eutrophic waters are able to reach the biotic and euphotic zone, where photosynthesis takes place. Thermocline depth rises and falls several times over course of a the year. When the thermocline is deep, the production is high (i.e., the production pulses follow the rhythm of the thermocline). The water transparency follows a similar, fluctuating pattern. There is no oxygen in the water below 100-200 m (Coulter et al. 1991).

An increase in air temperature has been noted at stations around Lake Tanganyika since the 1960s (a mean increase of about 0.7°C in the north and 0.9°C in the south). During the same period, the wind speed over the lake seems to have decreased; the yearly mean speeds at Bujumbura fluctuated between 1.4-2.5 m/s from 1964 and 1979, and between 0.5-1.5 m/s between 1986 and 1990 (Plisnier 1997).

These climatic changes seem to have caused an increase of surface water temperature of 0.40°C during the dry season, and 0.28°C during the wet season near Bujumbura, a greater stratification (upwelling becoming rarer, even in the south), a shallower thermocline and oxygenated water layer, a decrease in water transparency, and a higher surface primary production and zooplankton development in the north, compared to the south. These limnological changes in the lake (mainly lower water mixing and transparency) seem to have a negative impact on the catchability of *Lates stappersii* (a visual predator) in the north, and Clupeids abundance in the south (Plisnier 1997).

In the south of Lake Tanganyika, it has always been observed that the dry and windy season was a period of increased clupeid abundance, probably related to an increase in phytoplankton during the upwelling period. In the last 10 to 15 years, climatic changes have probably reduced upwelling in the south, resulting in a decrease in turbulence and wave amplitude for the whole lake, which would cause the lake to be less dynamic (Plisnier 1997).

Clupeids distribution patterns also may have changed, probably due to a reduced migratory behavior. The very low level of *Stolothrissa tanganicae* catches in the south over the last decades suggests there could be a change in their distribution pattern, related to environmental conditions. Climatic changes probably affect other aspects of the ecology of the lake and its drainage area as well. According to Verburg et al. (2003), there is no doubt that the climatic changes play a major role in the lake dynamics.

3.2 Threats to the Ecosystem

There have been a number of studies of the lake over the last 15 years (Odada et al. 2004) which have provided a good understanding of its chemistry, hydrology and ecology. These studies include the following:

- Lake Tanganyika Research (LTR) Project "Research for the Management of the Fisheries on Lake Tanganyika" (GCP/RAF/271/FIN);
- Pollution Control and Other Measures to Protect Biodiversity in Lake Tanganyika (LTBP) UNDP/GEF RAF/92/G32;
- Limnologic and Paleolimnologic Investigations of Lake Tanganyika by University of Arizona researchers;
- Global Warming is Choking the Life Out of Lake Tanganyika by Steve Connor;
- Nyanza Project by National Science Foundation (NSF)— A project for Research Experience for Undergraduates

(REU) funded by the NSF Paleoclimate Program, University of Arizona;

- CLIMLAKE—Climate variability and ecological dynamics in Lake Tanganyika—DWTC-project IGBP/PAGE, IDEAL;
- Recent ENSO and paleo-ENSO events during the last 1000 years in Lake Tanganyika—DWTC-Duurzame Ontwikkeling; and,
- UNDP/GEF/UNOPS Lake Tanganyika Management Planning Project (LTMP).

Based on these studies, the following are identified as the main threats facing Lake Tanganyika.

1. **Over-exploitation of the biological resources because of very high fishing pressure and the use of destructive methods, reducing the fishery potential and the unique biodiversity**. Annual recorded fish catches on Lake Tanganyika have shown an upward trend since 1970s, standing today at about 200,000 tons. Recent estimates per country indicate a yield of about 21,000 tons for Burundi in 1992 (94.5 kg/ha/yr), 55,000 tons during 1994-95 for Tanzania (60 kg/ha/yr), 12,900 tons for Zambia (69 kg/ha/yr), and 90,000 tons in the DR Congo (34 kg/ha/yr). These estimates translate into an average catch range between 54-66 kg/ha/yr for the whole lake (Lindqvist et al. 1999). Thus, the actual catches are much higher for Burundi and Zambia than elsewhere, while for the Tanzania and DR Congo waters, representing 86% of the total lake, the figures are much lower. Such differences probably reflect greater fishing intensity in the northern and southern parts of the lake, rather than the actual lake productivity. The observed fish yields in Burundi (94.5 and 111.5 kg/ha/yr, respectively in 1992 and 1995) are close to the potential yield of 100 kg/ha estimated by Coulter (1977). This means that, on a lake-wide scale, Lake Tanganyika is probably under-fished, but that the fishery pressures are very high in the north and the south. Evidence of over-fishing in Burundian and Zambian waters is suggested in that the trend of catch per unit effort (CPUE) for industrial units (purse seiners) has been declining. Nightly CPUE for commercial units in Burundi decreased from 166 kg in 1994 to 111 kg in 1996; in Mpulungu, it dropped from 877 kg in 1994 to 535 kg in 1996. The decline in catchable stocks of *L. stappersii* around the vicinity of Mpulungu is not compensated, even with an increased duration of fishing trips. In the northern end of the lake, commercial units have stopped their activity; *L. stappersii* now make up only around 20% of the commercial catch, with juveniles accounting for most of this contribution.

2. **Siltation, due to erosion in the drainage area as a result of increased deforestation**. The topsoil is transported to the lake, where it joins fertilizers and pesticides washed from the lake's drainage area. An astounding 100% of the northern drainage area, and around 50% of the central areas, have been cleared of their natural vegetation, leading to increased erosion. The Malagarasi and Rusizi Rivers provide a major share of the inflowing waters to the lake, also contributing most of the suspended solids load to the lake. Siltation is the most damaging threat to the lake's biodiversity, especially siltation from the heavily-impacted smaller watersheds of northern Lake Tanganyika, where large-scale deforestation and farming practices have led to a dramatic increase in soil erosion rates. The freshly eroded sediments entering the lake adversely affect its biodiversity, not only because of decreasing species habitat, but also because of efficiently complexing certain essential nutrients/trace elements.

3. **Untreated wastewater discharges**, including industrial and domestic wastewater from large cities such as Bujumbura in Burundi, Kigoma in Tanzania, Uvira and Kalemie in Congo, and Mpulungu in Zambia. These waters might contain nutrients, organic matters, heavy metals (mercury, chromium), pesticides, ash residues as cement, and fuel from ports, harbors, shipping places and boats, etc.

4. **Agricultural runoff**, particularly via the Malagarasi and Rusizi Rivers. The agricultural expansion in the region could be accompanied by an increased use of agrochemicals.

5. **Increased population, urbanization and industrialization**. The annual population growth rate of most countries in the region is 2.5-3.1%. This progressive increase in population pressure (this region has one of the world's greatest rural population densities) has forced a change in land use from pristine tropical forests, to small agricultural plots located on steep, denuded slopes bordering the lake. As a result, accelerated erosion rates supply streams and rivers with an increased suspended particulate load, which is deposited as fine-grained silts and clays in the lake's rocky deltas. Record sediment accumulation rates in highly impacted river systems can reach up to 100 cm/yr. Unfortunately, traditional attitudes and responses to land and water resource management, as well as waste disposal practices, are no longer sustainable because they cannot keep pace with the rapid increase in human population density.

6. **Increased tourism** that will cause increased impacts on the lake, if not properly planned. Some are of the opinion, however, that the local infrastructure is not yet on a level that would allow mass tourism.

7. Recent studies indicate that **global climate change** is causing impacts to the lake.

Of the two first threats noted above, over-exploitation is thought to be the most acute for short-term fishery potential, while siltation is the most detrimental factor affecting the lake's biodiversity and long-term resource potential.

4. Management Environment

Management implementation arrangements for Lake Tanganyika are complex because its drainage basin comprises four riparian countries. Thus, any approach to improve the understanding and subsequent management of the lake must have an international and regional perspective. The main problems to be addressed include lack of resources for the involved institutions; poor enforcement of existing regulations; lack of appropriate regulations for the lake; and lack of institutional coordination.

4.1 National Institutions

It would be expected that the national institutions involved in Lake Tanganyika management efforts have the capability to act in matters of biological stock management, biodiversity conservation, water quality and pollution control, decreasing sediment transport to the lake, etc., and in a harmonized way with the other riparian countries. A common feature, however, is that each government at least has agencies responsible for fisheries, with local offices at or near the lake, even though the involvement in other aspects of lake management at the national level is not highly developed.

There are a large number of local and international NGOs in the four riparian countries, although most of them do not have the necessary resources for action.

4.1.1 Burundi

Bujumbura, the capital city of Burundi, located on the shores of the lake, depends on it both as a source of drinking water and as a receptacle of wastewater. Increased population and poor agriculture practices in the catchment accelerate erosion and sediment transport to the lake. Unfortunately, the activities of national institutions involved in lake management are not harmonized.

- Fisheries management and associated activities are under the responsibility of the Department of Water, Fish Culture and Fisheries, in the Ministry of Agriculture and Livestock. This institution has few resources to implement regulations prepared through the support of different FAO projects since the 1960s, as well as from other donors.

- Water quality monitoring and pollution control are under the responsibility of the National Institute of Environment and Nature Conservation (INECN), in the Ministry of Land Management and Environment. However, it does not have an equipped laboratory and other resources for performing its tasks.

- A wastewater treatment plant has been installed, with World Bank funding, to treat about 40% of the urban and industrial wastewaters from Bujumbura. The treatment plant is under the responsibility of the city of Bujumbura, but has yet to function properly.

- The Ministry of Health has interest in wastewater disposal and sanitation problems in inhabited zones, but has no special interest in the lake.

- INECN also has the national responsibility for biodiversity, although its conservation activities concentrate on national parks and reserves; no official Reserve or National Park has been established in the lake's waters.

- In regard to biodiversity, some studies have been done at the University of Burundi through short projects and student studies. Most focus on fish population structure and biodiversity evaluation in different lake habitats.

- No national institution has the responsibility to monitor or control sediment transportation to the lake. The exact impacts of sediment on the lake's biodiversity and water quality is still to be established. The Ministry of Agriculture only concentrates on controlling erosion on cultivated land, while the Ministry of Public Works concentrates on controlling erosion and land slides along roads. Action to decrease sediment transportation to the lake should be under the technical services in these two ministries.

4.1.2 Democratic Republic of Congo

- DR Congo's Ministry of Scientific Research has a Natural Sciences Research Centre (CRSN) at Uvira.

- The Centre d'Actions et de Développement et d'Initiatives Communautaires (CADIC), a local NGO in South Kivu Province, is involved in community development, including fisheries-related activities.

4.1.3 Tanzania

- The National Environmental Management Council (NECM), under the President's Office, has the mandate for all environmental matters. The UNDP/GEF LTBP project was coordinated by this institution.

- Tanzania's Ministry of Scientific Research includes the Tanzanian Fisheries Research Institute (TAFIRI), with a regional office at Kigoma. The FAO/FNNIDA LTR project was coordinated by this institution.

- Tanzania National Parks (TANAPA) is responsible for management and tourism in important Parks bordering Lake Tanganyika; Gombe Stream National Park and Mahale Mountain National Park.

- Tanganyika Catchment Reforestation (TACARE), a local NGO, focuses on women's development, especially community development training focusing on improving the standard of living in the region of Lake Tanganyika, while also promoting reforestation, curbing soil erosion, and delivering conservation education to the local population.

4.1.4 Zambia

- The Zambian Ministry of Agriculture has a Department of Fishery (DOF), with a provincial fishery office at Mbala. The FAO/FNNIDA LTR project was coordinated by this institution.

- Environmental Council of Zambia (ECZ), under the President's Office, has the mandate for all environmental matters. The UNDP/GEF LTBP project was coordinated by this institution.

4.2 Regional Mechanisms

Since the 1960s, lake management coordinated at the regional level has been concerned only with fisheries, through FAO projects working at national levels and coordinated periodically by the FAO Committee for Inland Fisheries for Africa (CIFA). The latter has had a Sub-Committee for Lake Tanganyika since the 1970s. Issues such as fish stock management, fishing regulations, fisheries statistics and information, post-harvest processing and fish marketing, etc., have been discussed nationally and regionally in those FAO meetings. Unfortunately, most of the recommendations issued in these meetings have not been implemented in a coordinated regional program. Laws and regulations regarding fishing and associated activities also are yet to be harmonized across the lake.

In the 1990s, the following two projects, with a lake-wide view to address Lake Tanganyika management issues, were undertaken:

- FAO/FINNIDA Lake Tanganyika Research Project (LTR), from 1992-1999; and,

- UNDP/GEF Lake Tanganyika Biodiversity Project (LTBP), from 1995-2000.

These two projects had institutional and managerial components. All the projects had significant research components, with much of our understanding about the lake and its fishery garnered through these projects. The FAO/FINNIDA project (LTR) came up with a Framework Fisheries Management Plan (FFMP) in 1999.

The other aspects of lake management (biological diversity conservation, water quality and pollution control, habitat protection, etc.) had not been addressed at a regional level before the UNDP/GEF Lake Tanganyika Biodiversity Project (LTBP). The LTBP outcomes are a Transboundary Diagnostic Analysis (TDA), a Strategic Action Program (SAP) and a Convention for the Management of the Lake between the four riparian countries.

Other initiatives were limited geographically, focused on limnology, biodiversity and fish ecology, and did not have a management component. Those applicable for the northern part of the lake include:

- UNESCO/MAB/DANIDA Ecotones Project at University of Burundi (1991-1994);

- Centre Régional de Recherches en Hydrobiologie Appliquée (1992-1995), sponsored by Belgian Government aid to Burundi and DR Congo; and,

- Ecological and Limnological Studies on Lake Tanganyika and its Adjacent Regions (1985 –1995) by Japanese research teams in localized places around the lake, sponsored by the Japanese Government.

The outputs of these local projects was incorporated in LTBP's literature data, especially for biodiversity evaluations of the lake.

4.2.1 LTR's Framework Fisheries Management Plan (FFMP)

(Note: This section draws heavily on FAO (1999).)

LTR's Framework Fisheries Management Plan (FFMP) was endorsed by the FAO Committee for Inland Fisheries for Africa (CIFA) in 1999, being the first important mechanism that could facilitate regional management of the lake's resources (especially fisheries) in a sustainable way.

The conclusion of the LTR studies on Lake Tanganyika fisheries is that, under current circumstances, none of the fisheries management institutions within the four riparian states is in a position to effectively carry out the tasks entrusted to them by national legislation. The principal deficiencies common to institutional frameworks can be summarized as follows: (a) inadequate budgetary allocations to fisheries sectors by central governments; (b) inadequate research funding; (c) lack of human resources and equipment; (d) poor to non-existent enforcement of fisheries regulations; and (e) insufficient linkages between central administration and field agents at the local level.

To solve the problem, LTR proposed the FFMP to the Lake Tanganyika riparian nations. The governments have ratified a convention (see section 4.2.2 for more detailed discussion on the convention), necessitating the formation of the Lake Tanganyika Management Authority to reduce pressures on the lake resources. The convention harmonizes management policies, laws, regulations monitoring and data exchange, and provides a forum for the countries to engage in lake management discussions.

The Code of Conduct for Responsible Fisheries (CCRF) provides a framework of basic policy orientation, through which the FFMP may be accommodated in an integrated fashion. It calls for establishment of responsible fisheries management, which will be elaborated, adjusted, and reviewed as part of an ongoing process. Other issues covered by the CCRF are: (a) policy matrix; (b) partnership and resource access; (c) institutional and legal modalities; (d) harmonization of fishing regulations; and (e) possible input controls to regulate fishing.

Adoption of CCRF Policy Matrix. First, in order to ensure that the four riparian states act with a common set of development objectives in mind, it is important that their respective competent authorities implement the CCRF as the policy matrix for the shared fisheries of Lake Tanganyika. It also is important that the respective competent authorities adopt and pursue management policy directions in support of: (a) adaptive or interactive management practices allowing for adjustments in fishing pressures, and for flexible application of management treatments appropriate to different circumstances encountered around the lakeshore; (b) multi-disciplinary monitoring capability for measurements of continuity and change across a range of biophysical and socio-economic parameters, as appropriate to the complexities of ecosystem-human system interactions; (c) partnerships with local stakeholder groups in management decision-making and in fashioning modalities of enforcement and compliance; (d) allocation of access and fishing rights at the local community level; and (e) use of integrated development strategies and coastal area management models at the local level, both in order to accommodate complex interactions and possible conflicts between fishing and non-fishing activities and, at national and regional 'macro-levels', to foster economic diversification to reduce pressures on the fishery resource base.

Partnership Arrangements and Local Control of Resource Access. Establishment of co-management structures and operational arrangements around the lakeshore would be an important step in promoting local community participation in the management of the lake. Because attitudes towards co-management appear to vary by country, co-management arrangements must be encouraged in a somewhat flexible manner, depending on local pre-dispositions. Community outreach activities, with a strong environmental education component, will be crucial for building local awareness and acceptance of responsibility in fisheries regulation decision-making and compliance processes. Local attitudes towards various forms of access limitation are not uniform. Nevertheless, it is clear that a 'free-for-all' or unlimited access regime will be impossible to sustain in the face of growing population pressures within the Lake Tanganyika region. Licensing mechanisms, in combination with allocation of use rights by zone or water territory between individual fishing communities, would seem to be the most appropriate way of countering the 'race to fish'.

Institutional Modalities. The FFMP proposes to modify the Terms of Reference of the CIFA Sub-Committee for Lake Tanganyika, in order to allow it to function more effectively as a mechanism to facilitate co-ordination of regional fisheries-related matters, and especially to:

- Facilitate discussions for all related fisheries matters, including coastal zone management, environment and water quality;
- Promote the exchange and dissemination of information and data;
- Develop and recommend conservation and management measures;
- Facilitate periodic elaboration and implementation of a regional fisheries management plan and monitoring program;
- Harmonize national measures for the sustainable utilization of the lake's living resources;
- Facilitate the harmonization of fisheries regulations for Lake Tanganyika; and,
- Explore ways and means of establishing an autonomous inter-governmental organization or arrangement.

Legal Modalities. Actions that can be immediately undertaken in all four riparian states, on the basis of existing legal framework to implement or facilitate the measures proposed in the FFMP, include:

- Implementation of the FAO Code of Conduct for Responsible Fisheries;
- Use of existing traditional institutional arrangements and customary fishing rights, where appropriate, for enhancing local control of fisheries resource access; and,
- Organize and conduct an awareness campaign designed to inform local fishers of FFMP objectives, and enlist their support for its implementation.

In Zambia and Tanzania, where fishing operations in Lake Tanganyika remain virtually unregulated, drafting of a comprehensive set of regulations applicable to the lake fisheries is recommended. The regulations should address the following tasks: (a) devising various classes of fishing units or categories of fishing operations; (b) determining which classes of fishing units are required to carry a fishing license; (c) determining the number of fishing licenses that can be issued for industrial fishing units; (d) determining prohibited or authorized methods of fishing and restrictions on certain methods of fishing (e.g., banning or gradual phasing out of beach seining); (e) establishing prohibited fishing areas

(for all purposes, or for the protection of spawning grounds, and/or in respect of any fishing method or any species of fish); (f) establishing and demarcating prohibited industrial fishing areas and beach seining areas; (g) establishing closed times and/or closed seasons for fishing; (h) setting gear specifications (mesh sizes, height and length of nets and other fishing implements); and (i) banning the introduction of non-native species of fish and aquatic plants.

For DR Congo and Burundi, it is recommended that reviews of fisheries regulations applicable to Lake Tanganyika be conducted in light of the findings and conclusions of the FFMP. In DR Congo, fisheries regulations applicable to Lake Tanganyika should include provisions for: (a) banning the introduction of any non-native species of fish and aquatic plants; (b) limiting the number of industrial fishing licenses that can be issued; (c) banning beach seining throughout Lake Tanganyika waters falling under DR Congo jurisdiction; and (d) reviewing the classification of fishing units with a view to harmonizing fisheries regulations. In Burundi, fisheries regulations applicable to Lake Tanganyika should include: (a) banning beach seining throughout Lake Tanganyika waters placed under Burundi jurisdiction; (b) modifying, if necessary, the limit imposed on the number of industrial fishing licenses that can be issued in the Burundi portion of Lake Tanganyika; and (c) reviewing the classification of fishing units, with the goal of harmonizing fisheries regulations.

Harmonization of Fisheries Regulations. Emphasis should be placed on three specific measures, including: (a) elaboration of a common classification of fishing units or categorization of fishing operations; (b) development of mechanisms of management in partnership, including measures to ensure consultation with fishers and other stakeholders prior to devising fisheries regulations; and (c) improvement of enforcement of fisheries legislation; including reassessment of the regime of sanctions provided for in existing legislation.

Monitoring, Control, and Surveillance (MCS). The Lake Tanganyika Monitoring Program (LTMP), designed under LTR auspices, is consistent with the CCRF guidelines in as much as: (a) its feasibility is undeniably one of its underlying principles (proposed monitoring measures have been thoroughly tailored to the availability of both human and equipment resources in each research station around the lake); (b) the cost of implementation has clearly been kept to a minimum; and (c) it reflects the characteristics of the local fisheries. A timeframe and financial scheme designed to ensure the long-term sustainability of the monitoring program should be incorporated in the LTMP, bearing in mind that current funding for the LTMP is of limited duration. It is further recommended that a comprehensive set of regulations be developed in all four riparian states, and that periodic frame surveys, designed to assess the state of the fishing industry, be required in every fisheries legislation.

Possible Technical Measures to Regulate Fishing. The beach seine is an especially serious problem impacting fishing in the southern end of the lake. Management measures should focus on the gradual, but eventually total, retirement/phasing out of beach seining on the lake. As a step toward achieving this objective, 'beach seining prohibited' areas should be identified and established. Initiatives to restrict beach seining would require important complementary measures, in the form of environmental education, and the utilization of other gear and method options, as viable alternatives to the practice.

There are also indications of high exploitation pressure on *L. stappersii* within the extreme northern waters of Lake Tanganyika, although in this case a result of a concentration of artisanal liftnetting, on top of a history of industrial purse seining. For this reason, 'off-limits' areas for industrial units should be considered for both the extreme north and extreme south sub-basins of the lake. The establishment of prohibited fishing areas would need to be complemented by the devising of alternative enforcement schemes, such as the involvement of fishers and local communities in enforcement activities.

Input Controls to Regulate Fishing. It is recommended that licensing ceilings be established for both industrial units in the south and liftnet units in the north end of the lake. In the case of the purse seine fishery, efforts should be reduced to levels that prevailed ten years ago. That is, licensing measures should aim at the gradual retirement or transfer to other fishing zones of units that entered the southern fishery within the last decade. The implementation of licensing ceilings for both industrial fishing units in the south, and liftnet units in the north, should be accompanied by the inclusion of specific provisions in the FFMP encouraging the negotiation and conclusion of access agreements between riparian states. Such a measure is designed to ensure the redeployment of fishing units that would no longer be authorized to operate in their traditional fishing grounds.

4.2.2 LTBP's Outputs: Transboundary Diagnostic Analysis (TDA), Strategic Action Program (SAP) and Convention

(Note: See West (2001) for an extensive discussion on the LTBP project.)

One of the immediate objectives of the UNDP/GEF Lake Tanganyika Biodiversity project was to formulate a Strategic Action Program (SAP) that established clear priorities endorsed at the highest levels of the partner governments. The SAP should identify priority transboundary concerns, as well as sectoral interventions needed to resolve the transboundary problems, as well as institutional mechanisms for implementing the SAP.

Thus, a Transboundary Diagnostic Analysis was one major step needed to facilitating the formulation of the SAP. The first phase of the process was a Project Inception Workshop in 1996, wherein the country representatives identified the main threats to Lake Tanganyika's biodiversity. The country representatives ranked their perceived threats in order of

national importance. The summation of these discussions provided the initial prioritization of threats for the region.

From this first priority issues meeting, the project team prepared a consultation document for a Preliminary Strategic Action Program in 1997. The Regional Steering Committee (RSC) committed to formulating this regional SAP through a process of consultation from the national level by National Working Groups, to the regional level by the Technical Advisory Committee. After a planning meeting in each country, the national consultation process consisted of two workshops. The first was a National Sectoral Problem Review, and the second a National Environmental Priorities and Strategic Review. With the completion of these two workshops, each national working group came to a national understanding regarding the priority biodiversity and management concerns and priorities for intervention.

Consultations at regional level were conducted through an expanded Planning Group, whereby each country was represented by a team of members with a range of skills and knowledge of the lake management problems, led by the National Coordinators. This consultation developed a draft preliminary TDA in November 1998, which was subsequently endorsed by the Project Steering Committee in May 1999. The same Planning Group met to discuss and adopt the draft of the first Strategic Action Program (SAP) in January 2000. In March 2000, the Group issued the final TDA, incorporating the conclusions of the special studies programs relevant to management needs of Lake Tanganyika and that was proposed to be included in the final SAP. The Strategic Action Program (SAP) was adopted by the Project Steering Committee in July 2000 at the closure of the Project.

The purpose of the TDA was to define immediate management objectives within the overall management goal of conserving the biodiversity of Lake Tanganyika. After analysis of the main threats and the specific problems involved in managing the lake, it established priorities for possible interventions and ultimately proposed a sequence of management interventions to counteract each specific identified problem.

The main threats to biodiversity and sustainable use of Lake Tanganyika and its resources that were identified include: unsustainable fisheries; excessive sedimentation; increasing pollution; and habitat destruction. The general actions to be used to combat these threats include: reduction of fishing pressures; control of sedimentation; control of pollution; and habitat conservation.

Of the many identified specific problems making up each of these major threats, those ranked as the priority for interventions in the four action areas, based on considering the score of each for such criteria as severity, feasibility, and additional benefits, are:

- Reduction of fishing pressure: Excessive fishing efforts in the littoral zone; excessive fishing efforts in the pelagic zone; excessive or uncontrolled extraction of ornamental fish;
- Control of sedimentation: Erosion from inappropriate farming practices and deforestation;
- Control of Pollution: Urban and industrial pollution; harbor pollution; pollution from future mining or oil exploitation; risk of major marine accidents; and,
- Habitat conservation: Threats to resources in National Parks; degradation of key habitats.

The Strategic Action Program (SAP) is a document that identifies the National Actions and key institutions planned to counteract each of the priority problems identified in the TDA. These actions were defined during the same process that led to the TDA.

The Convention for the Sustainable Management of Lake Tanganyika. The Convention is a legal agreement, identifying the rights and duties of the four states concerning Lake Tanganyika. It establishes institutional structures for co-operative management, management principles and related matters. Like the SAP, the Convention was developed through a series of regional workshops, bringing together senior lawyers and policymakers from each of the four riparian countries. The first of these workshops (February 1998) issued a set of recommendations that included detailed instructions, so that a nominated drafting team could produce the first draft of the Convention. This first draft was discussed at three subsequent workshops. The first two brought together participants that shared a common language; namely, an Anglophone workshop (August 1999) and a Francophone workshop (September 1999). The third meeting brought together the participants of the four countries, resulting in a version of the draft being agreed upon regionally (November 1999). This latter draft was adopted by the Steering Committee (July 2000) at the completion the UNDP/GEF Lake Tanganyika Biodiversity Project (LTBP), and forwarded to each riparian government for further negotiation and agreement.

The Convention was signed by the four riparian states on 12 June 2003, a result of the GEF PDF-B grant, Lake Tanganyika Management Planning Project (LTMPP). It is now in the process of ratification by the different parliaments. Once it enters into force (after its ratification by at least two countries), the Convention will provide the legal authority for implementing the SAP and revising it on a regular basis.

The Convention defines the management principles, as well as the obligations and specific procedures. It particularly defines a Lake Tanganyika Authority (LTA), whose function is to co-ordinate the implementation of the Convention itself, as well as the priority actions planned in the SAP. The LTA organs are:

- The Conference of Ministers, the supreme body of the authority;

- The Management Committee, made up of 3 members appointed by each contracting State; and,
- The Secretariat, under the direction of an Executive Director assisted by a Deputy Executive Director.

It is planned that the Management Committee will be assisted in the performance of its functions by:

- A Socio-economic Technical Committee;
- A Fisheries Management Technical Committee;
- A Biological Diversity Technical Committee; and,
- A Water Quality/Pollution Control Technical Committee.

The financial resources of the Authority will come from contributions of the contracting states in equal proportions. The Authority also will seek funds for its operations and projects from donors and other sources.

The TDA and SAP documents, as well as the Convention, produced through an in-depth consultation process, probably contain some of the elements proposed by the LTBP Coordination staff in the draft SAP of 1997. The main difference is that their ownership is now accepted nationally and regionally. This is one of the lessons learned from the Project; namely, the participation of all the partners in all the phases of the Project, from conception to implementation of agreed actions, is essential to facilitate its success.

4.2.3 Towards Implementation of Conventions and Programs

The implementation of the LTBP's SAP, which will begin with the ratification of the Convention and the effective establishment of the Lake Management Authority, will be something very important for the region, and a great hope for the future of Lake Tanganyika and a better sharing of its resources. Although these regional mechanisms have not yet been implemented, donors such as UNDP/GEF, African Development Bank (AFDB), FAO, IUCN and other partners are interested in being part of a Lake Tanganyika Integrated Regional Program (LTIP). A number of projects directed to meeting the priority actions proposed by the UNDP/GEF Project SAP and the FAO/FINNIDA Project FFMP are planned. AFDB and GEF, for example, have agreed to work together and harmonize their initiatives under the Lake Management Authority, including being willing to fund some of the projects proposed in the areas of pollution control, catchment management, and monitoring programs in Lake Tanganyika riparian countries.

A meeting of the Lake Tanganyika Partners (UNDP/GEF, African development Bank, FAO and IUCN) was held in June 2003. The following projects are components of an Integrated Lake Tanganyika Regional Program (LTIRP) agreed upon during this meeting:

- An Interim Lake Tanganyika Management Authority (ILTMA), which has the same institutional organs as the Authorities, except the Council of Ministers;
- A Lake Monitoring Program;
- Lake Pollution Control in Bujumbura, Burundi;
- Lake Catchment Management in Uvira Region, DR Congo;
- A Lake Catchment Management project in the Kigoma and Kasulu regions, and a Lake Pollution Control project in the cities of Kigoma and Ujiji, Tanzania; and,
- A Lake Catchment Management project in the Mpulungu Region, Zambia.

5. Lessons Learned

Management of Lake Tanganyika and its drainage basin is the responsibility of the "owners" of the resource; namely, the governments and people of Burundi, DR Congo, Tanzania and Zambia. These riparian countries alone could not have established coordinated sustainable management mechanisms for this shared resource. Important inputs to this goal have come through regional projects outputs, the most important being: (a) FAO projects working at national levels and coordinated by the FAO Committee for Inland Fisheries for Africa (CIFA); (b) FAO/FINNIDA Lake Tanganyika Research Project (LTR); and (c) UNDP/GEF Lake Tanganyika Biodiversity Project (LTBP). FAO projects focused on fisheries management, while LTBP focused mainly on biological diversity conservation, water quality and pollution control, and habitat protection.

The main lessons learned from the involvement of each of the riparian countries and their institutions is that:

- There is a need for a national institution (body) that should coordinate all activities related to the lake and management of its drainage basin; within each country, responsibilities for lake resources management, water quality protection, land management and soil protection in the watershed, and tourism organizations currently are fragmented in independent sectoral institutions;
- The sectoral institutions must establish clear programs incorporating better management of the lake's resources and its watershed;
- These institutions require more financial and human resources; and,
- There is a need for more regional cooperation among the riparian states.

The main lessons learned from the regional initiatives can be summarized as follows.

From an early stage, clear common goals and objectives, planning of activities, and good communication and transparency between the primary implementing agencies, the partner countries and the executing agencies, are essential in multi-country projects. An initial phase (pre-project phase) to undertake these preparatory activities also is needed.

Ownership of the Convention for the Sustainable Management of Lake Tanganyika, which resulted from the LTBP, is highly accepted nationally and regionally because the Convention was produced through an in-depth consultation process, mainly between technical experts of the four riparian States. A good indication for this conclusion is that the Ministers in all the riparian countries have readily signed the document. The experts in the different countries have been effective in informing the decision-makers (politicians). The general lessons learned from these experiences are that:

- The process is time- and budget-consuming for meeting at the national and regional levels; and the project design must be prepared for many, sometimes lengthy, consultations; and

- The human dimension is very important for the success of such long-term programs. When experts meet and discuss important issues on multiple occasions, they are better prepared to work effectively on the programs they have jointly developed; a limitation in the region is that personnel in key positions (technical and political) in most of the countries often do not occupy their positions long. Thus, it is important that such programs be implemented as quickly as possible, while the "designers" are still there, and local populations should be empowered for action in the field. Because the latter do not change, they often are the only groups available to better ensure the long-term viability of proposed actions.

Participation and commitment of political authorities at the highest level is extremely important for multinational environmental management projects. Thus, it is recommended that awareness-raising at the highest political level be undertaken. In this context, a formal assessment of institutional mandates and capacities should be conducted before implementation of projects, and be sanctioned by the highest levels of government. Because poverty reduction has a high political priority, it is important that the linkages between sustainable lake management and poverty reduction be made very clear at an early stage, to ensure (political) engagement of all stakeholders.

In implementing multi-country projects, it is tempting to treat all the countries equally. Multi-country projects, however, should recognize very early the differences between the countries, and tailor work plans to capitalize on the opportunities rooted in the specific conditions in each country, as well as compensating for constraints.

Long-term planning, although indispensable, must nevertheless incorporate flexibility, in order to allow consideration of unexpected situations in the field, on the regional (or international) scene, or in funding realities. Thus, the best ways to adjust to new situations must be agreed-to regularly between the local and regional (international) partners.

In the Lake Tanganyika region, the security situation can deteriorate suddenly, as well as rapidly improve thereafter. Thus, the creation of security plans is recommended, in coordination with local and international security organizations. Projects should be flexible enough to adjust programs to take account of such unexpected situations in the field. Past projects involving Lake Tanganyika have shown that national staff (scientific, technical, local teams in villages, etc.) may accomplish valuable goals in places where international staff are not officially allowed to work, or when there are sensitivities to the interest of the project by countries and their communities.

Because the ultimate success of an action plan is strongly dependent on the participation of the entire population, it is important to strengthen local citizen's participation in lake management projects. This requires regular public hearings about lake management, whereby the citizens are informed about the progress of the project and have occasion to give advice and direction on the best ways to proceed.

Inadequate communication is a major hindrance to effective lake management. Thus, appropriate facilities (transport, communication links, etc.) and budgets should be provided for any institutions, projects, or program with a regional scope.

For lakes shared by riparian countries in which two official languages are used, budget time and translation must be allocated to address this issue. In such situations, it is generally proposed that the key personnel in the projects be bilingual, although this condition is often difficult to meet. A good alternative solution is that, within the project, an equivalent number of the key personnel should use the two languages to ensure that the needs of the participating countries are equitably met.

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