Experience and Lessons Learned Brief
for Lake Tanganyika

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1. Introduction
Lake Tanganyika has the largest volume of the three African Great Rift Valley lakes. It is also the second deepest and the second largest lake in the world by volume: almost 19 000 km$^3$ – only Lake Baikal is larger. The lake contains almost as much freshwater as the five great American lakes combined. The lake 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 its average width is 48 km. The length of the shoreline is about 1900 km, of which 43% is rocky, 21% is mixed rock and sand, 31% is sand and 10% marshes.

There have been a number of studies on the lake in the last 15 years (Odada et al., 2003) which have provided a good understanding of its chemistry, hydrology and ecology (Box 1).

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<th>Box 1. Recent Studies on Lake Tanganyika</th>
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<td>• Lake Tanganyika Research (LTR) Project 'Research for the Management of the Fisheries on Lake Tanganyika' - (GCP/RAF/271/FIN)</td>
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2. Background

The main activity of the 10 million people living in the drainage area is agriculture. The main produce include maize, cotton, tobacco, rice, sugar-cane, sisal, coffee, beans, groundnuts, cassava, cattle and goats. The industrial products encompass textile, leather, brewing, various food products and cement. The area is also important for mining of tin, copper, gold and coal. The socio-economic statistics for the riparian nations of Lake Tanganyika are given in Table 2. Tanzania, Burundi, Zambia and Democratic Republic of Congo (DRC) all have low levels of economic development with GNIs per capita of $250, $140, $320 and $110 respectively (http://www.afrodad.org/debt/burundi.htm). However dependence on the lake varies significantly.

Agriculture, livestock raising and the processing of these products as well as the mining (tin, copper, coal, etc.) are the main industries in the drainage basin of L. Tanganyika.

The lake plays a crucial travel and trading role with neighbouring countries of Tanzania, Burundi, Democratic Republic of Congo, and Zambia. Bujumbura, Kigoma and Mpulungu serve as shipping centres for Lake Tanganyika trade in coffee, tea, cotton, hides, and tin ore with neighbouring countries. Well-developed regular ship lines connect Kigoma (Tanzania), Kalemie (Zaire) 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 of the country. The Nsumbu National Park provides a fine world-class game fishing. Goliath Tiger fish of over 35 kg, Nile perch of over 50 kg and giant catfish of over 50kg have been landed at the three lodges, namely Kasaba Bay, Nkamba Bay Beach and Ndole Bay. The lake also provides boating expeditions. Every year in February or March a national fishing competition is held at Kasaba Bay, which is attended by fishermen from all over the world.

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. Visitors can discover these fascinating creatures for themselves. The chimpanzees are accustomed to humans and therefore somewhat approachable. Having more than 550 plant species, Mahale is rich in plants. Researchers believe that at least 1,000 flower plants are found within the national park boundary. The plant species have had a major influence on the life of chimpanzees, who 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 “Musée Vivant” in Bujumbura and Reptiles Park are some of the interesting places to be seen. Uvira and Kalemie in D.R. Congo provide also provide tourist attractions.

In recent years, Lake Tanganyika, like many other biologically sensitive areas, has begun to feel the effects of increased population pressure. Fishing practices, for example, have become much more efficient, and consequently, more destructive. Commercial fishing began in the mid-1950s and has had an extremely heavy impact of the fish stocks and the majority of fish species.
The fisheries of Lake Tanganyika are far the most important source of animal protein for human consumption in this region of Central Africa. Lake Tanganyika has traditionally supplied between 25 and 40 per cent of the protein needs of the local people, citizens of the four countries bordering the lake, Burundi, Tanzania, Zambia and the Democratic Republic of Congo. About 45,000 people are directly involved in the fisheries operating from almost 800 sites, while 1 million people are dependent on the fishery. The main fishery product, the "Tanganyika sardine" (Stolothrissa tanganikae, Herring Family), is also very important for the local economy. It constitutes 55-90% of the industrial fishery and 80-99% of the traditional artisanal fishery (Rufli, 2001).

A major increase of the number of fishermen has been observed throughout large parts of the lakeshore. Many people are now exploiting the more accessible coastal waters that are richest in fish biodiversity and the nursery for most of the pelagic fish.

In spite of the need for maintenance of sustainable fisheries that is essential for the livelihoods of coastal populations, traditional approaches to enforcement have had little success, often constrained by very limited resources. Particularly, ornamental fishery is a problem because it is a serious threat to the biodiversity. A reasonable management of this exportable resource could provide sustainable economic benefits.

However, the most damaging threat to the lake's biodiversity appears to be due to a heightened rate of sediment influx, especially 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. Lake Tanganyika acts as a source of fish, a highway, a supply of drinking and washing water and a receptacle for effluent. Unfortunately, traditional attitudes and responses to land and water resource management as well as practices of waste disposal are no longer sustainable because they cannot keep pace with the rapid increase in human population density.

Pollution will inevitably lead to increased risks to human health associated directly with the declining water quality. In addition, the associated loss of 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% in the coming twenty years. This will inevitably increase the pressure on the aquatic environment, for instance by increasing fishery and water demands, as well as a higher pressure on land, with an increased erosion on farms resulting in more sediment transport to the lake.

3. Biophysical Environment

3.1. The ecosystem

Some basic information about the lake is summarized in Table 1 and Figure 1 shows a map of the lake with indication of the most important towns. Figure 2 shows a map of the most important studies. A bathymetric map is shown in Figure 3. The references applied are Hecky (2000), Hecky et al., (1981 ), Hecky et al., (1994) and Odada et al., (2003). The lake is located between latitude 3°20’ and 8°48’ south and between longitude 29°03’ and 31°12’ east. Of tectonic origin, it is estimated to be about 12 million years old. The maximum depth can be found in the southern part of the lake, while almost the same depth, namely 1250 m, is in the central northern part of the lake.
The lake has four riparian countries: Burundi (8% of the lake area) Congo (45% of the lake area) Tanzania (41% of the lake area), and Zambia (6% of the lake area) (see Figure 1). The lake is an important source of drinking and domestic water and as an international transportation route, among other uses. The lake is bordered by four national parks or nature reserve:

- The Rusizi River Nature Reserve in Burundi
- The Gombe River National Park, in Tanzania
- The Mahale Mountains National Park in Tanzania
- The Nsumbu National Park in Zambia

The lake could serve as an example for other lakes in the developing countries to learn from. As prevention is much more cost effective than abatement, it is of importance to set up a management plan at this stage to maintain the lake in an oligotrophic state. The residence time is 440 years which implies that, if the water quality becomes deteriorated it will take a very long time for the lake to recover. Many rivers enter the lake, but only one river, the Lukuga River, flows out. The 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. It is therefore of utmost importance to prevent the pollution and general over-exploitation of the lake.

Fortunately, the lake has received relatively less human impact than many other African lakes, included Lake Victoria. The population in the drainage area of ten million is, however, growing very rapidly (about 2.5% per annum) indicating that the 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 oligotrophic and has not yet suffered from eutrophication. The chlorophyll a concentration is the South lake is on the level of $1 \mu g \text{l}^{-1}$, while it is about $2 \mu g \text{l}^{-1}$ the North lake and even about $5 \mu g \text{l}^{-1}$ in the Central lake. The concentration of reactive inorganic nitrogen (mainly nitrate) is 50-90 $\mu g \text{l}^{-1}$, and the reactive inorganic phosphorus concentration is 5-10 $\mu g \text{l}^{-1}$.

Today, limited but very sensitive areas, Bujumbura bay in Burundi and Kigoma bay in Tanzania, show evidence of unfavourable change in water quality, due to urban and industrial runoff. It is a high priority that these places remain unpolluted, as drinking water for more than 400,000 people in Bujumbura and 80,000 in Kigoma is extracted from the lake. Nobody dare to think about the catastrophe that would arise if the lake, for one reason or an other, would become unsuitable as source of drinking water and its fish unfit for human consumption.

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

The lake contains around 500 endemic species out of the total of 2156 species (Coulter & al., 1991). The number of species that inhabit the lake is 325 fish, 759 algae, 81 aquatic plants, 219 crustaceans and 171 birds. That includes about 200 species of cichlids. It has 8 species of crab, 15 species of shrimp and some 60 species of snails. The lake has a unique high biodiversity which however is endangered. The lake is important for its fishery (commercial,
subsistence and ornamental fishing). The estimates for fish harvest in Lake Tanganyika are 165,000 to 2,000,000 tons/year (Mölsa et al., 1999), which is 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, that is from September to November. As a result, thermal stratification establishes all over the lake with temperature difference between surface and bottom layers within a 4°C (see Figures 5 and 6). The dry season from May to August has dry weather and strong southern and southern-eastern winds. The lake loses heat by evaporation caused by strong winds. This cooling is strongest in the southern basin from May to September (Coulter et al., 1991).

South eastern winds drive warm epilimnion surface water towards the north of the lake, while water flows south as a deep current, causing up-welling along the southern coast. This results in a tilting of the epilimnion (Lewis, 1996). Thermocline depths at Bujumbura and Kigoma was 74-83 m in the dry season of 1993, while the epilimnion in the south was reduced in May and disappeared in June during the up-welling (Lewis, 1996). The productivity of the lake is highly dependent on these hydrodynamic states and on climatic conditions particularly wind and temperature. The monsoon wind from the South East causes the accumulation of water in the epilimnion as mentioned above and thereby deepens the thermocline in the north, while in the south deep rich waters up-well (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. A regular pulse of production is consequently induced, when the deep eutrophic waters are able to reach the biotic and euphotic zone, where photosynthesis takes place. Figure 5 shows how the depth of thermocline changes over the year. When the thermocline is deep the production is high, i.e. the production pulses follows the rhythm of the thermocline. The transparency follows the same pattern. Figure 6 shows the Secchi depth in meters at Bujumbura as a function of the time. Below 100-200 m there is no oxygen in the water (Coulter et al., 1991).

Since the 1960’s, an increase in air temperature has been noted at stations around Lake Tanganyika (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 and 2.5 m/s from 1964 and 1979, and between 1986 and 1990, the range was from 0.5 to 1.5 m/s (Plisnier, 1997).

These climatic changes seem to have led to 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 (up-welling becoming rarer even in the south), a shallower thermocline and oxygenated 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 Lates stappersii (a visual predator) catchability in the north and Clupeids abundance in the south (Plisnier, 1997).

In the south of Lake Tanganyika, it had always been observed that the dry and windy season was a time of increased clupeid abundance, probably related to phytoplankton increase 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. This would cause the lake to be less dynamic (Plisnier, 1997).

Distribution patterns of Clupeids may also have changed, probably due to a reduced migratory behavior. The very low level of S. tanganicae catches in the south in the last decades suggest that 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. According to Verburg et al., 2003, there is no doubt that the climatic changes play a major role.

3.2. Threats on the ecosystem

From different studies conducted on the lake and its drainage basin (see Box 1), the following are identified as the main threats facing the lake:

1. Over-exploitation of the biological resources due to very high fishing pressure and use of destructive methods, reducing the fishery potential and the unique biodiversity. Annual recorded catches on Lake Tanganyika have shown an upward trend since 1970s and today stand at about 200000 tones. Recent estimates per country indicate a yield of about 210000 tones for Burundi in 1992 (94.5kg/ha/year), 550000 tons during 1994-95 in for Tanzania (60 kg/ha/year), 12900 tons for Zambia (69 kg/ha/year), and 90000 tons in D.R. Congo (34/kg/ha/year). These estimates translate into an average catch range from 54-66 kg/ha/year for the whole lake (Lindqvist et al., 1999) The actual catch are then much higher for Burundi and Zambia than elsewhere, while in Tanzania and DRC waters, which represent 86% of the total lake, the figures are much lower. Such differences reflect probably greater fishing intensity in northern and southern part of the lake rather than actual lake productivity. The observed yields in Burundi (94.5 and 111.5 kg/ha/year respectively in 1992 and 1995), is 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 fisheries pressure is very high in the north and the south. Evidence of over-fishing in Burundian and Zambian waters is that the trend of catch per unit effort (CPUE) for industrial units (purse seiners) has been declining. Nightly CPUE for industrials units in Burundi dropped from 166 kg in 1994 to 111 kg in 1996, while in Mpulungu it dropped from 877 kg in 1994 to 535 kg in 1996. 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 are 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 occurring in the drainage area as a result of increased deforestation. Topsoil is removed to the lake where it joins fertilizers and pesticides washed from the 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. Malagarasi and Rusizi Rivers have a major share of the inflowing waters to the lake and contribute also most to the suspended solids load to the lake (see Figure 4). Siltation is the most damaging threat to the lake's biodiversity, especially the 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 biodiversity not only by decreasing species habitat, but also by efficiently complexing certain essential nutrients/trace elements.

3. Untreated waste water discharge, including industrial and domestic waste water from large cities such as Bujumbura in Burundi, Kigoma in Tanzania, Uvira and Kalemie in Congo, and Mbulungu in Zambia. These waters might contain generally nutrients born from organic matters, heavy metals like mercury and chromium, pesticides, ash residues as cement, as well as fuel from ports, harbours, shipping places and boats, etc

4. Agricultural run-off, particularly with the rivers Malagarasi and Rusizi. The agricultural expansion in the region could be accompanied by an increase in the 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 among 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 rocky deltas. Record sediment accumulation rates in highly impacted river systems can reach up to 100 cm yr\(^{-1}\). Unfortunately, traditional attitudes and responses to land and water resource management as well as practices of waste disposal are no longer sustainable because they cannot keep pace with the rapid increase in human population density.

6. Increased tourism that will involve increased impact on the lake, if not properly planned, although some are of the opinion that the local infrastructure is not yet on a level which allows mass tourism.

Of the two first threats above, over-exploitation is felt as the most acute for short-term fishery potential, and siltation the most detrimental for the lake’s biodiversity and long-term resource potential.

4. Management Environment

Lake management implementation arrangements are complex because the lake has four riparian countries. Therefore, any approach to improve the understanding and subsequent management of the lake must have an international and regional perspective. The main problems that are to be addressed are: 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 have the capability to act in matter of biological stock management, biodiversity conservation, water quality and pollution control, slowing down sediment transport to the lake, etc., and in a harmonized mechanism with the others countries. However, what is common is that each government has at least agencies responsible for fisheries with local offices at or near the lake, but the national involvement in other aspects of lake management is not highly developed.
There are a large number of local and international NGOs in the four countries, but most of them do not have resources for action.

**Burundi**

In Burundi, where a large population means a high demand for fish resource, the capital city is by the lake, drinking water in Bujumbura is pumped from the lake, and discharge urban and industrial waters reach easily the lake. On the lake catchment, increased population and poor agriculture practice accelerate erosion and sediment transport to the lake. One could then expect that national institutions involved in lake management are harmonized to protect the resources as they try to meet the need of the populations, but it is still to be done.

- Fisheries management and associated activities are under the responsibility of the Department of Water, Fish culture and Fisheries (DEPP), in the Ministry of Agriculture and Livestock. This institution has poor resources to implement valuable regulations that have been prepared through the support of different FAO projects since the sixties and 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, but does not have an equipped laboratory and other resources for that.
- A wastewater treatment plant has been installed with World Bank funding to treat about 40% of the urban and industrial wastewater for Bujumbura. The treatment plant is under the responsibility of the town city of Bujumbura. It is yet to start functioning properly.
- The Ministry of Health has interest in wastewater disposal and sanitation problems in inhabited zones, not specially the lake.
- The INECN has also nationally the responsibility for biodiversity, but its conservation activities concentrate on national parks and reserves; no official Reserve or National Park has been set yet in lake’s waters.
- Regarding biodiversity, there have been some studies done at University of Burundi through short projects and student studies. Most of them are about fish population structure and biodiversity evaluation in different lake habitats.
- No national institution has the responsibility to monitor or to control sediment transportation into the lake; the exact impact of sediment on lake’s biodiversity and water quality is still to be established. Services of the Ministry of Agriculture only concentrate on control of erosion on cultivated land, while services in the Ministry of Public Works concentrate on the control of erosion and land slides along roads. Action to slow down transportation of sediment to the lake should be under the technical services in these two ministries.

**Democratic Republic of Burundi**

- The D. R. of 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.
Tanzania

- The National Environmental Management Council (NECM), under the President’s Office, has the mandate for all the environmental matters. UNDP/GEF LTBP project was coordinated by this institution.
- Tanzania’s Ministry of Scientific Research includes the Tanzanian Fisheries Research Institute (FAFIRI) with a regional office at Kigoma. FAO/FNNIDA LTR project was coordinated by this institution.
- The University of Dar es Salaam has an active biology department with an interest in aquatic biology, and experience on the lake in biology and pollution aspects. It could generated valuable data if involved.
- Tanzania National Parks (TANAPA) is responsible management and tourism in to 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 training the community development aspect focusing on improving the standard of living in the region of Lake Tanganyika while promoting reforestation, curbing soil erosion, and delivering conservation education to the local population.

Zambia

- The Zambian Ministry of Agriculture has a Department of Fishery (DOF) with a provincial fishery office at Mbala. FAO/FNNIDA LTR project was coordinated by this institution.
- Environmental Council of Zambia (ECZ), under the President’s Office, has the mandate for all the environmental matters. UNDP/GEF LTBP project was coordinated by this institution.

4.2. Regional mechanisms

Since the sixties, lake management coordinated at regional level has been concerned with only fisheries, through FAO projects working at national levels and coordinated periodically by the FAO Committee for Inland Fisheries For Africa (CIFA); the later has a Sub-Committee for Lake Tanganyika since the seventies. Issues like fish stock management, fishing regulation, 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 programme. Laws and regulations about fishing and associated activities are yet to be harmonized across the lake.

In the nineties, 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 to 1999, and
- UNDP/GEF Lake Tanganyika Biodiversity Project (LTBP) from 1995 to 2000.

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

The others aspects of Lake management like 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 outcomes of LTBP are a Trans-boundary Diagnostic Analysis (TDA), a Strategic Action Plan (SAP) and a Convention for the Management of the Lake between the four riparian countries.

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

- UNESCO/MAB/DANIDA Ecotones Project at University of Burundi (1991-1994);
- Centre Regional de Recherches en Hydrobiologie Appliquée (1992-1995) sponsored by the Belgian Government to Burundi and D.R. Congo;

The outputs of these local projects have been incorporated in LTBP’s literature data, especially for biodiversity evaluation in the lake.

**4.2.1. LTR’s Framework Fisheries Management Plan (FFMP)**

LTR’s Framework Fisheries Management Plan (FFMP) was endorsed by FAO Committee for Inland Fisheries For Africa (CIFA) in 1999. It is the first important mechanism that could help a regional management of Lake’s resources, specially fisheries, in a sustainable way.

The conclusion of LTR’s 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. Principal deficiencies common to institutional frameworks can be summarised as follows: a) inadequate budgetary allocation to fisheries sectors by central governments, b) inadequate funding for research, c) lack of human resources and equipment, d) poor to non-existent enforcement of fisheries regulations, and e) insufficient linkage between central administration and field agents at local level.

To solve the problem, LTR proposed the FFMP to the Lake Tanganyika riparian States. The governments have ratified a convention necessitating the formation of Lake Tanganyika Management Authority to reduce the pressures on the lake resources. The convention harmonises management policies, laws, regulations monitoring and data exchange, and provides a forum for the countries to engage in discussions of lake management.

The Code of Conduct for Responsible Fisheries (CCRF) provides a framework of basic policy orientation through which the Framework may be accommodated in an integrated fashion. It calls for establishment for responsible fisheries management, which will be elaborated, adjusted, and reviewed as part of an ongoing process. Others issues covered by the CCRF are: a) policy matrix; b) partnership and resource access; c) institutional and legal modalities; d) harmonisation of fishing regulation, e) and 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 recommended that their respective competent authorities implement the CCRF as the policy matrix for the shared fisheries of Lake Tanganyika. It is further recommended that the respective competent authorities, adopt and pursue management policy directions in support of: a) adaptive or interactive management practices that allow for adjustments in fishing pressure, and also allow for flexible application of management treatments appropriate to different circumstances encountered around the lakeshore; b) multi-disciplinary monitoring capability for measurement of continuity and change across a range of bio-physical 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 local community levels; and e) use of integrated development strategies and coastal area management models at the local level, in order to accommodate complex interactions and possible conflicts between fishing and non-fishing activities, and, at national and regional ‘macro-levels,’ moves to foster economic diversification to reduce pressure on the fishery resource base.

Partnership arrangements and local control of resource access
Co-management structures and operational arrangements should be established around the lakeshore. Because attitudes towards co-management appear to vary by country, co-management arrangements need to 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. It is nevertheless the case 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 coordination 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;
- develop and recommend conservation and management measures;
- facilitate periodic elaboration and implementation of a regional fisheries management plan and monitoring programme;
- harmonize national measures for the sustainable utilization of the living resources of the Lake;
- facilitate the harmonization of fisheries regulations for Lake Tanganyika;
- explore ways and means of establishing an autonomous intergovernmental 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;
- organisation and conduct of 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, it is recommended to draft a comprehensive set of regulations applicable to Lake Tanganyika fisheries, which should address the following tasks: a) devise various classes of fishing units or categories of fishing operations; b) determine which classes of fishing units are required to carry a fishing license; c) determine the number of fishing licenses that can be issued for industrial fishing units; d) determine prohibited or authorised methods of fishing and restrictions on certain methods of fishing (e.g. banning or gradual phasing out of beach seining); e) establish prohibited fishing areas (for all purposes for the protection of spawning grounds in respect of any fishing method or any species of fish); f) establish and demarcate prohibited industrial fishing areas and beach seining areas; g) establish closed times and/or closed seasons for fishing; h) set gear specifications (mesh sizes, height and length of nets and other fishing implements); and i) ban the introduction of non-native species of fish and aquatic plants.

For the Democratic Republic of 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 the Democratic Republic of 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 the Democratic Republic of Congo jurisdiction; and d) reviewing the classification of fishing units with a view to harmonising fisheries regulations. In Burundi, fisheries regulations applicable to Lake Tanganyika should include the following provisions: 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 a view to harmonising fisheries regulations.

**Harmonisation of fisheries regulations**
Emphasis should be placed on three specific measures: a) elaboration of a common classification of fishing units or categorisation 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 Programme (LTMP) designed under LTR auspices is consistent with the CCRF guidelines in as much as: a) 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 local fisheries. A time frame and financial scheme designed to ensure the long-term sustainability of the monitoring programme 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 the carrying out of periodic frame surveys, designed to assess the state of the fishing industry, be required by every fisheries legislation.

Possible Technical Measures to Regulate Fishing
The beach seine is an especially serious problem in the southern end of the lake. Management measures should aim at the gradual but eventually total retirement/phasing out of beach seining on the lake. As a step towards 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 opening up of other gear and method options as viable alternatives to the practice.

There are also indications of high exploitation pressure on *L. stappersii* within extreme northern waters, though in this case resulting from a concentration of artisanal lift netting 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. 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 lift net units in the north. In the case of the purse seine fishery, effort 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 lift net 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 authorised to operate in their traditional fishing grounds.

4.2.2. LTBP’s Outputs: Transboundary Diagnostic Analysis (TDA), Strategic Action Plan (SAP) and Convention.

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

A Trans-boundary Diagnostic Analysis was therefore one major step needed during the process of formulating the SAP. The first phase of the process was a Project inception workshop in 1996, where 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 provided the initial prioritisation of threats for the region.
From this first priority issues, the project prepared a consultation document for a Preliminary Strategic Action Programme in 1997, but the Regional Steering Committee (RSC) committed to formulating this regional SAP through a process of consultation from national level by National working groups, to regional level by Technical Advisory Committee. After a planning meeting in each country, the national consultation process consisted of 2 workshops: the first on the National Sectoral Problem Review, and the second on the National Environmental Priorities and Strategic Review. With these 2 workshops, each national working group came to a national understanding on the priority biodiversity and management concerns and priorities for intervention.

Consultations at regional level were conducted through an expanded Planning Group where 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 came up with a draft preliminary TDA in November 1998, that was 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 Programme (SAP) in January 2000. In March 2000, the Group issued the final TDA that incorporates the conclusions of the special studies programmes relevant to management needs of the Lake and that was proposed to be included in the final SAP. The Strategic Action Programme (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 the Lake Tanganyika. After analysis of the main threats and the specific problems in managing the lake, it established priorities for possible interventions and finally proposed a sequence of management interventions to counteract each specific problem.

The main threats to biodiversity and sustainable use of lake Tanganyika resources that have been identified are: 1) unsustainable fisheries, 2) excessive sedimentation, 3) increasing pollution, and 4) habitat destruction. The general action areas against these threats are: 1) reduction of fishing pressure, 2) control of sedimentation, 3) control of pollution, and 4) habitat conservation.

Of the many identified specifics problems that make up each of these major threats, those which have been ranked as the priority for intervention in the 4 action areas are the following (considering the score of each for chosen criteria (severity, feasibility, and additional benefits):

- Reduction of Fishing Pressure: Excessive fishing effort in littoral zone, Excessive fishing effort in pelagic zone; Excessive or uncontrolled extraction of ornamental fish
- Control of sedimentation: Erosion from inappropriate farming practices; Deforestation
- Control of Pollution: Urban and industrial pollution; Harbour pollution; Pollution from future mining or oil exploitation; Risk of major marine accident
- Habitat conservation: Threats to resources in National Parks; Degradation of key habitats

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

The Convention is a legal agreement setting out the rights and duties of the four States concerning the Lake. 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 policy makers 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 further workshops. The first two brought together participants sharing a common language: an Anglophone workshop (August, 1999) and a Francophone workshop (September 1999). The third meeting brought together the participants of the four countries and resulted in version of the draft being agreed regionally (November, 1999). This draft was adopted by the Steering Committee (July 2000) at the completion the UNDP/GEF Lake Tanganyika Biodiversity Project (LTBP) and forwarded to each government for further negotiation and agreement.

The Convention was signed by the four riparian States on June 12, 2003 as 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 ratification of at least two countries), the Convention will provide the legal authority to implementing the SAP and regularly revising it.

The Convention defines the management principles, as well as obligations and specific procedures. The Convention defines particularly a Lake Tanganyika Authority (LTA) whose function is to co-ordinate the implementation of Convention itself and 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 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
- a Water Quality / Pollution Control Technical Committee

The financial resources of the Authority will come from contribution of the contracting States in equal proportion, but it will also seek to obtain funds for its operations and for projects from donors and other sources.

The TDA and SAP documents, as well as the Convention, produced through an in-deep consultation process, contain probably some of the elements the draft SAP that were proposed in 1997 by the LTBP Coordination staff. The main difference is that, now, their ownership is highly felt nationally and regionally. This is one of the lessons learned from the Project: the participation of all the partners in all the phases of the Project, from conception to implementation of agreed actions, is essential.
4.2.3. Toward implementation of Convention and Programmes

The implementation of the LTBP’s SAP, which will begin by the ratification of the Convention and the effective setting up of the Lake Management Authority, will be something very important for the region and a great hope for the Lake’s future and a better sharing of its resources. Today, these regional mechanisms have not been implemented yet, but donors as UNDP/GEF, African Development Bank (AfDB), FAO, IUCN, and other partners are interested to be part of a Lake Tanganyika Integrated Regional Program (LTIP), made of a number of projects meeting the priority actions proposed by the UNDP/GEF Project born SAP and FAO/FINNIDA Project born FFMP. AfDB and GEF, for example, have agreed to work together and harmonize their initiatives under the Lake Management Authority, and are willing to fund some of the projects proposed in Pollution control, Catchment management, Monitoring programmes in Lake Tanganyika riparian countries.

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

- an Interim Tanganyika Management Authority (ILTMA), which has the same institutional organs as the Authorities except the Council of Ministers.
- a lake Monitoring Program
- a lake Pollution Control in the City of Bujumbura, Burundi
- a lake Catchment Management in Uvira Region, D. R. Congo
- a lake Catchment Management in Kigoma and Kasulu region and a lake Pollution Control Project in the Kigoma and Ujiji town cities, Tanzania
- a lake Catchment Management in Mpulungu Region, Zambia

5. Lessons Learned

Lake Tanganyika management is under the responsibility of the “owner” of the resource, i.e. the governments and people of Burundi, D.R. Congo, Tanzania and Zambia. These riparian countries, alone, could not have set up a coordinated sustainable management mechanisms for shared resource. Important inputs to this goal have come through regional projects outputs, the most important of them 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); 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, habitat protection.

1. What arises from the involvement of each of the countries and its institutions is that:

- there is a need for a national institution (body) that should coordinate all activities related to the lake and watershed management; within each country, responsibilities for lake resources management, water quality protection, land management and soil protection on the watershed, and tourism organisation are fragmented in independent sectoral Institutions;
- the sectoral institutions need to set up clear programmes that incorporate a better management of the lake’s resources and its watershed;
- these institutions need more resources; and
- there is a need for more regional co-operation.
The main lessons learned from the regional initiatives could be summarized as follows:

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

3. LTBP’s Convention’s ownership is highly felt nationally and regionally, because it has been produced through an in-depth consultation process, mainly between technical experts of the four riparian countries. A good indication for this is that the Ministers in all the riparian countries have easily signed the document. The experts in the different countries have been convincing when informing the decision makers (politicians). The general lessons learned from this experience are that:

   • such process is time and budget consuming for meeting at national and regional level; project design must be prepared for many and sometimes lengthy consultations;
   • the human dimension is very important in the success of such long term programmes. When experts meet and discuss on several occasions, they finally get prepared to better work in the programmes they have set up together; a limitation in the region is that the occupants of key positions (technical as well as political) in most of the countries often do not last long. It is therefore important that such programmes be implemented as quickly as possible while the “designers” are still there, and local populations be empowered for action on the field. Because the later do not change, they are the only groups to insure the long term viability of the proposed actions.

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

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

6. Long term planning, although indispensable, must allow flexibility to unexpected situations in the field, on regional (or international) scene, or in the funding conditions. The best ways to adjust to new situations must be agreed regularly between local and regional (international) partners.

7. In Lake Tanganyika region, the security situation can deteriorate suddenly, but also improve afterwards. It is therefore recommended to create security plans, in coordination with local and international organizations on security matter. Projects should be prepared
to be flexible enough to adjust programs in such unexpected situations on the field. Projects on Lake Tanganyika have shown that national staff (scientific, technical, local teams in villages, etc.) may obtain valuable achievements in places where international staff are not officially allowed to work, when there are sensitive to the interest of the project for their countries and their communities.

8. It is important to strengthen the local citizen’s participation in lake management projects, as the over-all result of a later action plan is strongly dependent on the entire population. It requires regular public hearing about the lake management where the citizens are informed about the progresses of the project and have occasion to give directions on how to proceed.

9. Communication is a major limitation around the lake. Appropriate facilities (transport, communication links, etc.) and subsequent budgets should be provided for to any institution, projects, or programme with a regional scope.

10. For shared lakes where two official languages are used, budget time and translation must be allocated. In such situations, it is generally proposed that the key personnel in the projects should be bilingual, but this condition is very difficult to meet. A good solution is that globally, within the project, an equivalent number of people in the key personnel should use the 2 languages so that the needs of the participating countries are met.

References


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Fisheries Principal Regulations, (1989). Tanzania
Fisheries Act (1974) Zambia
Lake Tanganyika Results and Experiences of the UNDP / GEF Conservation Initiative (RAF/92/G32) in Burundi, D.R. Congo, Tanzania and Zambia, prepared by Kelly West, 28. of February 01.

Relevant web pages:

www.wetlands.org/RDB/Ramsar_Dir/Tanzania/TZ001D02.htm
www.zambiatourism.com/travel/places/tanganyi.htm
www.st.nmfs.gov/st1/fus/fus98/percapita/pc-wld
www.geo.arizona.edu/nyanza/chororoka.pdf
www.st.nmfs.gov/st1/fus/fus98/percapita/pc-wld
Figure 1: Map of Lake Tanganyika.
Figure 2: Map of some of the important studies
Figure 3. Bathymetric map of Lake Tanganyika
Figure 4: Map of the contribution to erosion in the drainage area.
Figure 5: Formation of thermocline is shown.

Figure 6: Seasonal changes of the depth of the thermocline (off Bujumbura)
Figure 7: Seasonal fluctuations of the Secchi transparency (off Bujumbura)
Table 1. Basic information, Lake Tanganyika

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<th>Congo</th>
<th>Tanzania</th>
<th>Zambia</th>
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Table 2. Socio-economic statistics for Tanganyika’s riparian nations

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<td>Population without access to (%)</td>
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<td>34</td>
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<td>safe water</td>
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<td>49</td>
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<td>14</td>
<td>29</td>
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<td>Per capita GNP ($)</td>
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<td>Life expectancy (yr)</td>
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