Lake Tanganyika Biodiversity Project

Projet sur la Biodiversité du Lac Tanganyika

Lake Tanganyika:

Results and Experiences of the UNDP/GEF Conservation Initiative (RAF/92/G32) in Burundi, D.R. Congo, Tanzania, and Zambia

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ACRONYMS

AfDB	African Development Bank
BIOSS	Biodiversity Special Study
CBD	Convention on Biological Diversity
CRH	Centre de Recherche en Hydrobiologie (Uvira, D.R. Congo)
DOF	Department of Fisheries
D.R. Congo	Democratic Republic of Congo
ECZ	Environmental Council of Zambia
EE	Environmental Education
EIA	Environmental Impact Assessment
FAO	Food and Agriculture Organization of the United Nations
FINNIDA	Finnish Development Agency
FPSS	Fishing Practices Special Study
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GIS	Geographic Information System
GNP	Gross National Product
HDI	Human Development Index
ICAD	Integrated Conservation and Development
IFE	Institute of Freshwater Ecology
ILMB	Interim Lake Management Body
ILMC	Interim Lake Management Committee
ILMS	Interim Lake Management Secretariat
INECN	Institut National pour l'Environnement et la Conservation de la Nature
IZCN	Institut Zairois pour la Conservation de la Nature
LARST	Local Application of Remote Sensing Techniques
LTA	Lake Tanganyika Authority
LTBP	Lake Tanganyika Biodiversity Project
LTR	Lake Tanganyika Research project
MRAG	Marine Resources Assessment Group
NGO	Non Governmental Organization
NOAA	National Oceanic and Atmospheric Administration
NP	National Park
NRI	Natural Resources Institute
NWG	National Working Group
OAU	Organization of African Unity
PA	Protected Area
PC	Project Coordinator
PCU	Project Coordination Unit
PDF	Project Development Fund
POLSS	Pollution Special Study
PRA	Participatory Rural Appraisal
RVC	Rapid Visual Census
SAP	Strategic Action Programme (sometimes called Plan, but should be Programme)
SC	Steering Committee
SCM	Steering Committee Meeting
SCUBA	Self contained underwater breathing apparatus
SLO	Scientific Liaison Officer
SEDS	Sedimentation Special Study
SESS	Socio-Economic Special Study
SVC	Stationary Visual Census
TAC	Technical Advisory Committee
TAFIRI	Tanzania Fisheries Research Institute
TANAPA	Tanzanian National Parks Authority
TANGIS	Geographic Information System created by LTBP for Lake Tanganyika

TDA	Transboundary Diagnostic Analysis
TEEC	Training Education and Communications Coordinators
TNA	Training Needs Assessment
TOT	Training of Trainers
UK	United Kingdom
UN	United Nations
UNCED	United Nations Conference on the Environment and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNHCR	United Nations High Comission for Refugees
UNOPS	United Nations Office for Project Services
VC	Village Council
VCDC	Village Conservation and Development Committee

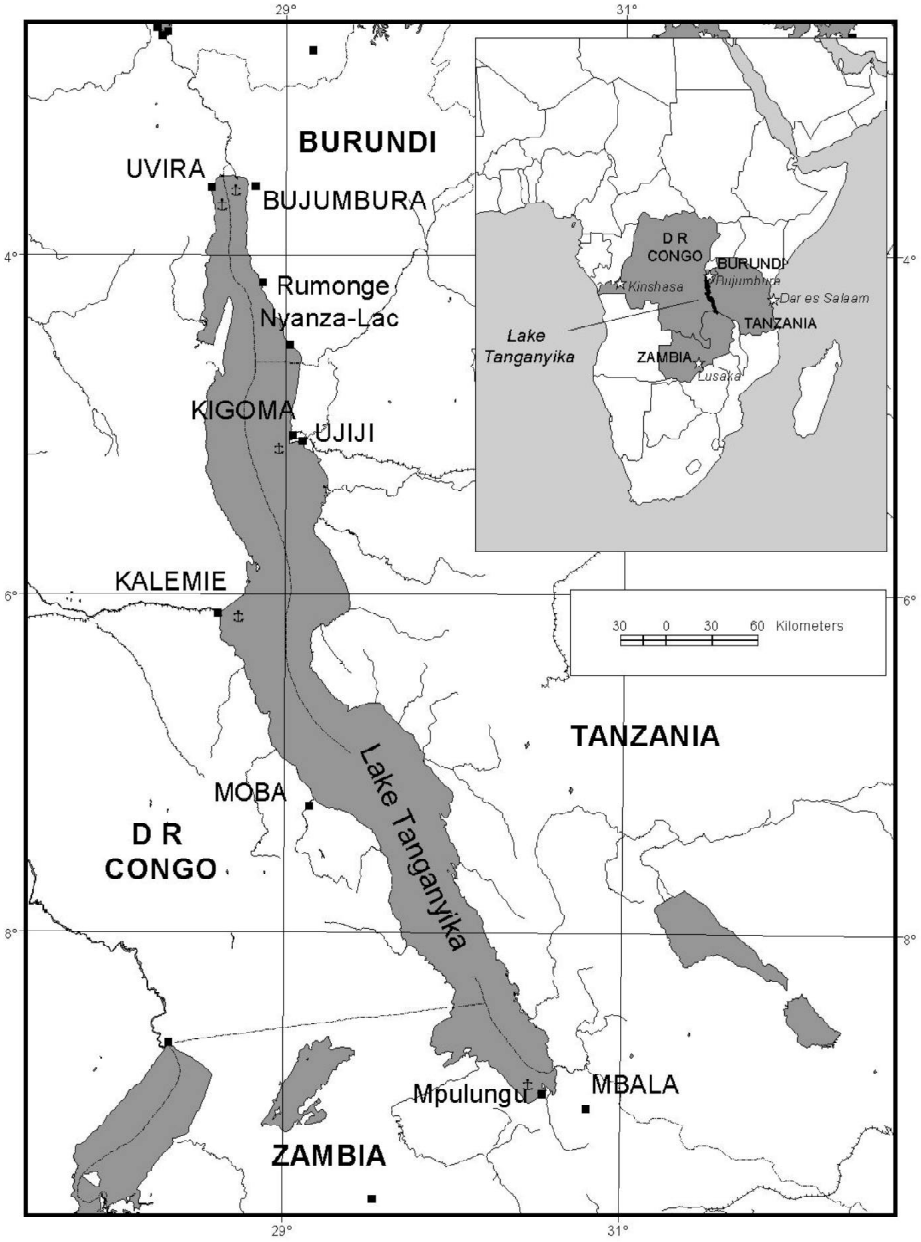

Figure 1.1 Lake Tanganyika and its riparian nations:
Burundi, Democratic Republic of Congo, Tanzania and Zambia.

CHAPTER 1.
INTRODUCTION to LAKE TANGANYIKA

1.1 Why is Lake Tanganyika Special?

A variety of factors, in concert, make Lake Tanganyika an exceptionally rich and interesting ecosystem. The following sections detail the geological, physiographical, biological and socio-political settings and context of Lake Tanganyika.

1.1.1 Physiographic Considerations

Rifting is separating the African continent into two blocks, the African block to the west and the Somalian block to the east. Lakes Turkana, Albert, Edward, Kivu, Tanganyika, Rukwa and Malawi/Nyasa[1] mark the scars of this NW-SE trending rift (see Fig. 1).

These African lakes have persisted for long periods, which is unusual among lake ecosystems. Whereas most modern lakes were formed by glaciation within the last 12,000 years and have a history of frequent water chemistry fluctuations and/or desiccation (Wetzel 1983), the African Great Lakes are geologically long-lived. Based on sediment accumulation rates in the basin, geologists estimate that Lake Tanganyika has existed for approximately 12 million years (Scholz and Rosendahl 1988; Cohen ***et al***. 1993). Lake Tanganyika is the oldest of the African Lakes, and after Lake Baikal in Russia, it is the second oldest lake in the world.

However, this long history has not been geologically static. Lake Tanganyika consists of two major basins, northern and southern, separated by a complex, block-faulted structure known as the Kalemie shoal. Major border faults have further delineated these two major basins into several sub-basins (Tiercelin and Mondeguer 1991). Seismic reflection data suggest that Lake Tanganyika was divided into three hydrologically, chemically and biologically distinct paleolakes during lake low stands between 150,000 and 50,000 years ago (Scholz and Rosendahl 1988). However, for the past 2,800 years, lake levels have been relatively stable, fluctuating between 765-775 meters above sea level for most of this time (Cohen ***et al***. 1997). Modern annual lake level variation is about one meter (Edmond ***et al***. 1993).

Situated between the latitudes of 03º20' and 08º48' South and the longitudes of 29º03' and 31º12' East, Lake Tanganyika is an elongate lake. At 673 km along its major axis, Tanganyika is the longest lake in the world and ranges from 12 to 90 km in width with a shoreline perimeter of 1,838 km (statistics from Hanek ***et al***. 1993). Geologic processes have, to a great extent, determined the shoreline substrates around the lake. Of the 1,838 km shoreline perimeter, 43 percent is rocky substrate, 21 percent is mixed rock and sand substrate, 31 percent is sand substrate and 10 percent is marshy substrate (Coenen ***et al***. 1993).

A catchment area of 220,000 km^2 feeds Lake Tanganyika. The lake's average depth is 572 meters, with a maximum depth of 1,310 meters in the northern basin and 1,470 meters in the southern basin, making it the world's second deepest lake, after Lake Baikal. Lake Tanganyika is fed by numerous small rivers and two major influent rivers, the Rusizi draining Lake Kivu to the north, and the Malagarasi, draining Western Tanzania south of the Victoria Basin. Only a single outlet, the Lukuga River, drains Lake

[1] Lake Victoria, also in this region, is not a rift lake ***per se***, rather it fills a depression on the platform between the eastern and western branches of the African Rift. Victoria, Tanganyika and Malawi/Nyasa are often collectively referred to as the 'African Great Lakes.'

Table 1.1 Physiographic statistics for Lake Tanganyika (modified from Coulter 1994).

Latitude	03º20' - 08º48' South
Longitude	29º03' - 31º12' East
Age	about 12 million years
Altitude	773 m above sea level
Length	673 km
Width	12 – 90 km, average about 50 km
Surface Area	32,600 km^2
Volume	18,880 km^3
Shoreline Perimeter	1,838 km
Maximum Depth	1,320 m in north basin, 1,470 m in south basin
Mean Depth	570 m
Catchment	220,000 km^2
Stratification	permanent, meromictic
Oxygenated Zone	- 70 m depth in north, - 200 m depth in south
Temperature	23-27 ˚C
pH	8.6 – 9.2
Salinity	approx. 460 mg/liter

Tanganyika, though the flow of this river has changed directions in historical times (Beadle 1981). Most of Tanganyika's water loss is through evaporation. Calculations from Lake Tanganyika's water budget suggest a water residence time of 440 years (lakevolume/ [precipitation+inflow volume], roughly the time it takes a given particle which has entered the system to exit) and a flushing time of 7,000 years (lake volume/lake outflow volume, roughly the time it takes to exchange all the water in the system) (Coulter 1991). Lake Tanganyika, with an approximate surface area of 32,600 km^2 and volume of 18,940 km^3, contains 17 percent of the Earth's free fresh water (statistics from Hutchinson 1975, Edmond ***et al***. 1993, Coulter 1994).

Lake Tanganyika is stratified into an oxygenated upper layer (penetrating to about 70 m depth at the north end and 200 m at the south end) and an anoxic lower layer, which constitutes most of the lake's water volume (Beauchamp 1939, Hutchinson 1975, Coulter and Spigel 1991). Stratification is permanent (meromictic), that is the oxygenated and anoxic layers generally do not mix, though wind-induced upwelling results in some mixing at the lake's southern end (Coulter and Spigel 1991). The lake's morphology, a steeply sided rift cradling a deep anoxic mass and capped by a thin oxygenated layer, has profound implications for the distribution of organisms in Lake Tanganyika. Most of Lake Tanganyika's water mass is uninhabited. Organisms are limited to the upper oxygenated zone. Because of the steeply sloping sides of the Tanganyika basin, benthic organisms (which rely on the substrate for at least some aspect of their life cycle) are limited to a thin habitable ring fringing the lake's perimeter which extends sometimes only tens of meters offshore. Coulter (1991) makes the following delineation: littoral zone – from shore to 10 m depth; sub-littoral zone – from 10 m to 40 m depth; benthic zone – from 40 m to the end of the oxygenated zone. The temperature and pH of surface waters vary between 23-28º C and 8.6-9.2, respectively (Coulter 1994).

1.1.2 Biological Considerations

Lakes Malawi/Nyasa, Victoria and Tanganyika are famous for their endemic species flocks[2]

[2] The term 'species flock' refers to a closely-related group of organisms, descended from a common ancestor, endemic to a geographically circumscribed area and possessing unusual diversity or richness relative to other occurrences of this group.

of cichlid fishes. Lake Malawi hosts a large flock, estimated to include 700+ cichlid fish species (Snoeks 2000). Before the introduction of the predatory Nile Perch, the Lake Victoria cichlid fish species flock included 500+ species (Seehausen 1996). Lake Tanganyika hosts 250+ cichlid species parsed between several subflocks (Snoeks ***et al***. 1994). The African cichlid fish are the largest and most diverse radiation of vertebrates on earth.

However, unlike the other African Great Lakes, Lake Tanganyika also hosts species flocks of non-cichlid fish and invertebrate organisms, including gastropods, bivalves, ostracodes, decapods, copepods, leeches and sponges. Table 1.2 (modified from Coulter 1994) lists the number of species in Lake Tanganyika by taxonomic grouping. The invertebrate species numbers are probably significantly underestimated, as these groups in general have received relatively little attention from taxonomists and in addition, much of the Tanganyikan coast has not been adequately explored. Nonetheless, it is clear that invertebrates in other lakes do not show nearly these levels of diversity. Lake Tanganyika, with more than 2,000 species of plants and animals, is among the richest freshwater ecosystems in the world.

Table 1.2 Inventory of species in Lake Tanganyika (modified from Coulter 1994).

Taxon	# Species	% Endemic
Algae	759	
Aquatic plants	81	
Protozoans	71	
Cnidarians	02	
Sponges	09	78
Bryozoans	06	33
Flatworms	11	64
Roundworms	20	35
Segmented worms	28	61
Horsehair worms	09	
Spiny head worms	01	
Pentastomids (small group of parasites)	01	
Rotifers	70	07
Snails	91	75
Clams	15	60
Arachnids (spiders, scorpions, mites, ticks)	46	37
Crustaceans	219	58
Insects	155	12
Fish (family Cichlidae)	250	98
Fish (non-cichlids)	75	59
Amphibians	34	
Reptiles	29	07
Birds	171	
Mammals	03	
Total:	2,156	

More than 600 of these species are endemic to the Tanganyika Basin, ***i.e***. they are not found anywhere else. This includes a remarkable 98 percent of the cichlid fish species, 59 percent of the noncichlid fish species, 75 percent of the gastropod species, 60 percent of the bivalve species, 71 percent of the ostracod species, 93 percent of the decapod species, 48 percent of the copepod species, 60 percent of the leech species, 78 percent of the sponge species, and others – more than 600 species in all- are unique to the Tanganyika basin (Coulter 1994). It is thought that the proto Lake Tanganyika was colonized by organisms from the ancient Zaire River system (which pre-dates the lake), and these pioneer species evolved and radiated within the lake basin, creating Tanganyika's great diversity (Coulter 1994). In many cases these taxa also represent endemic genera and sometime endemic families. With its great number of species, including endemic species, genera and families, it is clear that Lake Tanganyika makes an important contribution to global biodiversity.

An abundance of species in a large and nearly closed system is bound to produce interesting morphological, physiological, evolutionary, ecological and behavioral patterns. Most biological studies on Lake Tanganyika's faunas fall within five major categories: taxonomy and systematics, biological limnology, fisheries biology, evolutionary biology and behavioral ecology (refer to Coulter 1991 for a review of literature on the Tanganyikan faunas). Below is a brief, selective review of some aspects of Lake Tanganyika's biology. These examples were chosen to illustrate interesting aspects of the Tanganyika system and ways in which this system may help us understand larger biological processes.

It is not only the number of species within the lake which is remarkable, but also the composition and characteristics of this diversity. For example, Lake Tanganyika hosts a species of freshwater jellyfish ***Limnocnida tanganyicae*** (Martens 1883). When it was discovered there were no other known occurrences of freshwater jellyfish. Today, we know of several other examples, but how jellyfish came to live in a virtually closed lake, thousands of kilometers from the nearest ocean, remains one of the lake's great biological mysteries.

In contrast, the absence of cladoceran arthropods (water fleas) from Lake Tanganyika is equally puzzling (Sars 1909). Given the great species flocks of other arthropods in Tanganyika, the presence of at least 20 cladoceran species in associated waters, and the ubiquity of Cladocera throughout inland African waters, the absence of Cladocera in the lake proper is noteworthy. While several authors have speculated that Tanganyika does not offer a suitable food source for Cladocera (Sars 1912; Leloup 1952), others propose that predation by the sardine ***Limnothrissa miodon*** accounts for their absence (see Coulter 1991).

Lake Tanganyika's snails have also created considerable debate. With their thick and ornamented shells that resemble marine species more closely than they resemble other freshwater species, the first biologists that described these organisms did not hesitate to classify them in marine families, genera and species. Early investigators proposed that Lake Tanganyika was once connected to the ocean due to the presence of jellyfish and the marine-like appearance of Tanganyika's snails. This hypothesis was abandoned (Cunnington 1920) when geological evidence failed to support it and biological evidence suggested an association between the Tanganyikan snails and other African freshwater snails which they did not closely resemble in shell form. More recently, researchers (West ***et al***. 1991, 1994, 1996) proposed that the marine-like appearance of the Tanganyikan snail shells had evolved for the same reason biologists put forth to explain the morphologies of marine snail shells: ***i.e***. to protect the snails from shell-crushing

predators (Vermeij 1977). While this is thought to be one of the major forces guiding the evolution of snail shells in marine systems, such a predator-prey coevolutionary relationship between snails and shell-crushing crabs and fish had not been previously documented in freshwater systems.

The Tanganyikan cichlid fish exhibit a variety of unusual behaviors and evolutionary strategies. With so many species packed into a narrow habitat (requiring oxygenated waters and substrate, cichlids are confined to the upper 100 m [in the north] to 200 m [in the south] of water), cichlids have adapted to exploit seemingly any and every available niche. The term 'evolutionary plasticity' has been used to describe cichlid jaws. Cichlid jaws have evolved into many diverse forms and feeding specializations (including: algal scrapers, plankton feeders, deposit feeders, scale eaters, egg eaters, fish eaters, shrimp eaters, and mollusc eaters) and are thought to be a mechanism promoting cichlid diversification (Fryer and Isles 1972; Liem 1974, 1979).

The Tanganyika cichlids confer considerable parental care to their offspring, brooding the fry in their mouths, guarding them in nests or a combination of both (Brichard 1989). Brood parasitism in the endemic catfish ***Synodontis multipunctatus*** offers a bizarre example of feeding and parental care specialization (Sato 1986). The catfish deposits its fertilized eggs at the same time and place as the cichlid host species. The mouth-brooding cichlid species picks up the catfish eggs when she recovers her own eggs and incubates both in her mouth. However, the catfish eggs develop faster and after they have absorbed their yolk sacs, the catfish fry proceed to feed upon the host's eggs and fry. The catfish thus exploit the cichlid hosts for protection and food, and at the same time, they may also destroy the host's entire parental investment!

Predatory fish-feeding strategies have led to other unusual phenomena. For example the ***Perissodus*** species have asymmetrical mouth openings, with some individuals having mouths turned to their right side and others having mouths turned to their left. Fish with the right-sided asymmetry attack the left side of their prey whereas individuals with the left-sided mouths attack their prey's right flank. These two different morphologies are not evenly represented in natural populations. Prey species apparently become habituated to attacks from the dominant morphology, with the result that the rare morphology is the more successful predator. The dominance of right versus left mouth asymmetry in ***Perissodus*** populations oscillated every five years in this, the first field study documenting frequency-dependent natural selection (Hori 1993).

The patterns of genetic evolution in the African cichlids are equally compelling. Genetic variation in the Lake Victoria species flock is extremely low, as the 500+ species are genetically less variable than the human species (Meyer ***et al***. 1990). However in Lake Tanganyika, the ***Tropheus*** lineage, comprised of six species differentiated only by color patterns, shows six times as much genetic variation as the entire Victoria flock (Sturmbauer and Meyer 1992). The Victoria flock shows significant morphological evolution without much molecular evolution whereas the ***Tropheus*** lineage shows considerable molecular diversification without much morphological differentiation. It appears that in the evolution of African cichlids, anything is possible.

While Lake Tanganyika's cichlid species flocks are world famous, six non-cichlid species have drawn even more human interest. Two clupeid (sardine) species and four centropomid species from the genus ***Lates*** dominate the lake's biomass and are the target of the lake's artisanal and industrial fisheries. The sardine species, like their marine relatives, are small, numerous, short-lived and highly fecund. The ***Lates*** species are large predators. All are pelagic fish

(residing offshore), though some species may spend a portion of their lifecycle in nearshore regions. The potential yield of these fish stocks has been estimated at 380,000 – 460,000 tonnes per year, making them an important part of the ecosystem and economy (Coulter 1991).

With its significant fish stocks and its species exhibiting complex, derived evolutionary patterns and behaviors, Lake Tanganyika is a biologically fascinating and complex system. What factors have promoted this? Many hypotheses have been put forward over the years to explain the extraordinary evolutionary patterns in Lake Tanganyika. For example, formation of the rift lakes created vacant ecological niches (which are generally rare on the planet) and it was perhaps the rapid colonization of these empty niches that encouraged the faunal diversification (see West 1997). Or perhaps it was the partitioning of the lake into three basins and the lake level fluctuations prior and subsequent to this time that promoted dispersal and diversification (Verheyen ***et al***. 1996). Also, compared to other freshwater ecosystems, Lake Tanganyika has offered a relatively stable environment, where selective pressures could perhaps advance beyond strategies for survival and reproduction in a fluctuating environment (Cohen and Johnston 1987, West 1997). Intrinsic biological factors, such as reproductive mode, dispersal abilities and trophic specializations have also been implicated (Fryer and Isles 1972, Liem 1974, Cohen and Johnston 1997). While these hypotheses will continue to be debated, it is certain that Lake Tanganyika is an extraordinary biological system and it provides a natural laboratory for investigating a myriad of evolutionary and ecological questions (***e.g***. Michel ***et al***. 1992).

Table 1.3 Socio-economic statistics for Tanganyika's riparian nations
(UNDP, World Bank 2000)

	Burundi	**D.R.Congo**	**Tanzania**	**Zambia**
Population (in millions)	6.7		49.8	32.99.9
Population Growth Rate	2.0%	3.2%	2.4%	2.2%
Population per square km.	249.9	20.6	35.4	12.7%
Life Expectancy at Birth (years)	42	51	47	43
Adult Literacy (% > age 14)	45.8%	58.9%	73.6%	76.3%
School Enrollment (% of school age pop.)	51%	78%	67%	89%
Per Capita GNP (in US$)	$120	$110	$240	$320
Population < Natl. Poverty Line (%)	36.2%	-	51.1%	86%
Population Living on <$1/day (%)	-	-	19.9%	72.6%
Population without access to:				
safe water (%)	48%	32%	34%	62%
health service	20%	-	7%	25%
sanitation	49%	-	14%	29%
Share of income or consumption:				
poorest 20%	7.9%	-	6.8%	4.2%
richest 20%	41.6%	-	45.5%	54.8%
richest 20% - poorest 20%	5.3%	-	6.7%	13%
Human Development Index (of 174)	170	152	156	153

1.1.3 Socio-Political Considerations

The countries of Burundi, Democratic Republic of Congo, Tanzania and Zambia share Lake Tanganyika. Of the lake's shoreline perimeter, 9 percent is in Burundi, 43 percent is in D.R. Congo, 36 percent is in Tanzania, and 12 percent is in Zambia (Hanek ***et al***. 1993).

These four countries are among the poorest in the world. The Human Development Index (HDI), ranked D.R. Congo at #152, Zambia at #153, Tanzania at #156 and Burundi at #170 from a total of 174 countries (UNDP 2000). The HDI is an indexed measure of standard of living (per capita GDP), longevity (life expectancy at birth), and education (combination of adult literacy rates with primary, secondary, and tertiary school enrollment ratios). See Table 1.3 (extracted from World Bank 1999 and UNDP 2000) for relevant indicator statistics for these countries. Life expectancy in Tanganyika's riparian nations averages 42-51 years. Literacy rates range from 45-76 percent. Per capita income ranges from 110-320 US$ per year with significant proportions of the population living below the national poverty lines and at less than $1 US per day. While these statistics are in many cases several years old, they provide a general idea of the socio-economic situation faced by many citizens of the Tanganyika Basin. With the exception of Bujumbura Marie, the lakeside province hosting Burundi's capital, it is frequently the poorest and least developed regions of these poor countries which border Lake Tanganyika.

An estimated 10 million people reside in the Tanganyika catchment (UNDP 1999) representing diverse ethnic groups of predominantly Bantu origins. Many Bantu languages are spoken in the Tanganyika basin. Swahili, a national language of Tanzania and D.R. Congo, but also common in the lake regions of Burundi and Zambia, is the ***lingua franca*** on the Lake for commerce, transport and communications. Dating back to their respective Belgian and British colonial periods, Burundi and D.R. Congo both list French as an official language whereas Tanzania and Zambia similarly list English.

Compared to other regions of these four countries, the Tanganyika Basin is not endowed with significant mineral resources or especially fertile agricultural grounds. This, coupled with its distance from seaports resulted in much of the region being comparatively marginalized during colonial administrations. Except for Burundi which has its capital on the lake, the lakeshore regions of D.R. Congo, Tanzania and Zambia are remote, far from international airports, seaports and their countries' capital cities and economic centers. Except for a few large towns and one city, the basin still lacks basic infrastructure (access, electricity, running water, communications) and little industrialization has taken place.

Population growth rates range from 2.0-3.2 percent in Tanganyika's riparian nations, resulting in a rapid doubling time of 25-30 years (World Bank 1999). Population densities vary considerably in the Tanganyika Basin. In 1999 World Bank statistics, Burundi's population density was estimated at 250 persons per km^2, Congo was 21 persons per km^2, Tanzania 35 persons per km^2 and Zambia 13 persons per km^2. In the Tanganyika Basin, settlements are typically small and concentrated on areas of relatively flat topography. Relief is often steep between them. The main lakeside urban settlements for the four countries are:

- Bujumbura, Burundi (pop: 400,000), a capital city with an international airport and more than eighty industries (paint, brewery, textile, soap, battery etc.);
- Kalemie (population unknown) and Uvira, D.R. Congo (pop: 100,000), Kalemie has some industries and a rail link to other centers in D.R. Congo,

Uvira has cotton processing and sugar production industries but depends heavily on nearby Bujumbura for goods and services;

- Kigoma, Tanzania (pop: 135,000) the largest transit point for goods and people entering/exiting the lake region, with a rail link to other centers in Tanzania;

- Mpulungu, Zambia (pop: 70,000) the seat of the industrial fishing fleets.

These towns are all served by ports, which link people and cargo between Tanganyika's riparian nations. Land-locked Burundi and Eastern Congo in particular, depend heavily on goods coming by rail from Dar es Salaam to Kigoma or by road from South Africa to Mpulungu. Railways link Kalemie and Kigoma to larger economic centers in D.R. Congo and Tanzania, respectively. Mpulungu links to other economic centers in Zambia by a paved and maintained road. Burundi has a good road extending the length of its coastline. Congo has a poor, unmaintained road extending from Uvira to Baraka. Most of the other roads run tangential to the lake and are not well maintained.

At population centers, people are often involved with administration and aspects of international trade between the four countries (***e.g.*** buying/selling goods, providing transport). Outside of these areas, subsistence and small-scale commercial fishing and farming dominate people's livelihoods (Quan 1996, Meadows and Zwick 2000). Most households have diversified into both domains. Commercial fishing activities are controlled by the phase of the moon and the primary gears are lift nets used with catamarans, beach seines, gill nets and lines, though with more than 50 different fishing gears identified in Lake Tanganyika, every niche is exploited (Lindley 2000). Fishermen (women are not involved in harvesting fish) typically begin their activities in the late afternoon and work all night. The catch is processed during the day.

Flat, fertile land in the Tanganyika Basin is extremely limited and most farming occurs on steep slopes or narrow strips of land between the rift escarpment and the lake. The principal crop is cassava, grown primarily for subsistence. Cash crops include oil palm and limited rice, beans, corn and banana production (Meadows and Zwick 2000). Historically, cattle-herding has not been widespread in the basin due to tsetse flies (however, regional insecurities have caused some cattle owners in Burundi and D.R. Congo to move their cattle to nearby lakeside areas). As a result of clearing land for agriculture and fuel-wood demands, there are fuel-wood shortages in many lakeshore villages (Meadows and Zwick 2000).

Riparian governments have designated 'protected areas' (PAs) in several locations bordering the lake. Burundi has two PAs, the Rusizi Natural Reserve (recently downgraded from National Park) and Kigwena Forest; Tanzania has two PAs, Gombe Stream National Park and Mahale Mountains National Park; and Zambia has one PA, Nsumbu National Park. Congo currently has no protected areas along the lake. The Rusizi Natural Reserve is a site of international ornithological interest as it hosts a diverse resident and migrant bird fauna. Gombe Stream and Mahale Mountains National Parks, hosting chimpanzees and other primates, are the sites of the longest-running primate studies. Nsumbu National Park harbors elephants, lions, leopards, gazelles and other game, but in low densities. Both Mahale Mountains and Nsumbu National Parks provide some protection to the lake as their borders extend 1.6 km into the lake. To date, tourism remains relatively undeveloped in this region because of the remoteness, lack of infrastructure, regional insecurities, and competition from other locales.

Refugee movements and wars have ravaged the northern Tanganyika Basin during the last decade. Much of the Burundi and

Congolese coastlines have experienced recurrent fighting and instability, dating back to October 1993 in Burundi and October 1995 in D.R. Congo. Consequently, 100,000 Burundians remain internally displaced while 285,000 have sought refuge in Tanzania. In Congo 700,000 people are internally displaced while 118,000 have sought refuge in Tanzania (UNHCR 2000). Most refugees reach Tanzania via Lake Tanganyika. While some refugees (not reflected in these figures) settle in relatively unpopulated areas along the Tanzanian coast or in villages with family/ friends, many live in camps within the Kigoma region in order to benefit from international assistance. While population movements are concentrated in the Northern Basin, all of Tanganyika's riparian nations have hosted refugees. These population movements have had repercussions on society, the regional economy and the environment. Population movements and ongoing civil wars have also effected the relationship between Tanganyika's riparian states.

Lake Tanganyika is an important resource for its riparian nations. It provides freshwater for drinking and domestic use. Between 165,000-200,000 tonnes of fish are harvested annually from Lake Tanganyika (Reynolds 1999). This represents a significant source of protein in the local diet. Harvesting, processing, transporting and marketing these fish – some of which are sent to markets hundreds of kilometers away in Lubumbashi, the Zambian Copper Belt and Dar es Salaam - provides jobs and livelihoods for more than 1 million people (Reynolds 1999). Finally, the lake serves as an 'international highway' linking people and cargo between the four riparian countries.

1.2 Threats to this Resource

In spite of its unique physiographic setting, contribution to global biodiversity, and its importance as a resource for its riparian nations, Lake Tanganyika faces a variety of threats, including: pollution, sedimentation and over-fishing or fishing with destructive gears. These environmentally destructive activities are a function of the socio-economic conditions of the riparian citizens and countries. This section provides background information on each of these threats as we understood them at the beginning of the project in 1995 (subsequent sections will detail the findings of the project).

1.2.1 Pollution

While the Tanganyika Basin is not nearly as industrialized or populated as other parts of sub-Saharan Africa, pollution is a threat to Lake Tanganyika because the basin's population is rapidly increasing and little legislation exists to protect the environment. Given the lake's fluid medium for transport and that it is a nearly-closed system, with long water residence and flushing times (440 years and 7,000 years respectively), pollution is potentially catastrophic to the lake's water quality, economically important fish stocks and overall biodiversity. Pollution abatement facilities in the basin are extremely limited.

Currently Burundi, with the largest population density and the most industries in the basin, poses the greatest pollution threat. Bujumbura hosts a variety of industries and potential pollution sources within several kilometers of the lakeshore, including: a textile-dying plant, a brewery, paint factories, soap factories, battery factories, fuel transport and storage depots, a harbor and a slaughterhouse, among others. Fuel depots, Kigoma's harbor and electricity-generating facilities, industrialized fishing in Mpulungu, and cotton and sugar processing plants in D.R. Congo present other cases of potential industrial pollution. The wastes from these enterprises typically are not treated before they are discharged and ultimately make their way to the lake. The same is true for domestic waste. Even in highly populated areas, no municipal or household wastewaters are treated before they are discharged. Run-off from agricultural pesticides may also be an

important source of pollution. Mercury and other chemicals used in small-scale gold and diamond mining in the catchment represent other potential lake pollutants. Leaks and accidents in the lake's cargo/shipping industry, executed by a fleet of ancient vessels, is another potential environmental hazard. Finally, although no production is occurring yet, petroleum exploration has been conducted on the Rusizi Plain and the Kalemie Trough while plans for nickel mining in Burundi are well underway. Table 1.4 (modified from Table 3.3, Patterson and Makin 1998) summarizes the various types and sources of pollution identified in the Tanganyika Catchment.

The impact of these various discharges is poorly understood. While Environmental Impact Assessments (EIAs) have not been conducted, some studies suggest that pollution has altered, in some areas, the composition of phytoplankton communities (Cocquyt ***et al***. 1991). As the Tanganyika Basin's population continues to grow we can expect industrial and domestic pollution to grow accordingly.

1.2.2 Sedimentation

Another form of pollution affecting Lake Tanganyika is sediment pollution. Increased deforestation and consequently erosion in the catchment has caused an increase in suspended sediment entering the lake through streams. Increased sedimentation can have a profound negative effect upon biodiversity by altering habitats (e.g. changing rocky substrates to mixed or sandy substrates) and disrupting primary productivity and food webs, thereby leading to a reduction in species diversity.

Cohen (1991) reports that Landsat image analysis revealed that 40-60 percent of original forested land in the lake's central basin, and almost 100 percent in the northern basin, had been cleared, as evidenced by headward erosion, stream incision and gully formation, all features associated with deforestation. Much of this land was probably cleared for fuel-wood, burned and converted for subsistence agriculture or grazing. Analyses of sedimentation rates from ^{14}C dated cores (Tiercelin and Mondregeur 1991) confirmed the high sediment impact in the northern basin with the southern and central basins receiving < 1,500 mm / 1,000 years

Table 1.4 Sources of Pollution in the Tanganyika Catchment
(modified from Patterson and Makin 1998)

Type of Pollution	Sources within the Catchment
Industrial wastewater	>80 industries in Bujumbura, Burundi
Urban domestic wastewater	Bujumbura, Uvira, Kalemie, Kigoma, Rumonge, Mpulungu
Chlorinated hydrocarbons, pesticides	Rusizi Plain, Malagarasi Plain
Heavy metals	North Basin waters from industrial wastes
Mercury	Malagarasi River
Ash residues	Cement processing in Kalemie
Nutrients associated with fertilizers	Rusizi Plain, Malagarasi Plain and other catchments
Organic wastes, sulphur dioxide	Sugarcane refining plant near Uvira
Fuel, oil	Ports, harbor and shipping and boats in all four countries

and < 500 mm / 1,000 years respectively, compared to the northern basin which received about 4,700 mm / 1,000 years. Bizimana and Duchafour (1991) have estimated soil erosion rates in the deforested and steep sloping Ntahangwa River catchment in northern Burundi to be between 20 and 100 tonnes/hectare/year. Increased sedimentation rates are manifested in the lake by sediment inundated rocky habitats, common along the Burundi coast, and prograding river deltas, such as the Rusizi River Delta. The Rusizi River Delta is the major drainage in the northern basin and appears to have increased its outbuilding by an order of magnitude during the past 20 years (Cohen 1991).

The dynamics and behavior of sediment entering the lake are complex and not well understood. It appears, however, that much sediment deposition occurs in the littoral zone, precisely where most of the lake's biodiversity is concentrated. Increased water turbidity as a function of sediment load and sediment deposition thwart algal growth, which may have profound effects upon other components of the foodweb. In studying ostracodes across a variety of habitats that were lightly, moderately or highly disturbed by sediment, Cohen et al. (1993) found that ostracodes from highly disturbed environments (both hard and soft substrate) were significantly less diverse than those from the less disturbed environments with differences in species richness that ranged from 40-62 percent. Species richness for deepwater ostracodes followed the same general pattern, though the differences were not as great. These data suggest that sediment input may have already had an important role in altering ostracod community structure.

1.2.3 Overfishing

Overfishing and fishing with destructive methods are another major threat to Lake Tanganyika's biodiversity. Fishing activities on Lake Tanganyika include: commercial fishing by both industrial and artisanal fishermen, subsistence fishing, and ornamental fish extraction for export.

Each of Tanganyika's riparian nations hosts one or more companies which export ornamental fish to markets in Europe, America and Japan. A variety of fish, predominately cichlids, are targeted by divers and snorkellers, captured alive and exported to aquarium enthusiasts abroad. Though the impact of ornamental fishing has not been studied, the effects on population and community structure could be considerable by the very nature of the work, which is to target rare and exotic species and extract as many as possible because of the high mortality rates in shipping.

Subsistence fishermen primarily target the sardines and ***Lates*** species, though in their efforts they catch and utilize many other species. They operate close to shore, from small canoes, using lusengas (large, conical scoop nets), bottom-set gill nets, beach seines, basket traps and handlines. Oftentimes the lusengas and beach seines are outfitted with small mesh netting, even mosquito netting, which is thought to be especially destructive to stocks, for it catches everything, including juveniles. In addition to disrupting population structure in this way, beach seines are additionally harmful because they drag along the bottom, turning-over the substrate, and thus obliterating food sources and cichlid nests.

Commercial fishermen target the sardine and ***Lates*** species and work further offshore in the pelagic zone. Commercial fishers, both artisanal and industrial, have usually made a significant financial investment in gears and motors to access the pelagic zone. Artisanal fishing relies on canoe-catamarans that use lights to attract fish and deploy lift-nets to collect them. Industrial fishing typically employs 15 m purse seiners and a number of smaller vessels to

attract the fish and deploy seines. Industrial fishing has been limited to a few areas (Bujumbura, Uvira, Kigoma, Mpulungu) which have access to larger markets.

Several studies have suggested that commercial fisheries have already drastically reduced the fish stocks. Burundi once hosted a large industrial fishing fleet, but by the early 1990s they could no longer make a living and all the vessels were dormant or had been sold to companies in Congo or Zambia (Petit and Kiyuku 1995). Pearce (1995) calculates that the fishing effort in Zambia had tripled by the early 1990s and catches had been decreasing since 1985. These efforts have apparently effected the community structure of the stocks in Zambia for initially the catch was 50 percent sardines, 50 percent ***Lates*** (Coulter 1970) whereas since 1986 the catch has been 62-94 percent ***Lates stappersi***. The fishery has evolved from a six-species fishery (two sardines, four ***Lates*** spp.) to a single species fishery (***Lates stappersi***).

In addition to impacting biodiversity by altering population and community structures of fish stocks and food webs, overfishing and fishing with destructive methods have negative repercussions on the socio-economic circumstances of riparian communities through loss of jobs and livelihoods.

1.2.4 People

Ultimately all of these threats to Tanganyika's biodiversity, ***i.e***. pollution, sedimentation and overfishing/destructive fishing practices, are human behaviors. More specifically, they are the behaviors of people who either do not understand the implications for the future of the resource or who do not have any alternatives. Poverty and overpopulation in some areas, combined with lack of environmental education and regional insecurities are the ultimate causes of environmentally damaging behaviors and habitat destruction in the Tanganyika Basin.

CHAPTER 2.

ORIGIN, STRUCTURE and EVOLUTION of LTBP

2.1 History

International Conference on the Conservation and Biodiversity of Lake Tanganyika:

Following a 1989 International Limnological Society workshop on conservation and resource management in the African Great Lakes, a group of scientists concerned with conservation issues at Lake Tanganyika was organized. Their efforts led to the First International Conference on the Conservation and Biodiversity of Lake Tanganyika held at the University of Burundi in Bujumbura, Burundi from 11-13 March 1991. This meeting brought together key individuals from the fields of research, resource management (water, fisheries and agroforestry) and conservation to discuss the current state and the future of the Lake Tanganyika Basin. The 65 participants included scientists, non-governmental organizations (NGOs), natural resource managers and policy makers from Tanganyika's four riparian nations (Burundi, Tanzania, Zaire [now D.R. Congo] and Zambia) as well as technical and scientific experts and donor agencies from eight other countries. The participants were charged with discussing research, immediate to long range conservation goals and formulating specific recommendations and goals for the same.

Among its principal outputs, this meeting identified excess sedimentation, overfishing and pollution as the primary threats to Lake Tanganyika. Most of the 27 presentations addressed the nature and severity of these threats and the state of the system. Working groups on land-lake interactions, underwater reserve development, conservation research, and industrial fisheries/conserving the fisheries resource base made a series of recommendations for safe-guarding the health of the ecosystem.

Based on their findings, the workshop participants expressed grave concern for the future of Lake Tanganyika's unique biodiversity and economically important resources. The conference's proceedings were published by the Biodiversity Support Program (Cohen 1991). Led by Dr. Andrew Cohen (University of Arizona), several conference participants used the ideas expressed therein to form the basis of a proposal for a large-scale regional conservation initiative in Lake Tanganyika. The team then sought to attract the interest of international funding agencies to support this initiative.

The Global Environmental Facility

The Global Environmental Facility (GEF) was created in 1991 to promote cooperation and provide financing for initiatives that address critical threats to the global environment.

In 1992 The Convention on Biological Diversity (CBD) was presented and opened for signature at the UN Conference on the Environment and Development (UNCED) in Rio de Janeiro (this meeting is also referred to as the Earth Summit). The CBD promotes the conservation of global biodiversity through the sustainable use of its components and the equitable sharing of benefits arising from this use. It was also recognized at UNCED that while agreeing philosophically with the CBD, many developing nations would have difficulty putting the principles of the CBD into practice. At UNCED the World Bank

committed funds to GEF to assist developing countries in meeting their obligations as signatories to international environmental agreements, such as the CBD. The GEF is the principal financing mechanism of the CBD.

Since 1991 GEF has invested almost $3 billion US in more than 680 projects in 154 countries. Public and private co-financing for GEF projects is almost $8 billion US, including $2 billion US from developing countries themselves (GEF 2000). The UN Development Program (UNDP), the UN Environment Program (UNEP) and the World Bank all implement projects on behalf of GEF.

GEF was a natural source of funding for a conservation/biodiversity initiative for Lake Tanganyika and was one of the first projects to be approved during the GEF pilot phase. Following the three-year pilot phase, GEF was restructured in 1994 into its current form. GEF currently finances activities that address at least one of four critical threats to the global environment: loss of biodiversity, climate change, degradation of international waters and ozone depletion. Activities addressing land degradation are also eligible for GEF funding. Although originally conceived as a biodiversity initiative, under the current system the Tanganyika initiative corresponded to both GEF's 'Biodiversity' and 'International Waters' focal areas. 'Biodiversity of Coastal, Marine and Freshwater Ecosystems' and 'Waterbody-based Programme' were the relevant operational programmes within these focal areas. The 'Integrated Land and Water Multiple Focal Area' operational programme was also relevant. Following the GEF Council's adoption of the new GEF Operational Strategy, an effort was made to modify the Tanganyika project, making it more consistent with the International Waters portion of the Operational Strategy. These modifications included adopting the Transboundary Diagnostic Analysis and Strategic Action Programmes as principal project activities (Section 3.3.3).

Pollution Control and Other Measures to Protect Biodiversity in Lake Tanganyika:

In late 1991 UNDP/GEF mounted a project appraisal mission to the countries bordering Lake Tanganyika. The mission assessed the interest and canvassed the views of the four riparian governments and other key organizations for a project aimed at assessing the threats to Lake Tanganyika and developing mechanisms to monitor and ameliorate these threats.

By February 1995, after some delay in the approval process, the project document "Pollution Control and Other Measures to Protect Biodiversity in Lake Tanganyika" had been signed by all four riparian countries as well as the funding agency (UNDP/GEF) and the executing agency (UN Office for Project Services [UNOPS]). With this document UNDP/GEF committed $10 million US to a five-year project designed to "improve understanding of the ecosytems function of Lake Tanganyika and the effects of stresses on its lake system, take action to maintain the health and biodiversity of the ecosystem and coordinate the efforts of the four countries to control pollution and prevent the loss of the exceptional diversity of Lake Tanganyika." The governments of Burundi, Tanzania, Zaire (now D.R. Congo) and Zambia are listed as counterpart agencies and committed to in-kind contributions.

In early 1995 the executing agency, UNOPS, opened the "Pollution Control and Other Measures to Protect Biodiversity in Lake Tanganyika" project up for international tender. As a result of this process, a UK-based Consortium consisting of the Institute of Freshwater Ecology (IFE) (now called the Center for Ecology and Hydrology), the Marine Resources Assessment Group (MRAG) and the Natural Resources Institute (NRI) as lead agency was selected as the Implementing Subcontractor. Their contract for $7.8 million US (subsequently amended

to $8.12[3] million US) to implement the project took effect 7 August 1995. Early in the project, the name Lake Tanganyika Biodiversity Project (LTBP) became a popular abbreviation for the full project title, "Pollution Control and Other Measures to Protect Biodiversity in Lake Tanganyika."

2.2 Project Objectives

The project's ultimate objective, as stated in the Project Document, was:

> ***to demonstrate an effective regional approach to control pollution and to prevent the loss of the exceptional diversity of Lake Tanganyika's international waters. For this purpose, the development objective, which has to be met, is the creation of the capacity in the four participating countries to manage the lake on a regional basis as a sound and sustainable environment.***

In developing the project's logical framework during the Inception Workshop, this objective was summarized into the definitive project purpose: ***A Coordinated Approach to the Sustainable Management of Lake Tanganyika.***

This larger development objective was broken down into six immediate objectives, each with its own list of outputs and activities (Project Document). The six immediate objectives were to:

- establish a regional long term management programme for pollution control, conservation and maintenance of biodiversity in Lake Tanganyika;
- formulate a regional legal framework for cooperative management of the lake environment;
- establish a programme of environmental education and training for Lake Tanganyika and its basin;
- establish tested mechanisms for regional coordination in conservation management of the Lake Tanganyika basin;
- produce a comprehensive strategic plan for long-term application to be based upon the results of a series of special studies aimed at improving the understanding of the lake as a whole. Information derived from these studies is fundamental in the development of long-term management strategies and will in some cases provide the baseline and framework for long-term research and monitoring programmes;
- implement sustainable activities within the Lake Tanganyika Strategic Plan and incorporated environmental management proposals.

The Project Document also recognized that successfully achieving these objectives depended upon the participation of a wide range of stakeholders.

A Project Inception Workshop, marking the end of the literature reviews and baseline studies and the beginning of regional activities, occurred in March 1996. This workshop brought together, for the first time, members of the UK-based consortium and a variety of stakeholders from the four countries, including scientists, NGOs and policy makers. The Inception Workshop delegates scrutinized the project's immediate objectives, outputs, activities and framework. Preliminary workplans were also created.

2.3 Project Structure

The project had a complex, multi-tiered structure, Figure 2.1. It should be noted that the organogram depicted in Figure 2.1 was modified from earlier versions published in project documents. It was revised with hindsight to reflect the organs, order and r

[3] The difference, $1,319,068 (operational budget of $9,440,609 less the $8,121,541 contract to the NRI consortium), was used to finance the interagency agreement with FAO for lake ciruculation studies, related vessel leasing expenses, mid-term and final evaluations, translation and reporting, and monitoring expenses (UNDP and UNOPS participation atTripartite Reviews and Steering Committee meetings).

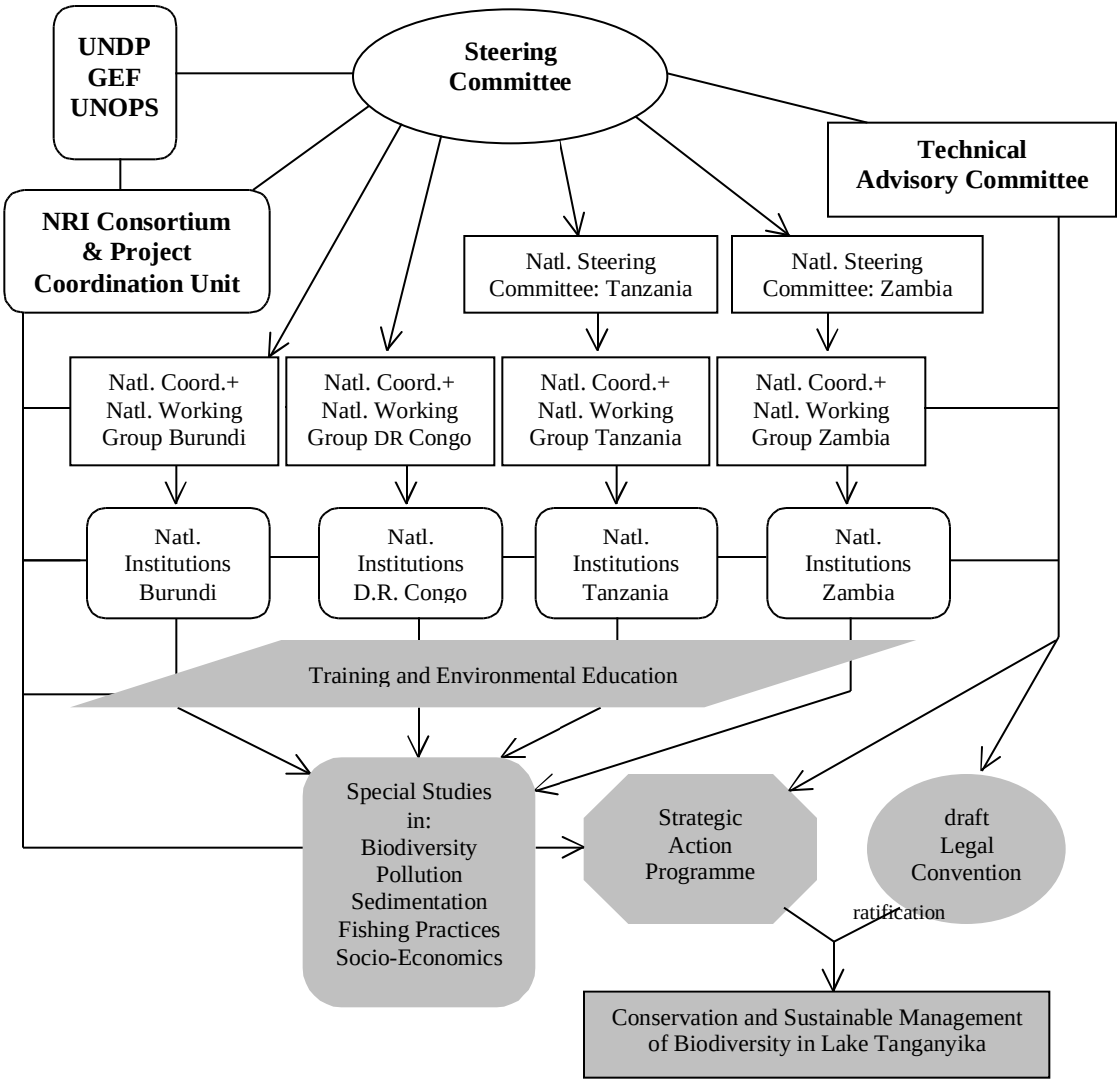

Figure 2.1 Organogram for the Lake Tanganyika Biodiversity Project.
Organs are listed in outlined shapes, those in bold type had a regional mandate. Grey shapes represent components of LTBP, with the grey outlined shape representing the main LTBP objective.

relationships established during the project. Key organs of LTBP included: the regional Steering Committee; the Technical Advisory Committee; National Steering Committees in some countries; National Coordinators and National Working Groups; National Institutions; Biodiversity, Pollution, Sedimentation, Fishing Practices and Socio-Economic Special Studies teams in the four countries, Training and Environmental Education Components, the Project Coordination Unit, the Implementing Subcontractor (NRI Consortium), the executing agency (UNOPS) and the donor agency (UNDP/GEF).

The regional Steering Committee (SC) consisted of the National Coordinator and three senior civil servants from each country representing ministries of the environment, natural resources, development and other sectors. The Project Coordination Unit (PCU) and UNDP were also represented on the SC. The SC was responsible for: providing overall direction to the project, reviewing project progress, directing and decision making on policy matters and approving future planning. A regional Technical Advisory Committee (TAC), consisting of technical experts from agencies actively involved in the project (e.g. fisheries,

parks, water, universities), supported the SC, providing guidance on implementing the technical studies and drafting the Strategic Action Programme (SAP).

Tanzania and Zambia elected to have formal National Steering Committees with senior representatives from relevant ministries directing project activities in their countries. In Burundi and D.R. Congo, the National Working Groups (NWGs) fulfilled this role. In all four countries, the National Coordinator (NC), who in each case was a senior representative from the lead agency for conservation and the environment (Table 2.1), led the NWG. The NWG, consisting of 8-12 members drawn from the participating national institutions and stakeholder groups, guided the implementation of the technical programmes in each country and through a consultation process established their national priorities for the SAP.

The project included a large technical programme to support the development of the SAP. This programme consisted of scientific studies in biodiversity and the threats to it, namely: pollution, sediments, fishing practices as well as socio-economic conditions around the lake. Training and environmental education programmes supported these studies. These programmes will be developed in Section 3.2

In addition, the NRI Consortium furnished the Project Coordination Unit (PCU) consisting of the Project Coordinator (PC), Scientific Liaison Officer (SLO) and support staff. The PCU administered and facilitated all regional activities, with the PC tending to the management aspects and the SLO tending to the technical programme. The NRI Consortium also provided technical expertise in the form of special study leaders and facilitators in the areas of: biodiversity (MRAG), pollution (IFE), sedimentation (NRI), fishing practices (MRAG), socio-economics (NRI), training and EE (NRI with subcontracts to consultants), strategic planning (NRI) and

Table 2.1 Lead Agencies and National Coordinators for LTBP

Lead Agencies and National Coordinators	
Lead Agency in Burundi:	National Institute for the Environment and Conservation of Nature
National Coordinator:	Dr. Gaspard Bikwemu (1995-1997) Jean-Berchmans Manirakiza (1997-1999) Boniface Nykageni (1999-2000) Jérôme Karimumuryango (2000)
Assistant National Coordinator:	Gabriel Hakizimana
Lead Agency in D.R. Congo:	Dept. for Management of Renewable Natural Resources
National Coordinator:	Mady Amule
Assistant National Coordinator:	Dr. Nshombo Muderhwa
Lead Agency in Tanzania:	Division of the Environment
National Coordinator:	Rawson Yonazi
Assistant National Coordinator:	Hawa Msham
Lead Agency for Zambia:	Environmental Council of Zambia
National Coordinator:	James Phiri
Assistant National Coordinator:	Munshimbwe Chitalu

the legal convention (MRAG with subcontract to ***En***Act). These consortium members were responsible for developing regional workplans, coordinating activities, contributing to the SAP process, and producing the final outputs for their studies or programmes.

2.4 Chronology of LTBP

The Lake Tanganyika Biodiversity Project (LTBP) experienced its share of difficulties in implementation. Replacement of key personnel, both within the implementing consortium and within the four countries, caused inevitable delays. Frequently-changing security conditions delayed and constrained project activities in Burundi and D.R. Congo throughout much of the project. And a major lesson we learned is that establishing infrastructure and human capacity should not be underestimated. It takes a great amount of time. These factors caused delays in implementation.

During the first Transboundary Diagnostic Analysis (TDA, Lusaka, November 1998), delegations objected to establishing environmental priorities without all the data in hand from the special studies. While it would have been ideal to have completed the special studies before beginning the process of establishing environmental priorities, the project was forced to conduct the research and strategic planning processes simultaneously due to the delayed start of the special studies. However a special effort was made in the final TDA (Arusha, March 2000) to incorporate the findings of the special studies.

Table 2.2 provides a chronology of LTBP management activities. Additional information on management activities can be found in the 17 quarterly progress reports, the minutes and reports associated with the various management meetings, and other project documents, which are available at http://www.ltbp.org/PDDGEN.HTM

Table 2.2 Chronology of key LTBP activities

Date	Activity
October 1993	UNDP approves the Project Document
7 August 1995	Official start date of contract between NRI and UNOPS for implementation
November 1995	PC and SLO establish offices in Dar es Salaam and Kigoma, respectively
January 1996	Production of the Baseline Reviews for Special Studies
March 1996	Inception Workshop
8 August–3 September 1996	Institution and resource assessment, mobilization mission by special studies
19-20 September 1996	1st Meeting of the Project Steering Committee
14-18 September 1997	Meeting in Bujumbura to launch technical programmes in francophone countries
22 September–3 October 1997	Research Methods Training Workshop in Kigoma to launch technical programmes in the anglophone countries
19-20 January 1998	1st Tripartite Review, 2nd Meeting of the Project Steering Committee
June 1998	SLO moves her office to Bujumbura
12-13 August 1998	3rd Meeting of the Project Steering Committee
October 1998	Facilitators have mobilization tour & begin at their lakeside posts
1-29 November 1998	LTBP undergoes mid-term evaluation
23-27 November	Initial Transboundary Diagnostic Analysis
16 December 1998	Project personnel regain access to D.R. Congo after six months of insecurity
25-27 May 1999	4th Meeting of the Project Steering Committee and 2nd Tripartite Review
22 August 1999	Inauguration of renovated Centre de Recherche en Hydrobiologie, D. R. Congo
24-27 August and 30 August–3 September 1999	Workshop to draft the legal convention, anglophone countries, followed by a workshop to draft the legal convention for the francophone countries
21 October 1999	LTBP expatriate personnel evacuated from Burundi following an upgrade to UN phase IV security rating which persisted until April 2000.
1-5 November 1999	Regional legal workshop to discuss the draft Legal Convention
2-3 December 1999	5th Meeting of the Project Steering Committee
4-7 January 2000	Regional workshop to draft the SAP
27-30 March 2000	Final Transboundary Diagnostic Analysis
1-3 May 2000	Final meeting to draft the SAP
4-5 May 2000	6th Steering Committee Meeting: presentation of the SAP and Convention
May 2000	LTBP undergoes final evaluation
12 July 2000	Conference 'Lake Tanganyika – Investment for a Sustainable Future' Nairobi
13 July 2000	7th Steering Committee Meeting, 3rd Tripartite Review in Nairobi
31 July 2000	Official Project Termination Date

CHAPTER 3.
IMPLEMENTATION and OUTPUTS of LTBP

3.1 Capacity-Building and Training

One of LTBP's primary objectives was to increase the capacity for the riparian governments and national institutions to monitor and manage Lake Tanganyika's resources. LTBP special studies leaders conducted an extensive tour of the four countries (8 August – 3 September 1996) to forge partnerships with national institutions that were potential LTBP collaborators. At the same time, the team was assessing the human and material needs of these institutions to study and monitor the lake and its environment (Allison et al. 1996). A series of training strategies followed (Moreau 1997, Garnett 1997, Willoughby 1997, Roland and Trudel 1998). Based on these assessments, LTBP undertook a variety of initiatives to increase material, human and institutional capacities in the four countries.

3.1.1 Material Capacity Building

Material capacity building in the form of refurbishments, equipment acquisition and other infrastructural provisions were also needed at the riparian stations in order to realize the project's technical programs. Allison et al. (1996) identified many of the principle technical needs at the lakeside stations. Individuals from collaborating institutions in the four countries identified others.

Infrastructural improvements included the provisionment of: communications equipment, vehicles, computers, building refurbishments, boat refurbishments, laboratory equipment, scientific literature etc. Table 3.1 summarizes some of the major material contributions. Varying circumstances in the four countries dictated different needs and strategies. For example, the lack of line-based telephone service in Uvira throughout the project prevented conventional email and

Table 3.1 Material resources and infrastructure provided by LTBP

Provisionments	Burundi	D.R. Congo	Tanzania	Zambia
Laboratory renovations		X	X	X
Research vessel refurbishment			X	X
Laboratory equipment	X	X	X	X
Computers and printers for stations	X	X	X	X
Email connections	X		X	X
HF radio installations*			X	X
VHF radio installations	X		X	X
Cellular phone links		X		
Fiberglass/inflatable work boats + motors	X	X	X	X
SCUBA equipment	X	X	X	X
Back-up power source		X	X	X
Computer and printer for Natl. Coord.	X	X	X	X
4WD Field Vehicles	X	X	X	X

***** The prevailing security conditions in Burundi and D.R. Congo did not allow the project to obtain HF radio frequencies for these stations.

fax connections. Consequently the Uvira station was equipped with a cellular telephone to maintain links to the other project centers.

Burundi with its capital on the lakeshore, already hosted numerous well-equipped national institutions to carry out the technical studies. Consequently, rather than creating redundant facilities, the project reinforced existing laboratories and made equipment purchases targeted to their specific needs. In D.R. Congo, Tanzania and Zambia, however, most of the lakeside fieldwork was conducted from a single institution within each country, the Centre de Recherche en Hydrobiologie (CRH), Tanzania Fisheries Research Institute (TAFIRI) and Department of Fisheries (DOF), respectively. Unlike Burundi, these institutions were rather remote stations within their countries and required significant improvements before the technical studies could be initiated. Laboratory renovations in these facilities included: laboratory benches, microscopes, centrifuges, refrigerators, freezers, glassware, reagents and other consumables. The historic CRH building, in addition to basic laboratory provisionments, required a new roof, plumbing and electrical fittings to render it operational.

CRH building renovations were suspended several times due to deteriorated security conditions. Although renovations were completed late in the project, August 1999, some of the technical programs had functioned nonetheless. Renovations and installations at the TAFIRI and DOF stations were largely completed by January 1998. With these renovations and installations in place, LTBP's technical programs could begin.

3.1.2 Human Capacity Building and Training

The training component of LTBP was complicated by the fact that in the project document training was linked to environmental education (objective 3: "the project will establish a programme of environmental education and training for Lake Tanganyika and its basin") whereas in the project budget, environmental education had been linked to the socio-economic study as both programmes were targeting the riparian communities. Furthermore all of the technical studies had training components to them. This meant that for some years perceptions of who LTBP training was targeted to varied considerably depending on who one asked, and included: fishing and farming communities, primary through post-graduate students, scientists and technicians, project staff, park wardens, natural resource managers and government officials.

The training strategy went through several incarnations during the project's life (Moreau 1997, Garnett 1997, Willoughby 1997), culminating in the adoption and implementation, in large part, of the training strategy developed by Roland and Trudel (1998). Roland and Trudel conducted a detailed Training Needs Assessment (TNA), based on more than 100 interviews with stakeholders at the riparian capitals and lakeside stations. They identified the following priority training needs:

- Training of Trainers (TOT) and Communication Skills for project affiliates who were training others and/or working with lakeside communities,
- Creating a multidisciplinary team at the lakeshore to relate and translate special studies findings for non-scientists,
- Training in project management and conflict management skills for the training officers and other project affiliates,
- Training in environmental issues specific to Lake Tanganyika.
- Specialized technical training (in country or abroad).

Table 3.2 LTBP Training Activities
BD=Burundi, CO=D.R. Congo, TZ=Tanzania, ZM=Zambia

DATE	PARTICIPANTS	TITLE of TRAINING	LOCATION	TRAINING LEADER(S)
Jan 97		Training Needs Assessment	Tanzania	S. Garnett
Jan-Feb 97	local officials	PRA Training Workshop	Mpulungu, ZM	P. Townsely
April 97		Training Needs Assessment	Kinshasa, CO	J. Moreau
on the job	FPSS teams: 6 Tanzanians, 5 Zambians	Fishing Practices Methods	Kigoma, TZ & Mpulungu, ZM	P. Petit
6-8 May 97	80 Local Stakeholders	Stakeholders Workshop	Mpulungu, ZM	S. Nsongela P. Chipungu
May-June 97	EE leaders in Tanzania & Zambia: S. Nsongela, B. Tarimo, J. Wakibara, D. Sellanyika	'Awareness to Actions' Environmental Education Methods	ICCE, UK	P. Vare, ICCE
June, 97	Local drama groups	Drama group training	Mpulungu, ZM	P. Vare ICCE
Sept-Nov 97	4 Burundians, 4 Congolese 3 Tanzanians, 4 Zambians from lakeside institutions	Dive training & under-water survey methods	Kigoma, TZ	3 Frontier Trainers
June-Sept 97	local officials, TZ	PRA methods	Kigoma, TZ	S. EvisonC. Mung'ong'o
Sept 97	18 scientists from TZ, ZM	Introduction to GIS	Kigoma, TZ	J. Rutter
Sept 97	18 scientists from TZ, ZM	Joint SS Training Workshop	Kigoma, TZ	C. Foxall, E. Allison, T. Bailey-Watts, R. Bills, R. Duck, K. Martens, K. West
Sept-Oct 97	8 Tanzanians from NGOs	SE/EE Methods Workshop	Kigoma, TZ	S. Evison, C. Mung'ong'o
Nov. 97	5 Tanzanians from the Nat. Meteorological Training School	NOAA/LARST Satellite Syst. Data Capture & Processing	Kigoma, TZ	R. Loftie
on the job 98-99	Tanzanian POLSS team 8 members	Pollution Study Methods	Kigoma, TZ	F. Chale
98-99	SEDSS participant, E. Msaky	Pollen Analyses	U Arizona, USA	A. Cohen
June-July 98	11 university students from BD, CO, TZ, ZM	Nyanza Project: training in the geology, limnology, biology of African Lakes		Plisinier, C. Scholtz, G. Ntakimazi
June-July 98	16 Biologists from BD D.R. Congo	BIOSS Methods & Training Workshop	Bujumbura, BD	L. DeVos, M. Gashagaza, K., Martens, E. Allison, K. West
98-00	SEDSS participant, C. Rubabwa	M.Sc. in hydrology	Univ. of Dar TZ	H. Nkotagu & others

Table 3.2 LTBP Training Activities (continued)
BD=Burundi, CO=D.R. Congo, TZ=Tanzania, ZM=Zambia

DATE	PARTICIPANTS	TITLE of TRAINING	LOCATION	TRAINING LEADER(S)
Jan 99	4 NTCCs & 4 colleagues from BD, CO, TZ, ZM + SS facilitators	Workshop to Establish Training & EE Program	Bujumbura, BD	R. Roland M. Trudel
Feb-Mar 99	8 biologists from BD, CO, TZ & ZM	Dive Training & Underwater Research Methods	Kigoma, TZ	C. Furrer + others
8-19 Mar 99	24 biologists from BD, CO, TZ & ZM	Taxonomic Training	Kigoma, TZ	G. Ntakimazi, M. Nshombo, K. West
March 99	4 TECCs & 4 colleagues from BD, CO, TZ, ZM	Workshop for EE Programme Development	Kigoma, TZ	M. Trudel
July 99	4 TECCs & 8 colleagues from BD, CO, TZ, ZM	Training of Trainers & Communications Skills Workshop	Bujumbura, BD	R. Roland M. Trudel
July-Aug 99	12 university students from BD, CO, TZ, ZM	Nyanza Project: training in the geology, limnology, biology of African Lakes	Kigoma, TZ	A. Cohen, K. Lezzar, E. Michel, P.D. Plisinier, G.Ntakimazi
Nov 99	8 socio-economists from BD, CO, TZ & ZM	SESS Programme Development Workshop	Kigoma, TZ	K. Meadows, K. Zwick
2-6 Feb 00	8 pollution specialists from BD, CO, TZ, ZM	Methods for the Industrial Pollution Inventory	Kigoma, TZ	C. Foxall, O. Drieu
14-25 Feb 00	7 specialists from BD, CO, TZ, ZM	Introduction to the LTBP GIS & Metadatabases	Dar es Salaam, TZ	A. Mills V. Obsomer
Feb 00	TECC teams, BD, CO, TZ, ZM	Follow up & monitoring visit with specialized EE training	Kigoma, TZ Mpulungu, ZM	M. Trudel R. Roland
Feb 00	7 biologists from BD, CO, TZ, ZM	BIOSS database training & data analysis workshop	Kigoma, TZ	E. Allison, R. Paley, P. Ndamama
July-Aug 00	12 university students from BD, CO, TZ, ZM	Nyanza Project: training in the geology, limnology, biology of African Lakes	Kigoma, TZ	A. Cohen, K. Lezzar, E. Michel, P.D. Plisinier, G.Ntakimazi

On the basis of these priority training needs, they developed a training strategy (Roland and Trudel 1998) which emphasized the achievement of LTBP goals and objectives through the appropriate training of key stakeholders. Their strategy encouraged training which brought the project's different groups together and which brought participants from the four countries together, with the aid of bilingual trainers, for training sessions that were short-term, practical and participatory in nature.

The training strategy was hindered because the project was not able to appoint a regional facilitator for training, as recommended by Roland and Trudel (1998) and the project had completed or committed to much of its training before the training strategy and national Training Education and Communications Coordinators (TECCs) were in place. Nonetheless, the TECCs, working with the international consultants, advanced the training process through a series of workshops designed for training and environmental education needs. In these

workshops they established national training and environmental education programs, from TNAs to proposal writing to implementing activities, and developed the skills to execute their programs. Between workshops and field visits, the international consultants for training and environmental education provided technical support through emails to the TECC teams, helping them refine and focus their activities. These activities, and other LTBP sponsored training activities, are summarized in Table 3.2.

In addition, each special study had significant on-the-job training for its technicians. These training activities included: learning river gauging techniques, participating on sediment coring expeditions, learning fish species identifications, mastering water-quality monitoring techniques, writing proposals, learning techniques for rapid rural appraisals and other socio-economic methods, organizing fieldwork and managing field budgets. Special study facilitators recruited by LTBP had training responsibilities in their terms of reference and on-the-job training was one of the principal tasks in their day-to-day contact with the special studies teams.

3.2 Technical Programmes

A series of technical programmes formed the basis of the Lake Tanganyika Biodiversity Project (LTBP). These included: special studies in biodiversity, pollution, sedimentation, fishing practices, and socio-economics which were designed to collect data on the current state of biodiversity in Lake Tanganyika and the threats against it to inform and aid the development of the Strategic Action Programme (SAP); an environmental education programme designed to feed back information on sustainable use and conservation of Lake Tanganyika's resources to local communities; the SAP which provides a prioritized list of management interventions to ensure the sustainable use and conservation of Lake Tanganyika; and finally, a draft Legal Convention which binds the four countries in a legal agreement to sustainably manage and conserve Lake Tanganyika. Figure 3.1 is a schematic diagram depicting the relationships between these studies. Section 3.2 describes the objectives and outputs of these different programmes and special studies.

3.2.1 Biodiversity Special Study

The Biodiversity Special Study (BIOSS[4]), one of the five special studies to advise the SAP process, collected and synthesized information on the state of Lake Tanganyika's biological resources. As such, BIOSS underpinned the threat-based special studies (pollution, sedimentation, fishing practices) which were trying to assess the impact of various threats on Lake Tanganyika's biodiversity.

3.2.1.1 Objectives and Strategy

LTBP's overall objective was to establish a 'regional long-term management program for pollution control, conservation and maintenance of biodiversity in Lake Tanganyika' (Project Document 1993). Recognizing that 'biodiversity' means different things to different project stakeholders, BIOSS took the lead in facilitating discussion about the term and promoting the definition from the Convention on Biological Diversity (UNEP 1994) that biological diversity or biodiversity is the

> ***"variability among living organisms from all sources including inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems"***

[4] Within the UK-based consortium, MRAG had responsibility for the management of BIOSS and subcontracted a researcher from the School of Development Studies at the University of East Anglia to lead the technical aspects of the study.

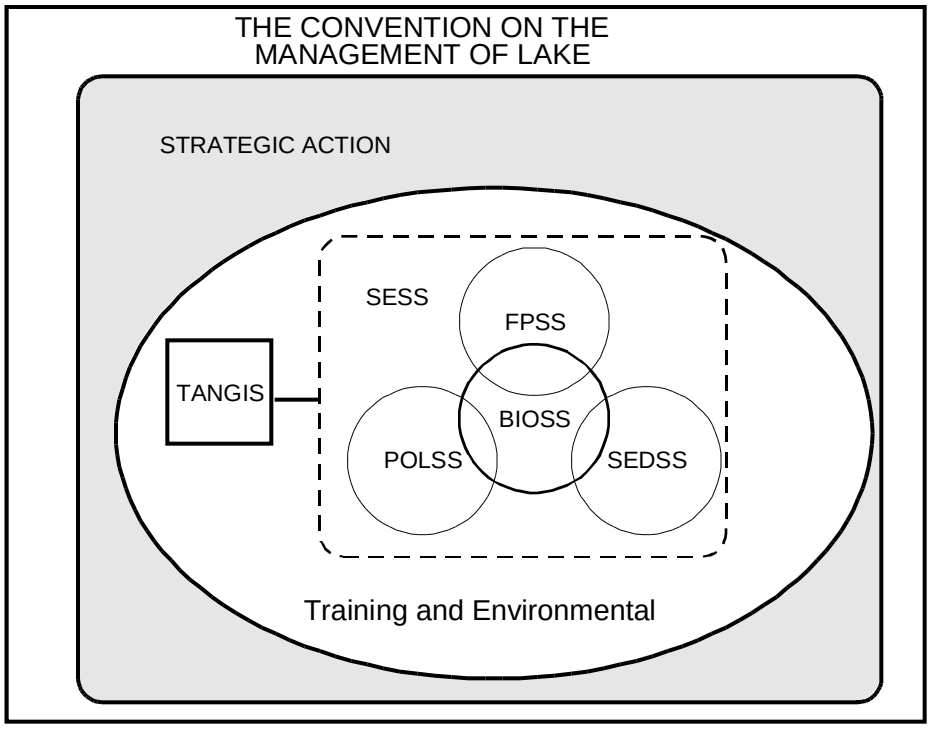

Figure 3.1 Relationships between the various technical components of LTBP (Allison *et al*. 2001)

Allison (1998) produced a useful 'Aide-Memoire to the Convention on Biological Diversity and the Global Environmental Facility,'(http://www.ltbp.org/FTP/CBD.PDF) which served a range of LTBP stakeholders, from special studies technicians to the Steering Committee, as a key document which described LTBP's role in fulfilling the riparian nations commitment to the Convention on Biological Diversity (CBD) and the Global Environmental Facility (GEF).

In addition to facilitating project-wide discussion on biodiversity issues, BIOSS developed a research program to collect and archive information on Lake Tanganyika's biodiversity. From scientific publications dating back to the mid-nineteenth century to the First International Conference on the Conservation and Biodiversity of Lake Tanganyika in 1991, scientists from all over the world have recognized that Lake Tanganyika is an extraordinarily rich and diverse ecosystem. While Lake Tanganyika's exceptional biodiversity is well-accepted, our knowledge about this biodiversity (what is it? where is it? how is it distributed?) is varied and scattered through the literature. Consequently, one of BIOSS' first objectives was to review current levels of biodiversity in Lake Tanganyika from the literature. Other objectives were to: identify the distribution of major habitat types in the lake, with particular focus on existing and suggested protected areas; suggest priority areas for conservation based on existing knowledge and additional survey work where necessary; and develop a sustainable biodiversity monitoring programme. With guidance from international consultants, BIOSS assembled, trained and fostered the development of a regionally integrated team with the capacity to collect, archive and conduct limited analyses of biodiversity data to address these objectives.

3.2.1.2 Products

BIOSS was a technical, process-oriented study with a variety of outputs that included: aquatic survey methodologies, trained teams, databases, and scientific reports. Cowan and Paley (2000) described the BIOSS process in detail and provided an overview of the

BIOSS' achievements and outputs. All of the BIOSS reports are available on the LTBP web site [http://www.ltbp.org/PDD1.HTM]

3.2.1.2.1 Methodology

Biodiversity assessment is a relatively new science, and most of the methodologies and protocols were developed for ecological settings that were very different from Lake Tanganyika. Consequently, BIOSS devoted considerable time and energy to developing aquatic biodiversity survey methodologies appropriate for the Tanganyika setting. The Tanganyika setting encompasses a diverse range of habitats, including rocky, sandy and/ or mixed substrates along steep or gradual slopes. In addition to accommodating these variables, methodologies had to be developed for sites where researchers could not enter the lake, owing to localized populations of crocodiles and hippopotami. Procedures and methodologies were modified throughout the life of the project based on scientific and practical considerations raised during on-going field-testing. These procedures, with discussion and justification, are detailed in Allison et al (2000). They represent the first comprehensive attempt to survey components of the lake's biodiversity in a standardized, quantitative and replicable manner using SCUBA (self-contained underwater breathing apparatus). In a project involving numerous scientists from the four riparian nations and the larger international scientific community, the importance of standardizing procedures and documenting them cannot be overemphasized. To this end, Allison et al (2000) will serve as an important resource for training new team members and developing additional protocols.

Biodiversity inventories seldom sample the entire biota. Owing to the rudimentary taxonomy for many Tanganyikan groups and the considerable effort in training BIOSS survey participants in taxonomy and methodology, BIOSS selected two groups, fish and molluscs, to serve as total biodiversity surrogates (TBS). Fish and molluscs have the advantages of being relatively: diverse, wide-spread, well-known taxonomically, and easy to survey (abundant, noncryptic). These groups also complement each other as fish are mobile vertebrates and molluscs are sedentary invertebrates.

Biodiversity Surveys begin with a site assessment by the BIOSS team and coarse-scale mapping of coastline and littoral to shallow sublittoral zone habitats with a manta tow survey. This underwater mapping provides habitat and substrate information and the necessary data for selecting sites for detailed biodiversity surveys. Once the sites for detailed surveys are selected, BIOSS team members conduct the following surveys using SCUBA:

- Fine scale habitat mapping at survey site (0-15 m depth). Including data on substrate profile, inclination, type and other characteristics. Detailed substrate and profile maps of survey sites are created from this data.
- Mollusc biodiversity survey (15, 10, 5, 0 m depth)
- Stationary Visual Census (SVC) for fish (15, 10, 5, 0 m depth)
- Rapid Visual Census (RVC) for fish (15, 10, 5, 0 m depth)
- Gillnet survey for fish (10 m depth)

The rationale and procedures for these methods are fully explained in Allison ***et al***. 2000, a detailed field-guide for BIOSS teams and others interested in surveying Tanganyika biodiversity. At sites where divers cannot enter the lake because of crocodiles or hippopotami, BIOSS teams conducted limited surveys of the habitats, molluscs and fish using grab samplers, dredges and gillnet surveys. In addition to biodiversity surveys, these procedures also form the basis of the BIOSS monitoring programme for biodiversity.

3.2.1.2.2 Human Capacity

In addition to developing methods for assessing biodiversity in Lake Tanganyika, another principle output of the BIOSS was a regionally integrated team with skills to conduct biodiversity surveys. Developing this team was a long process requiring training inputs in a variety of specialties including: SCUBA diving, biological and ecological survey methods, taxonomy of the Tanganyikan biota, logistics planning, data management and analysis and reporting.

At two bilingual training courses, 21 divers from lakeside institutions in the four countries were trained to dive, gaining either BSAC or PADI certification. Once dive-certified, these BIOSS team members fully participated in the development and field-testing of the biodiversity survey methods outlined in section 3.2.1.2.1. Even though BIOSS limited its surveys to fish and molluscs as indicators of total biodiversity, these groups still include over 400 different species that team members had to learn to identify. Several taxonomic training sessions for fish, molluscs and invertebrates were conducted to enable team members to conduct surveys. During the BIOSS surveys all team members gained practical experience in logistics. The planning and organization for mobilizing teams of up to 24 researchers from four countries to remote sites lacking electricity, food and fuel provisions for weeks at a time was enormous. Finally, while all BIOSS team members gained experience in collecting and managing data, subsets of the team participated in data analysis and report writing. The result of these efforts is a network of lakeside researchers with a history of shared training and research experience that form a regionally integrated BIOSS team.

3.2.1.2.3 Databases

Two Microsoft Access Databases were developed as a part of BIOSS. The first was a literature database created in order to fulfil the BIOSS objective to 'review current levels of biodiversity in Lake Tanganyika.' The literature, encompassing almost 150 years worth of biological research on Lake Tanganyika, is diverse and scattered throughout the world. Some of this information does not even reside in Tanganyika's riparian nations. BIOSS made a priority of centrally compiling information on species locations and ranges, among other data, in a database. The database is designed to be queried and to interact with the LTBP Geographical Information System (GIS) so that natural resource managers and planners can make informed decisions based on current knowledge of species distributions as they plan for the management and conservation of Lake Tanganyika's biodiversity. At the end of the project, this literature database contained 3,473 species-location entries from 144 references. It is hoped this literature database resource will continue to grow and serve as a clearing-house of biological information about Lake Tanganyika. It is distributed to key institutions in the region and available through the Marine Resources Assessment Group (MRAG) in the UK [http://www.ltbp.org/BIODB.HTM].

In addition to the literature database, BIOSS also developed a survey database to archive and manage all data collected on habitat, mollusc and fish diversities according to the methodologies described in section 3.2.1.2.1. This includes all data collected by BIOSS teams during the life of the project and allows for analyses on national, regional or lakewide scales. The survey database interacts with the literature database and the LTBP GIS. This is the first comprehensive set of taxonomic data that has been produced on a lakewide scale according to standardized procedures; all data have also been transferred to the literature database. Queries of this database on habitats, species richness and diversity form the basis for the BIOSS technical reports (section 3.2.1.2.4) and

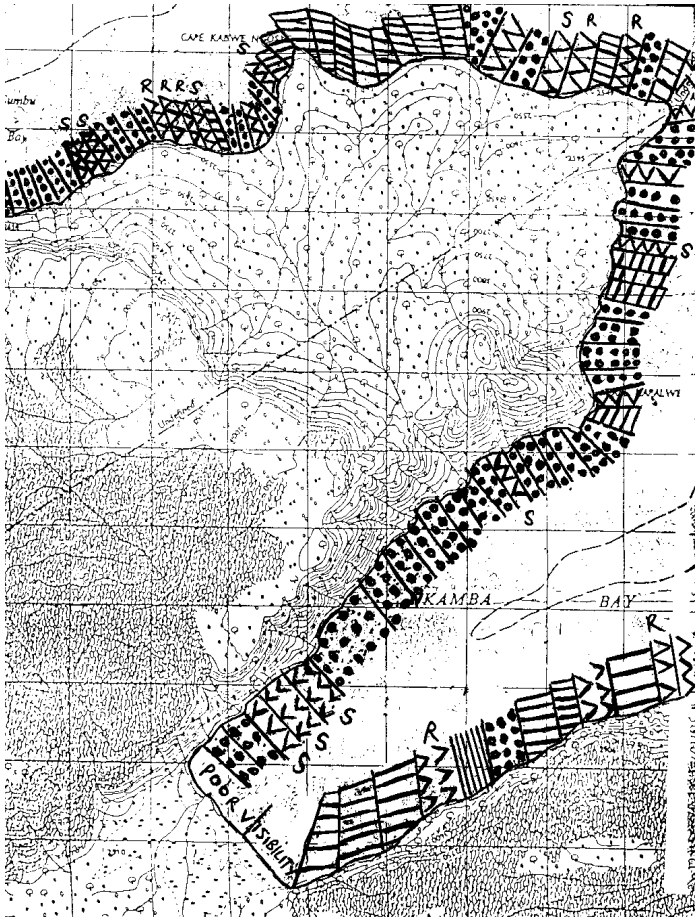

Figure 3.2 Sample littoral zone substrate map derived from manta survey of Nsumbu NP (Paley and Sinyinza 2000)

advice to the Strategic Action Plan (Allison ***et al*** 2000 and section 3.3.2.1).

3.2.1.2.4 Biodiversity in Lake Tanganyika

This section considers the technical results of BIOSS. Because of its mandate to provide information on protected areas and conservation in Lake Tanganyika, much of the BIOSS survey efforts were concentrated in the waters adjacent to national parks (NPs) or protected areas (PAs). However additional survey work and the BIOSS literature database allow for some consideration of lakewide biodiversity patterns in fish.

This section summarizes the patterns in biodiversity reported in Allison ***et al.*** (2001). Please refer to this document for: details about sampling effort and analyses, species names and lists of the fish and mollusc diversity patterns discussed in this section, and other information.

Habitats:

Sublittoral habitats adjacent to PAs and at other locales were mapped using the manta survey technique described in Section 3.2.2.2.1. This method provides a coarse map of the distribution of sublittoral habitats in 2-10 m water depth. Figure 3.2 provides an example of a manta-survey substrate map. More than 500 km of Tanganyika coastline (including nearly the entire coastlines of Burundi and Zambia) have been mapped this way. The results of the manta surveys show that the major habitat types (sandy, rocky and mixed sand/rock) are well represented in the waters adjacent to PAs (Table 3.3). Mahale

Table 3.3 The proportion of each major substrate-type recorded by Manta-board surveys in the waters adjacent to NPs, in kilometers and as a percentage of protected area shoreline (Allison *et al*. 2001)

Survey area*	Substrate type											
	Rock		Gravel		Sand		Mixed		Mixed rock		Mixed sand	
	(km)	(%)	(km)	(%)	(km)	(%)	(km)	(%)	(km)	(%)	(km)	(%)
Gombe	4.8	24.5	-	-	10.7	54.9	4	20.5	-	-	-	-
Mahale	25.2	42	0.6	1	12	20	12.6	21	6	10	3.6	6
Nsumbu	34	44	1	1	18	23	2	3	13	17	9	12
All areas	64	40.9	1.6	1	40.7	26	18.6	11.9	19	12.1	12.6	8.1

*Owing to the poor visibility and density of crocodiles and hippopotami, Rusizi NP was not sampled by manta tow technique. However, subsequent sampling for molluscs by dredge confirmed that soft substrates (sand, silt, mud) predominate

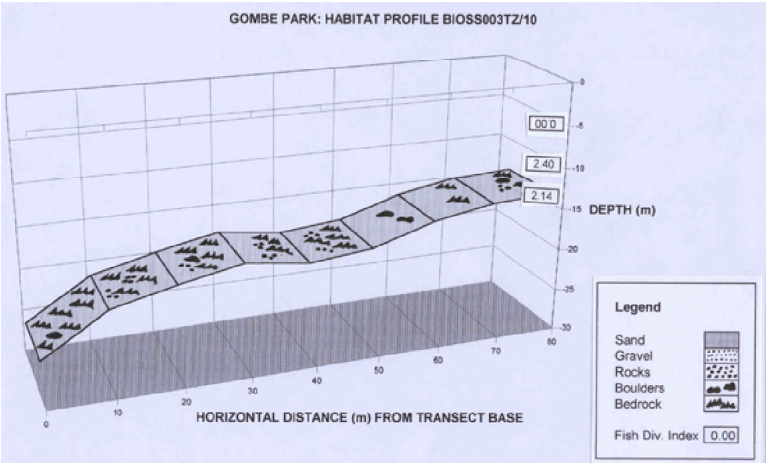

Figure 3.3 Habitat profile map from BIOSS surveys using SCUBA (Paley *et al*. 2000)

Mountains and Nsumbu NPs are clearly dominated by rock and mixed rocky substrates, while sand dominates at Gombe Stream. At all three parks the majority of these habitats were found to be relatively pristine. In addition, specialized habitats (***e.g***. shell beds, emergent macrophyte stands, stromatolite reefs) are also represented in the aquatic zones adjacent to NPs. Though it hosts a more limited ranged of habitats, Rusizi Natural Reserve has large emergent macrophyte stands, a major river delta with associated muddy substrates and turbid, nutrient rich waters which are not otherwise well-represented near the other PAs.

These coarse-scale habitat maps and substrate classifications were used to select sites for biodiversity surveys and more detailed habitat mapping. Numerous sites have been surveyed in detail for habitats, molluscs and fish by BIOSS teams using

SCUBA and remote techniques. Data for detailed habitat maps and profiles were collected in conjunction with biodiversity surveys. Figure 3.3 offers an example of a detailed habitat map and profile.

Lakewide Biodiversity Patterns:

The initial gross assessment of biodiversity considered fish distribution patterns with reference to Lake Tanganyika's three bathymetric basins. These three basins are thought to be an important factor controlling the biogeography of the Tanganyika faunas (Ruber ***et al***. 1997). Clearly this has profound implications for conservation, as management strategies would be quite different if, for example, 90 percent of the species were confined to a single basin than if 90 percent of the species were distributed throughout the lake.

In considering a combined BIOSS survey and literature database of the 194 species for which BIOSS has species location data, the largest percentage of fish species, 70 percent, is found to be circumlacustrine, i.e. occurs in all three basins. The middle basin is the poorest, with only two percent of the species found exclusively, while the northern and southern basin host 16 and 12 percent, respectively (Table 3.4).

These database records list between 175 (D.R. Congo) and 205 (Zambia) fish species present in each country. As expected, the pattern is fairly standard among all countries: cichlids represent the majority of all fish species found (about 68 percent) with only one to three other families contributing more than five percent to the overall total (Table 3.5).

In the current literature database, 49 fish species were found to be exclusive to one of the four countries. These species are distributed as follows, Burundi: 17, D.R. Congo: 7, Tanzania: 5 and Zambia: 17. The high number of species found exclusively in Burundi and Zambia reflects the intensity of aquatic survey work in these waters, as well as the rich fish diversity of these waters. Further sampling in D.R. Congo and Tanzania will undoubtedly increase the values for these countries.

Similar analyses were conducted for the molluscs found in BIOSS surveys (the literature database does not currently list molluscs other than those found in BIOSS surveys). A total of 30 mollusc species were recorded, less than half of the 67 species known from the Tanganyika Basin (West ***et al***. 1998). The total number of species recorded in each country is as follows, Burundi: 28, D.R. Congo: 18, Tanzania: 29, and Zambia: 24. It is interesting to note the numbers of species found in each country are not vastly different, though the coastlines are quite variable in length. This probably reflects differences in BIOSS sampling efforts. Most of the species in Burundi were found over the course of two years of periodic surveys at a single site whereas more than 75 km of Tanzanian coastline was surveyed, but the majority of these were single survey events. Much remains in surveying molluscs and entering existing information in the literature database.

Biodiversity Patterns near PAs:

BIOSS conducted extensive aquatic surveys in the waters adjacent to the four PAs bordering Lake Tanganyika: Gombe Stream NP (Tanzania), Mahale Mountains NP (Tanzania), Nsumbu NP (Zambia) and Rusizi Natural Reserve (NR) (Burundi). These surveys are compiled as individual reports for each PA (Tierney and Darwall 1998, Ntakimazi ***et al***. 2000, Paley ***et al***. 2000, Paley and Sinyinza 2000, respectively) and analyzed in the BIOSS Final Technical Report (Allison et al. 2001). An additional 29 published studies collated in the literature database also informed biodiversity assessments in these areas.

Table 3.4 Number of species found exclusively in each basin of Lake Tanganyika (Allison *et al*. 2001)

Basin	No. of species	% of total
North	32	16
Middle	03	02
South	23	12
Circumlacustrine	136	70
Total:	194	100

Table 3.5 Number of species per family recorded in each riparian country (Allison *et al*. 2001)

Family	Burundi		DR Congo		Tanzania		Zambia	
	no. spp	%	no. spp	%	no. spp	%	no. spp	%
Anabantidae	1	1%						
Bagridae	13	7%	11	6%	10	5%	12	6%
Centropomidae	4	2%	4	2%	4	2%	4	2%
Characidae	6	3%	1	1%	4	2%	5	2%
Cichlidae	131	68%	127	73%	138	72%	149	73%
Citharinidae							1	0%
Clariidae	3	2%	4	2%	4	2%	4	2%
Clupeidae	2	1%	2	1%	2	1%	2	1%
Cyprinidae	11	6%	5	3%	7	4%	3	1%
Cyprinodontidae	2	1%	2	1%	2	1%	2	1%
Distichodontidae	1	1%						
Malapteruridae	1	1%	2	1%	2	1%	1	0%
Mastacembelidae	9	5%	9	5%	7	4%	5	2%
Mochokidae	6	3%	6	3%	7	4%	10	5%
Mormyridae	1	1%	1	1%	1	1%	3	1%
Polypteridae					2	1%	2	1%
Protopteridae	1	1%	1	1%			1	0%
Tetraodontidae					1	1%	1	0%
Totals	192	100%	175	100%	191	100%	205	100%

Table 3.6 Number of fish species recorded in the waters adjacent each NP (Allison et al. 2001)

National Park	Number of species	Number of species BIOSS contributed to the total (%)
Mahale	160	45 (28%)
Rusizi	105	5 (5%)
Nsumbu	99	66 (67%)
Gombe	62	52 (84%)

The total numbers of species recorded in each PA and the contribution the BIOSS surveys made to these species lists are cited in Table 3.6.

The BIOSS survey contributed to these park lists to varying degrees. In Gombe Stream NP's waters BIOSS found 52 species (***i.e***. 84 percent of the total) not recorded in any other references included in the literature database. BIOSS added 66 species (67 percent of the total) to Nsumbu NP's species list, 45 species (28 percent of the total) to Mahale Mountain NP's species list, but only five additional species (five percent of the total) to Rusizi NR's list. These results may reflect the sampling intensity of previous surveys. For example, the Ecotones survey (Ntakimazi 1995) at Rusizi NR was a significant, long-term effort, while Gombe has received considerably less attention from aquatic surveys.

Of the 194 fish species in the BIOSS database, 163 species occur in the waters adjacent to one or more PAs, and thus benefit from some degree of protection from land and water based threats. The remaining 31 species occur in currently 'unprotected' areas, but some of these locales, such as south of Uvira in D.R. Congo, have been already been identified as areas warranting further protection (Allison ***et al***. 2000).

The BIOSS fish survey data were subjected to analyses for three different measures of diversity: species richness, Shannon-Weaver diversity index and Simpson's diversity index. Three measures were used because each method has its strengths and weaknesses and can be expected to perform differently under certain conditions. Species richness measures are simply the number of species collected for a given level of sampling effort (combined with techniques for estimating richness from incomplete or variable sampling efforts). This measure is useful in cases where data on relative abundance are not collected. Diversity indices incorporate both the number of species and the number of individuals of each species. The BIOSS Final Technical Report (Allison et al. 2001) gave a full description of each diversity measure and an analysis of its performance with BIOSS survey data. Allison ***et al***. (2001) found that these three different measures provided approximately similar assessments of biodiversity. This was an important result because significant sampling effort is expended in attempting to quantify the abundances of species. Allison ***et al***. (2001) thus conclude that since there are now several procedures for estimating species richness that do not rely on relative abundance data, the pursuit of diversity indices can probably be abandoned for broad-scale survey activities, in favor of rigorous estimation of species richness. Allison ***et al***. (2001) noted that diversity indices might be useful for monitoring programmes where they can provide evidence of systematic change in selected groups.

A wide variety of biodiversity analyses and comparisons were made among subsets of the BIOSS survey database. These subsets included daytime gillnet, nighttime gillnet, combined gillnet and Stationary Visual Census (SVC) datasets examined through analyses of species richness (using up to seven different estimators) and diversity (Shannon-Weaver and Simpson Indices) and Rapid Visual Census (RVC) and mollusc survey datasets studied through measures of species richness. Allison ***et al***. (2001) reports the statistics and significance levels for these analyses, interested readers are referred to this report. These analyses demonstrated that:

- significant differences in aquatic biodiversity exist between the protected areas;
- diversity indices for nighttime gillnet sampling ranked: Mahale Mountains NP>Nsumbu NP>Rusizi NR; for

Table 3.7 Complementarity analysis, fish species richness (Allison et al. 2001)

Country	Area	Cumulative total species	Cumulative % surveyed species represented	% of total species recorded from lake
Tanzania	Mahale Mountains NP	128	64.6	52.7
Burundi	Rusizi NR	157	79.3	64.6
Zambia	Nsumbu NP	169	85.4	69.5
Tanzania	Gombe Stream NP	178	89.9	73.3
Zambia	Lufubu/Chisala	184	92.9	75.7
Congo	Pemba/Luhanga/ Bangwe	187	94.4	77
Congo	Uvira	190	96 78.2	
Burundi	Bujumbura Bay	193	97.5	79.4
Zambia	Mpulungu	195	98.5	80.2
Zambia	Kalambo/Lunzua	197	99.5	81.1
Burundi	Burundi South	198	100	81.5
ALL	ALL	198	100	81.5

Approximately 243 species of fish are known from the lake (up to 100 additional species are found in the catchment, but not the lake). Of these, 198 (81.5%) were recorded in the present survey.

daytime sampling: Nsumbu NP>Rusizi NR>Gombe Stream NP (for logistical reasons gillnets were not set during the day at Mahale Mountains NP nor during the night at Gombe Stream NP);

- Mahale Mountains NP had the highest levels of fish diversity on both rocky and sandy sites;

- rocky and sandy sites in the same area themselves showed significant differences in biodiversity, with rocky sites, not surprisingly, being more diverse;

- undisturbed or relatively pristine habitats (such as those in waters adjacent to PAs, except for Rusizi which receives considerable influence from heavily impacted Bujumbura bay) supported higher diversity than areas close to population centers and subject to disturbance from fishing, pollution and sedimentation.

Finally, BIOSS team members conducted Complementarity analysis to aid in formulating conservation recommendations about the existing PAs. Complementarity analysis assesses different areas on the basis of their species richness and how well they complement each other biologically. The total species list for each area is used to derive the smallest combination of areas that includes the most species. This was accomplished by first ranking the areas by species richness, selecting the area that had the most species, and then adding additional sites in a stepwise fashion based on how many ***new*** species they contribute to the 'protected area network.'

Mahale Mountains NP was selected first, since it had the greatest number of species. Although not the next most species rich area, Rusizi NR had the largest number of species not found in Mahale (***i.e***. the highest complementarity to Mahale), followed by Nsumbu NP and Gombe Stream NP. This analysis indicated that the waters off the four existing PAs include at least 73 percent of known fish species from the lake and almost

Table 3.8 Complementarity analysis, mollusc species richness (Allison *et al*. 2001)

National Park	Cumulative total species	Cumulative % of surveyed species represented	% of total species recorded in the lake**
Nsumbu NP	16	35.6	23.9
Mahale Mountains NP	31	68.9	46.3
Gombe Stream NP	34	75.6	50.7
Rusizi NR	34	75.6	50.7
Gitaza	41	91.1	61.2
Pemba, Luhanga, Bangwe	43	95.6	64.2
Katoto, Kapembwe, Kasakalawe	44	97.8	65.7
Uvira	45	100	67.2

** Currently, 52 species of gastropod and 15 species of bivalve have been described in the lake, although taxonomic work continues.

90 percent of species recorded by this survey. BIOSS concluded that the waters adjacent to existing protected areas thus protect a good amount of Tanganyika's fish diversity. The other BIOSS survey sites not adjacent to PAs would add fewer new species, six or less per site, to the total number of species protected and significant areas would have to be gazetted to protect these few species not already included.

In contrast, analysis of the mollusc data showed that the area with the second most unique species (Gitaza), which would normally be selected first after Mahale Mountains NP, was outside the protected area network (i.e. not adjacent to a terrestrial PA). Since one of the main purposes was to see how much biodiversity resides in waters adjacent to existing PAs, the analysis was first carried out on the four existing PAs before complementarity with other sites was assessed.

The proportion of the total number of species in the lake found in the waters adjacent to PAs is clearly much less than for fish (Table 3.8). In some cases additional sampling might be needed (***e.g***. Rusizi NR). In all, 45 mollusc species were recovered by BIOSS surveys and 11 of these species are outside the existing protected area network of Nsumbu NP + Mahale Mountains NP + Gombe Stream NP + Rusizi NR. Gitaza alone had seven of these species. The existing PA network offers protection to about 50 percent of the known mollusc species and this would increase to 61 percent if Gitaza were added to the PA network.

3.2.2 Pollution Special Study

Pollution was identified as a potential threat to Lake Tanganyika's biodiversity at the First International Conference on the Conservationand Biodiversity of Lake Tanganyika (Cohen 1991). Sections 3.4.2 detail the objectives, strategy and outputs of the LTBP Pollution Special Study (POLSS).

3.2.2.1 Objectives and Strategy

The Tanganyika Catchment contains a range of human establishments, from small villages to towns to capital cities. These population centers host a variety of human activities, including: farming with fertilizers and pesticides, international ports and harbors carrying passengers and cargo, factories (paint, sugar, soap, battery, textile, beverage brewing, pharmaceutical etc.), commercial fishing industries and power generating stations.

Pollution, for the purposes of the LTBP POLSS, is defined as:

"…the anthropogenically accelerated inputs of: nutrients (especially phosphorus and nitrogen), some organic compounds (e.g. sewage and effluent from palm oil or sugarcane plantations), and inorganic compounds (e.g. pesticides, heavy metals, oil residues, etc.) into the lake."

The anthropogenically accelerated inputs of sediments, as a result of erosion, into the lake is another form of pollution, but because it was recognized as one of the principal threats to Tanganyika's biodiversity (Cohen 1991), a whole special study was devoted to this subject (Section 3.4.3).

The objectives of LTBP's POLSS were to: identify the main sources of pollution in Lake Tanganyika, establish how pollution is impacting biodiversity, and develop the capacity to monitor pollution and water quality. To address these objectives the POLSS carried out water quality studies, an industrial pollution inventory, and limited analyses for pesticides and heavy metals.

One obstacle the POLSS encountered was that except for Burundi, which has its capital city on the lakeshore, none of the other countries had national agencies mandated to study pollution or water quality based on the lakeshore. However, for pollution monitoring programs to be sustainable, the POLSS leaders felt the studies must be based on the lakeshore. Consequently considerable effort went into training members of other institutions, (***e.g***. Fisheries Departments) so they could carry out the POLSS work program. This arrangement seemed adequate during the project and indeed all the teams collected considerable data. However the long-term sustainability and whether these lakeshore institutions will ultimately adopt water-quality monitoring as a part of their mandate remains to be tested.

3.2.2.2 Products

In addition to trained lakeside teams capable of monitoring limnology and water quality parameters, other significant outputs to the POLSS include the results of the water quality studies (Bailey-Watts 2000), industrial pollution inventory (Drieu ***et al***. 2000) and heavy metals and pesticide surveys (Foxall ***et al***. 2000). The full reports for these studies are available at:
http://www.ltbp.org/PDD4.HTM

3.2.2.2.1 Water Quality Studies

National teams in Burundi, Tanzania and Zambia[5] collected at least 18 consecutive months of water quality data in each country.

Table 3.9 Basic Limnological Parameters for Lake Tanganyika (data from Bailey-Watts 2000)

Parameter	Lakewide	Burundi	Tanzania	Zambia
Transparency	7 - 16 m			
Conductivity	700 S/cm			
Chlorophyll a concentration		—	1.5-6 µ/l	4-14 µ/l
Ammonium-nitrogen		0.5-1.0 mg/l		
Nitrate-nitrogen		0.5-1.0 mg/l	< 100 µ/l	75-130 µ/l
Phosphate-phosphorous		0.5 mg/l	7-8 µ/l	12 µ/l
Total phosphorous		—	30 µ/l	12 µ/l
Sulfate		3-4 mg/l		

[5] Unfortunately the Centre de Recherche en Hydrobiologie in Uvira, D.R. Congo did not have a functional limnology/chemistry laboratory for most of the project. LTBP renovated these facilities, but the changing security situation caused several long delays in this process and the laboratories were completed only a couple of months before the data-collecting phase of the project concluded.

These data included more than 5,500 physical-chemical data points across the following categories: carbonate alkalinity, bi-carbonate alkalinity, suspended solids, phosphate-phosphorous, total phosphorous, silica, chlorophyll a, dissolved oxygen, pH, ammonium-nitrogen, nitrate-nitrogen, nitrite-nitrogen, sulfate, electrical conductivity, water clarity, temperature and phytoplankton diversity (summarized in Bailey Watts 2000). Sampling sites in the three countries were selected to encompass a range of human impacts, from nearly pristine control sites within national parks, open water control sites and a variety of near-shore sites close to ports, markets, towns, villages, municipal water supply intakes and industries. In addition, the Burundian sampling protocol included rivers that passed through urban areas and their points of entry into the lake.

Unfortunately, this vast and rich data set has not yet been fully analyzed. However, initial considerations (Bailey-Watts 2000) show that Lake Tanganyika can be generally characterized by the limnological parameters in Table 3.9.

Selected time series trends for these and other parameters are available in Bailey-Watts (2000). Unfortunately detailed analyses and comparisons with other lakes are lacking.

However, all available data (Bailey-Watts 2000, Bailey-Watts ***et al***. 2000) suggest that Lake Tanganyika currently falls into the 'oligotrophic' range of lake productivity levels (Wetzel 1983). While not 'ultra-oligotrophic,' which typically describes pristine systems, oligotrophic lakes are nonetheless considered healthy in terms of water quality as a function of nutrient enrichment.

While the overall perspective is healthy, Dr. Francis Chale's (POLSS Coordinator for Tanzania) work in Kigoma Bay, Tanzania shows early warning signs that should be cause for local concern (Chale 2000). Kigoma Bay, which is about 4 km long, 3 km wide and 25 m deep, is surrounded by Kigoma Town (population 135,000) and the town draws its domestic water supply from the Bay. In comparisons of water quality between Kigoma Bay and offshore waters, Kigoma Bay waters were found to be significantly higher in nutrients and 2.23 times less transparent than offshore waters (Nitrogen: 56 µg/l vs. 36 µg/l; Phosphorus: 12.55 µg/l vs. 6.47 µg/l). A similar trend was found in comparisons with unimpacted near-shore areas, suggesting that nutrient input into the bay from external sources is considerable. These values are elevated enough to render Kigoma Bay 'meso-eutrophic' on the classification of lake productivity levels. Kigoma lacks a wastewater treatment facility. Many households have diverted their plumbing to enter the town's storm drains. These drains thus act as conveyers for domestic effluents to enter the bay, which may ultimately be responsible for the high nitrogen and phosphorus concentrations and enrichment in plant nutrients.

3.2.2.2.2 Industrial Pollution Inventory

Industrial activities on or about Lake Tanganyika vary considerably in nature and scale between the four riparian countries. POLSS members from the four countries met in Kigoma, Tanzania in February 2000 for a regional workshop to discuss the industrial pollution inventory strategy. The output of this workshop was a detailed questionnaire about the nature and quantities of chemical products and energy used in various enterprises, with detailed descriptions of solid and liquid waste treatment measures. The workshop delegates returned to their countries and conducted interviews with managers of the various lakeside industries in their country. The results are reported in Drieu ***et al***. (2000) and compiled into a Microsoft Access Database that interacts with the LTBP GIS.

Industries near Lake Tanganyika are concentrated in and around the five largest settlements: Bujumbura, Burundi; Kalemie, D.R. Congo; Kigoma, Tanzania; Uvira, D.R.

Congo and Mpulungu, Zambia. Unfortunately security conditions did not allow the Congolese POLSS team to survey Kalemie. The survey results from the other towns are summarized below:

Bujumbura, Burundi:

Population: approximately 400,000. ***Industries*** include: brewery, textile, paint, battery, soap, pharmaceutical, cottonseed oil factories, slaughterhouse, dairy processing, the port and petrol depots (more than 80 enterprises in total).

The brewery and textile factories discharge significant amounts of wastewater, 2,100 and 2,350 cubic meters per day, respectively. The remaining industries together discharge about 5,000 cubic meters per day. Wastewater from these sources can contain the following substances in varying concentrations and quantities: ammonium sulfate, blood and offal, calcium hydrochloride, cadmium, calcium hydroxide, chrome, chromium hydroxide, cobalt, copper, detergent, disinfectants, hydrocarbons, iron sulfate, lead, mercury, nitric acid, sodium carbonate, sodium hydroxide, sulfuric acid, and zinc. Industrial wastewaters are discharged, untreated, directly into the lake or its influent rivers.

Parts of Bujumbura have sewage canalization, other areas rely on septic tanks and cesspools. However, none of these wastes are treated before they ultimately re-enter the lake ecosystem. Burundi has nearly finished a treatment facility designed to treat 38 percent of Bujumbura wastewater (almost the total amount of industrial wastewater) but it is not yet operational due to a lack of funds for finishing works. The industrial pollution survey also highlighted that many enterprises have rudimentary pre-treatment facilities and/ or are aware of the importance of pre-treatment measures, however, are not functional due to a lack of funds.

Uvira, D.R. Congo:

Population: more than 100,000 (1996 census). ***Industries*** include: the port and associated oil products depot, cotton processing factory, sugar processing factory and the general hospital.

Owing to the current political-economic instability in Uvira, daily operations at these industries are limited and little is known about the nature and quantities of activities. However, environmental problems are already evidenced by the film of petrol products seen on the lake's surface at the port and because no industrial or domestic wastewaters are treated before they enter the lake.

Kigoma, Tanzania:

Population: about 130,000. ***Industries*** include: the TANESCO power station, the port and oil storage depots.

The TANESCO power-generating station has been recognized as a source of oil pollution in Kigoma Bay. The project has worked closely with the TANESCO management and several ameliorations have already been made (e.g. the leaky below ground storage reservoirs have been decommissioned and replaced with a new above ground system). It was felt that pollution abatement measures already in place at the port, train station and oil depots were sufficient. However, current sewage treatment facilities were overloaded and deemed inadequate as untreated sewage is discharging directly into the lake.

Mpulungu, Zambia:

Population: about 71,000. ***Industries*** include: the port and eight industrial fishing companies.

The eight industrial fishing companies were deemed to have little impact on the lake. Harbor authorities said that accidents sometimes happen and pollution abatement measures do not exist. The sewage system was considered inadequate and, especially

during the rainy season, untreated sewage directly enters the lake.

3.2.2.2.3 Pesticide and Heavy Metals Studies

Owing to problems in the execution of the POLSS, pollution surveys for heavy metals and pesticides in Lake Tanganyika were limited in scope. Chale (2000) however, did conduct some analyses at the Tanzanian Pesticide Research Institute in Arusha on fish and molluscs samples from the Tanzanian Coast. Foxall ***et al***. (2000) review this data, comparing them with similar data from Burundi in the published literature.

Pesticides, including DDT, DDE (a breakdown product of DDT), and their component residues (endosulphan, heptachlor and dieldrin etc.), are used in agriculture, especially coffee and cotton, in the Tanganyika Basin. Heavy metals (Cu, Fe, Mn, Zn, Pb and Cd) are associated with industries and mining. Both pesticide residues and heavy metals accumulate in sediment and ultimately may be mobilized into the lake during the rainy seasons. In addition to time-averaging the presence of these pollutants, fish and mollusc tissues were selected for these studies because they would indicate, if present, that the pollutants had not only entered the lake but had been incorporated into the food chain, possibly posing health risks to humans.

Chale's studies (Foxall ***et al***. 2000) and Deelstra ***et al***. (1976) detected pesticide residues in molluscs and in the fish that are the main targets of Tanganyika's commercial fishing industry (the sardines ***Limnothrissa miodon*** and ***Stolothrissa tanganicae*** and ***Lates*** species), thus indicating that pesticides have entered the lake and food chain. However, both studies concluded that the values detected were not anomalous when compared to fish from other African waters and moreover, these values were within acceptable tolerance ranges set by the World Health Organization.

Chale's studies (Foxall ***et al***. 2000), along with those of Benemariya ***et al***. (1991) and Sindayigaya ***et al***. (1994), examined concentrations of Cu, Fe, Mn, Zn, Pb, and Cd metals in molluscs and economically-important fish from Tanzanian and Burundian waters. Again, heavy metals were accumulating in these organisms, but at concentrations that were comparable to those of organisms from other African waters. These concentrations were within acceptable tolerance ranges set by the World Health Organization.

While these pesticide and heavy metal concentrations are currently not cause for immediate concern by humans consuming fish from Lake Tanganyika, Foxall ***et al***. (2000) note they may have subtle effects on the lake's biodiversity, effecting the reproductive success and survival rate of organisms. Foxall ***et al***. (2000) and discussions at the Transboundary Diagnostic Analysis (Arusha, March 2000) highlighted the need to make organized periodic studies of pesticides and heavy metals a routine part of the lake's long-term monitoring program.

3.2.3 Sedimentation Special Study

Sediment deposition, as a function of accelerated erosion rates within the catchment, was also identified as a significant threat to Lake Tanganyika's biodiversity at the First International Conference on the Conservation and Biodiversity of Lake Tanganyika (Cohen 1991). Section 3.4.3 describes the objectives, strategy and outputs of the Sedimentation Special Study (SEDSS).

3.2.3.1 Objectives and Strategy

Human activities in the catchment, especially agriculture and fuel-wood gathering, have greatly decreased the original forest cover in the Lake Tanganyika catchment (Cohen 1991). It is thought that this reduction in forest

diverse array of separate studies that examined: current sediment input into the lake (river gauging studies), historical sediment input into the lake (coring studies), basin-wide erosion potential (erosion modelling) and sediment transport within the lake (sediment transport studies). In addition to these studies of sediment dynamics, the SEDSS also examined nutrient dynamics (nutrient dynamics) and the effect of sediments on primary productivity and selected taxa through a series of field observations, habitat manipulation studies and laboratory experiments (biological impact of sediments).

Because sedimentation was perceived to be the greatest threat to biodiversity at the project's start, this special study had the largest budget of all the special studies and the largest number of subcomponent studies and resources. Unlike some of the other special studies, the strategy of the SEDSS was to recruit institutions interested in various aspects of Tanganyikan sedimentary geology, hydrology, erosion modelling, nutrient cycling etc. and contract them to conduct specific components of the work program. One result of this strategy was that different activities took place in different countries so comparisons between the countries and catchments are difficult. Where technical expertise did not already exist in the region, in the cases, for example, of the coring, erosion modelling and nutrient dynamics studies, institutions from other countries were involved and every effort was made to involve participants from the region in these studies.

3.2.3.2 Products

The SEDSS produced 14 technical reports on sediment dynamics in the Lake Tanganyika catchment and its effect on biodiversity. These reports are available, in full, at: http://www.ltbp.org/PDD5.HTM

3.2.3.2.1 River Gauging Studies

During the project 19 gauging stations on rivers entering Lake Tanganyika were installed or rehabilitated by LTBP collaborators. Gauging data, specifically river flow and suspended sediment load, provide a crucial link between activities in the catchment and sediment deposition in the lake. SEDSS participants (Patterson 2000) highlighted the importance of continuing and adding to this river monitoring network as a means of understanding long-term trends in erosion and hydrology.

Based on this gauging data, Table 3.10 provides examples of estimated annual sediment input from several of Tanganyika's influent rivers (Sichingabula 1999, Kakogozo ***et al***. 2000). While these data represent a few select rivers, it is clear from this sampling

Table 3.10 Some Water and Sediment Discharge Rates into Lake Tanganyika (from Sichingabula 1999 and Kakogozo *et a*l. 2000)

River	Water Discharge Rate	Sediment Discharge Rate
Kalimabenge, D.R. Congo	36.54 x 10^6 m^3/year	25.299 tons/year
Kavimvira, D.R. Congo	9.22 x 10^6 m^3/year	18.761 tons/year
Mulongwe, D.R. Congo	34.05 x 10^6 m^3/year	21.311 tons/year
Izi, Zambia	31.4 x 10^6 m^3/255 days	318.2 tons/255 days
Kalambo, Zambia	386.3 x 10^6 m^3/243 days	9,617.1 tons/243 days
Lucheche, Zambia	36.3 x 10^6 m^3/257 days	358.8 tons/257 days
Lufubu, Zambia	2.2 x 10^9 m^3/258 days	53,819.7 tons/258 days
Lunzua, Zambia	297.5 x 10^6 m^3/254 days	6,595.8 tons/254 days

that the annual lake-wide sediment input into Lake Tanganyika is enormous. Other results from these studies are summarized below.

Burundi:

The SEDSS team in Burundi surveyed the flow, nature and quantity of suspended sediments and other physical-chemical parameters (pH, temperature and conductivity) for six rivers entering Lake Tanganyika. These rivers include the Ntahangwa, the Karonge, the Kirasa, the Nyamusenyi, the Gatororongo and the Rusizi, which is one of Tanganyika's two largest influent rivers. Sebahene et al. (1999) found that the Rusizi River, as a function of the catchment it drains and its flat relief, carries the most suspended sediment, ranging from about 0.22 g/l to 2.46 g/l during the dry and rainy seasons, respectively (the Rusizi discharges between 112 – 220 m^3/s, varying by season). While the sediments carried by the Rusizi are quite fine (>90% of the fine fraction is 125 - 500µm) the other rivers are characterized by torrential currents carrying courser sediments. The mineralogy of sediments carried in these different rivers, however, was essentially the same: predominantly quartz and micas with oxides, limonite and metamorphic minerals (epidote, staurolite, garnet).

Three significant landslides occurred near Gatororongo, showing that especially in the rainy season, significant amounts of sediment (estimated at more than 11,280 tons at this site alone) can be introduced into the lake ecosystem without transiting through rivers.

D.R. Congo:

The Kalimabenge, Mulongwe and Kavimvira Rivers near Uvira were surveyed by the SEDSS team in D.R. Congo for the flow, nature and quantity of suspended sediments, quantity of organic material, and other physical-chemical parameters (pH, temperature, conductivity).

Kakogozo ***et al***. (2000) found the average flow rates for these rivers are typically low, around 2 m^3/s for the Kalimabenge and the Mulongwe and 0.5 m^3/s for the Kavimvira. However, flow rates jump to 9.53 m^3/s, 10.92 m^3/s and 3.59 m^3/s for these rivers, respectively, during rainy season flooding. Sediment load for these rivers varied seasonally, with an average of: 13.85 mg/l during the dry season and 1,252 mg/l during the rainy season for the Kalimabenge; 17.6 mg/l during the dry season and 880 mg/l during the rainy season for the Mulongwe; and 18 mg/l during the dry season and 3,197 mg/l during the rainy season for the Kavimvira. In March 1999 the Mulongwe River was flowing fast enough to carry a large transport truck down river!

The authors note that while the volume of water discharged by these rivers is negligible compared to the lake's total water volume, the volume of sediment discharged (ranging from 18.761 – 25.299 tons/year) is considerable (Kakogozo ***et al***. 2000).

Tanzania:

Nkotagu and Mbwambo (2000) compared streams from two similar-sized adjacent catchments, the Mitumba, forested and protected (in Gombe Stream National Park), and the Ngonya, an impacted catchment, colonized and cultivated by people. These are small rivers, with average flow rates < 1 m^3/s for both streams. Their work revealed that 70-80 percent of the stream component consists of groundwater, which they believe plays an important role in the transport of nutrient and sediment pollutants into Lake Tanganyika. The Ngonya, in the impacted catchment, showed an order of magnitude greater suspended sediment load than the Mitumba in the protected catchment. Clay minerals, including smectite and kaolinite, were the dominant component of the suspended sediment load.

Zambia:

The Zambian SEDSS team studied the flow and suspended sediment load of five rivers in Zambia, the Lucheche, the Kalambo, the Izi, the Lunzua and the Lufubu. Sichingabula (1999) reported the flow rate of these rivers varied considerably, from a dry season low of 0.18 m^3/s on the Lucheche to rainy season maxima of 346.58 m^3/s on the Lufubu. Average flow discharges ranged from 1.43 m^3/s on the Izi to 90.56 m^3/s on the Lufubu. Average suspended sediment loads deposited in Lake Tanganyika ranged from 1.25 tons/day on the Izi to 208.60 tons/day on the Lufubu. He also noted that water levels in Lake Tanganyika varied 2.0 m over the study period, and 11.0 m over the period 1957-1992, for which archival data are available.

3.2.3.2.2 Coring Studies

While river gauging studies can estimate sediment loads currently entering the lake, coring studies can provide historical sedimentation rates. Radiometric dating of various layers in sediment cores allows one to estimate sedimentation rates over time. Pollen from the cores give an idea of the nature of vegetation in the adjacent catchment. In addition, fossilized microfauna (***e.g***. diatoms, molluscs, crustaceans) from the cores can be studied in order to understand biodiversity as a function of sedimentation rates.

The LTBP mounted a major coring effort on Lake Tanganyika's eastern coast alongside a variety of catchment types, from protected forests in national parks (Gombe Stream National Park and Mahale Mountains National Park) to high-impact areas that have been completely deforested in favor of agriculture. Suites of cores were extracted from six deltas in Tanzania Lubulungu, Kabesi, Nyasanga/Kahama, Mwamgongo) and Burundi (Nyamuseni and Karonge/ Kirasa) and geochronology, sedimentology, paleontology and geochemistry analyses were conducted. Cohen ***et al***. (1999) provides the complete report from this effort. They noted that the results were sometimes confusing and complex to interpret. The principle findings are summarized below:

Many cores showed a vegetation shift from grass pollen to tree pollen and fern spores over the past few centuries. Cohen ***et al***. (1999) interpret this surprising pattern as the result of mixed grassland/woodland conditions (in which the dominant tree species are poor pollen producers thus grass pollens dominate) to agricultural land use where the dominant crops (cassava, bananas, coffee, legumes) are also poor pollen producers. The pollen rain accumulating in the cores is transported by wind from residual high elevation forests.

In addition to vegetation changes, the cores revealed markedly increased sedimentation rates over time, with a threefold increase in rates at some Tanzanian sites and up to a ninefold increase in rates at the Burundian sites. Cohen et al. (1999) interpret this as the result of 'increased hydrologic discharge and erosion rates on a progressively deforested landscape.' This pattern appears before the 20th century, but a major acceleration in sedimentation rates dates back to 1961, a year which is on record for exceptionally high rainfall and lake levels throughout East and Central Africa. The authors believe while human activities are responsible for the change in vegetation and increased erosion rates, climate factors, such as an especially rainy wet season, can greatly exacerbate the effect.

Invertebrate fossils, especially ostracode crustaceans that are abundant in the cores, offer a glimpse at the biodiversity that responded to these increasing sedimentation rates. Paleontological analyses found accelerating erosion rates correlated with declines in species diversity. Highly disturbed catchments with increasing erosion rates supported low species diversity,

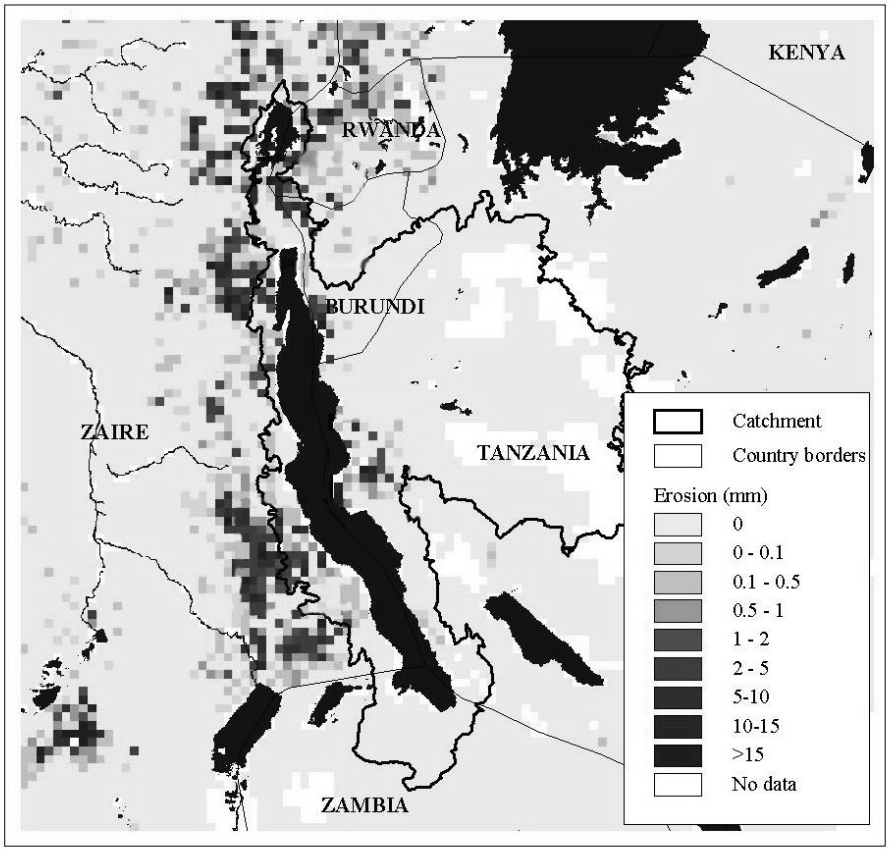

Figure 3.4 Sediment Source and Erosion Hazard Zones (Drake et al. 1999)

unimpacted catchments supported high diversity.

The overall conclusions of the coring studies suggest that the susceptibility and risk of coastal (littoral, sublittoral, profundal) ecosystems of Lake Tanganyika to sedimentation varies depending on the nature of the catchment topography and the underwater slope conditions. Larger catchments discharging onto relatively gently sloping lake floors, ***e.g***. those studied in northern Burundi, are at greatest risk and even low to moderate disturbances in such catchments can probably trigger significant changes in sediment deposition in the lake. Cohen et al. suggests that particular attention should be paid to similar, but currently undisturbed catchments, in southern Tanzania and Zambia. They maintain that steeply sloping lake bottoms, particularly those adjacent to small watersheds, are at a lesser risk to severe ecosystem damage from deforestation.

3.2.3.2.3 Erosion Modelling

Using remote-sensing data on vegetation cover and rainfall, and GIS data on topography and soil erodability, Drake ***et al***. (1999) developed a model for soil erosion in the Tanganyika Catchment. In accounting for soil composition, topography and rainfall, this model is much improved over previous estimates of sediment input into the lake, which assessed only forest cover. The model's implementation could provide information on erosion and sediment yield that could forecast problem areas, target research and coordinate remediation. Output from the model, tested with rainfall and vegetation cover data from 1996, is shown in Figure 3.4.

Adjacent to the lake, there is only one large area along the Burundi Coast that appears to be subject to severe erosion (because it has little vegetative cover). However, many catchment areas were susceptible to erosion in 1996 (having steep slopes and little vegetation at certain times of the year). If rainfall was significant, severe erosion would occur at these sites. If forests were removed or reduced at the Tanzanian Coast, the area would be vulnerable to severe erosion.

3.2.3.2.4 Sediment Transport Studies

Two different LTBP studies - Huttula ***et al***. (1997) and Bryant (1999) - examined aspects of sediment transport in Lake Tanganyika.

As part of a UNOPS-FAO interagency agreement, Huttula ***et al***. (1997) developed a water circulation model for pollutant and sediment transport in Lake Tanganyika. Using data they collected on water currents and wind patterns (direction and magnitude), and sediment load estimates from the published literature, Huttula ***et al***. (1997) developed and tested flow and sediment transport models for two of Lake Tanganyika's major effluent rivers, the Malagarasi River (Tanzania) and the Lufubu River (Zambia). The authors noted that their model may also be applicable to other river deltas.

Huttula ***et al***. (1997) found that winds generated significant currents travelling at high speeds and penetrating down to 20-40 m depth. Their water temperature data revealed that the thermocline (the zone of rapid temperature change in the water column between the warmer surface waters and colder bottom waters) is tilted along the axis of the lake. They confirmed that upwelling (the rapid movement of anoxic, hydrogen-sulphide rich bottom waters to the surface) occurs at the lake's south end during the dry season. This phenomenon might be responsible for massive fish kills noted in the lake's south end.

Huttula ***et al***. documented currents directed N-NW near the Malagarasi Delta which seem to account for the dispersion of suspended matter in the same direction. In contrast, the deeper bathymetric profile and the lighter loads of suspended particles at the Lufubu River restrict the dispersion of the sediment plume at the Lufubu River.

In addition these regional and lakewide models, Huttula ***et al***. (1997) developed mainframe and PC versions of their particle tracking model 'TangPath.' This program, available from the authors or in downloadable form from the LTBP web site, offers users the chance to study the transport of buoyant and settling particles under the different meteorological conditions of the wet and dry seasons.

In a separate sediment transport study, Bryant (1999) studied the sediment plumes that emanate from Lake Tanganyika's two largest influent rivers, the Rusizi River (Burundi) and the Malagarasi (Tanzania). The author's objective was to test a method for detecting near-surface sediment plumes which combines remote sensing satellite images, modern image processing techniques and some field data. Surprisingly, he did not detect any near-surface sediment plumes at the Rusizi Delta, which is thought to be one of the main contributors to the lake's sediment yield. Bryant's in situ data (1999), however, suggest that Rusizi River waters may be more dense than the lake waters such that subsurface plumes are created which cannot be detected using his methodology. However, large plumes were detected at the Malagarasi River and several other smaller rivers in the catchment. Bryant believes "the huge buoyant plumes of the Malagarasi could possible indicate a previous underestimation in the significance of this river as a sediment contributor to the lake." His method provides a valuable management tool for monitoring near-surface sediment plumes.

Huttula ***et al***. Report:
http://www.ltbp.org/FTP/IAA.PDF

TangPath Program:
http://www.ltbp.org/DLOAD.HTM

3.2.3.2.5 Nutrient Dynamics

The SEDSS also examined rivers as nutrient sources for Lake Tanganyika's water column. Nutrients (inorganic nitrogen, phosphorous and silica), together with light and temperature, control primary productivity in aquatic ecosystems. In large tropical lakes, nutrients are expected to be low, with nitrogen usually being the most limiting nutrient (Talling 1966, Moss 1969).

Brion ***et al***. (1999) showed that several rivers entering northern Lake Tanganyika, including the Rusizi River, one of the lake's largest influents, carry 477 tons/year of nitrogen, most of it in the oxidized nitrite and nitrate forms. The Rusizi alone contributes 450 tons/year. The Mutimbuzi contributes 11 tons/year and the Ntahangwa contributes 16 tons/year, with seven tons of this as ammonium which is understandable as this river passes through Bujumbura where it receives untreated domestic wastewater. In the lake's surface waters, nitrite and nitrate concentrations were typically below detection limits (0.05 µM) and ammonium was the most abundant source of nitrogen during the wet season. During the dry season dissolved inorganic nitrogen concentrations escalated up to 18 µM, with nitrite and nitrate as the most abundant sources.

Based on nitrate and ammonium uptake rates by phytoplankton in the lake, Brion ***et al***. (1999) conclude that, even with low nutrient concentration, the nitrogen-uptake rates are quite significant. This implies there must be very rapid nitrogen cycling in the surface waters, with ammonium and nitrate being taken up at the same rates that they are produced.

3.2.3.2.6 Biological Impact of Sediments

LTBP studies by Eggermont (2000), O'Reilly (1998) and Irvine ***et al*** (2000) explored the dynamics of how sediments effect Lake Tanganyika's biodiversity.

It was thought that sediments would have a profound and immediate effect upon primary productivity, and these effects might propagate further up the food web (Cohen 1991). O'Reilly (1998) studied benthic algae productivity at sites with varying amounts of sediment input as a result of land-use practices in the adjacent catchment. Though she did not find a significant difference in net productivity between the high human impact and low human impact sites, there was a clear relationship between deforestation and productivity at these sites. The relationship showed that benthic respiration, the amount of inorganic material on rocks and the algal biomass was significantly greater at the impacted site while there was significantly less oxygen in the water at this site. She attributes the increased respiration and lower oxygen concentrations to the decay of organic matter that has been transported to the site, probably from land. She also noted that increased sediment inputs from deforestation are probably also reducing the amount of available habitat for colonization. If sedimentation rates are high enough, she proposed, existing algae will be covered in sediment, eliminating these zones from further algal recolonization. In addition, the sediments decrease the nutritive value of the food source and reduce the feeding efficiency of primary consumers.

In a study of chironomids (a kind of insect) from the cores discussed in Section 3.4.3.2.2 (Cohen ***et al***. 1999), Eggermont (2000) concluded that, though the highest species diversity was found at a relatively undisturbed site and the lowest species diversity was found at a relatively highly disturbed site, 'no clear relationship was found between the degree of disturbance of a delta and the species richness of the chironomids present.' Her work, however, did note that chironomid assemblages are unique to each delta, suggesting that conservation strategies should include as much coastline, and thus

as many different chironomid species, as possible.

Irvine and collaborators (Irvine ***et al***. 2000) collected and processed sediment samples (monthly and seasonally) at the Kalambo, Lunzua and Lufubu River Deltas in Zambia to assess the effect of sediments on benthic invertebrate biodiversity. They found a decrease in the number of taxa and overall densities of organisms during periods of greatest turbidity (invariably the rainy season, when more sediment is suspended in the rivers). In addition, they found that larger invertebrates (those retained in a 2000 µm sieve) were sensitive to sediments, suffering greater reductions in numbers of taxa and abundance, than smaller organisms.

The same team conducted habitat manipulation studies in which they dumped loads of sediment onto rocky substrates to see how sediment affects the composition and abundance of fish and invertebrates. Irvine ***et al***. (2000) found that within a short time of adding the sediment, the sites were colonized by several fish species typical of sandy sites that were not present prior to the introduction of sediment. Rock-dwelling species remained at the site for several days after the introduction of sediment, probably due to their territoriality, which prevents them moving to adjacent and probably already occupied territories. Sediment also affected gastropods. Compared to control sites, gastropods were very slow to recolonize the sites that had been inundated by sediments.

3.2.4 Fishing Practices Special Study

In addition to pollution and sedimentation, the First International Conference on the Conservation and Biodiversity of Lake Tanganyika (Cohen 1991) also identified overfishing or fishing by destructive methods as a significant threat to Lake Tanganyika's biodiversity. Section 3.4.4 describes the objectives, strategy and outputs of the Fishing Practices Special Study (FPSS).

Table 3.11 The 12 most important fishing gears in Lake Tanganyika (Lindley 2000)

Gear	Description
Industrial purse seine	boats with inboard diesel engines that target the pelagic resources with purse seines typically launched from the master vessel and pulled by another boat
Light assisted beach seine	uses kerosene lamps on boats to attract sardines, which are captured in beach seines
Beach seine	a three-sided net which is launched and pulled to shore by teams of net pullers, targets and catches fish in the littoral zone, this gear is banned in Tanzania
Ring net	targets sardines with lamps and captures them with a quarter-sphere shaped net that is anchored by one boat and pulled by another.
Bottom set gill net	a net of various mesh sizes and depths with weights on the bottom and floats on the top, the net is set on the bottom and recovered at a later time, all four countries have mesh size restrictions
Encircling gill net	like a gill net, but deeper and used in a circle with draw lines from a boat with a frightening device, this gear is illegal in all four countries
Lift nets	a long funnel-shaped net launched from two or more boats (catamaran) with lights, a significant investment is required to set up a lift net operation
Simple lines	lines with baited hooks, including vertical hand lines, targeting fish near the bottom
Jigged lines	lines with 50 or more unbaited hooks used to catch Lates stappersi
Bottom set long lines	lines with 40-400 baited hooks laid along the bottom, set from a boat
Pole and line	baited or unbaited hook attached to a line and pole, used mainly by children
Non-return traps	wooden traps placed in rivers or swamps, fish enter but cannot escape

3.2.4.1 Objectives and Strategy

In terms of budgetary resources allocated to it, the FPSS was a small special study designed to compliment the large FAO/ FINNIDA Research for the Management of the Fisheries on Lake Tanganyika project (commonly referred to as the Lake Tanganyika Research or "LTR" Project). The LTR mandate covered biological, limnological and socio-economic research supporting the development of a fisheries management plan and focussed on the large commercial offshore fisheries. In contrast, the LTBP FPSS focussed on the small-scale nearshore fisheries, examining the relationship between these fishing activities and the lake's biodiversity.

The FPSS teams conducted some participatory rural appraisals jointly with the socio-economic special study in Tanzania and Zambia during LTBP's early stages. The focus then changed towards a comprehensive review of the various fishing gears, methods, and the processing and marketing of the catch in Zambia, Tanzania and limited areas of Burundi and Congo that were accessible during the study. In addition, the FPSS examined the relationship between fishing communities and protected areas on the lake and also the capabilities of lakeside fisheries institutions to monitor and regulate Lake Tanganyika's fisheries.

3.2.4.2 Products

FPSS' most significant product is the comprehensive review of the small scale subsistence and artisanal fisheries on Lake Tanganyika – over 50 different practices operating in the littoral zone are included. The early participatory rural appraisal (PRA) work from Tanzania and Zambia is captured in a series of reports. FPSS also produced national reports with regional overviews on fishing in protected areas, fishing practices in the littoral zone, and the institutional capabilities of lakeside fisheries departments to undertake monitoring of the fishery. All these reports are available at: http://www.ltbp.org/PDD3.HTM

3.2.4.2.1 Fishing Gears of Lake Tanganyika

Lindley (2000) documented more than 50 different fishing gears in use on Lake Tanganyika, noting that 12 of these (industrial purse seines, light-assisted beach seines, regular beach seines, ring nets, bottom set gill nets, encircling gill nets, lift nets, simple lines, jigged lines, bottom set long lines, pole and line and non-return traps (Table 3.11)) are the most significant in terms of number of users, amount of fish caught and management implications.

Of these 12 gears, the subsistence[6] and artisanal[7] fisheries rely on beach seines, bottom set gill nets, encircling gill nets, simple lines, jigged lines, bottom set long lines, pole and line and non-return traps as the other gears require significant financial investments not available to small-scale fishermen. The other gears are typically exploited by teams of industrial fishermen[8]. See Lindley (2000) for detailed descriptions of design, materials, and specifications of fishing gears and fishing boats.

In addition to the means and resources available to the fishermen, the nature of the habitat also dictates what kinds of gears they use. For example, gears that must be pulled over the bottom, such as

[6] For purposes of this study, the LTBP FPSS teams used the term 'subsistence' to refer to fishermen who fish mainly for food rather than money, though excess catch may opportunistically be sold. They do not catch pelagic fish with purse seines from diesel powered vessels.
[7] For purposes of this study, the LTBP FPSS teams used the term 'artisanal' to refer to fishermen who fish mainly for money, rather than food, and do not catch pelagic fish with purse seines from diesel powered vessels. Some of the food may be consumed or given away, but the investments required (fuel, kerosene, boats and engines, wages) necessitate that income is regularly made.
[8] For purposes of this study, the LTBP FPSS teams used the term 'industrial' to refer to fishermen who target the pelagic stocks with purse seine.

beach seines, cannot be deployed in rocky habitats where they will snag. Gill nets and lines are popular in such areas. Beach seines are popular on muddy or sandy substrates.

The 1995 LTR frame survey (Coenen ***et al***. 1998) noted: 786 active fish landing sites, 44,957 fishermen and 15,980 active vessels on Lake Tanganyika. They found the following fishing gears: 28 industrial fishing units, 2,976 lift nets, 128 Apollo-style lift nets, 16 ring nets, 1,143 beach seines, 154 light assisted beach seines, 20,744 lines, 6,300 gill nets, 316 scoop nets and 13 traps. Paffen ***et al*** (1998) estimated the total lakewide catch at 196,570 tonnes (range of estimates from 176,913 to 216,227 tonnes), based on the following country totals: Burundi, 24,946 tonnes; D.R. Congo, 94,517 tonnes; Tanzania, 60,701 tonnes; and Zambia, 16,406 tonnes.

The industrial fishery in Zambia freezes its catch after landing. The larger towns along the lakeshore (Bujumbura, Kalemie, Kigoma, Mpulungu, Uvira) support markets for fresh fish. But the great majority of the catch from Lake Tanganyika is dried in the sun, smoked, salted, roasted or some combination of these processes (see Lindley 2000 for details). These fish are then sent to distant markets in the Copper Belt, Lubumbashi, Dar es Salaam, Bukavu and Rwanda.

Fishing is an important livelihood option for lakeside communities. Most lakeside households are dependent on both fishing (undertaken by men) and farming (largely undertaken by women) activities. Lindley (2000) notes that fishing gears used by subsistence and artisanal fisheries are 'minimalist, constructed of the simplest and cheapest materials and no gears exploiting the biodiverse littoral zone are mechanized…the gears are efficient and appropriate to the human and other resources of the lacustrine peoples. The diversity of gears reflects the fishermen's attempts to exploit every niche, every species and every habitat.'

Lindley (2000) reported that 'even in the light of a presently healthy artisanal pelagic fishery for sardines on most of the lake, more effort is being put into the subsistence fishery.' He attributes this increase in subsistence fishing to: the economic decline of the riparian communities (due in part to the lack of security) which has meant larger, more expensive gears cannot be repaired or replaced, resulting in fishermen returning to cheaper, traditional gears; the deterioration of food security which has prompted lots of people to enter the 'subsistence fishery' at the low end with inexpensive gears so as to ensure food supplies; and the price increase in outboard motors which has meant that fewer and fewer vessels are motorized and their ranges and methods have been reduced accordingly.

3.2.4.2.2 Fishing Threats to Protected Areas

Four protected areas (PAs) border Lake Tanganyika. PAs confer some protection to the adjacent lake resources. This section reviews the status of fishing activities in waters adjacent to each of the four terrestrial PAs (FPSS 2000).

<u>Gombe Stream National Park, Tanzania:</u>
The western park boundary extends to within 100 m of Lake Tanganyika. A buffer zone of 200 m (100 m each side of the lake-land interface) was established along the western park boundary. Until 1998 when beach seines were banned, fishermen from neighboring villages habitually used this buffer zone for beach seining. Park authorities now enforce the ban, probably more to keep people out of the park than to preserve fish stocks or biodiversity. The park issues three gill net licenses to fishermen to fish in the buffer zone.

<u>Mahale Mountains National Park, Tanzania:</u>
This is the largest reserve on the lake. Its western border along the Tanganyika coastline is 60 km in length and extends 1.6 km into the lake. All fishing activity is banned

in this area. There are villages on the lakeshore at the northern and southern ends of the western park boundary. Though the villages have had some disputes with the park about boundaries, the villages seem to have accepted that they cannot fish in the park. The high penalty for fishing in the park, confiscation of fishing gears, serves as an adequate disincentive.

Nsumbu National Park, Zambia:

Nsumbu Park's boundary extends 1.6 km into the lake, following the coastline's contours. Fishing is currently permitted from June to November at Chisanza Beach by artisanal fishermen at specified times using specified gears. The Parks Authority issues licenses and collects license fees. There is no limit to the number of licenses issued. The status of this arrangement is not certain now that Zambia National Parks and Wildlife Service is being converted to a parastatal, the Zambia Wildlife authority. The park is at risk from burgeoning populations on both sides.

Rusizi Nature Reserve:

Rusizi National Park was recently down-graded to 'Natural Reserve' status. The reserve includes portions of the Rusizi River, but its borders do not extend into the lake. The reserve, like the park before it, is under enormous pressure from neighboring villages and the city of Bujumbura. Cattle-grazing and fishing camps exist in the reserve boundaries. With more than 12 km of gill net set nightly and four beach seines and more than 1,200 traps in use, fishing pressure is perhaps more intense here than anywhere else on the lake.

The Rusizi Natural Reserve aside, Gombe Stream, Mahale Mountains and Nsumbu National Parks appear to confer protection to the adjacent aquatic resources. Fishing activities are closely managed in these areas, aiding the conservation of these resources, but at the same time, bringing the conflict between conservation and sustainable development aims into focus.

3.2.4.2.3 Capacity of National Institutions to Monitor Fishing

Many livelihoods depend upon the effective management of the lake's fish stocks. To this end, the FPSS reviewed the status of existing programmes, in the four countries, to monitor fishing in the lake. The results for each

Table 3.12 Summary of Capacity to Monitor Fisheries in Each Country (FPSS 2000)

	BURUNDI Dept. Eaux, Peche, Pisciculture	**D.R. CONGO Service de Peche**	**TANZANIA Dept. of Fisheries**	**ZAMBIA Dept. of Fisheries**
Scope of activities	· Beach Surveys · Gear Surveys · Catch Assessment -annual -main landings -whole country	· Licensing of fishermen · Catch Assessment -main landings -Uvira and Fizi	· Licensing of fishermen · Boat registration · Gear Surveys · Catch Assessment	· Surveys of purse seine fishery catches · Surveys of dried fish markets · Catch Assessment in selected villages · 10 year gillnet survey
Most recent year of data collection	1999	1999	1999	PS, market and CA surveys 1997 Gill net survey 1990
Methods of data collation	Raw data to spread-sheets, compiled into an annual report	Raw data stored on datasheets	Raw data compiled into an annual report and sent to HQ	Raw data to spread-sheets, compiled into an annual report and sent to HQ
Interpretation of data	Central HQ, at lakeshore	None	Central HQ, no current feedback to lakeshore	Central HQ, no current feedback to lakeshore
Use of results for management	Unclear	Unclear	Unclear	Unclear

country are summarized below in Table 3.12.

Data on fishermen, gears and catches is generally being collected in all four countries. However, the data, whether collated and analyzed or not, is not currently being used for the management of the lake's resources. Lakeside institutions lack the capacity to analyze the data and use the improved information base for management. FPSS teams (FPSS 2000) recommend the status and purpose of fisheries monitoring should be reviewed against national and regional needs and the four riparian countries integrate and standardize their monitoring programs.

3.2.5 Socio-Economic Special Study

Unlike the Pollution, Sedimentation and Fishing Practices Special Studies, the Socio-Economic Special Study (SESS) is not a direct threat-based study. However, since pollution, deforestation and over-fishing of the Tanganyika Basin are ultimately actions by humans, the authors of the Project Document considered it important to devote a study to analyzing the socio-economic setting and constraints of the people of the Tanganyika Basin.

3.2.5.1 Objectives and Strategy:

The LTBP SESS aimed to provide an understanding of current livelihood strategies in the Tanganyika Basin as well as the sustainability of these strategies and the constraints faced by the local people. With a better understanding of the reasons behind livelihood strategies and natural resource utilization, the SESS teams could: consider alternative livelihood and income earning opportunities, cultivate local participation in sustainable natural resources management and promote local awareness of the importance of sustaining the lake's resources.

National SESS teams in each country addressed these objectives through a combination of participatory methods and detailed household interviews conducted at select sites. Participatory methods were used to discover the broad patterns of activity that characterize livelihoods at the village level, with focus group discussions used to highlight village infrastructure and services as well as gender differences. Focus group discussions facilitated the classification of households into broad income and SESS groups. Household interviews were undertaken with sample households to establish variation in livelihood strategies.

While some SESS activities occurred in Tanzania and Zambia during the project's early years, the majority of the field work occurred in 1999-2000. The study's late start is attributed to the multiple changes of study coordinator and delays in recruiting a field-based facilitator.

3.2.5.2 Products:

LTBP socio-economic surveys focussed on four thematic areas: fisheries livelihoods and practices; agricultural land use and livestock; deforestation, energy needs and woodland management; and population growth and movements. The following section will provide an overview of the key finding in each theme. Subsequent sections will summarize the surveys in each country. These findings are based on 18 surveys that were conducted by national teams in the four countries. These original survey reports, as well as national summary reports for each country, and other summaries, overviews and recommendations of the socio-economic special study are available at:
http://www.ltbp.org/PDD6.HTM.

3.2.5.2.1 Overview

Livelihood strategies around the lake are complex, diverse and dynamic. Fishing and farming are the primary wealth producing systems, though the range of activities and income sources and the ways in which these are combined within households varies ac-

cording to season and circumstance. Most households depend on a diverse range of activities and income sources and livelihood diversification was found in all locations and income ranges surveyed. Wealthy households often diversify from fishing into transport, trade and shop keeping and reinvest their wealth in more assets and income-generating activities. Poor households tend to sell their labor as fishermen or farmers. In poor households, even school age children contribute to the household economy through line fishing, fish processing or selling various cooked snack foods. Large communities tend to support a greater diversity of livelihoods than smaller ones as they offer more opportunities for specialization, such as civil servants, boat builders, brick makers, carpenters, mechanics, etc.

Cassava meal porridge (known locally as ugali or nshima) is the main staple food around the lake and sardines are the most common addition. Many households produce sufficient food for their immediate needs, though the political/economic problems in Burundi and D.R. Congo have resulted in food shortages, especially for the poor who are not able to buy food.

Fisheries livelihoods:

The most important fishing gears for the subsistence and artisanal fishermen on Lake Tanganyika are lift nets used from catamarans, beach seines, gillnets and various types of lines (see section 3.4.4.2.1 for details of these gears).

Lift nets deployed from catamarans were introduced in the north part of the lake in the 1950s and brought to Tanzania in the 1980s by Burundian and Congolese fishermen. This gear, used at night to target sardines in the pelagic zone, is expensive to acquire (nets, outboard engines and boats are a $10,000+ investment) and owned by only a few individuals who inherited the gear, purchased it through past credit schemes or in a few cases, saved their earnings. Some lift net owners are investors who are not involved in the operation of the gear and may not even live near the lake. This fishery employs tens of thousands of fishermen and is a lucrative business, with the profits divided in favor of the gear owners (the catamaran owner's share of the catch is 4-6x that of a crewmember). Piracy, specifically outboard engine theft, is a significant concern.

Beach seines may be used at night or during the day in nearshore sandy settings. Beach seines require considerably less capital than lift nets, but ownership is still limited to the more affluent households. Beach seines employ tens of thousands of hired fishermen and the division of the catch and profits again in favor of the gear owners (the owner's share of the catch is typically 20x that of a net puller). Beach seines are illegal in some parts of the lake, but lack of alternatives for the fishermen and lack of resources to enforce the law mean they are still used in places where they have been outlawed.

Gillnet and line fishing occur throughout the year in almost all habitats. Both methods target larger fish that can be sold for high prices in urban areas. Young boys often employ these methods in conjunction with other types of fishing or to supplement low catches.

Fishing is hard work (typically a 14-16 hour night shift) and conducted exclusively by men. Women and children are often involved in the processing (sun-dried, smoked, salted or roasted) or marketing of the catch. They may purchase fresh fish to process and sell or they may be paid in kind for their labor. Processed fish is sold throughout the region and shipped to far away markets such as Lubumbashi, Dar es Salaam, and the Copper Belt of Zambia. Women are often involved in the small-scale trading with a few dollars worth of capital. Large-scale long distance or cross border trade is dominated by men and requires many hundreds of dollars of capital. It can be highly profitable.

Different types of fishing activities peak at different seasons in different locations

around the lake. The pelagic fisheries are also dependent on the phase of the moon. When catches are high, prices drop. This is particularly true during the rainy season when it can be difficult to sun process (sun dry) the catch before it spoils. The health of the fishery varies. In some places catches remain high, in other places, the wealthier fishermen have diversified into other activities. The poorer hired fishermen have fewer options and tend to continue fishing, and perhaps diversify into subsistence agriculture.

Agricultural land use and livestock:

Flat land suitable for agriculture is limited in the Tanganyika Catchment (***e.g***. the Rusizi and Malagarasi flood plains), consequently farmers have resorted to cultivating the steep slopes of the rift valley escarpment and small strips of relatively flat land where it can be found. The principal crop in the Tanganyika Catchment is cassava, which is grown for subsistence, though surpluses may be sold. The principal cash crop, particularly in the north, is oil palm in addition to rice and cotton. Other crops include maize, beans and bananas.

Around the lake, subsistence farming is primarily undertaken by women, though men dominate the oil palm production which requires an investment of 5-7 years before the trees reach maturity. FPSS teams noted a perception among villagers that farming is not as important as fishing and this, coupled with a lack of hill-farming traditions and limited access to markets, has meant that farming practices have not been improved or diversified. Competition for land is fierce in some areas and has resulted in the clearing and cultivation of marginal lands for farming. This practice contributes to soil erosion and landslides. Subsistence farming, on its own, without interests in fishing or other livelihood strategies, provides for survival only and is typically the mark of the poorest households.

Except for Burundi, cattle are not common along the lakeshore as the terrain is not suitable and tsetse flies are widespread. In Burundi, cattle are found along the lakeshore, even in Bujumbura. When security in the country's interior became a concern, many affluent Burundian households moved their cattle near Bujumbura where security was better. Wasukuma pastoralists have also introduced cattle into the Rukwa Region in Tanzania. Most lakeside villages have some other livestock, such as goats or chickens.

Deforestation, energy needs and woodland management:

SESS teams noted that many villages have experienced fuel-wood shortages due to fuel-wood demands for smoking fish, processing palm oil, brewing traditional beer, curing tobacco, producing charcoal, cooking and other domestic use. Fuel-wood is traded within lakeside villages and between lakeside and inland villages. Uncoordinated burning and overharvesting have also been cited as threats to woodland resources. Large influxes of refugees have also had a significant impact on the forests near their camps. Loss of tree cover contributes to soil erosion and landslides, reducing the soil fertility and threatening the lake. SESS teams in the Tanganyika Catchment noted a number of mudslide scars.

Population growth and movements:

Population growth and movements are a major threat to the sustainable use of natural resources in the Tanganyika Basin. Growth rates are 4.0 percent for Makamba Province in Burundi and 4.3 percent for Rukwa Region in Tanzania, yielding population doubling times of only 17-18 years. Even the 2-3 percent growth rate typical of the Tanganyika Catchment, produces a doubling time of 25-30 years. High population density has already created competition for land and other socio-political problems in Burundi, northern D.R. Congo and Tanzania.

Migration is not a new phenomenon in this area. The decline in mining and other

activities have resulted in migrations to the lakeshore areas of D.R. Congo and Zambia by people seeking livelihoods in fishing. Also, many fishermen are not particularly attached to one place and will migrate to other areas in pursuit of better fishing. The insecurities in Burundi and D.R. Congo have resulted in recent mass migrations to Tanzania and Zambia. While some refugees have integrated themselves into fishing and/or farming livelihoods, many go to camps maintained by international aid agencies and the host countries. These sorts of mass migrations tend to have a high impact on natural resources.

3.2.5.2.2 Burundi Surveys

Owing to its unique mix of rural and urban features, SESS surveys in Burundi focussed on the peri-urban zone around Bujumbura, the most urbanized site on the lake. Security conditions also limited the range of SESS teamwork.

Since 1993, violent ethnic conflict has effected nearly every aspect of daily life in Burundi and resulted in internal and cross border displacement, death, loss of or reduced infrastructure and loss of or reduced livelihoods. General economic decline, currency devaluation and inflation compounded the effects in the area.

Owing to historical taboos, the lakeshore area of Burundi was one of the last to be colonized. However, high population densities in the interior and potential livelihoods in fishing, farming and opportunities associated with the capital, Bujumbura, have drawn people to this area in recent decades. Due to the insecurity since 1993, populations in and around Bujumbura have swelled as people have sought refuge in the relative security of this area. Such displaced people generally base their livelihoods on activities requiring little or no capital, such as the sale of natural resources, small scale trade or daily paid labor. However, without access to land to supplement livelihoods by farming, survival is precarious and many people depend on aid from international or religious organizations. In addition to internally displaced peoples, the peri-urban zone around Bujumbura has also attracted people fleeing the high cost of living or ethnic cleansing of certain areas of Bujumbura. Also waves of Congolose have sought refuge and/or economic opportunities in these areas. The end result being that many of these areas are comprised of up to 50 percent non-native inhabitants.

Communities in the peri-urban zone have traditionally enjoyed a relatively well-developed infrastructure and social services. However these structures and services have been severely impacted by the current conflict, with health services, schools etc. in the peri-urban zone damaged, functioning at a reduced capacity and/or unaffordable.

Although individuals may be occupied by one livelihood strategy, households tend to rely on a variety of activities to make ends meet and reduce risk. Bujumbura is a major market for fish, agricultural products, natural resources and labor, and many people in the peri-urban zone are involved in these sectors. Subsistence and small-scale commercial farming (cassava, beans, maize, bananas, cotton, rice and tomatoes) are common activities, especially for women. Many households also keep small livestock and men may be involved in tending cattle for others. Fishing, especially lift net fishing, is an important part of the national economy. However in recent years, households dependent on fishing have suffered due to regular government bans on night fishing for security reasons. The collection and sale of other natural resources such as fuel-wood, thatching grass or reeds also provides livelihoods for many individuals. In addition, many seek opportunities in Bujumbura in the civil or military service or various industries.

In spite of its good transportation infrastructure and proximity to the large and

varied markets of Bujumbura, the SESS team in Burundi identified conflict, insecurity and the related deterioration of infrastructure as a major obstacle to the development necessary to ensure sustainable use of natural resources. Land shortages and insecurity of land tenure, low educational levels, and inadequate access to clean drinking water and affordable health care were also listed as concerns.

3.2.5.2.3 DR Congo Surveys

Owing to security constraints at the time of the study, the SESS team in D.R. Congo focussed on three communities at the lake's north end, near Uvira: Kilomoni, Makobolo and Kigongo. The dominant ethnic groups in the study area are the Bavira, the Bafuliro and the Babembe, with small numbers of Bahutu fleeing ethnic conflict in Burundi and Rwanda. At the time of the study Uvira Territory was controlled by rebels supported by Rwanda, and as such, was effectively cut off from much of the country, including the capital, Kinshasa.

Household interviews revealed that even with high infant and child mortality, the general population is young. Civil wars and violence have resulted in mass migrations to other areas in D.R. Congo or other countries (e.g. Tanzania and Burundi). Population shifts were evidenced by the fact that less than half of any village residents were native. During the study period, there was movement on an almost daily basis in response to incidents throughout the area. Consequently, the SESS team emphasizes that these findings are a snapshot of conditions at a particular time in which households and villages were in a constant state of flux. At this time, government services and infrastructure was practically non-existent, and daily survival was the primary concern of most people. While some communities formerly enjoyed services such as piped water and reasonable transportation in the region, such services were in a state of disrepair during the study.

The dominant theme emerging from studies of livelihoods and survival strategies is that although the three communities are considered to be fishing villages, the majority of the population, despite its mobility, survives on agriculture. Cassava, oil palms, maize, groundnuts, beans and rice were the dominant cash and subsistence crops. Before the insecurities in 1996, there were significant cattle herds in the area, but theft has eliminated cattle from the area. Many houses, however, keep small numbers of small livestock. Half of the households in these communities were involved in fishing with lift nets, beach seines, gill nets, traps and/or lines. Massive currency devaluations and extended periods of non-payment of salaries have forced almost all members of the community to diversify their livelihood strategies. In addition to farming and fishing, some enter into harvesting and sale of other natural resources (fuel-wood, charcoal, thatching grass, reeds, or papyrus), production and sale of handicrafts (mats, baskets, fish traps, traditional medicines or beer), or other skilled or paid work (carpentry, masonry, tailoring, radio or bicycle repair, bicycle taxi men).

SESS teams in D.R. Congo identified the ongoing conflict and insecurity as the major constraint to development and the sustainable use of natural resources. Until political stability and law and order return to this area, most people will continue to be preoccupied with short-term survival needs rather than long-term concerns for sustainable development.

3.2.5.2.4 Tanzania Surveys

The SESS team in Tanzania was able to survey a variety of communities along the lakeshore and within the larger catchment. Their target communities encompassed a diverse range of environmental, socio-economic and socio-cultural conditions with the result that they sometimes found

contrasting results from different areas. The dominant ethnic group along the northern Tanzania coast of Lake Tanganyika is the Waha, along the southern coast it is the Wafipa. Wabembe and Watutsi migrations over the past centuries have introduced fishing and the cultivation of cassava, sorghum and groundnuts to the region. Arabs from the coast introduced Islamic culture and some tree crops such as coconuts, mangos and oil palms.

In spite of its own stability, ethnic and political conflict in neighboring countries over the last 35 years have greatly affected population and land use patterns along the Tanzanian coast. During the study period Kigoma Region hosted eight official refugee camps with more than 96,000 Congolese and 184,000 Burundian refugees. Many refugees live unregistered in the larger community. The rapid influx of refugees has created environmental problems, including rapid deforestation and resource depletion in and around the camps. The issue is politically sensitive.

Poor sanitation and malaria are the major health concerns in Kigoma and Rukwa Regions. Most lakeshore villages are served by a dispensary and ward headquarters will also typically have a health center. However, they generally have too few staff, little medicine or supplies and no facilities for operations. The educational level of most lakeshore inhabitants is low with many having some, but often not the required seven years of, primary schooling. There is considerable pressure for boys and girls to get involved in fishing and/or farming at a young age.

Along the northern coast, as many as 80 percent of the households are involved in fishing or fish processing, along the southern coast the greater emphasis is on agriculture. The main fishing operations are lift nets, beach seines, gillnets and lines. Processed fish is transported to Kigoma and then larger markets in Burundi and Dar es Salaam. Where conditions are particularly favorable (***e.g***. the Malagarasi Delta) or where fishing has declined, farming is common. Maize, beans, cassava, coffee, cotton and bananas are the main crops. Livestock is generally limited to a few goats, sheep and fowl except around Kirando where Wasukuma pastoralists have recently reintroduced cattle. Many households have diversified into running shops, kiosks, market stalls, or selling natural resources (fuel-wood), handicrafts, traditional beers or cooked food products.

The Tanzanian coast is served by a variety of institutions, including Non Governmental Organizations (NGOs), local community groups and national government institutions. National institutions have appropriated the legal ownership of natural resources such as land and water, however, most government departments lack the basic resources necessary to fulfil their mandates. The villages surveyed adhered to the formal organized structure of a 25 member Village Council (VC). Variations in VC subcommittees demonstrated that villagers are able to adapt the VC structure to their local conditions. Nonetheless, popular participation in socio-political life was generally low, and village level institutions were perceived more as instruments for enforcing regulations and orders from higher administrative levels than instruments of democratic representation. Many international NGOs and aid organizations in Kigoma Region are concerned with humanitarian aid to Burundian and Congolese refugees, though some have branched out and supported national or local NGOs to further local development issues as well.

Many lakeshore villages' economies are vulnerable to the effects of regional circumstances beyond their control, particularly conflict and insecurity in Burundi and Congo. For example, small-to-medium scale traders have lost their markets due to regional insecurities. However, large-scale traders, prepared to take significant risks, have found lucrative business in smuggling

goods to Burundi during the embargo or selling fish to Burundi during periods the Burundi coast was closed to fishing. Within Tanzania, SESS teams noted an overall lack of commitment to effect change in environmental issues, perhaps because land competition is not so high as it is in other areas and people usually still have access to other land if they need it.

3.2.5.2.5 Zambia Surveys

In Zambia, SESS surveys focussed on lakeshore villages along the length of the coastline: Chisanza, Kapoko, Kabyolwe, Lupiri and Munshi. The Mambwe, Lungu and Tabwa are the dominant ethnic groups in this area, followed by the Wabembe. The population of Zambia's northern province is young, with a median age of 16.2 years and 47 percent of the population under 14 years of age. Population density is low, with 5.6 persons per square kilometer.

Mpulungu, the largest town on the Zambian Coast, has a district administrator and people live in compounds and benefit from good education, health facilities, electricity and water. The other lakeshore villages, and much of the catchment, are administered by a Chief, in the traditional way, with clusters of communities headed by a village headperson under the authority of the Chief.

Except for Mpulungu town, infrastructure and social services are extremely limited along the Zambian coast. Most people use traditional or herbal medicines or bring their sick to Mpulungu. Most people are educated in matters of child immunization and basic sanitation.

Most livelihoods are dependent on the natural resources base. Farming is the most widely undertaken economic activity and in some areas involves almost every household. The most important crop for subsistence or sale is cassava, other crops include: maize, rice, millet, sweet potatoes, yams, bananas, beans, groundnuts, pumpkins, vegetables and sugar cane. Livestock is extremely limited and veterinary restrictions prohibit cattle to prevent the spread of disease from Tanzania. Fishing is a major part of the lakeshore economy, with the main gears being: beach seines, gill nets, lift nets and lines. Throughout the Zambian coast, people feel that catches had been declining despite increased effort. Traditionally fishing was a dry season activity with people devoting their efforts to agriculture during the wet season. Now, however, there is considerable activity year round. Fishermen sell fresh fish to local traders or markets at Mpulungu or Lupiri. Fish sold locally is processed by women and children and transported to larger markets in the Copper Belt, Lusaka or Lubumbashi. There is trade in other natural resources, such as firewood, poles and thatching grass. Shop keeping and trade of manufactured goods are important activities in the larger villages.

Government development activities in the region include the District Water, Sanitation, Health & Education Project. Other initiatives are aimed at developing the private sector, e.g. tourism in Nsumbu National Park. The SESS teams identified numerous constraints to the development necessary to ensure sustainable use of the area's natural resources. Poor road access, the risks of water transport, limited communications and banking facilities, distances to commercial centers and strong local beliefs in witchcraft were all cited as obstacles to development for sustainable use of natural resources.

3.2.6 Environmental Education Programme

The LTBP Project Document, various project Training Needs Analyses and the SESS recognized the need to implicate the riparian communities in managing Lake Tanganyika's resources through an Environmental Education (EE) programme.

3.2.6.1 Objectives and Strategy

While certain EE activities occurred during LTBP's first years, such as World Environment Day celebrations and sponsorship of a few individuals to attend international EE courses, LTBP's EE program did not really get underway and create a shared vision until early 1999. National Training, Education and Communication Coordinators (TECCs) for LTBP participated in a series of regional workshops designed to plan their national EE programs and provide the TECCs with the necessary skills to execute these programs and activities. The TECCs consulted the preliminary Transboundary Diagnostic Analysis (TDA) and their national Strategic Action Programme (SAP) documents in designing their national EE programmes. Consequently the EE programmes varied from country to country, based on each team's perceived needs.

3.2.6.2 Products

During the project's final year, after working with international consultants to refine their EE programs and develop their skills, national teams conducted EE activities in lakeshore communities in each of the four countries. These reports are available at: http://www.ltbp.org/PDD2.HTM.

3.2.6.2.1 EE activities in Burundi

The EE team in Burundi identified a number of themes worth developing into EE programs, including: training of journalists in the role of environmental education, training of fishermen in sustainable fishing practices, and awareness-raising among city-dwellers about domestic waste disposal. However, due to the Ministry of Land Use, Planning and the Environment's decision to degazette 3,000 hectares of Rusizi National Park and downgrade its status to a 'Natural Reserve,' the Burundi EE team decided to focus their energies on this issue.

The Biodiversity, Fishing Practices and Socio-economics teams studied Rusizi Natural Reserve and their findings aided the EE team in preparing their activities.

The Burundian EE team organized '2 Days of Reflection' on the theme 'The Importance of the Rusizi Natural Reserve in the Protection of the Biodiversity of Lake Tanganyika.' The purpose was to raise awareness among authorities and decision-makers about the Rusizi Natural Reserve's rich biodiversity, the importance of protecting it and the various human activities that threaten these resources. National experts gave presentations to more than 50 participants, including local and provincial administrative authorities, NGOs, development organizations and representatives from different government ministries and various sectors of the community whose activities have an impact upon the reserve. Presentations and follow-up discussions were centered around three themes: the 'Biodiversity of Lake Tanganyika and the Importance of the Rusizi Reserve in Protecting It,' 'Exploitation of the Resources of the Rusizi Natural Reserve by the Local Population,' and 'International Conventions Ratified by Burundi for the Protection of the Environment.' During these presentations and discussions, participants were made aware of: the exceptional species diversity in the Reserve, especially in fish and birds, some of which are found only at this site; the extensive human activity in the Reserve, including harvesting of reeds and grasses, cattle-grazing, and fishing and how this has effected the biodiversity; and the various international treaties (Convention for Lake Tanganyika, Ramsar, CITES and the Convention on Biological Diversity) which Burundi is bound to in protecting the environment and the consequences of not respecting these treaties. A field trip to the Reserve was included so participants could gain a better appreciation of these issues from

the field. Finally the participants divided into working groups to analyze the problems and make recommendations.

The Burundian EE team also organized a series of speeches and cultural activities to coincide with World Environment Day (5 June 2000) to raise awareness about the Reserve and its importance among the local population. A pamphlet entitled, 'The Rusizi Natural Reserve, Irreplaceable Richesse for the Biodiversity of Lake Tanganyika' was also produced by the Burundian EE team to educate people about the Reserve.

3.2.6.2.2 EE activities in D.R. Congo

Rather than targeting decision makers and authorities, the EE team in D.R. Congo decided to concentrate on the fishing and farming communities. Using facilitators and resource people from the Center for Hydrobiological Research and local NGOs, the Congolese EE team organized four-day workshops on 'Sustainable Fishing' and 'Sustainable Agriculture.'

The first workshop, which targeted 30 members from local fishing communities (specifically boat owners, heads of fishing associations and village chiefs), included presentations and discussions on: ecology and reproductive biology of the economically important fish, different fishing methods, reasons for the observed reduction in fish catches around Uvira, D.R. Congo, the importance of controlling fishing activities and the importance of protecting fish reproductive grounds. At the workshop's end , participants had gained an understanding of sustainable and unsustainable fishing practices and the importance of using appropriate gears at appropriate times in order to conserve the fish stocks.

Where possible, participants in the second workshop on 'Sustainable Agriculture' were selected from the same villages implicated in the 'Sustainable Fishing' workshop. The 30 participants included heads of agricultural associations, local farmers and village chiefs. Presentations and discussions aimed at giving participants an understanding of soil fertility, causes and consequences of erosion and soil conservation measures. The impact of erosion on the lake was also discussed.

In addition, journalists from the local radio station were included in these workshops. They reinforced the seminars' content and continued discussion on the topics through subsequent interviews and radio broadcasts. The Congolese EE team also strengthened the message of these workshops through follow-up field visits to the fishing and farming communities to discuss problems, answer questions and monitor activities. Finally, the Congolese EE team produced inexpensive educational materials (posters and pamphlets) using simple images and cartoon story-lines in Swahili to further transmit their messages to the local population.

3.2.6.2.3 EE activities in Tanzania

Recognizing that various sectoral extension workers often work in isolation and send conflicting messages to the local population about the environment, the Tanzanian EE team chose to combine training methodologies and environmental education in their work with six lakeshore villages. The team targeted their message, about a coordinated approach to environmental education within villages and sustainable practices in exploiting natural resources, to sectoral extension workers (health, education, fisheries, agriculture, community development, forestry) as well as other community leaders (village chairpersons, ward secretaries and religious leaders).

In the first set of workshops EE team members encouraged participants to discuss their observations and experience with environmental change. Most participants

expressed a familiarity with and concern for problems such as decreases in fish catch over time, loss of soil fertility, and pollution from domestic waste and ships. With the EE team serving as resource people and facilitators, participants designed posters to communicate messages about the environment. Two of these posters, one on fishing gears and the other on human activities and the health of the environment, were improved by a professional artist and printed in Dar es Salaam. Follow-up workshops were conducted to introduce the posters to the participants and discuss effective ways of using the posters, along with related questions and discussion materials, with local populations to promote environmentally sustainable practices. In addition, reports were produced in Swahili and distributed to participants to reinforce the process and findings.

3.2.6.2.4 EE activities in Zambia

In the early years of LTBP, various socio-economic, fishing practices and environmental teams working in Zambia were impressed by the existing administrative structure in villages along the lakeshore. Capitalizing on this structure, they encouraged the formation of Village Conservation and Development Committees (VCDCs) which served as focal points for project work with the lakeshore communities in Zambia.

In 1997-98, a campaign to raise awareness about fishing gears and fishing practices among the local population was launched through workshops and seminars for VCDC leaders. In subsequent activities, the LTBP TECC and team decided to conduct training exercises for these committees. The training was designed to address the VCDC role within the villages regarding conservation issues and to improve the committee's capacity and confidence to plan and coordinate conservation and development programs in their villages. Through group discussions, brain storming and role playing activities, the EE team helped the VCDCs develop their terms of reference, trained them to conduct ordered and participatory meetings and record the proceedings, and appreciate the importance of 'Action Planning.' At the close of LTBP, 27 VCDCs had been trained in this fashion. The VCDCs are currently undertaking small programmes within their villages that do not require external funding.

3.2.7 Other Studies

LTBP also had other studies to support and complement the biodiversity, pollution, sedimentation, fishing practices and socio-economics studies and the environmental education programme. These included the Local Application of Remote Sensing Techniques (LARST) station and the Geographical Information System (GIS). Images and additional information on these studies are available at:
http://www.ltbp.org/TANGIS.HTM

3.2.7.1 LARST Station

LTBP established a local capture system for the direct reception of National Oceanic and Atmospheric Administration (NOAA) satellite images in Kigoma, Tanzania. A team from the Tanzania Meteorological Training School was trained to operate the LARST Station. The team collected Advanced Very High Resolution Radiometer (AVHRR) satellite data, ranging from several kilometers to catchment-wide in scale. Processing these data provided information on lake surface temperature and vegetation. The erosion modeling study (discussed in Section 3.2.3.2.3), for example, relied on such data. Table 3.13 lists the archived images stored at the Tanzania Meteorological Training School and the Natural Resources Institute.

3.2.7.2 Geographic Information Systems

Managing the wide variety of data on biodiversity, pollution, sediment discharge, fishing practices and socio-economics was a great challenge to LTBP. As much of this information has a geographical component to it, LTBP relied on Geographical Information Systems (GIS) to provide the tools to visualize, manipulate and store these spatial data. The GIS component of the project was a key resource for integrating data and project activities.

A metadatabase was developed to catalogue data from LTBP and other sources. With more than 400 entries, including paper maps, national statistics, computer datasets, satellite images among others, the metadatabase was designed to document all data pertaining to the Tanganyika system. A catalogue of the current metadatabase holdings is available at: http://www.ltbp.org/SMDB.HTM. The data themselves are available through a GIS interface, TANGIS, based on the widely used ArcView software package. TANGIS allows non-GIS users to easily access and manipulate the datasets. The datasets come from a wide range of sources and include topographical, bathymetric, environmental, physical, chemical, biological, social and economic data.

Integrating a variety of datasets through the metadatabase, TANGIS users can: graph and map data, interrogate data and compare data sets. As a result of these queries, TANGIS can produce maps, charts, statistics and models to explore aspects of the Tanganyika system. TANGIS is thus an important link between scientists and resource managers. It allows one to study data sets as a function of other data sets, so users can examine how pollution, sedimentation and fishing practices correlate with e.g. species distribution and richness. As a data repository and a powerful tool for studying the system, TANGIS will be an important tool supporting the implementation of the Strategic Action Programme (SAP).

In February 2000 a workshop was held in Dar es Salaam to train selected LTBP participants in the use of TANGIS and management of the metadatabase. Resource materials from this workshop, including the TANGIS User Manual and the three-volume training course (Training of Trainers, GIS Theory and Application, Metadatabase Management) developed by Mills and Obsomer (1999) are available at: http://www.ltbp.org/PDD8.HTM.

Security constraints, coupled with budgetary limitations at the conclusion of LTBP, precluded wider consultation and training sessions for TANGIS and the full integration of some LTBP data (***e.g***. the BIOSS databases) into TANGIS. As TANGIS will be a valuable resource to researchers and managers of Lake Tanganyika, it is hoped that future phases, notably the implementation of the SAP, will continue to develop and exploit TANGIS.

3.3 The Strategic Action Programme

The Strategic Action Programme (SAP) is one of LTBP's principal outputs. The result of national and regional consultations and consideration of the special studies data sets,

Table 3.13 Data collected at the LARST Station in Kigoma, August 1998 – July 1999

Images	No. of Images
Total Successful Acquisitions	479
Lake Surface Temperature (Daytime)	122
Lake Surface Temperature (Nighttime)	279
Vegetation	146

the SAP provides a regional framework for a prioritized set of national and regional actions to conserve the biological diversity and assure the sustainable use of Lake Tanganyika's natural resources.

3.3.1 Process: Special Studies Contributions to the SAP

The LTBP special studies in biodiversity, pollution, sedimentation, fishing practices, and socio-economics were designed to collect data on the current state of biodiversity in Lake Tanganyika and the threats to it, so as to inform and aid the development of the SAP. Based on their findings and outputs (summarized in sections 3.2.1 through 3.2.5), each special study made management recommendations to the SAP. These recommendations were made to the LTBP Technical Committee at the Transboundary Diagnostic Analysis (Arusha, March 2000) as a series of presentations by special study facilitators and background papers drafted by special study teams.

The Biodiversity Special Study (BIOSS) set the tone for TDA and SAP discussions and priorities with the following analysis of the reasons for conserving biodiversity. Noting the Convention on Biological Diversity's (CBD) objectives for 'the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources,' BIOSS notes that 'conservation must not be carried out at the expense of sustainable development and that great care should be taken to address who bears the costs of any management interventions. BIOSS notes that the definition of biodiversity as variation (genetic, taxonomic, ecologic) implies the more variation, the more valuable a system is in conservation terms. This is true only if all species have the same value. This is seldom the case. Humans place different economic values on biodiversity, depending on whether it has 'direct-use,' 'indirect-use' or 'non-use' values. These economic values (from Allison ***et al*** 2000) are described below:

> **Direct Use Value** refers to economic benefits that accrue directly as a result of the continued existence of a genotype, species, community or ecosystem. Direct uses may be consumptive (the organism is harvested or removed from its environment, e.g. fisheries) or non-consumptive (benefits gained without removing organism, e.g. revenue from ecotourism).
>
> **Indirect Use Value** refers to the economic benefits that arise indirectly from the continued existence of biodiversity. For example, the snail-eating fish and crabs in Lake Tanganyika may be an important reason why Bilharzia (a disease in which parasites are hosted in snails before being transmitted to humans) is not found in Lake Tanganyika. The economic benefits can be measured in terms of reduced health costs.
>
> **Non-Use Value** acknowledges that biodiversity has a value beyond mere utility. It is difficult to measure this, but includes the concepts of existence values (knowing that a species exists), intrinsic values (the rights of all living things to share the planet) and bequest values (the value of our environment to future generations).

BIOSS emphasizes that: species richness alone is not a reliable guide to biodiversity value. Areas of low richness (***e.g***. the pelagic zone of Lake Tanganyika) can have very high use values. Also, costs and benefits of biodiversity conservation accrue to different groups of people (local resource users, international scientists etc). An understanding of the distribution of values should direct conservation action.

With these considerations of the economic values of biodiversity in mind, BIOSS proposed the following guiding principles for conserving biodiversity in Lake Tanganyika to the SAP (from Allison ***et al***. 2000):

- The purpose of biodiversity conservation in Lake Tanganyika is to maintain the lake's unique, diverse ecosystems and their constituent taxonomic and genetic diversity. This will be achieved through efforts to maintain habitat quality and ecosystem integrity, and through regulation of the exploitation of the fish species.
- Biodiversity conservation in Lake Tanganyika should aim to emphasize the conservation of ecosystem function. The most important ecosystem function, regionally, is the production of fish. Another important ecosystem function, of international interest, is the set of conditions that have allowed rapid evolutionary radiations in several taxonomic lineages, making the lake an important scientific resource, and of exceptional species richness.
- Biodiversity conservation in Lake Tanganyika should also aim to promote the sustainable use of biodiversity, principally through fisheries management, but also through tourism and other non-consumptive uses.
- Any economic benefits derived from biodiversity conservation in Lake Tanganyika need to be shared equitably within the lake region.

3.3.1.1 Biodiversity Special Study Recommendations

The Biodiversity Special Study (BIOSS) surveys found that much of Tanganyika's biodiversity is widespread throughout the lake but that some taxa have spatially restricted distributions. The highest biodiversity, in terms of number of species, is situated in the littoral to sublittoral zones (down to 40 m depth). The littoral zone adjacent to existing protected areas host 73 percent of the fish and 52 percent of the mollusc species known from Lake Tanganyika. BIOSS recommends the SAP adopt a regionally integrated strategy to deal with localized threats to the littoral zone and maintains and/or extends existing protected areas to include adjacent waters.

3.3.1.1.1 Coastal Zone Management

The littoral zone is threatened most by localized environmental degradation. This includes industrial and domestic pollution, inundation by sediments because of the loss of terrestrial vegetation, and unsustainable fishing practices. BIOSS recommends that a strategy of coastal zone management (CZM) be adopted in Lake Tanganyika where areas are zoned according to their conservation importance, degree of threat and requirements for human development (see Allison ***et al*** 2000 for a review of CZM). This zoning system would set out the type of coastal development permitted in different areas, thus concentrating effort and resources on ensuring that development minimizes its threat to littoral zone biodiversity. The planning process would aim to minimize conflicts between identified coastal zone uses and to locate developments according to an agreed plan, rather than the current unplanned approach to lakeshore development.

A coastal zone management approach would provide appropriate levels of protection to specific habitats. Previous discussion and documentation on conservation in Lake Tanganyika recognized only two options - national parks or unprotected areas. An integrated CZM strategy that specified permissible coastal development on a zone basis could be a more relevant and cost-effective strategy for biodiversity conservation and threat mitigation in Lake Tanganyika. The principle of sustainable development requires that the wider strategy of littoral zone conservation takes into account human-development needs. By adopting a coastal zone management strategy, the riparian countries

can target their development and conservation resources to specific areas, thus avoiding the probably ineffective strategy of spreading resources widely to maintain a whole-base, whole-lake approach to development and conservation.

In recommending a CZM strategy, BIOSS is not ignoring the existence of transboundary threats, such as overharvesting of the pelagic fish stocks. Rather BIOSS considers CZM as complimentary, not contradictory, to the effective management of transboundary issues. CZM provides a framework which should achieve a coordinated approach to addressing threats across the region, and perhaps ultimately preventing localized threats from becoming transboundary in nature.

3.3.1.1.2 Protected Areas

Because of its objectives to 'identify the distribution of major habitat types, with particular focus on existing and suggested protected areas and suggest priority areas for conservation' BIOSS focussed much of its fieldwork on surveying the waters adjacent to national parks or protected areas. These protected areas include: Gombe Stream National Park in Tanzania, Mahale Mountains National Park in Tanzania, Nsumbu National Park in Zambia and Rusizi Natural Reserve in Burundi (D.R. Congo has no protected areas adjacent to the lake). Mahale Mountains and Nsumbu's boundaries extend 1.6 km into the lake, Gombe Stream's boundary falls 100 m short of the lake, Rusizi's boundary includes the beach but not the lake. The rationale for concentrating on aquatic zones adjacent to existing terrestrial parks or protected areas is that conservation of aquatic habitats will be most effective in areas where: the adjacent catchment is protected from deforestation and pollution, the disruption to local communities is minimized and the amount of new resources required for park management is minimized.

BIOSS surveys revealed that Mahale Mountains, Gombe Stream and Nsumbu National Parks and Rusizi Natural Reserve together include a variety of sandy, rocky and mixed sand/rock habitats as well as specialized habitats including shell-beds, stromatolite reefs and reed stands. These areas together host 73 percent (178 species) of the fish species and 52 percent (35 species) of the mollusc species known from Lake Tanganyika. The species assemblages associated with these habitats are representative, in terms of overall diversity and structure, of communities in similar habitats elsewhere in the lake. The actual species compositions differ between these protected areas, with each area containing unique species. At all sites surveyed around the lake, unique species were present as a small proportion of total species richness, so it would be impossible to guarantee protection of all species without protecting a very high percentage of the whole coastal zone. Based on these findings (refer to section 3.2.1.2.4 for a more data and discussion of biodiversity in protected areas), BIOSS makes the following recommendations regarding existing protected areas near Lake Tanganyika as a way of maximizing the protection afforded to the significant proportion of Tanganyikan biodiversity residing there:

- Mahale Mountains National Park: The existing 1.6 km offshore zone is maintained as an integral part of this national park.

- Nsumbu National Park: The 1.6 km offshore zone is also maintained. BIOSS notes that due to the deeply recessed coastline, particularly in the area of Nkamba Bay, administration of the boundary is difficult because the boundary is ambiguous for both fishermen and park staff. BIOSS therefore agrees with suggestions made by

George Coulter (pers. comm. MRAG) to delimit the boundary by drawing lines between the Nkamba Bay and Kasaba Bay headlines. This modification should be implemented in consultation with local communities and should reduce areas of conflict with local users.

- Gombe Stream National Park: A buffer zone should be extended into the lake to provide some protection of this diverse littoral zone. The boundary need not be as far as 1.6 km, the distance should be determined with respect to the offshore depth profile, 300 m would probably be sufficient. Local communities must be consulted over implementation of this recommendation.

- Rusizi Nature Reserve: Rusizi was recently downgraded from a 'National Park' to a 'Nature Reserve' and is currently under significant pressure from people (see Section 3.2.4.2.2). Nonetheless, Rusizi adds a significant number of species that are not represented in other protected areas and if human pressures relax (e.g. owing to improved security in Burundi and D.R. Congo) it is recommended that the Reserve's boundaries be discussed with the intention of providing protection for the unique riverine and littoral species as well as nursery grounds for the commercially important species.

3.3.1.2 Pollution Special Study Recommendations

Pollution Special Study (PSS) data on water quality, industrial pollution and heavy metal and pesticide contamination of fish and molluscs indicate that, overall, the lake is currently relatively unaffected by pollution. The waters are generally oligotrophic and though PSS lacks quantitative data on industrial pollutants, all available data offer little indication that pollution is significantly altering the lake's water quality or food web as of yet. This news should be reassuring as maintaining healthy ecosystems is a much easier task than repairing damaged systems.

PSS data, however, do show that human activities are altering the quality of littoral habitats. Kigoma Bay is on a eutrophying trajectory. Furthermore, the variety of industrial contaminants being emitted into the lake, especially in Bujumbura Bay, is cause for concern. Nowhere on the lakeshore are domestic and industrial wastes treated before they return to the lake.

The fact that Lake Tanganyika is healthy, in spite of the range of chemicals and untreated wastewaters emitted into it, is probably because it is a big lake and outside of Burundi, the riparian communities are relatively small. With relatively low levels of pollutants entering the lake, they are rapidly diluted. However, current growth rates suggest that the population around the lake will double every 25-30 years. Industries will undoubtedly continue to increase as well. As populations and industries grow, maintaining a healthy, pollution-free status will require active changes.

To this end, the PSS has several fundamental recommendations for controlling pollution in Lake Tanganyika:

- The larger villages, towns and cities on Lake Tanganyika must make a concerted effort to improve the current practices for disposing of domestic wastes and wastewater. Nutrient enrichment, local eutrophying tendencies and regular cholera epidemics in several villages and towns attest to the problem. Town councils must put this problem on their agendas.
- Environmental Impact Assessment (EIA) capabilities, especially with respect to industrial practices near the lake, must be established in the

francophone countries and reinforced in the anglophone countries.
- A long-term monitoring programme for hydrocarbons, pesticides, heavy metals and overall water quality must be established.

The importance of implementing these recommendations is underscored by the fact that Lake Tanganyika is a nearly closed ecosystem. Many rivers, draining 250,000 km^2, enter the lake but only a single river exits it. With an average residence time of 440 years and a flushing time of 7,000 years, pollutants that enter the lake will remain there for a long time. Unlike Lake Victoria, which has a residence time of five years, severe pollution in Lake Tanganyika would not be ameliorated within a few years or even within a few generations.

3.3.1.3 Sedimentation Special Study Recommendations

The Sedimentation Special Study's (SEDSS) technical findings (summarized in section 3.2.3.2) concluded that recent rates of sediments entering the lake have increased dramatically over historical rates of input. This rate increase is a result of deforestation and agricultural practices in the catchment. Though signs of eutrophication are, as yet, limited, increased sediment input is associated with an increase in nutrient and organic matter input to lake. Studies by LTBP and others suggest that diversity in the littoral zone is negatively correlated with sediment input and that sediments have played a role in dictating the distribution of organisms over a long period of time. SEDSS concludes that sediment input into Lake Tanganyika is a real threat to the lake's biodiversity and the sustainability of livelihoods that depend on the production of the lake.

A complex suite of factors affects the distribution and therefore impact of sediments within the lake. Data suggests that medium-sized catchments (50,000 – 24,000 km^2) are particularly responsible for changing the ecology and thus biodiversity adjacent to their deltas. Climate and topography influence how far sediments are transported in the lake. Studies showed that significant quantities of sediment can be transported at least 10 km from the delta and their impact is most severe where rivers discharge onto gently-sloping lakebeds.

Considering this evidence and these circumstances, SEDSS makes a number of management recommendations regarding the control of sediment input into Lake Tanganyika. SEDSS participants noted that erosion is primarily due to clearing land for cultivation. Erosion is so severe in some places that all soil cover has been removed, exposing bedrock. Implementing better agricultural practices is the first step in reducing erosion. SEDSS notes that erosion is also a severe problem for farmers and improving soil conservation practices protects farming livelihoods as well as the lake's biodiversity. SEDSS makes a number of specific recommendations to reduce erosion, including:

- Limit tree cutting and initiate more programmes for reforestation.
- Practice terraced farming techniques on sloping lands.
- Reduce or prevent cultivation near stream banks where erosion can be severe.
- Require Environmental Impact Assessments (EIAs) for industrial activities such as sand or rock extraction.
- Promote energy-efficient stoves and alternatives to charcoal production.
- Manage brush burning in the region.
- Construct sediment retention dams in locations of severe erosion.

SEDSS recognized that protecting the livelihoods of the riparian citizens was priority and that local communities must be consulted

in implementing these recommendations. To this end, they identified environmental education about soil conservation measures as the most important management action in controlling sediment.

SEDSS participants make a number of recommendations regarding future research and monitoring of sediments in the Tanganyika Catchment (SEDSS, March 2000). They emphasize the importance of maintaining and expanding the existing river monitoring network established during LTBP. River monitoring, SEDSS notes, is the key to understanding hydrology and erosion in the catchment and necessary for establishing trends and long-term patterns of sediment dynamics.

3.3.1.4 Fishing Practices Special Study Recommendations

The Fishing Practices Special Study (FPSS) addresses its recommendations to the SAP in three different categories: pelagic zone fisheries, littoral zone fisheries and monitoring the effect of fishing practices.

3.3.1.4.1 Pelagic Zone Fisheries

Tanganyika's pelagic fishery supports many tens of thousands of fishermen throughout the lake. While not in the remit of LTBP (the pelagic fisheries of Lake Tanganyika, as noted in section 3.2.4.1, were the subject of an intensive, long-term study by the Lake Tanganyika Research [LTR] project), the importance of sustainably managing these stocks to Tanganyika's biodiversity is highlighted by predictions for the fate of pelagic fishermen should the pelagic stocks collapse. A failed pelagic fishery would probably drive many fishermen to direct their efforts at littoral zone resources or agriculture. Either outcome would have serious implications, in the form of increased pressure on the littoral zone or increased sedimentation, for the sustainable management of the lake ecosystem and the conservation of biodiversity. In directing attention to the pelagic stocks and the livelihoods they support, FPSS recognizes that to the riparian communities, the pelagic stocks are the most valuable component of Lake Tanganyika's biodiversity. FPSS asserts that protecting the livelihoods of offshore fishermen through the sustainable use of the ***Lates*** and sardine stocks is a key contribution to conserving biodiversity in the species-rich littoral zone.

To ensure the sustainable harvesting of pelagic fish stocks, FPSS encourages the SAP to review the Fisheries Management Plan developed by LTR in light of the SAP's broader biodiversity objectives. This plan, and any other fisheries management plans, must be integrated into the larger SAP process. A coordinated effort saves resources and ensures that major resource plans will be considered in concert with other regional priorities.

3.3.1.4.2 Littoral Zone Fisheries

Many inshore fishing grounds adjacent to areas of high population settlements bear heavy fishing pressure from a range of fishing gears (see section 3.2.4.2.1). The littoral zone fisheries are complex, involving many species, many different gears and both artisanal and subsistence fishermen. FPSS notes it is not easy to manage a complex fishery in a large, remote lake with few institutional resources to enforce legislative rules. Traditional legislation to control and regulate fishing efforts is not well suited to the characteristics (size, logistics, resources) of Lake Tanganyika. This is evidenced by the fact that while all four countries have banned the use of the encircling gillnet, and two countries have banned the use of beach seines, enforcement has largely been ineffective as both methods can still be widely seen in zones where they were banned.

FPSS notes that the current trend in managing fisheries world-wide is to look

toward partnership arrangements amongst groups of stakeholders (e.g. fisher communities, NGOs and governments). This is often called co-management, a broad term describing a range of partnerships from community-led to government-led arrangements (see Cowan and Lindley 2000 for a discussion of co-management). Effective fishery controls require a particular set of physical, social and institution conditions. FPSS notes that while areas adjacent to national parks have, in some cases, been successfully regulated, the resources necessary to enforce legislation of fisheries on a national or regional scale does not currently exist in any of the four countries. Consequently, FPSS recommends that co-management options be developed as the most appropriate mechanism to manage fishing activity in the littoral zone with the aim of conserving biodiversity and livelihoods. While co-management requires a fundamental shift from the traditional 'law-enforcement' control of fisheries by government agencies and encourages increasing participation of local stakeholders, experience from around the world indicates co-management of resources leads to improved sustainability.

To this end, FPSS recommends co-management options be explored for the nearshore fisheries in Lake Tanganyika. These options should reflect the complex nature of the fisheries (many species, many gears, many different stakeholders with differing efforts, marketing opportunities and constraints) and actively involve the local fishing communities. FPSS recognizes that institutional and socio-economic conditions vary along the Tanganyika coastline and proposes that the Village Conservation and Development Committees (VCDCs) in Zambia are a logical place to target pilot projects for co-management.

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3.3.1.4.3 Monitoring the Effect of Fishing Practices

All four riparian countries have some programme for monitoring fishing practices in Lake Tanganyika. These programmes (reviewed in section 3.2.4.2.3) vary in implementation and effectiveness. However, given the problems already experienced in monitoring fishing in the lake, FPSS is reluctant to recommend additional monitoring responsibilities for these institutions. FPSS points out that existing programmes lack the lakeside capacity to analyze data and use the improved information base for management decisions. FPSS recommends a regionally integrated training programme on monitoring to review the goals of monitoring and tailor the practices accordingly, as well as improving skills in information management, interpretation of results and methods for making and implementing recommendations based on monitoring data.

3.3.1.5 Socio-economicSpecial Study Recommendations

The Socio-economic Special Study (SESS) has shown that livelihood strategies in the Tanganyika Basin are complex and dynamic and there are vast differences between the poor and wealthy populations. The subsistence farming and fishing communities are some of the poorest communities in some of the world's poorest countries. SESS points out that the links between poverty and environmental degradation are well known. It is often the poor who are most directly dependent on natural resources and who are also most often unable to continually manage these resources over the long-term because of their efforts to meet urgent short-term needs. Even when there is a good understanding of the long-term benefits, the poor usually can not afford to sacrifice the short-term benefits. SESS believes that unsustainable fishing efforts and agricultural

practices are the result of poverty, underdevelopment and a lack of alternatives among people living around the lake. SESS points out that the poor face a vicious circle: poverty leads to continuing environmental degradation, the degraded natural resource base is then less able to support life, which perpetuates poverty. The biodiversity of Lake Tanganyika will only be managed sustainably and conserved, SESS asserts, through programmes of poverty alleviation, livelihood diversification and social and economic development in lakeshore communities. SESS consequently identifies such programmes as priorities of the SAP and develops these recommendations (from Meadows and Zwick 2000) below.

3.3.1.5.1 Alternative livelihoods

SESS recommends that the SAP support activities which: add value at the lakeshore to existing fish or agricultural production, bring revenue to or redistribute wealth within lakeshore communities and/or equitably increase wealth or well-being around the lakeshore without increasing erosion or fishing pressure. Such activities could minimize damage to and maximize profits from the natural resource base. To this end, SESS suggests some alternatives to be investigated (for further details see Meadows and Zwick 2000):

- Improved (cleaner, sand and grit free) processing of sardines to increase the quality and value of the product
- Promotion of improved fish smoking ovens where fuel-wood is scarce
- Eliminate insect infestations of fish product
- Production of fermented sardine products (***e.g.*** anchovies)
- Introduce ice-making to larger fishing villages to allow higher value fresh iced fish to be marketed
- Introduce small-scale aquaculture where conditions are suitable
- Improve processing of other cash crops such as cassava, sunflowers
- Improve land transport to markets for fish and agricultural products
- Promote the use of non-wood forest/woodland products
- Savings and micro-credit projects

3.3.1.5.2 Poverty alleviation and development

SESS also recommends that the SAP support attempts to improve living standards and alleviate poverty. Worldwide studies have demonstrated links between general socio-economic development, capacity to manage renewable natural resources, and reduced population growth rate. To this end, SESS asserts that diversification of local economies and more attention to these areas by national governments and international donors would be important steps to improving the income and profile of lakeshore communities. SESS encourages the SAP process to investigate social and economic development initiatives such as:

- Improvements to the diet of poorer households through the promotion of legume proteins, zero grazed cows (where possible) and poultry and small animals
- Improved sanitation
- Health education and improved delivery of health care services
- Improved access to formal education
- Support to democratic processes, peace, market liberalization, decentralization of power to rural communities, etc.

3.3.1.5.3 Sustainable fisheries

Like the FPSS, SESS argues that the large offshore fishery (worth tens of millions of dollars annually) is the backbone of the economy of the riparian communities. If the offshore fishery were not managed sustainably and fish stocks were to collapse,

SESS asserts, tens of thousands of fishermen would be forced into farming and/or the inshore fishery for survival. The impacts on sedimentation rates and the biodiversity would likely be dramatic. Like FPSS, SESS urges that the sustainable management of the offshore fishery be accorded very high priority.

It has been suggested that micro-credit programmes, which allow fishermen greater access to the more profitable and less biodiverse offshore fishery, are a means of reducing pressure on the littoral zone. SESS cautions that the offshore fishery has a limited capacity and some studies (LTR technical document 97, 1999) suggest that pressure is already too high in some areas. SESS also points out that the investment in lift nets and outboard motors is approximately $10,000, which is not 'micro-credit' and that the fleet has been steadily expanding for the past 20 years despite limited access to credit. SESS also cautions that any credit schemes must include a direct buy out (and destruction) of old gear because the goal is not to facilitate more fishing, but to facilitate less destructive gears and/or fishing in different zones. If left in circulation, old gear would likely be passed on to others resulting in an increase in overall effort and no decrease in the biodiverse littoral zone. Finally, SESS notes that the banning of certain gears (***e.g***. beach seines) must be implemented in a participatory manner and be accompanied by alternatives.

3.3.1.5.4 Sustainable agriculture

SESS notes that reducing erosion, in addition to reducing the threat to biodiversity, will also contribute over time to improved soil fertility and improved agricultural yields. SESS notes there are two complimentary strategies for reducing erosion that should be encouraged among cultivators in the Tanganyika Catchment. The first is to reduce erosion from existing fields through soil conservation measures such as contour ridges, terracing, trapping eroded material in thick vegetated borders and/or protecting bare tilled soil with a mulch. The other means is to make existing fields more productive so the rate of clearing for agriculture is reduced. This can be accomplished through improved crop varieties and the use of intercropping, manure and compost.

3.3.1.5.5 Sustainable woodland management

SESS advocates the sustainable management of wood resources, including protecting existing resources, reforestation, afforestation, agroforestry, and planting of trees for sustainably produced wood and nonforest wood products.

3.3.1.5.6 Institutional factors

SESS notes that to conserve biodiversity in the medium to long-term, capital assets must be enhanced to allow livelihoods to be diversified to include more non natural resource-based activities. This means a shift in focus from farming, fishing, sale of fuel-wood and other natural resource based activities, to trade, manufacture, and services. This diversification can potentially conserve biodiversity in two ways. First, it could provide options that make time spent on exploiting natural resources, such as farming and fishing, less remunerative than time spent undertaking alternatives. Second, it could generate resources that can then be invested in improving the natural resource base as well as other capital assets.

3.3.2 Process:

3.3.2.1 Principles and Analytical Framework

Lake Tanganyika's riparian nations agreed upon a set of principles and values in their quest to ensure the conservation and sustainable use of the lake's resources. Many of these principles are embodied in existing Conventions to which the four donor coun-

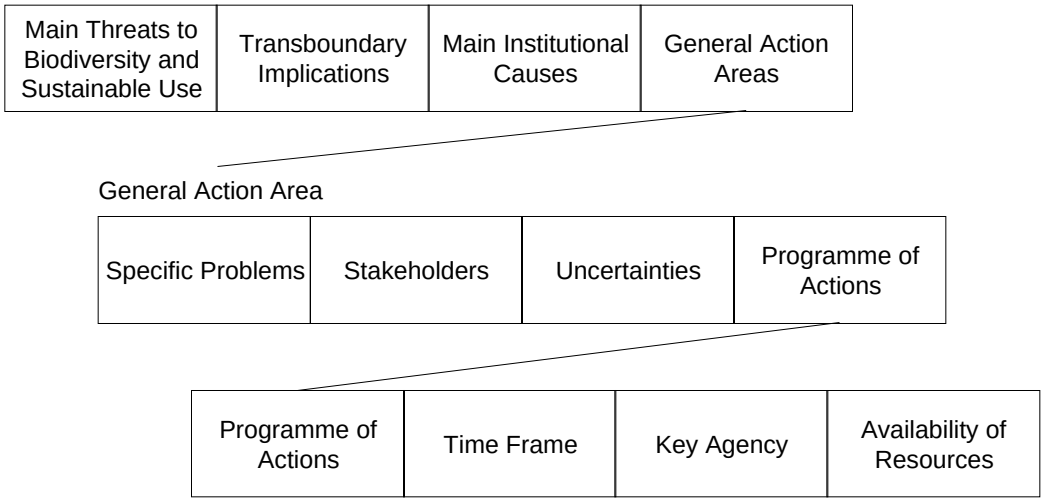

Figure 3.5 Analytical Framework for the SAP (LTBP 2000)

tries are signatories, in particular the environmental and social principles that underlie the Convention on Biological Diversity, Agenda 21 and the Dublin Principles. These principles include the:

- ***Precautionary Principle*** which states that preventive measures are to be taken when there are concerns that an actual or planned activity may bring about an adverse impact, even if there is no conclusive scientific evidence of a causal relationship between the activity and the adverse impact;
- ***Polluter Pays Principle*** and the related concept of user pays, which states that the polluter or user of a natural resource should pay for the cost of maintaining the resource or repairing damage done to it;
- ***Principle of Preventative Action*** which states that timely action shall be taken to address the actual or potential causes of the adverse impacts, before they occur in recognition of the fact that many adverse impacts are irreversible or if they can be reversed, the cost of remedial action is higher than the costs associated with prevention;
- ***Principle of Participation*** which states that all stakeholders, including communities, individuals and concerned organizations must be given the opportunity to participate, at the appropriate level, in decision-making and management processes that affect the lake;
- ***Principle of Equitable Benefit Sharing*** which states that all stakeholders, especially primary stakeholders within the community, are entitled to share in the benefits derived from local natural resources;
- ***Principle of Gender Equity*** which stresses the importance of recognizing the roles of both men and women in environmental management, noting that the key role of women as users and guardians of specific natural resources is often overlooked.

Guided by these principles, LTBP held national and regional consultations to develop the SAP. These consultations employed a specific analytical framework in evaluating the problems and the opportunities associated with managing the lake's resources. This analytical approach was divided into three tiers: main threats and general action areas, specific problems and proposed actions, and proposed actions and key agencies (Figure 3.5).

The first level of analysis listed the main threats to biodiversity and sustainable use of lake resources and identified general action areas to counteract these threats. The second level of analysis identified and grouped specific problems within each general action area and then proposed a programme of action to counteract each problem. Each specific problem was defined in terms of site and impact. Stakeholders that needed to be involved in the consultation process and uncertainties, e.g. where further research is required to develop solutions, were identified as well. The specific problems were then prioritized during this level.

Priorities were established on the basis of three criteria: severity of the problem threatening the lake's resources, feasibility of the solution and additional benefits to local communities. The first criteria assessed the severity of the problem and the benefits, in terms of conserving or sustainably managing the lake's resources, that could be expected in addressing it. This judgement considered all available scientific data bearing on the problem, but acknowledged that given the complexity of some problems and lack of comprehensive data, oftentimes judgement must be applied following the Precautionary Principle. The second criteria in establishing priorities was the feasibility of the solution. The planners acknowledged there is little point in addressing management concerns that have no practicable management solutions (***e.g***. expansion of the lake basin through tectonic rifting). Finally, in recognition that the benefits of these interventions may have wider implications than the lake's natural resources, additional benefits were considered. For example, eliminating a pollution source might have benefits for public health, in addition to biodiversity. For each identified problem, a score of 1, 2 or 3 was allocated to each criteria, with high scores allocated to: serious problems, feasible interventions likely to succeed and additional benefits to wider sustainable development. Specific problems that scored a total of 8 or 9 using these criteria were given High Priority status, scores of 6 or 7 were considered Medium Priorities and scores of 5 or less were considered Low Priority. This process of prioritization occurred at both national and regional levels, with high priorities integrated into the SAP. Subsequent versions of the SAP may include the medium to low priority interventions as more resources become available or as they increase in priority.

The final level of analysis considered the proposed actions for each specific problem and assigned a time frame - ***on-going***, could start ***now*** given adequate resources or needs to take place ***after*** (some) ***previous*** action has been completed. In addition, the key agency responsible for leading the intervention was also identified. Finally, the availability of human and material resources to accomplish the intervention was assessed.

3.3.2.2 National Consultation

The LTBP National Working Group (NWG) in each country engaged in a national consultation process to identify national priorities in managing Lake Tanganyika and to ensure that the national representatives responsible for developing the regional SAP were in a position to bring national concerns into the regional planning process. Following an initial planning meeting, two workshops were held in each country: the National Sectoral Problem Review and the National Environmental Priorities and Strategies Review (see Table 3.14).

Table 3.14 National Consultation Meetings for the SAP

	Burundi	**D.R. Congo**	**Tanzania**	**Zambia**
National Sectoral Problem Review Workshop	7-11 Sept. 98 Bujumbura	20-24 Oct. 98 Arusha[9]	27-31 July 98 Dar es Salaam	29 June-3 July 98 Lusaka
National Environmental Priorities & Strategies Review Workshop	2-6 Nov. 98 Bujumbura	26-30 Oct. 98 Arusha[9]	12-16 Oct. 98 Dar es Salaam	31 Aug- 4 Sept 98 Lusaka

[9] Owing to prevailing security conditions, D.R. Congo held its two workshops back to back in Arusha, Tanzania.

In addition to the NWG, the consultation process implicated a range of stakeholders, including: representatives from lakeshore communities and town councils, commercial enterprises, national and international NGOs, research institutions and universities and government ministries and parastatals. To ensure a common understanding of the problems and issues, the National Sectoral Problem Reviews began with an overview provided by specialists tasked with preparing briefing materials and presentations on national concerns about Lake Tanganyika. These workshops: considered the main problems for the lake's biodiversity, identified the causal chain from the perceived problems to the societal roots and reviewed possible management actions. The second set of workshops, the National Environmental Priorities and Strategies Reviews, considered the potential and limitations of existing institutional mechanisms to counteract threats and support the actions identified in the previous workshop. It also established the overall national priority for the sequence of proposed actions.

3.3.2.3 Regional Consultation

The LTBP Technical Advisory Committee (TAC), consisting of delegations from each riparian state, was mandated to develop the SAP. Each country was represented in this process by the LTBP National Coordinator and three or four additional experts identified by the national working groups. The team members were selected to provide a range of skills and knowledge of the lake and its problems. These delegations met in a series of regional meetings (see Table 3.15) to develop and draft the SAP.

With the support of the special studies and the regional perspective they provided, the TAC prepared a Transboundary Diagnostic Analysis (TDA) which defined regional priorities for management interventions. It was at the TDAs that the TAC, based on the concerns identified in the national consultation process, developed a prioritized list of regional management interventions with the overall aim of conserving and sustainably managing Lake Tanganyika's biodiversity.

GEF refers to the TDA, part of the methodology they endorse, as 'the centerpiece of the GEF strategy…it is the concept of "strategic joint fact finding" as a means of arriving at a consensus on what actions are needed to address threats…collaborating states establish technical teams that work to establish a common baseline of facts and analysis of the problem in the form of a transboundary diagnostic analysis (TDA) which is then used to set national priorities for actions to address threats to international waters in the form of the SAP."

In the TDAs the TAC, supported by the special studies teams, reviewed the major threats, defined the specific problems or sub-problems which together make up the threat and then proposed a sequence of management interventions to counteract each specific problem. This process used the same

Table 3.15 Regional Consultation Meetings for the SAP

Date	Location	Event
13 Aug 98	Arusha, Tanzania	Technical Advisory Committee mtg
23-26 Nov 98	Lusaka, Zambia	preliminary Transboundary Diagnostic Analysis
4-7 Jan 00	Arusha, Tanzania	SAP drafting workshop
27-30 March 00	Arusha, Tanzania	final Transboundary Diagnostic Analysis
1-3 May 00	Lusaka, Zambia	final SAP drafting workshop
July 00	Nairobi, Kenya	SAP endorsed by LTBP Steering Committee

analytical approach (outlined above) that was employed in the national consultation process. The value of this approach is that what initially appeared to be an ambitious and daunting management objective, such as controlling pollution, was reduced to a series of manageable objectives addressing specific problems, many of which could be initiated by local authorities and implemented with available resources.

Specific problems that were identified as High Priorities in the TDA were included in the SAP. The SAP defines regional priorities and offers a regional framework for addressing them. However it is important to note that as all activities proposed to mitigate environmental problems will be carried out within national waters or national territories of the participating countries, the actual implementation of these actions will be a national responsibility. In this way, the SAP is a series of national actions within a regional framework.

After establishing the regional management priorities for Lake Tanganyika, the TAC met on two occasions to draft the SAP. The drafting process was supervised by the LTBP Steering Committee. On 13 July 2000 the Steering Committee endorsed the final draft document, entitled, 'The Strategic Action Programme for the Sustainable Management of Lake Tanganyika.'

3.3.2.4 Interim Lake Tanganyika Management Body

The proposals in the SAP are based on 'best available knowledge' and draw on the considerable experience of those using and managing lake resources, as well as the published results of more than 100 years of scientific research on Lake Tanganyika and the findings of LTBP's special studies. However, even as the actions in the SAP are undertaken, the lake will continue to change. New activities within the Tanganyika Basin may require new responses to conserve and manage lake resources. New research may allow proposed actions to be refined and may define the need for further interventions. The SAP consequently requires a management body that will oversee its implementation and have the capacity to update the SAP in response to changes in the lake's status or the needs and aspirations of lakeshore communities and regional development.

The Lake Tanganyika Convention (see Section 3.4) provides for such a management body in the Lake Tanganyika Authority, which consists of a Management Committee and a Secretariat. As the Convention has not yet been signed, and thus has not entered in to force, the SAP proposes an Interim Lake Tanganyika Management Body (ILTMB), also consisting of an Interim Lake Management Committee (ILMC) and an Interim Lake Management Secretariat (ILMS), to fulfil this function until the Convention has been signed. The ILMS will: coordinate, support and prepare costed project proposals for the priority actions listed in the SAP; act as the lead group to coordinate and leverage funding at national and regional levels in support of the SAP; coordinate lake management interventions implemented by national institutions within the framework of the SAP, support the finalization of the draft Convention among other tasks. The ILMC is mandated to: supervise activities detailed in the SAP, direct the activities of the ILTMS, approve and support project proposals developed by the ILTMS, approve and finalize funding agreements developed by the ILTMS; among other tasks. The ILTMB will ensure the actions identified in the SAP are implemented and that the SAP is updated as necessary. It is anticipated that the SAP will be regularly reviewed and amended, initially by the ILTMB and later by the Lake Tanganyika Authority.

Table 3.16 Main Threats and General Action Areas (LTBP 2000)

Main Threat to Biodiversity and Sustainable Use	Cross-Cutting Transboundary Implications	Cross-Cutting Institutional Problems	General Action Areas
Unsustainable Fisheries	Global Loss of Biodiversity	Lack of Resources	Reduce Fishing's Impact
Increasing Pollution	Loss of Shared Fisheries Resource	Poor Enforcement of Existing Regulations	Control Pollution
Excessive Sedimentation	Decline in Water Quality	Lack of Appropriate Regulations for Lake Tanganyika	Control Sedimentation
Habitat Destruction		Lack of Institutional Coordination	Habitat Conservation

3.3.3 Products:

These national and regional consultations resulted in prioritized lists of national environmental concerns, the TDA and the SAP. These documents are available at: http://www.ltbp.org/LATSAP.HTM

3.3.3.1 Transboundary Diagnostic Analysis

During the TDA, initial analyses reaffirmed that unsustainable fisheries, increasing pollution and excessive sedimentation, which were first identified at the 1991 First International Conference on Conservation and Biodiversity of Lake Tanganyika and subsequently investigated by LTBP's special studies, were significant threats to the biodiversity and sustainable use of Lake Tanganyika's resources. In addition, the TAC added habitat destruction to the list of threats. The transboundary implications, main causes of and general action areas were also identified for these threats (see Table 3.16).

In their identification of main threats and assessment of transboundary implications, the TAC highlighted global biodiversity and international waters issues. This assessment justifies the need for regional cooperation and international donor support in addressing these threats. The TAC also described the institutional constraints faced by riparian states in addressing those threats, including: lack of resources, poor enforcement of existing regulations, lack of appropriate regulations for Lake Tanganyika and lack of institutional coordination. At the conclusion of this first level of analysis, the TAC identified: reducing the fishing impact, controlling pollution, controlling sedimentation and conserving habitat as the general areas requiring action to mitigate the threats to Lake Tanganyika's biodiversity.

The second level of analysis in the TDA has four parts, one for each identified general action area. Within the general action areas of reducing fishing impact, controlling pollution, controlling sedimentation and conserving habitats, the TAC listed all of the problems that together form the threats and prioritized them, following the procedure used to establish national priorities (outlined above). The specific problems identified and how their priority rank was established for each general action area are listed in Tables 3.17 – 3.20. See the full text of the TDA for justification of priorities.

In the category of reducing fishing pressure, this prioritization exercise identified excessive fishing effort in the littoral zone, excessive fishing effort in the pelagic zone and excessive or uncontrolled extraction of ornamental fish as 'high priority' problems. They were consequently the subject of further planning and analysis in the SAP.

Table 3.17 Prioritization of Problems - Reduction of Fishing Pressure (LTBP 2000)

Specific Problem	S	F	B	T	C
Excessive fishing effort in the littoral zone	3	2	3	8	A
Excessive fishing effort in the pelagic zone	3	2	3	7	A
Excessive or uncontrolled extraction of ornamental fish	3	2	3	8	A
Use of beach seines	3	1	3	7	B
Use of inappropriate mesh sizes	3	1	3	7	B
Lack of economic alternatives for fishermen	3	1	3	7	B
Insecurity and piracy	2	1	3	6	B
Fishing in sensitive areas	3	1	3	7	B
Destructive methods (others than seines or mesh)	1	1	3	5	C
High demand for fish	2	1	1	4	C
Insufficient data in the southern part of lake in Congo	1	1	2	4	C

S: severity, F: feasibility, B: additional benefits, T: total, C: classification (A=high, B=medium, C=low priority)

Table 3.18 Prioritization of Problems - Control of Pollution (LTBP 2000)

Specific Problem	S	F	B	T	C
Urban and Industrial pollution	3	2	3	8	A
Harbour pollution	3	2	3	8	A
Pollution from future mining activities or oil exploitation	3	2	3	8	A
Risks of major marine accidents	3	2	3	8	A
Risk of water hyacinth expansion	2	2	3	7	B
Chronic pollution from boats	2	2	2	6	B
Introduction of exotic fish species	2	2	2	6	B
Pollution from farming in the catchment	2	2	2	6	B
Use of pesticides to control vectors of human diseases	1	3	1	5	C
Pollution by present mining activities	1	1	2	4	C
Atmospheric fallout from bush fires	1	1	2	4	C

S: severity, F: feasibility, B: additional benefits, T: total, C: classification (A=high, B=medium, C=low priority)

Table 3.19 Prioritization of Problems - Control of Sedimentation (LTBP 2000)

Specific Problem	S	F	B	T	C
Erosion from inappropriate farming practices	3	2	3	8	A
Deforestation	3	2	3	8	A
Human settlements badly designed or uncontrolled	3	1	3	7	B
Sand extraction and other activities in river banks	2+	2	2	6+	B
Overgrazing in plains	2	2	2	6	B
Bad installation or management of mines and quarries	2	2	2	6	B
Unsatisfactory designing or construction of roads	2	2	2	6	B
Erosion from uncontrolled bush fires	2	2	2	6	C
Potential mines and quarries	2	1	2	5	C

S: severity, F: feasibility, B: additional benefits, T: total, C: classification (A=high, B=medium, C=low priority)

Table 3.20 Prioritization of Problems - Habitat Conservation (LTBP 2000)

Specific Problem	S	F	B	T	C
Threats to resources in national parks	3	1+	3	8+	A
Degradation of key habitats	3	3	2+	7+	A

S: severity, F: feasibility, B: additional benefits, T: total, C: classification (A=high, B=medium, C=low priority)

In the general action area of controlling pollution, urban and industrial pollution, harbor pollution, pollution from future mining activities or oil exploration and risks of major marine accidents were considered high priority problems and were retained for further analyses in the SAP.

Within the general action area of controlling sedimentation, the high priority problems were: erosion from inappropriate farming practices and deforestation. These problems were analyzed further in the SAP. Finally, within the general action area of habitat conservation, threats to resources in national parks and degradation of key habitats were listed as high priorities and subject to further scrutiny by the TAC.

After identifying the high priority problems within each general action area, the TAC went on to: identify stakeholders whose participation is necessary in addressing the threats, analyze uncertainties where further information is required for effective management interventions and established a programme of actions which addresses the problem, breaking the intervention down into a series of manageable steps. In the third level of analysis, the timing of the action, key agency to lead the action and the availability of human and material resources were considered.

3.3.3.2 The Strategic Action Programme

The TAC used the high priority actions defined in the TDA as their focus of the SAP. With regional priorities established, national delegations to the TAC then formulated their national actions designed to address these regional concerns.

The national actions are still organized under the four general action areas: reduce the impact of fishing, control pollution, control sedimentation and conserve habitats. However, this sectoral-based classification is for convenience. Underlying all actions is the recognition that an integrated approach is needed to counteract what, at first sight, appears to be single sector problems. For example, the actions identified to reduce the impact of fishing pressure might include the promotion of improved agriculture as a means of diversifying livelihoods and reducing pressure on fish stocks. In addition, while the potential geographical scope of these interventions includes the watershed and wider economic catchment, the focus of attention is on actions that impact the lake. Priority is given to those activities with the greatest impact on the lake and on lakeshore communities, and indeed the majority of the activities will be directed at improved and integrated management of the coastal zone.

Some types of activities are common to many of the proposed national actions. Examples of these cross-cutting themes include: information management, environmental education, institutional reform and capacity building, environmental policy, socio-economic development and monitoring. It is hoped that these crosscutting themes will be combined into larger projects that integrate the themes on national and regional levels.

Tables 3.21. - 3.23 list the national actions aimed at developing sustainable fisheries by reducing excessive fishing pressures in the littoral zone and pelagic zone and controlling the extraction of ornamental fish. Tables 3.24 – 3.30 detail the national actions to control pollution, specifically by controlling urban and industrial pollution, controlling harbor pollution, managing future mining operations and responding to major marine accidents. Tables 3.31 – 3.32 describe the national actions to manage sediment by promoting sustainable agriculture and controlling deforestation. Finally, Tables 3.33 – 3.34 list the national actions aimed at conserving habitats by reducing the threats to national parks and conserving sensitive coastal habitats. For each problem, specific actions are proposed and lead agencies are identified. Other stakeholders and uncertainties are also identified. A key to the national agencies designated to lead actions precedes the tables.

National Institution Abbreviations

Burundi

BBN Bureau Burundais de Normalisation
BRB Banque de la République du Burundi
CCI Chambre du Commerce et de l'Industrie du Burundi
DG ATE Direction Générale de l'Aménagement du Territoire et de l'Environnement
ETP Ecole des Travaux Publics de Gitega
I**GEBU** Institut Géographique du Burundi
INECN Institut National pour l'Environnement et la Conservation de la Nature
MAE Ministère de l'Agriculture et de l'Elevage
MCIT Ministère du Commerce, de l'Industrie et du Tourisme
MDC Ministère du Développement Communal
MEM Ministère de l'Energie et des Mines
MINATE Ministère de l'Aménagement du Territoire et de l'Environnement
MSP Ministère de la Santé Publique
MTPE Ministère des Travaux Publics et de l'Equipement
ODEB Organisation pour la Défense de l'Environnement au Burundi
ONAPHA Office National Pharmaceutique
Regideso Régie de Distribution de l'Electricité et des Eaux
SETEMU Services Techniques Municipaux
UB Université du Burundi

Congo

AT Admimistration Territoriale
CADIC Centre d'Actions et de Développement et d'Initiatives Communautaires
CIC Conseil Interministériel de Consultation
CRH Centre de Recherches en Hydrologie
CRGM Centre de Recherches Géologiques et Minières
CRSN Centre de Recherche en Sciences Naturelles
ICCN Institut Congolais pour la Conservation de la Nature
INERA Institut National d'Etudes et de Recherches Agronomiques
ISDR Institut Supérieur de Développement Rural
ISP Institut Supérieur Pédagogique
MINAGRI Ministère de l'Agriculture
NOPTA Nouvelles Orientations de la Pêche au Lac Tanganyika
SENADEP Service National de Développement de la Pêche
SNV Service National de Vulgarisation

Tanzania

JGI the Jane Goodall Institute
NEMC National Environmental Management Council
NLUPC National Land Use Planning Commission
PMO Prime Ministers Office
TACARE Tanganyika Catchment Reforestation
TAFIRI Tanzania Fisheries Research Institute
TANAPA Tanzania National Parks
TANESCO Tanzania Electrical Supply Company
TRC Tanzania Railways Corporation
UWWS & S Urban Water Supply and Sewerage
WCST Wildlife Conservation Society of Tanzania

Zambia

DOF Department of Fisheries
D-WASHE District Water Supply and Sanitation Education
ECZ Environmental Council of Zambia
MAFF Ministry of Agriculture, Food and Fisheries
ZAWA Zambia Wildlife Authority

Table 3.21 National Actions in Response to Excessive Fishing Pressure in the Littoral Zone (LTBP 2000)

Specific Problem	Proposed Actions and Key Agency
Burundi: Excessive fishing pressure **Stakeholders:** Fisheries administration (including MAE– Fisheries Dept. and Territorial Admin.); Fishermen; Owners of fishing units; MINATE (INECN); NGOs; Local associations and communities; UB **Uncertainties:** Potential of resources	Ascertain potential, fishing standards and acceptable licensing quotas – MAE Support other income generating activities or those that supply animal proteins – MDC Strengthen capacities for Fisheries Dep. to control and supervise – MAE Raise awareness and train (fishermen, boat owners, administration) – MAE Update and issue draft law and by–laws, as well as ordinances – MAE Translation in Kirundi and extension – MAE
Congo: Excessive fishing pressure in the northern part of the lake **Stakeholders:** Min Env; Fishermen and associations of fishermen; Local authorities; CRH; Fish sellers; NGOs and local communities; MINAGRI **Uncertainties:** Maximal exploitable production Strengthen regulations: introduce licence	system (according to type of FU) with recording of existing fishermen; regional harmonisation – Min of Env Strengthen control – Min of Env Improvement of statistics – CRH Assessment of potential (maximal exploitable production) both in Northern and Southern zones – CRH Feasibility study of tax raising system aiming to regulate fishing effort (feeding at the same time a lake management fund) – CRH Identify reasons of catches increase in the South – CRH Identify actions to develop fish farming – CRH Raise awareness – information – Min of Env Research aiming at establishing how better fish conservation could decrease pressure on stock and favour transfer of demand towards bigger fish – CRH
Tanzania: Lack of quota on fishing licences **Stakeholders:** Fisheries; Communities; Local authorities; TAFIRI **Uncertainties:** Optimal quota; Available stock; Impact on biodiversity	Review LTR conclusions – TAFIRI Assess relevance to fish biodiversity issues – TAFIRI Assess trend in expansion of licensing – Fisheries Dept. Review licensing procedures – Fisheries Dept.
Zambia: Excessive coastal fishing **Stakeholders:** Artisanal fishermen; Subsistence fishermen; Dep. Of Fisheries; Local leaders;	Community-based organisations **Uncertainties:** Optimal level of extraction; Impact of fishing gear on fisheries and biodiversity Promotion of alternative livelihoods – Community Development Assess impact of fishing gear – Dep. of Fisheries Raise awareness – Dep. of Fisheries Strengthen capacity to implement activities – Dep. of Fisheries Negotiate co–management with identified communities in specific fishing zones – Dep. of Fisheries

Table 3.22 National Actions in Response to Excessive Fishing Pressure in the Pelagic Zone (LTBP2000)

Specific Problem	Proposed Actions and Key Agencies
Burundi: Excessive offshore fishing **Stakeholders:** Fisheries administration (including MAE– Fisheries Dept and Territorial Admin.); Fishermen; Owners of fishing units; MINATE (INECN); NGOs; Local associations and communities; UB **Uncertainties:** Acceptable catch	Establish standards and quotas for acceptable fishing practices – MAE Put in place a sufficient capacity to control lake fisheries – MAE Review national and regional components of the Framework Fisheries Management Plan within the context of the SAP – MAE Incorporate additional activities into national programmes within the framework of the SAP – MAE
Congo: Uncontrolled offshore fisheries **Stakeholders:** Min. of Env; Fishermen; Local authorities; Fish traders; Net manufacturers; CRH; NGOs; Local communities **Uncertainties:** Optimal mesh size and net type; Impact on biodiversity	Research into best mesh sizes and fishing methods – CRH Studies on secondary species – CRH Legislation distinguishing between three levels of activity, banning excessively fine nets, limited permits for appropriate net types and banning destructive fishing practices – Min of Env Support to control capacity – Min of Env Education and awareness raising – Min of Env Review national and regional components of the Framework Fisheries Management Plan within the context of the SAP – Min of Env Incorporate additional activities into national programmes within the framework of the SAP – Min of Env
Tanzania: Inadequate control of offshore fisheries **Stakeholders**: Fisheries Division; TAFIRI; Ministry of Regional Administration and local govt.; Fisheries investors; Communities; NGOs **Uncertainties:** Scale of problem	Build district statistics capacity– Fisheries Division Establish the existing fishing pressure (vessels, gear, fishermen…), differentiate between industrial and artisanal – Fisheries Division Establish optimal fishing pressure– Fisheries Division Set up appropriate monitoring, control and surveillance – Fisheries Division Implement education and awareness programmes for fishing communities – Fisheries Division Enforce regulations – Fisheries Division Review national and regional components of the Framework Fisheries Management Plan within the context of the SAP – Fisheries Division Incorporate additional activities into national programmes within the framework of the SAP – Fisheries Division
Zambia: Excessive industrial and artisanal fishing **Stakeholders:** Commercial fisheries; Artisanal fishermen; Local authority; Dep. of Fisheries; Community-based organisations; Local leaders; Licensing Committee **Uncertainties:** Optimal fishing levels; Market distribution	Raise national and Local Political Awareness – Dep of Fisheries Negotiate interim acceptable fleet and means of reducing fleet – DOF Establish optimal fleet composition – DOF Review licensing procedures – DOF Strengthen local capacity to monitor and enforce regulations – DOF Review national and regional components of the Framework Fisheries Management Plan within the context of the SAP – DOF Incorporate additional activities into national programmes within the framework of the SAP – DOF

Table 3.23 National Actions to Control the Ornamental Fish Trade (LTBP 2000)

Specific Problem	Proposed Actions and Key Agencies
Burundi: Excessive or uncontrolled extraction of ornamental fish **Stakeholders**: MINATE (INECN); MAE (Fisheries Dep.); Exporters; Sellers; Customs; BRB; NGOs; Local associations and communities **Uncertainties**: Scale of problem and impact	Prepare list of threatened species and proposal of inclusion in CITES lists – MINATE (INECN) Regulations, control, monitoring– MINATE (INECN) Encourage fish farming of those species – MAE Raise awareness– MINATE (INECN) Set up protected areas (demarcation, eco – tourism development, management plans) – MINATE (INECN)
Congo: Excessive or uncontrolled extraction of ornamental fish **Stakeholders**: Local authorities; CRH; Customs; Exporters; Min Environ; ICCN **Uncertainties**: Vulnerability of all the species potential per species and per site	Improvement and strengthening of licence delivery (authorised species, quantities, extraction sites) – Min of Env Strengthen extraction and exporting control– Min of Env Establish natural reserves : Luhanga, Pemba, Kalamba, Kiriza(Ubwari) and Bangwe – ICCN Additional prospecting in order to expand the network of protected areas – CRH Inscription of lake Cichlides on CITES list, except fish identified as capable to support extraction – Min of Env
Tanzania: Excessive or uncontrolled extraction of ornamental fish **Stakeholders**: Licensed traders; Fisheries; TAFIRI; Foreign Affairs; Home Affairs; Customs **Uncertainties**: Endangered species; Extent of threat	Identify threatened species – TAFIRI Regional agreement on exportable species by country of origin – Fisheries Dep. Monitor numbers and species exported – Fisheries Dep / Customs Raise senior level awareness of problems – Fisheries Dep Establish species quotas – TAFIRI Review number of licensees – Fisheries Dep Examine possibility of inclusion in CITES list – Fisheries Dep
Zambia: Excessive or uncontrolled extraction of ornamental fish **Stakeholders**: Commercial fishers; Local authorities; Fisheries Dept; ZAWA; Museums; Communities and local leaders; Revenue Authority **Uncertainties**: Scale/Impact of extraction	

Table 3.24 Burundi: National Actions to Control Urban and Industrial Pollution (LTBP 2000)

Specific Problem	Proposed Actions and Key Agencies
Burundi: Pollution from urban waste(particularly from Bujumbura and Rumonge) **Stakeholders**: MINATE (DG ATE ; INECN); Mairie (SETEMU); MCIT; CCIB; Regideso; MTPE; MSP; BBN; NGOs; Local associations and communities **Uncertainties:** Nature and quantity of effluents; Impact of pollutants on biodiversity	Expansion of treatment capacities – Mairie (SETEMU) Set up controlled site disposal and collect waste – Mairie (SETEMU) Raise awareness and train – MCIT Regulations for marketing of dangerous products for environment (notably batteries) – MINATE (DG ATE) Develop standards for enforcement of legislation relating to waste – MINATE (DG ATE) Implement land use plans in the framework of planning schemes – MTPE Strengthen capacities for INECN to monitor and control – MINATE (INECN) Support development of secondary urban centres – MTPE Surveying pollution and impact levels, monitor and follow up – MINATE (INECN)
Burundi – Industrial pollution from Bujumbura town (with particular concern to the paint industries, tanneries, soap industry, food industries, textiles and chemicals) **Stakeholders**: MINATE (DG ATE ; INECN); Mairie (SETEMU); MCIT; Industrial enterprises – the paint industries, tanneries, soap industry, food industries, textiles and chemicals; CCIB; Regideso; MTPE; MSP; BBN; NGOs; Local associations and communities **Uncertainties**: Scale of pollution, pollutant discharges and impact on biodiversity; Acceptable standards	Pre–treatment of industrial sewage and put to work the water treatment plant – Mairie (SETEMU) Expansion of the treatment capacities – Mairie (SETEMU) Set up controlled site disposal and collect waste – Mairie (SETEMU) Treatment, recycling and transformation of waste – Mairie (SETEMU) Improve industrial procedures – MCIT Raise awareness and train – MINATE (INECN) Regulations for facilities likely to pollute (Prior EIA technical specifications) – MINATE (DG ATE) Regulations for marketing of dangerous products for environment – MINATE (DG ATE) Develop standards for enforcement of legislation relating to waste – MINATE (DG ATE) Implement land use plans in the framework of planning schemes – MTPE Strengthen capacities for INECN to monitor and control – who's in charge here? Surveying pollution and impact levels, monitor and follow up – MINATE (INECN) EIA prior to industrial development – MINATE (INECN)

Table 3.25 D.R. Congo: National Actions to Control Urban and Industrial Pollution (LTBP 2000)

Specific Problem	Proposed Actions and Key Agencies
Congo: Pollution by domestic effluents and waste **Stakeholders**: Ministry of Environment; Local authorities; Population; NGOs and local communities; Urban services; INERA; Ministry of Energy **Uncertainties:** Nature and quantity of pollutants and impact on the lake's biodiversity	Identification of pollutants, evaluation of impact – CRH Sanitation (construction of latrines, installation of controlled disposal sites and waste collecting, setting up waste and sewage network connected to a treatment plant) : Uvira, Mboko, Kalemie, Moba, Baraka – Min of Env Health education – Health Services Research – focused on recycling through agricultural and energy – INERA Develop appropriate legislation and support enforcement capacity – Min of Env
Congo – Industrial pollution from Kiliba Sugar Factory **Stakeholders**: Kiliba Sugar Factory; CRH; CRSN; INERA; ISDR; NGOs and local communities; Min. of Energy; Ministry of Environment **Uncertainties**: Impact of pesticides and lime on the lake biodiversity; Alternatives	Recycling of by – products (bagasse, treacle, lime) – Min of Env Assessment of the impact of herbicides on the Lake waters and the biodiversity – CRH Research for more appropriate fertilising modalities – INERA Update legislation – Min of Env Control – Min of Env
Congo – Pollution from Kabimba Cement Factory **Stakeholders**: Ciment–lac; CRH; CRSN; INERA; ISDR; NGOs and local communities; Ministry of Environment **Uncertainties**: Impact of ashes, dusts and smokes on lake biodiversity	

Table 3.26 Tanzania: National Actions to Control Urban and Industrial Pollution (LTBP 2000)

Specific Problem	Proposed Actions and Key Agencies
Tanzania: Discharge of untreated domestic waste, Kigoma Town **Stakeholders**: Local Council; Regional Authority; Min of Water; Min of Health; Min of Lands **Uncertainties:** Impact on biodiversity; Quantity and type of effluents	Review existing town development plans – Min of Lands Incorporate proposals for sewage, waste water control measures and water supply – Min of Water Propose developments and promote awareness to counteract existing situation of open drains etc. – Min of Lands Monitor effluents – Min of Water
Tanzania: Discharge of untreated waste from institutions (police, prisons, railway station, docks) Kigoma Town **Stakeholders**: Police; Prisons; TRC; Local Council; Min of Water; Min of Health; Min of Transport; Regional authorities **Uncertainties:** Impact on biodiversity; Quantity and type of effluents	Enforce regulations – Min of Water Identify reasons for non–compliance – UWS&S Dept Promote Senior level awareness – Local Authorities Identify and propose practical treatment works and disposal sites – Min of Water Implement proposals and regulations – Min of water Monitor effluents – Min of Water
Tanzania: Inappropriately sited solid waste dumps Kigoma Town **Stakeholders**: Local Council; Regional authority; Min of Water; Min of Health; Min of Lands; Communities **Uncertainties:** Impact on biodiversity; Quantity and quality of leachates	Identify appropriate dump sites – Town Council Review present collection and disposal procedures – Town Council Check existing and introduce appropriate local regulations; Develop appropriate landfills – Town Council Monitor quantity and quality of leachates – Min of Water
Tanzania – Industrial pollution Kigoma TANESCO Power Station **Stakeholders**: TANESCO; Local Council; Min of Water; Min of Energy; **Uncertainties**: Extent of pollution	Implement appropriate management practices and structures – Energy Department Implement both short and long-term remedial measures – Energy Department Review TANESCO plans for rehabilitation, including funding – Energy Department

Table 3.27 Zambia: National Actions to Control Urban and Industrial Pollution (LTBP 2000)

Specific Problem	Proposed Actions and Key Agencies
Zambia: Discharge of untreated domestic effluent, Mpulungu and shoreline settlements **Stakeholders**: Local authority; Water Affairs; Fisheries Dept; Local communities; District Health Management Team; D–WASHE; ECZ **Uncertainties:** Scale of problem; Impact on biodiversity	Assess scale of problem and impact on biodiversity– ECZ Review design of existing sewerage systems, assess potential for alternatives – Local Council Link with existing D–WASHE programme– Local Council Implement alternatives– Local Council Monitor effluent disposal – ECZ Raise awareness of issues – ECZ
Zambia: Uncontrolled waste dumping in and around Mpulungu **Stakeholders**: Transports; Fishing companies; Local Authority; Water Affairs; Zambia Revenue Authority; Fisheries Dept; Local communities; District Health Management Team; ECZ **Uncertainties:** Scale of problem; Impact on biodiversity	Assess scale of problem and impact on biodiversity – ECZ Raise awareness of issues – ECZ Monitor disposal – ECZ Enforce regulations – Local Council
Zambia – Transboundary movement of industrial pollution **Stakeholders**: Communities; Min of Energy & Water Depart.; Dept. of Fisheries; Local Authorities; Min of Environment; NICER; ECZ; Maritime **Uncertainties**: Types of pollutants, distribution and build-up	

Table 3.28 National Actions to Control Harbor Pollution (LTBP 2000)

Specific Problem	Proposed Actions and Key Agencies
Burundi: Pollution in harbours **Stakeholders**: MTPET (Lake transport), Ship owners, EPB, INECN – MINATE (INECN), MCIT, Lake Guard **Uncertainties:** Scale of threats	Promulgation of Lake Traffic Act, and extension – MTPET Control enforcement of Act, and continue technical checking of ships – MTPET Monitor and evaluate scale of the problem of lake pollution – MINATE (INECN) Harmonise regulations and supervising activities and control with the other riparian states – MTPET Establish a shipyard for maintenance and repairing of ships – MTPET
Congo: Harbour pollution (Kalemie, Kabimba, Kalundu, Moba) **Stakeholders**: Ministry of Environment; Transport and Communication; CRH; Ship owners **Uncertainties:** Nature and quality of pollutants; Impact on the lake's biodiversity	Raise awareness – Min of Env Update regulations (eco tax combined system dissuading from legal pollution and penalising illicit pollution) – Min of Env Strengthen control – Min of Env Installation of controlled disposal sites on dry land – Min of Env Identification of pollutants and assessment of their impact on the lake biodiversity – CRH
Tanzania: Pollution in harbours (particular concern over storage and handling of oil) **Stakeholders**: TRC; Min of Water; Ship owners /operators; Local Council; Oil companies; Shipping Department; NEMC; Min of Transport **Uncertainties:** No information on specific handling problems; Impact on biodiversity	Identify specific causes of leaks and spillage – Min of Water Check and review regulations and recommended procedures – Min of Water Review reasons for non–enforcement of regulations – Min of Water Implement short-term and long-term remedial actions – Min of Water
Zambia: Pollution in harbours (particular concern over storage and handling of oil and other cargoes) **Stakeholders**: Communities; Water Affairs; Maritime Department; Harbours Authorities; Barge owners; Fisheries Dept; Local authorities; Police Service; Defence; ECZ; Disaster Management Unit **Uncertainties:** Impact on biodiversity of different cargoes and scenarios	Carry out risk assessment – Maritime Review potential impact on biodiversity – Fisheries Mitigate impacts and put in place emergency response capacity – Harbours Authorities

Table 3.29 National Actions to Manage Future Mining Operations (LTBP 2000)

Specific Problem	Proposed Actions and Key Agencies
Burundi: Potential pollution from future mining and oil exploitation activities **Stakeholders**: MEM (DMC); MINATE; Mining companies; Oil companies **Uncertainties:** Scale of pollution and effects on lake	EIA prior to start mining – MINATE (INECN) Review Oil and Mines Act in order to take into account environmental impacts – MEM Negotiate agreements with other riparian countries – MEM Support the existing chemical and biological laboratories – MINATE (INECN)
Congo: Potential pollution from future mining and oil exploitation activities **Stakeholders**: Min Environment; CRH; CRGM; Min. of Oil; Ministry of Energy **Uncertainties:** Probability and site of works	Studies of impact on the environment – CRH/Min of Env Environment follow up of activities – Min of Env
Tanzania: Discharge of toxic substances from mine workings **Stakeholders**: "Smallholder miners;" Min of Energy and Mines; Min of Water; Regional/ Local authorities; NLUPC; NEMC; Min of Health **Uncertainties:** Scale of problem	

Table 3.30 National Actions in Response to Major Marine Accidents (LTBP 2000)

Specific Problem	Proposed Actions and Key Agencies
Burundi: Pollution from major marine accidents **Stakeholders**: MTPET (Lake transport), Ship owners, EPB; MINATE (INECN), MCIT, Lake Guard; MAE (Fisheries) **Uncertainties:** Scale of threats	Promulgation of Lake Traffic Act, and extension – MTPET Control enforcement of Act, and continue technical checking of ships – MTPET Monitor and evaluate scale of the problem of lake pollution – MINATE (INECN) Harmonise regulations and supervising activities in riparian states – MTPET
Congo: Pollution from major marine accident **Stakeholders**: Min. of Environment; Transport and Communication service; CRH; Ship owners; CRSN; External Commerce; Congolese Office for Control **Uncertainties:** Nature and quantities of pollutants; Impact on lake biodiversity	Raise awareness (ship operators and other stakeholders) – Min of Env/Transp. and Comms. Review regulations (navigation rules; pollution and security standards, transport of hazardous cargo) – Min of Env Strengthen control – Min of Env Technical control of ships (with anti–pollution and security standards) – Trans. and Comms. Pollution monitoring – CRSN Evaluate impact (scale of problem, frequency of discharge, risks, harmfulness of pollutants) – CRH
Tanzania: Pollution from major marine accident **Stakeholders**: Ship owners/ barge operators; Regional Authorities; Shipping Department; NEMC; Min of Transport; Min of Water; NEMC; Insurance companies; TAFIRI **Uncertainties:** Level of risk	Risk analysis – NEMC Develop contingency plan – NEMC
Zambia: Pollution from major marine accident **Stakeholders**: Large transporters; Passengers; Maritime Department; Harbours Authorities; Insurance companies; Fisheries Dept; Local authorities; ZRA; Police Service; Defence; Disaster Management Unit; ZAWA; ECZ **Uncertainties:** Impact on biodiversity of different cargoes and scenarios	

Table 3.31 National Actions to Promote Sustainable Agriculture (LTBP 2000)

Specific Problem	Proposed Actions and Key Agencies
Burundi: Erosion from agricultural practices **Stakeholders**: MAE; MINATE (DG ATE); Territ. Admin.; Farmers; Research institutes; MTPE; NGOs; Local associations and communities **Uncertainties**: Impact on biodiversity; scale of sedimentation; relation between erosion and fragile areas receiving sediments at lake level	Evaluate impact of problem, study the extent of sedimentation in the lake and identify high risk erosion areas – MINATE (IGEBU) Plan catchment (agro–forestry, anti–erosive practices), raise awareness and promote participative approach – MINATE (DG ATE) Research – development and extension of suitable techniques – MAE Planning focused on sediment deposits in the valleys, traps for sediments – MINATE (DG ATE) Define special standards and prioritise interventions to identified areas – MINATE (DG ATE)
Congo: Inappropriate farming practices and extensive agriculture **Stakeholders**: Minagri (SNV); Ministry Environ; INERA; NGOs and local communities; CRH; Local authorities; AT; ISDR **Uncertainties**: Sensitive zones	Education and awareness – MINAGRI/SNV Identification of sensitive erosion zones – INERA Regulation of soil use in these zones – Min of Env Implementing demonstrations (anti erosive techniques, agrozootechnical, agroforestry integration) – INERA Extension and support to enforcement capacity – MINAGRI/SNV
Tanzania: Erosion from agricultural land (particular concern on steep slopes and cultivating down the slope) **Stakeholders**: Min of Agriculture; Communities; NLUPC; Local Authorities; JGI/ TACARE **Uncertainties**:	Identify with communities, sensitive areas – NLUPC Demarcate hazardous areas and reforest – NLUPC Raise awareness of critical issues – Min of Ag Promote soil conservation measures – Min of Ag Check/review bye–laws – Local Authority Assist villages in preparing land use plans – NLUPC
Zambia: Erosion from agricultural practices (particular concern slash and burn and stream bank cultivation) **Stakeholders**: Farming communities; Forestry Department; Ministry of Agriculture; Water Affairs; Local Chiefs; Chongololo Club; Local Authorities; Churches **Uncertainties**: Scale of problem and trend; Scale and impact on the lake; Cultural and economic viability of alternative farming practices	

Table 3.32 National Actions to Counteract Deforestation (LTBP 2000)

Specific Problem	Proposed Actions and Key Agencies
Burundi: Deforestation **Stakeholders**: MINATE, MAE; NGOs, Local associations and communities **Uncertainties**: Scale and distribution of clearings; State of resource	Inventory of forests and evaluate damage – MINATE (DG ATE) Strengthen legal basis for Protected Areas – MINATE (INECN) Expansion of network of Protected Areas to cover all natural forests – MINATE (INECN) Demarcate PAs and national forests boundaries – MINATE (INECN) Rehabilitation of destroyed parts of PAs and forests Environmental education – MINATE (INECN) Prepare participative management plans for woods and PAs and identify alternative resources – MINATE Promote agroforestry and private woods – MINATE (DG ATE) Compensate people expelled from Pas – MINATE Reinforce the capacity to supervise and control PAs and forests and INECN capacities – MINATE
Congo: Deforestation **Stakeholders**: Ministry of Environment ; ICCN; Local authorities; NGOs (CADIC) and local communities; Population; Ministry of Energy; MINAGRI; CRH **Uncertainties**: Scale and distribution of clearings; State of resource	Education and awareness (including authorities) – Min of Env. Promotion of private woods and agro forestry (extension, demonstration) – Min of Env. Protection and restoring of public forests along rivers – ICCN Identification of forestry areas to be protected – ICCN Establish protected forest areas – Min of Env. Update legislation – Min of Env. Strengthen environmental services capacities – Min of Env. Creation of micro hydropower plants in order to supply substitution energy to protect the catchment – Min of Env. Action towards improved stoves, improved process for smoking of fish and alternative energy (biogas, solar etc..) – Min of Env.
Tanzania: Deforestation **Stakeholders**: Local / Regional authorities; Communities; Forestry Department; NLUPC; Min of Lands: TACARE; Min of Local Govt. **Uncertainties**: Current scale and rate of deforestation	Identify critical encroachment and critical threatened zones – Forestry Dep Create political awareness of problems – Local Government Negotiate with communities to gazette sensitive areas – Local Authority Negotiate means of resettlement from sensitive areas – Local Authority Promote community forest management and access rights – Forestry Department Enforce by–laws – Local Authority
Zambia: Deforestation **Stakeholders**: Local communities; MENR; ZAWA; Water Affairs; Local Chiefs; Chongololo Clubs; Politicians **Uncertainties**: Scale of impact on sediment load	Assess impact on sediment load – Water Affairs Negotiate solution to current encroachment – MENR Rehabilitate sensitive areas – MENR Enable enforcement of current regulations – MENR Raise awareness of issues, particularly at the political level – ECZ Promote afforestation – MENR Raise local awareness – MENR Promote sustainable forest management, agroforestry and promote alternative energy – MENR

Table 3.33 National Actions to Support Parks Management (LTBP 2000)

Specific Problem	Proposed Actions and Key Agencies
Burundi: Encroachment in the Rusizi Natural Reserve **Stakeholders**: MAE (incl. Fishing dep.); MINATE (INECN); Territ. Adm.; Farmers; NGOs; Local associations and communities **Uncertainties**:	Compensation for expulsion from sensitive zones – MINATE (INECN) Extend the reserve into the littoral zone to 1,000 metres offshore of the 774 metre contour – MINATE (INECN) Plant hedge to demarcate the reserve in the Rusizi delta – MINATE (INECN)
Congo: Lack of protection of the Congolese side of the Rusizi delta **Stakeholders**: ICCN; CRH; CRSN; NGOs, Local communities **Uncertainties**	Establish a "protected area" in the Rusizi delta, adjacent to the Burundi Natural Reserve – ICCN
Tanzania: Exploitation of fisheries within parks **Stakeholders**: TANAPA; Fisheries Department; Local communities **Uncertainties**: Compliance of local communities	Raise awareness of parks issues – TANAPA Involve local communities in parks management – TANAPA
Zambia: Community pressure on Nsumbu National Park **Stakeholders**: ZAWA; Lodge operators; Local communities; Fisheries **Uncertainties**: Support from local communities	Involve communities in parks management – ZAWA Training in Aquatic Parks Management – ZAWA Define and mark aquatic parks boundary – ZAWA

Table 3.34 National Actions to Conserve Sensitive Coastal Habitats (LTBP 2000)

	Proposed Actions and Key Agencies
Burundi – Degradation of sensitive coastal areas **Stakeholders**: MAE (incl. Fishing dep.); MINATE (INECN); Territ. Adm.; Farmers; NGOs; Local associations and communities **Uncertainties**: Extent of lake shore activities; Impact on biodiversity	Mapping supra littoral area and cultivated area – MINATE (INECN) Raise awareness – MINATE (INECN) Participative management and restoration of natural resources – MINATE (INECN) Declare sensitive areas as protected areas (Murembwe, Nyengwe, Rwaba) - MINATE (INECN) Control lake shore vegetation exploitation – MINATE (INECN) Protect the rocky coastline through tree planting between Gitara and Flugara – MINATE (INECN)
Congo – Risk of degradation of coastal zone; Lack of protection of specific key zones (Rusizi, Lukuga, Luhanga, Pemba, Kalamba, Kiriza, Kazimia, Burton Bay) **Stakeholders**: ICCN; CRH; CRSN; NGOs, Local communities **Uncertainties**:	Establish a protected area – Lukuga – ICCN Establish a protected area – Rusizi – ICCN Establish protection for sites of special scientific interest – Luhanga, Pemba, Kalamba, Kiriza, Kazimia, Burton Bay – ICCN Participative preparation of a management plans – ICCN Hydrologic monitoring (Lukuga, Mutambala and Rusizi) – CRH
Tanzania – Degradation of wetland areas – in particular the Malagarasi **Stakeholders**: Communities; Fisheries Dept; TAFIRI; Local government; Tourism and Natural Resources **Uncertainties:** Impact on biodiversity; Optimal size of protected areas; Community compliance	Negotiate access with communities – Min of Agric Gazette areas – Min of Agric Raise awareness – Fisheries Ban destructive fishing practices – Fisheries Evaluate stock – TAFIRI Conduct hydrological and limnological monitoring – TAFIRI
Zambia – Damage to sensitive habitats Lufubu and Chituba Bay and Chisala River Mouth **Stakeholders**: Min. of Agriculture; Min. of Env.; Min of Tourism; Local authorities; Local communities; Traditional leaders **Uncertainties:** Extent of degradation; Impact on biodiversity	

3.4 The Legal Convention

The authors of the LTBP Project Document maintained that if the riparian states were to achieve an "effective regional approach to control pollution and prevent the loss of the exceptional diversity of Lake Tanganyika," they would require a legal framework binding the four countries toward this goal. Through a process of regional consultation, the LTBP legal component produced a draft legal convention for the sustainable management of Lake Tanganyika. The full text of the draft Convention as well as supporting documentation is available at: http://www.ltbp.org/PDD9.HTM.

Recognizing that Lake Tanganyika is a special system, that it is threatened by a variety of destructive behaviors, and that existing national legislation regarding the lake is inadequate, Tanganyika's riparian states drafted the Convention. The Convention provides the necessary rights, responsibilities, institutions and framework in international law which compel the countries to cooperate in managing Lake Tanganyika. Specifically, it creates a binding legal framework ensuring certain standards of protection, establishes the institutions for implementing the Convention, establishes the mechanisms for implementing the Strategic Action Programme and establishes procedures for settling disputes.

3.4.1 Process: Creating the Convention

3.4.1.1 The Process

Early in the project, legal consultants[10] conducted a legal and institutional baseline study of Tanganyika's riparian states. This document (MRAG 1995): proposed key legal and regulatory issues to be considered; reviewed the existing legislation and regulatory framework in Burundi, D.R. Congo, Tanzania, and Zambia; detailed the relevant obligations of these countries under international law; discussed the legal and institutional issues relevant to harmonizing the laws of the riparian states and addressed issues rising in connections with the process of implementing a new regulatory regime. They also prepared reports on 'International Environmental Law and the Law of Transboundary Water Courses' and 'Legal and Institutional Arrangements for the Management of Lake and River Basins: Issues to be covered in an agreement and possible approaches.'

These reviews and reports served as discussion documents for a regional legal workshop 25-27 February 1998 in Lusaka, Zambia. At this meeting, policy makers from the four riparian states discussed and agreed upon: the objective and aim of the legal agreement, scope and applications, guiding principles, fundamental rules and obligations and other issues. They also agreed upon a process for drafting, discussing and modifying the Convention. This meeting produced a detailed set of drafting instructions and mandated the legal consultants to produce the first draft of the Convention.

The Convention's first draft was circulated to environmental lawyers and key project personnel. Some modifications were made, resulting in working draft 1.2, and this document was circulated to the law services of FAO, UNOPS and UNEP and subject to regional consultation. At the 1998 Lusaka meeting, all delegations agreed that to advance the drafting process as quickly as possible, regional consultations would initially be divided into two separate sub-regional workshops for countries sharing the same language and system of law. Tanzania and Zambia, the anglophone states sharing common law traditions, met the 24-27 August 1999 in Dar es Salaam and Burundi and D.R. Congo, the francophone states with civil law systems, met 30 August–3 September 1999 in Arusha

[10] The legal consultants who conducted baseline review, prepared the legal workshops and drafted the Convention were recruited from ***En***Act International Ltd., under contract to the Marine Resources Assessment Group (MRAG).

to discuss the first draft, clause by clause.

At the end of these meetings delegates to the sub-regional workshops returned to their countries with a draft of the Convention, reflecting the modifications that had been agreed upon, for national consultation within their governments.

The legal consultants then revised the English and French versions of the Convention to reflect the amendments made at both sub-regional workshops and policy makers from all four countries met again in a final regional workshop, 3-5 November 1999 in Arusha, to discuss the amended text. The English and French versions were again modified to reflect the recommendations of the regional workshop, resulting in draft 4.0. This draft was presented to the LTBP Regional Steering Committee (SC) on 4 May 2000. The SC resolved to forward the draft Convention, together with various comments on it, to the governments of the four riparian countries with the recommendation that the governments should negotiate and sign a final version of the Convention as soon as possible.

3.4.1.2 The Next Steps

It is important to note that draft 4.0 of the Convention is a working document produced by LTBP. While is was developed with full participation and consultation of policy makers from the riparian states, these delegates were not formally negotiating on behalf of their countries at the legal workshops, as this would have considerably delayed the process. Rather, the goal was to agree on a text the delegates would feel able to recommend for adoption by their government. This process was based on the belief that if senior government officials could reach consensus on the document at the legal workshops, this would expedite the subsequent formal negotiations and signature.

After the SC meeting, draft 4.0 of the Convention should have been forwarded to the governments of each of the four countries. Each country will have to engage in national consultations to formulate a national position on the draft Convention. Guided by the national position, the governmental ministry responsible for foreign relations would be mandated to commence negotiations with the other riparian states. Signature of the final text by a government representative (usually a minister) would be expected to follow the conclusion of negotiations. Following common-law tradition, the parliaments of Tanzania and Zambia would be required to specifically debate and ratify the Convention (this step would not be necessary in Burundi and D.R. Congo). Finally, the instruments of ratification (notice of the signed, ratified Convention) would be submitted to the depositary (the Secretary General of the OAU in the current draft Convention). The Convention would become legally binding 90 days after the deposition of the second instrument of ratification.

3.4.2 Product: The draft Legal Convention

The Convention on the Sustainable Management of Lake Tanganyika (draft version 4.0) contains 44 Articles and four Annexes. The draft Convention draws on principles elaborated in other legal documents, in particular:

- the 1992 Convention on Biological Diversity which emphasizes global concerns on the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of benefits arising from the use of genetic resources;
- the 1995 SADCC Protocol on Shared Watercourse Systems in the Southern Africa Development Community as an example of coordinated regional

management of shared water resources;

- the 1997 Convention on the Law of the Non-navigational Uses of International Watercourses which, though not yet in force or binding, provides a basis for developing specific rules for Lake Tanganyika.

The remainder of this section provides an overview of the draft Convention.

3.4.2.1 Preamble

The parties recognize Lake Tanganyika's unique biodiversity, acknowledging that it is their shared heritage, it is threatened, and they share a common interest in the conservation and equitable utilization of the resource. Recognizing that integrated management of the lake by the riparian states is essential to the conservation and sustainable use of its resources, the countries agree to enter into a legal and institutional framework for cooperatively managing the lake.

3.4.2.2 Articles 1-3: Introductory Provisions

Defines terms relevant to the Convention (article 1). Establishes the convention's objective, namely to ensure the conservation of the biological diversity and the sustainable use of the natural resources of Lake Tanganyika by the contracting states' agreement to cooperate in developing and implementing harmonized laws and standards concerning the management of Lake Tanganyika and ensure that communities living near the lake benefit from the sustainable use of the lake's natural resources and amenities (article 2). Establishes the scope of the Convention (article 3).

3.4.2.3 Articles 4-12: Principle Obligations

These articles establish the principle obligations of the contracting states, namely to:

- cooperate in good faith with the other contracting states in managing the lake and its environment (article 4);
- apply the following guiding principles when making a decision affecting the lake: the precautionary principle, the polluter pays principle, the principle of preventative action, the principle of participation, the principle of equitable benefit sharing and the principle of peaceful use (article 5);
- prevent and minimize adverse impacts whether national or transboundary in nature (article 6), especially pertaining to: fisheries management (article 7), the prevention and control of pollution (article 8), the prevention of excess sediment deposition (article 9) and the conservation of biological diversity (article 10);
- adopt and implement appropriate legal, administrative and other measures to achieve the objective of the Convention, including provisions for access to genetic resources (article 11) and free navigation (article 12).

3.4.2.4 Articles 13-22: Mechanisms for Implementation

In drafting the Convention the parties recognized a variety of mechanisms that serve to fulfill the Convention's overall objectives. The most important mechanisms, listed below, are requirements imposed on the contracting states. These requirements include:

- to implement the Strategic Action Programme and revise it as necessary (article 13);
- to notify the other contracting states when engaging in certain proposed

activities (article 14, activities specified in Part A, Annex 1);
- to introduce Environmental Impact Assessments within each country for these same proposed activities (article 15);
- to implement education and public awareness programmes (article 16);
- to encourage public participation in the decision making processes (article 17);
- to facilitate the flow of information by (a) providing public access to information concerning the Lake (article 19), (b) requiring contracting states to exchange data and information concerning the sustainable management of the lake and the implementation of the Convention (article 20), (c) protecting confidential information (article 21) and (d) requiring the contracting states to report periodically on measures taken to implement the Convention and on their effectiveness (article 22);

3.4.2.5 Articles 23-28: Institutional Arrangements

A variety of institutions were envisioned to support the management of Lake Tanganyika. The funding mechanisms for these institutions and their mandates are described in articles 23-28. These institutions include the:

- Conference of the Parties – with delegations from each contracting state headed by a minister, this body evaluates the implementation of the Convention (article 23);
- Lake Tanganyika Authority – comprised of a Management Committee and a Secretariat, this body is mandated to coordinate the implementation of the Convention (article 24);
- Management Committee – consisting of three delegates from each country, this organ of the Lake Tanganyika Authority is responsible for coordinating and monitoring the implementation of the Convention. To this end, it will implement the decisions of the Conference of the Parties, provide scientific and technical advice, implement and monitor the Strategic Action Programme (SAP), amend the SAP as necessary, negotiate with donors interested in supporting the implementation of the Convention, and commission studies to enable the Convention to be effectively implemented and to evaluate its effectiveness among other tasks (article 25);
- Secretariat – consisting of an Executive Director, a Deputy Executive Director and others, this is the executive organ of the Lake Tanganyika Authority responsible for: formulating annual work plans and budgets, providing technical and scientific services or advice, performing administrative and financial services, and carrying out other tasks assigned by the Management Committee (article 26);
- Technical Subcommittees – these committees on socio-economics, fisheries management, biological diversity, and any other subjects identified, assist the Management Committee (article 27).

The Convention also establishes the principles to be applied in financing the Lake Tanganyika Authority (article 28).

3.4.2.6 Articles 29-32: Liability and Settlement of Disputes

These articles: establish mechanisms for resolving disputes between the Parties (article 29 with Annexes III and IV), introduce strict liability for the operators of dangerous activities (article 30), describe the liability and compensation (article 31) and facilitate

access to the courts and legal system in settling such matters (article 32).

3.4.2.7 Articles 33-44: Miscellaneous Procedural Matters

These remaining articles consider procedural matters, including:

- the right to vote (article 33);
- the addition of protocols (article 34), annexes (article 35), and amendments (article 36) to the Convention;
- the terms for signature (article 39), ratification (article 40), entry into force (article 41) and the depositary (article 44) of the Convention and protocols as well as terms for withdrawal (article 43);
- the relationship of the Convention to other international agreements (article 37) and national laws (article 38).

3.4.2.8 Annexes

The draft Convention includes four annexes. For purposes of Environmental Impact Assessments (EIAs), Annex 1 lists activities which will be presumed to result in adverse impacts on the lake environment and specifies the content of EIA documentation. Annex II lists activities recognized as dangerous to the lake environment. Annex III (with four articles and Annex IV (with 12 articles) set terms for fact finding commissions and arbitration.

3.4.3 Anticipated Benefits of the Convention

In addition to the responsibilities and obligations outlined in the Convention, riparian states that sign the Convention, thus becoming contracting states, can be expected to enjoy a number of benefits. Some of these include:

- increased national and regional benefits from the lake owing to the integrated and holistic management of the system;
- reduced risk of having the lake and its valuable resources degraded;
- an established forum in which information can be exchanged, issues discussed and joint approaches to management developed;
- reduced potential for conflicts between the riparian states concerning the use of the lake environment, as the Convention establishes a partnership on the basis of shared objectives, agreed principles and approaches and defined expectations for each partner;
- enhanced prospects for obtaining donor funding for the sustainable development of the lake owing to the existence of the institutional structures set out in the draft Convention.

3.5 Dissemination of LTBP Results

With its many partners based in the US, UK, and numerous national institutions in Burundi, D.R. Congo, Tanzania and Zambia, LTBP management deemed that a single project library or repository would not be adequate. Consequently LTBP, taking advantage of recent technologies and innovations, employed a number of different means to archive and distribute information.

3.5.1 The Project Documents Database

The Project Coordination Unit tried to distribute hard copies of reports and the minutes of meetings to all participants. However, it quickly became apparent that the audience for any particular report was usually larger than the direct contributors or participants. Many special studies, for example, wished to read reports from their counterparts in other countries or from the other special studies working within their country. LTBP found the easiest way to guarantee access to any and all project documents was to create an electronic documents database. All project reports were

coded in Adobe 'Portable Document Format™' (PDF), cataloged according to subject, archived in searchable format on the LTBP website and distributed on CD-ROM.

3.5.2 Website

The LTBP website (http://www.ltbp.org) was designed to serve many functions. Like other websites, it offers general information and publicity about the project, including: summaries of the various components, lists of collaborating institutions and participants, and photos of the lake, project activities and the LTBP stations.

The LTBP website also served as an international office and repository of information for the project. Any LTBP document, from the Project Document, to the Steering Committee Meeting Minutes, the 17 quarterly progress reports, the 125 Technical Reports, Strategic Action Programme, draft Legal Convention, and this final synopsis are all available in the web site's Publications Database. In addition, a password-protected section contained information for project affiliates, including: plane, train and boat schedules between project centers, project administrative forms, lists of public holidays for the region, etc.

3.5.3 CD-ROM

It became apparent that many places in the Tanganyika Basin lack the communications infrastructure and high-speed connections to access large web sites with photos and complicated graphics. Our Uvira Station, in D.R. Congo, for example, wholly lacked telephone lines and modem access. Other remote stations, like Kigoma and Mpulungu, had modem access but it was slow and unreliable. To ensure that collaborators would have access to project information, LTBP periodically pressed the web site and all its components, onto CD-ROMs along with the necessary software to access them.

CHAPTER 4.
LESSONS LEARNED FROM LTBP

4.1 Introduction

The Lake Tanganyika Biodiversity Project (LTBP) has many notable achievements, including: technical studies in biodiversity, pollution, sedimentation, fishing practices, socio-economics and an environmental education programme; a transboundary diagnostic analysis (TDA) of the threats to Lake Tanganyika's biodiversity; a Strategic Action Programme (SAP) providing a prioritised list of these threats and strategies for ameliorating them; a draft legal convention binding Tanganyika's riparian nations to the sustainable management of the lake's natural resources; and finally a commitment from GEF and the governments of Burundi, D.R. Congo, Tanzania and Zambia to continue this process through a PDF-B grant to support a planning and preparation phase to implement the SAP and ratify the convention.

These achievements were accomplished within a sometimes tense and unpredictable political climate. They were accomplished against numerous technical and logistical obstacles. While we enjoy these victories, we also note that we made some mistakes. This final chapter analyzes our experiences and summarizes the lessons we learned in implementing LTBP so that other projects may benefit from our experiences.

To canvas opinions from the region, questionnaires were sent to all LTBP National Coordinators, Assistant National Coordinators, and to key personnel involved in the technical programme (special studies and Strategic Action Programme). There was a 67 percent return rate for these questionnaires, with all countries having at least two respondents. In addition, the Project Coordination Unit (PCU), members of the agencies forming the NRI Consortium (implementing subcontractor) and some technical programme leaders contributed their opinions.

This chapter concentrates on issues for which there was broad consensus from the region and from the implementing subcontractors. Where there was not consensus, the statement was qualified or both viewpoints were reported.

4.2 Civil Wars and Insecurity

The African Great Lakes region has been the theatre for considerable conflict and turmoil during the last decade. Burundi has been in a civil war of varying intensity since the assassination of its first democratically elected president in 1993. As a result of a 1996 coup d'etat, Burundi was also subjected to an international embargo imposed by neighboring countries.

Nearby, D.R. Congo entered into a revolution backed by Rwanda in 1995 that eventually toppled the former president, Mobutu Sese Seko. Within 18 months the war had re-ignited, this time between the new Congolese government and Rwanda and Uganda. Throughout this project Rwandan troops occupied and controlled eastern Congo, including the lakeshore regions.

As a result of these wars and insecurities and events in neighboring Rwanda, Burundi and D.R. Congo both experienced massive refugee movements. Many displaced people from these three countries sought refuge in western Tanzania.

These are not ideal conditions for conservation initiatives. In our experience, however, while civil war and insecurity typically affect everybody in some way, they are perpetuated by a comparatively small portion of the population. And it is exactly during these times that the natural resource base is most vulnerable and conservation and resource planning initiatives are most

important. Bilateral and multilateral aid to countries at times of war is obviously a sensitive issue. Nonetheless, we found that in spite of the many constraints imposed by civil insecurity, a considerable amount can be achieved. Our experiences with this are outlined below.

4.2.1 Remain flexible and seek creative solutions

The Project Document specified that the Project Coordination Unit (PCU) would be based in Bujumbura, Burundi. Burundi was in a phase III UN security rating at the project's onset, thus following UN regulations, new project headquarters could not be established there. The PCU was relocated to Tanzania, with the Project Coordinator (PC) establishing an office in Dar es Salaam to coordinate the project's policy aspects and the Scientific Liaison Officer (SLO) establishing an office in Kigoma to coordinate the lakeside technical programme. This arrangement had the disadvantages of removing the PC from the lake and separating the PC and SLO by a considerable distance. It was also a sensitive issue for Burundi, which noted that a number of UN projects were operating in Burundi in spite of security constraints and felt that LTBP should as well.

The PCU and regional Steering Committee remained flexible on this point and during the project's third year, the SLO moved her office to Bujumbura. At a SC meeting it was decided that, given the security situation in Burundi, it would be too risky to move both the PC and SLO to Burundi. This caution was borne out when 1.5 years later the UN security rating was increased to phase IV, following the killings of two UN aide workers, and the SLO and facilitators were evacuated. The momentum that would have been lost if both the PC and SLO had been based in Burundi at that time could have been devastating to the project. The SLO returned to the Kigoma Office and was able to make short visits to Burundi until the security situation normalized six months later. While the project was never able to reunite the PC and SLO in the same location and this, both felt, was a distinct disadvantage, this was probably the best arrangement given the constraints.

In addition to Burundi, this arrangement also allowed D.R. Congo to be engaged in the project. D.R. Congo was under phase IV security during most of LTBP, which stipulates that expatriate staff cannot reside there. However it was fortunate that LTBP's lead lakeshore institution in D.R. Congo, the Centre de Recherche en Hydrobiologie (CRH), was based in Uvira which is a 30-minute drive from Bujumbura. Thus project staff could commute to Uvira when security permitted to meet with Congolese affiliates and tend to the technical and administrative aspects of the programme in D.R. Congo. Congolese staff was also able to commute to the Bujumbura Office and meet with project personnel there.

When Burundi and eastern Congo were both in phase IV security and the SLO and facilitators were relocated to Kigoma, the project was able to continue activities in Uvira and Bujumbura by periodically bringing key partners from national institutions to Kigoma (boat and plane service was functioning) for briefings and technical sessions with project staff. In this way activities were able to continue and momentum was not lost.

When the war re-ignited in D.R. Congo, transportation between Uvira and Kinshasa was cut off. This was another potentially fatal blow to the project for if the National Working Group (NWG) with partners in both locales could not meet, then there could be no meaningful consultation in establishing environmental priorities and the Strategic Action Programme (SAP) in Congo. The project arranged for the Kinshasa and Uvira delegations to meet in a neutral location (Arusha, Tanzania) for their National SAP consultations. This was an added expense, which was offset to some extent by the fact

that the National Sectoral Problem Review and the National Environmental Priorities and Strategies Review were held back-to-back whereas they were two separate meetings in other countries.

It was challenging and oftentimes stressful to function under these constraints. It required sacrifices and flexibility on all parts. We found an ample supply of support, patience and good will from national partners and expatriate staff in dealing with these constraints. This allowed the project to accomplish a considerable body of work in Burundi and D.R. Congo which implicated these countries as equal partners in LTBP and prepared the stage for fruitful regional collaboration.

- Flexible, creative and adaptive management strategies promote progress in unpredictable settings or periods of insecurity.

4.2.2 Maintain a presence

It is a challenge to coordinate activities in countries when expatriate regional staff is not allowed to live there. Still, we found that a considerable amount could be accomplished through emails, telephone calls and short-term visits to the country (as UNDP allowed) by regional staff or visits by national staff to other countries to meet with regional staff. It is important to go to these extra efforts to maintain a presence during times of conflict.

In neighboring Rwanda, conservation and civil war have also come into conflict during the last decade. Studies there have highlighted the importance of maintaining a national presence throughout periods of insecurity in preserving protected areas and the critical role of junior staff in facilitating this (Plumptre 2000; Plumptre ***et al***. 2000). During LTBP Rusizi National Park was downgraded to a Natural Reserve and 3,000 hectares were degazetted. The Rusizi River enters Lake Tanganyika in the reserve and it has a unique fish fauna and a bird fauna of global interest. The productive waters and reed beds associated with the delta may be important to the functioning of the Tanganyika ecosystem. The Reserve is located about 15 km from Bujumbura, hence it was subject to considerable human pressure from displaced people and displaced cattle. For sometime, the park staff had not been able to control grazing, fishing and harvesting of reeds and grasses from the park. The park was a study site for LTBP investigations on biodiversity, sedimentation, fishing practices and socio-economic settings of the nearby populations. When the plan for downgrading and degazetting was announced, the LTBP environmental education team, together with the technical teams organized a seminar/ workshop for policy makers and local and provincial officials on the importance of Rusizi National Park. There were informative presentations on subjects ranging from species diversity to honoring Burundi's commitment to the CBD, and there was considerable debate. In the end, the park was downgraded and land was degazetted anyway. We feel that this was a great loss, but perhaps not surprising given the human pressures Burundi is currently facing. The presence of the LTBP teams, however, was important in publicizing the issue. They were able to negotiate to minimize the losses and used the opportunity to promote the importance of biodiversity and the environment to policy makers and the media. They reinforced the message to local populations by hosting an educational campaign in association with World Environment Day at the Reserve.

- Maintaining a reduced presence and continuing to publicize conservation issues during times of conflict brings attention to conservation, and can minimize losses, at a time when natural resources are most vulnerable.

4.2.3 Facilitate regional collaboration

LTBP was able to hold regional meetings, formulate a Strategic Action Programme and draft a Legal Convention during a period of strained relationships among Tanganyika's four riparian nations. This was due, in part, to the close working relationships that members from these countries had formed while collaborating on various technical components of the project. LTBP frequently gathered together national participants in the technical programmes for regional workshops to share their experiences and develop strategies. Nationals assumed key leadership and training roles in some of these initiatives. Facilitating such experiences forced participants to see beyond the prevailing political climate and fostered regional collaboration. Such exchanges are also important to creating regional ownership and cultivating a shared vision (see Sections 4.3 and 4.4).

- Facilitating regional collaboration at all levels (from technicians to policy makers) enables individuals from different countries to form close working relationships. These bonds may permit project work to continue even when the political climate is tense between the countries.

4.2.4 Remain neutral

At all times, but especially in times of uncertainty, it is important that project staff remain politically neutral. The government and armed forces in charge of eastern D.R. Congo changed several times over the project's course. Burundi had four national coordinators during the life of the project. While it is tempting to build close personal alliances with key political figures in an attempt to accelerate progress, these alliances can seriously hinder progress and foster distrust by the successors if/when these people are replaced.

- It is crucial that expatriate staff and national staff in managerial and coordinating roles be agreeable to collaborating with any and all stakeholders and, moreover, be seen to be impartial.

4.2.5 Do not underestimate people's good will during difficult times

It is true that bad times can bring out the worst in people. But in our experience, they can also bring out the best in people. Even before the two recent wars, eastern D.R. Congo was in a dire political and economic state. Employees at the Centre de Recherche en Hydrobiologie, for example, had not received their government salaries for years at time. This is almost a moot point because with the inflation rate in D.R. Congo over the past decade, their salaries, even if they had received them, were not a livable wage. Everyone at CRH, and practically everyone we interacted with in D.R. Congo, was forced to diversify their livelihood strategies. In spite of circumstances that would have discouraged most, CRH staff were still reporting to work and collecting data. When the project arrived and was able to provide some basic assistance (rehabilitation of facilities, funds for activities and allowances) staff became confident, productive and took a new pride in their work. In our experience, people were tired and frustrated with the deteriorating political-economic situation that was beyond their control. They wanted to be a part of something bigger that they perceived to be a good cause. They showed an amazing resourcefulness, energy and good will in their work that was conducted under some of the most challenging circumstances conceivable.

- Small incentives such as basic supplies and materials and the sense of contributing to an important cause and can help stabilize communities during periods of conflict.

4.2.6 Be briefed on security and have contingency plans

LTBP fortunately never had to cope with a volatile security situation where project personnel were in immediate danger. This is probably due to a combination of good fortune and good planning. UN offices and embassies have security plans in place. It is important to become integrated into this system. In addition these organizations run regular security briefing sessions and periodic personal security workshops. We found this framework and these guidelines crucial in planning and executing activities. National staff was also an important source of information about security conditions. A radio network helped keep the project coordinated and updated with respect to security. Because we had contingency plans in place, when expatriate staff were evacuated, the process went smoothly and activities were able to continue under national administration and supervision.

While the security situation can deteriorate suddenly, in our experience it seldom improved suddenly. Working in these conditions is trying. In spite of the situation, a considerable amount can be accomplished toward national and regional goals. The current situation is likely to persist for some time and we hope others will continue work within the constraints. Many people are counting on it and their futures are too important and the resource is too valuable to neglect during such times of need.

- Create security and contingency plans, brief staff and liase with other organizations on security matters.

4.3 Project Ownership and Partnerships

4.3.1 National and regional ownership

Communications between Tanganyika's riparian states and GEF implementing and executing agencies were very limited during the long gap between the countries signing the project document and the implementing subcontractors (NRI consortium) beginning work. The countries pointed out that they were not adequately implicated in the project's design and the preparation of the Project Document. Nor were they involved in the selection of the implementing subcontractor. The NRI consortium's technical and financial bid was not circulated to the countries before their staff arrived in the field to begin work, thus the countries had no notions of the technical programme planned for their countries nor the resources available to realize it. All of these things diminished any sense of national or regional ownership of the project from the outset.

- Good communication and transparency between the primary implementing and executing agencies and the partner countries on these aspects is essential.

4.3.2 Need to implicate highest levels of government

Some of the next important steps for the conservation of the lake include ratifying the legal Convention, establishing the Lake Tanganyika Authority, implementing the Strategic Action Programme, and integrating conservation activities into other sectors. These steps will require the participation and commitment of political authorities in the highest levels of government. In retrospect, we regret that we did not, for example, convoke a meeting of ministers from the four countries early on in the project, to begin raising awareness and cultivating support at these levels. It is not clear that this would have been possible, given the prevailing political circumstances in the region at the time, but it is the next important step.

- The next phase should strive to raise awareness at the highest political levels from the beginning.

4.4. National Ownership

4.4.1 Lead institutions and their relationship to the lake

The lead agency for LTBP in all four countries was a department or division in government or a parastatal organization concerned with the environment and/or conservation. The lead agency played a central role in furnishing the National Coordinator (and in some cases the Assistant National Coordinator) and organizing the National Working Group (NWG) which were seen as key components in both implementing the technical programme and formulating the Strategic Action Programme. In most cases the lead agencies had a mandate for creating policy rather than implementing projects and they generally had little experience in working on lake issues. In D.R. Congo, Tanzania and Zambia the lead agencies had no representation near the lake.

LTBP's considerable technical programme, for practical reasons, had to be based at the lakeside of the four countries. This led, in some cases[11], to ambiguity as to the appropriate agency to conduct a study. Different LTBP studies adopted different approaches to dealing with this. The Pollution Special Study (POLSS), for example, trained lakeside fisheries researchers in Kigoma and Mpulungu to conduct basic water quality studies. Because the POLSS programme involved weekly sampling and the need for rapid analysis they decided to collaborate with fisheries institutions that were already working on the lake on a regular basis and give them additional responsibilities to study water quality parameters. The Sedimentation Special Study (SEDSS) opted for a different strategy, recruiting geology professors from Dar es Salaam and Lusaka to make periodic visits to the lakeside to guide the technical programme. Day to day river monitoring was contracted out to individuals living on the lake, but who did not necessarily have an affiliation with a national institution.

Neither strategy proved to be sustainable in the long-term. Without a project presence, monitoring water quality has taken a low priority for institutions mandated to study and regulate fisheries. Likewise, without the material and financial assistance the project afforded, researchers in capital cities are unable to travel to the lake and continue their studies of sediment dynamics, also river gauging has been discontinued in these countries.

In addition to ambiguities regarding the appropriate collaborating agencies, the distance between the lead agencies and the lakeside institutions also hindered collaboration and the development of a collective national ownership. NWG meetings typically occurred in capital cities and lakeside institutions generally felt underrepresented at these events. They expressed frustration by the fact that the project was sometimes represented nationally and regionally by people who had not visited the lake. Collaboration was complicated because the lead agencies and lakeside institutions oftentimes reported to different ministers or branches of government. In our experience, establishing close collaboration between ministries at a distant location where only one ministry has representation is a difficult thing to achieve.

This issue of lakeside representation will diminish somewhat as conservation issues are no longer considered the domain of the conservation sector but rather are integrated into the policies and agendas of all sectors. This, however, requires a major change in national policies and high level political commitment to facilitate it (see Section 4.3). Considerable consultation,

[11] This was not an issue for Burundi where the lead institution and all the logical collaborating partners had representation in Bujumbura, the lakeside capital. This might have been an issue for D.R. Congo, but with transportation links severed during the insecurity, the project was forced to rely exclusively on lakeside personnel for its technical programme. Fortunately, the CRH in Uvira already had a broad mandate to cover biological, physical-chemical and socio-economic aspects of the Lake.

coordination and time will be necessary to achieve this. In the meantime future interventions will have to deal with this obstacle. We recommend addressing it at the outset with national meetings implicating all relevant ministries to address the mechanisms for establishing this collaboration. We also point out that the ways to achieve this collaboration and collective national ownership, i.e. by enabling officials from the lead agencies to acquire lakeside field experience and representatives from lakeside institutions and communities to participate in NWG meetings, will have significant budgetary implications.

- Budget money and time and establish mechanisms for facilitating collaboration between the various stakeholder institutions that do not have a history of collaborating and/or are separated by considerable distance.

4.4.2 Assessment of institutional mandates and capacity

In retrospect, some of the confusion noted above could have been avoided if the project development or design had included a formal assessment of institutional mandates and capacities. Lacking such an assessment led to an ad-hoc process of developing working agreements with key institutions, with the Project Coordination Unit (PCU) usually negotiating directly with the director of the institute who may or may not have been mandated from higher levels to participate. In some cases this led to confusing arrangements in terms of responsibilities and accountability. It also exacerbated the impression that the national institutions were servicing the project rather than participating in a task of national importance mandated by higher authorities with the project's support

- A formal assessment of institutional mandates and capacities should be conducted before implementation and should be sanctioned by the highest levels of government.

4.4.3 National Coordinators and National Directors

The LTBP midterm evaluation suggested that LTBP National Coordinators should in fact be National Directors. Their seniority (all Directors or Director Generals) and their many other governmental obligations coupled with the many demands of coordinating LTBP national activities would support this. The midterm evaluation suggested recruiting full time NCs employed by the project to tend to the project's day to day administration and facilitation. This structure would also have avoided the conflict of interest noted by UNDP, that the LTBP National Coordinators were responsible for both implementing the project in their countries through the National Working Groups and monitoring or steering project progress through the Steering Committee. Normally these roles should be filled by two different people. Although in some cases the appointment of Assistant NCs mid-way through the project effectively achieved this, we would support a clear separation of roles from the outset.

- Establish the division between implementation and evaluation at national and regional levels early in the project.

4.4.4 Financial Control

Project ownership and financial decisions are linked. It is difficult to assume ownership of a project where budget lines are beyond one's control. LTBP eventually allocated a budget for the NCs to convoke NWG meetings, among other activities. However, some affiliates point out that allocation of part of the project budget to individual countries early in the project would also have strengthened feelings of ownership.

- Budgets and the ability to make financial decisions can enhance national ownership.

4.4.5 Stakeholder Participation

With the caveats noted above, many national stakeholders praised LTBP on its participatory nature and its ability to implicate many different stakeholders in the technical programmes and the strategic planning process. Some LTBP affiliates noted that participation from a wide variety of stakeholders is time-consuming to develop, expensive and may dilute the feelings of ownership of the principal institutions involved. However most collaborators agreed that sustainably managing Lake Tanganyika's biological resources is a cross-sectoral issue and necessarily demands the diverse viewpoints and specializations of a variety of stakeholders. Though some collaborators listed stakeholder groups that should have been better implicated (e.g. village governments and community-based organizations) it was generally felt that LTBP was successful in implicating a broad variety of stakeholders. The diverse technical programmes, the NWG structure in some cases and the SAP planning process were cited as good vehicles for generating broad stakeholder participation. Local participation was repeatedly cited among the project strengths by national collaborators. A formal stakeholder analysis at the project development stage (see Section 4.4.2) would certainly have strengthened and facilitated stakeholder participation.

- Allow time and create forums to establish broad stakeholder participation.

4.5 Execution and Implementation

4.5.1 Cultivating a shared vision

Some of the ideas presented in the special study reports are not new. For example the idea of extending the boundaries of existing protected terrestrial areas to include adjacent waters has been discussed for a decade (Cohen 1991, Cohen 1992, Coulter and Mubamba 1993, Coulter 1999). Some of these authors emphasize the need for urgent action given the magnitude of the threats to Tanganyika's biodiversity. The irony that we, 10 years later, reiterate some of these same recommendations to extend terrestrial park boundaries is not lost on us. We are perhaps the victims of what Coulter (1999) refers to as 'the present fashion for protracted planning (so-called strategic, iterative, long-term etc.)' which he points out can lead to 'a limbo of planning paralysis.' Coulter (1999) cautions that 'conservation will be retarded critically until the different perspectives can be bridged.'

We would caution that conservation is likely to be neither effective nor sustainable until these different perspectives can be bridged. Numerous studies have demonstrated that imposing a plan will not work (Ghimire and Pimbert 1997, Jentoft and McCay 1995, Mayers and Bass 1999). The plan itself needs to arise through consultation and compromise. LTBP attempted to do this through participatory training and research where national teams were given the chance to collect, analyze and interpret data on the state of the system and discuss it in national and regional fora with a variety of stakeholders. As a result of this process, and based on the habitats and the proportion of diversity that would be afforded some protection, the Biodiversity Special Study endorsed the idea of extending some of the existing terrestrial park boundaries (see Section 3.3.2.1), though they express concern about who will finance these conservation initiatives (see Section 4.6).

- Cultivating a shared vision takes time. It is expensive. But it is a crucial step in the process.

4.5.2 Establishing a coordinated project mission

LTBP's special studies in biodiversity, pollution, sedimentation, fishing practices, socio-economics and environmental education all had important training and capacity-building experiences and produced important outputs in a participatory way. However, they did so with little coordination and consultation among themselves.

Because the special studies did not coordinate sites and methodologies, it is impossible at the project's conclusion, to analyze the various datasets in a concerted or quantitative way. For example, it is not possible to assess and quantify the relative impacts of different threats on biodiversity at a particular site. Different special studies had different plans and different visions. Perhaps because they were contracted to different organizations within the NRI consortium or perhaps through weak scientific leadership, they were never able to work together on a lakewide scale for this larger cause.

There were a few sites where special studies were, to some extent, coordinated (notably the Rusizi Delta (BIOSS, POLSS, SEDSS, FPSS, SESS, EE) in Burundi and several sites near Mpulungu, Zambia) where more than one study collected data. These sites tend to be the most interesting sites for scientific consideration because multiple datasets exist, though for the most part, they cannot be analyzed in a coordinated way.

Coordinating the special studies would have required considerable planning, preparation and cooperation. In the end, less work might have been accomplished overall. But we would encourage future initiatives to attempt such coordination, for it is only through such an approach that the threats to Tanganyika's biodiversity can be compared and quantified in a scientific way.

- Future interventions should work with key participants to create a joint mission statement and harmonize work plans early in the project.

4.5.3 Linking the social sciences and the natural sciences

Linking the socio-economic data with data from the other technical studies (biodiversity, pollution, sedimentation, fishing practices) is perhaps the most challenging aspect of coordinating the technical programmes. Most natural scientists, who have visited the lake, do not refute the claim by the Socio-Economic Special Study (SESS) that it is "the balance between man's activities and protecting the environment that is the important thing" nor their assertion that "the biodiversity of Lake Tanganyika will only be managed sustainably and conserved through programmes of poverty alleviation, livelihood diversification and social and economic development in the lakeshore communities" (Meadows and Zwick 2000). These claims by the SESS team agree with other studies on the importance of socio-economics to conservation success (GEF 1998, GEF 1998). However, balancing conservation and development of local livelihoods is difficult. Most people involved in LTBP had experience in one domain or the other. Integrating data from the natural and social sciences in a meaningful way requires vision and for both groups to stretch their skills and understanding.

- Mechanisms to facilitate collaboration between the social and natural sciences need to be established at the beginning.

4.5.4 Financial incentives are necessary

It was originally intended that national staff would be partially seconded to the project. They would continue to receive their national salaries while committing a portion of their time to LTBP activities. The time and effort that national staff contributed to the project would be considered part of the government's contribution in kind.

In our experience, this plan was perhaps too idealistic and did not account for the socio-economic pressures facing our

national colleagues. The national institutions and economies of Tanganyika's riparian states are struggling and national salaries, when they were paid (see comments in Section 4.2), were very low such that many affiliates, from technicians to General Directors, were forced to diversify their livelihood strategies. Some were lucky to find additional consultancies in their field or in a related field, but many were involved in the private sector, fishing, farming, owning minibuses or taxis, etc. In such a climate, where everyone is forced to work outside of their regular jobs in order to make ends meet, it is unrealistic to expect people to make significant commitments to unpaid work where the benefits (saving biodiversity) seem distant to their immediate needs of feeding and educating their children. In our experience, people did want to contribute to conservation. They perceived it as a good cause and they worked to the best of their abilities with commitment and good spirit. Many collaborators made personal sacrifices and contributed considerably more than was expected of them. But it is unrealistic and unfair to think they would do so without modest financial incentives.

National collaborators pointed out that it is also unrealistic to expect national staff (who sometimes had the same level of training) to work in good faith alongside expatriate regional staff who were earning a comfortable living. Such discrepancies foster resentment rather than collegiality. National collaborators also emphasized the need for incentive payments to be uniform throughout the region and for them to be established and dispersed in a transparent way.

Other GEF reviews (GEF 1998) have noted that financial payments undermine sustainability. We can confirm this. When payments stopped at the project's end, so did the bulk of research and monitoring activities on Lake Tanganyika. However, for the reasons described above, they would have never started in the first place if it had not been for payments.

Once basic research and monitoring on Lake Tanganyika are integrated into the mandates of national institutions and these institutions find adequate funds to fulfil their mandates, we hope the need for financial incentives will diminish. But changing the mandates of national institutions and securing finances to support these changes requires high level political commitment and in a complex project spanning several different ministries in four countries this will require considerable more time and effort.

- Financial incentives do undermine sustainability, but they may be necessary in troubled economies when the rewards of conserving biodiversity are distant from people's immediate needs.

4.5.5 Be sensitive to language considerations and budget time and money for translation

The French-speaking countries (Burundi and D.R. Congo) perceived the project as having a bias toward the anglophone countries (Tanzania and Zambia). A variety of factors contributed to this perception. Important ways to avoid this in the future are to insist that key project personnel be bilingual (see Section 4.5.7) and to budget sufficient time and financial resources for translation. For all countries, in a multi-country project with multiple languages, to feel like equal partners, a considerable amount of time and financial resources must be allocated for translating documents. We found hiring a translator from the region as a full-time member of staff to be economical in the long-term. Funds must also be allocated for simultaneous translation at regional meetings.

- Budget sufficient time and money for translation and insist on language qualifications for regional staff.

4.5.6 Do not underestimate staffing needs

The project began with two full-time expatriate staff based in the region, the Project Coordinator (PC) and the Scientific Liaison Officer (SLO). The PC tended to the government and policy aspects of the project and the SLO oversaw the technical programme and served as the link between the UK-based study coordinators and the field teams. Given the project's complexity (eight technical programmes operating simultaneously in four countries) and its emphasis on capacity building, this design was overly optimistic. We found that full-time, regional-based facilitators having technical, training and some managerial responsibilities were essential for guiding and ensuring the completion of work programmes. They also proved to be more cost-effective and more satisfying to the national institutions (in terms of availability and continued feedback) than short-term visits by consultants.

- Do not underestimate staffing needs. For technical studies where training and capacity-building are important, full-time facilitators based in the region are usually preferable to short-term visits by senior consultants.

4.5.7 Recruitment of international posts

Recruitment of the expatriate, international posts (PCU, special studies leaders and facilitators) received mixed reviews from the region. National partners emphasized that in addition to a good level of competency in their respective fields, these key regional posts required people who were: proficient in both English and French, able to commit the necessary time to their study (for non-full-time personnel) and who had a 'bon esprit' for working under challenging circumstances.

- Consider language skills, but also availability and capacity to work under difficult conditions during recruitment for international posts.

4.5.8 It takes time

Other studies have noted that developing partnerships within governments, the private sector and communities takes time, effort, persistence and financial resources (GEF 1998, Ollila 2000), usually much more than was originally planned. Our experiences confirm this. LTBP would have benefited from an initial preparatory phase to conduct institutional, stakeholder and training needs assessments and establish necessary infrastructure. Lack of adequate preparation time caused significant delays in the technical programmes. The project was consequently forced to begin the strategic planning process before all the results from the special studies were finalized, though the final Transboundary Diagnostic Analysis attempted to compensate for this. A post-special study analysis phase would have allowed for a more detailed and coordinated consideration of the various technical data, some of which was still coming in as the SAP was being formulated.

- Budget the timing of activities carefully and allow for a preparatory phase.

4.5.9 Email links and websites facilitate communications

Long distance telephone connections within and between Tanganyika's riparian nations are extremely expensive. LTBP provided email links for the lakeside stations and the lead agencies. This relatively small investment paid back greatly in terms of increased communication within the region. We found that HF and cellular modems are not as convenient as telephone-line based links (e.g. they are too slow for worldwide web access) but still an important contribution at our more remote stations where telephone service was poor or nonexistent.

In addition to providing international publicity for the project, the LTBP web site was an important resource for project affiliates. All of the important project

documents, including progress reports, steering committee meeting minutes, data and reports from the special studies, the Strategic Action Programme and the draft Legal Convention can be accessed and downloaded from the LTBP web site. It serves as an archive and library for the project. The web site and document database is also available on CD-ROM, especially for those stations that cannot access the internet easily because of poor telephone connections. National collaborators cited these investments in communications and information accessibility as being among the most important outputs of LTBP.

- Email links and websites will increase productivity by facilitating inexpensive communication and document distribution.

4.5.10 Planning for the post-project phase

Project staff and partners expressed dismay at the abrupt cessation of LTBP activities at the close of the 5-year project. While LTBP had a considerable budget for 'sustainable activities,' most of this was used to support the essential national and regional consultations to formulate the SAP. Almost everyone agrees that the SAP is the project's key output and the key to conserving the lake's resources into the future. But many partners recognize other activities, such as monitoring and environmental education, to be important in the short and long-term future of the lake.

LTBP designed a basic monitoring programme as a part of its mandate (see Allison et al. 2000), in which coordinated special study teams would continue to monitor biodiversity, pollution, sediment inputs, and fishing practices at several sites in each country. At a total cost to the region of about $70,000 US per year, the programme was designed to be minimalist and relatively low-cost with the hope it could attract outside funding or be funded by the four riparian nations. However, the national governments had not or were not able to commit resources to funding the programme (also emphasizing the Need to implicate highest levels of government see Section 4.4) and the governments nor the project were able to attract outside funding for this on short notice. The same was true for the environmental education campaigns.

It is frustrating to all involved when initiatives begin, refine their methodology, get results and then are forced to stop. Institutional memory, momentum and collaborators' confidence is lost.

- Planning for continued activities and subsequent work needs to begin well before a project's conclusion and requires full, active and collaborative participation between the governments and implementing agency.

4.5.11 Use appropriate technologies

New technologies can have a profound impact. The introduction of email links at the remote lakeside stations changed communication both within and between riparian countries. Some of the project technologies, however, were perhaps overly ambitious for local conditions and the levels of funding available for training. The BIOSS databases and GIS are excellent resources, however, unfortunately they are presently underused and underappreciated. They are currently beyond the technical capacity of most of the appropriate national institutions. Unfortunately they were finished quite late in the project such that there were not sufficient funds to commit to adequate training sessions for these systems.

- Institutional assessments should evaluate technological capacity and project technologies, resources and training sessions should be designed accordingly.

4.5.12 The countries in a multi-country project are different

In implementing multi-country projects, it is tempting to try to treat all the countries the same. Many of our technical studies, for example, designed a single workplan and attempted to execute it in the same way in all four countries. This strategy was thought to be fair and equitable in terms of distributing resources and easier to implement and manage. We found that this strategy, however, almost always produced mixed results. Technical components with a single specific workplan typically succeeded in some countries and failed in others. The success or failure of a programme could often be attributed to some local governmental, socio-economic, cultural, political, historical or other aspect of the area, such as security, proximity to a university or other source of trained personnel, or the strength and level of participation in the local government.

Multicountry projects must recognize, early on, these differences between the countries and tailor workplans to capitalize on opportunities and to compensate for constraints. We found, for example, that our Tanzanian and Zambian stations were located in relatively small lakeside towns such that trained national staff were in short supply and in some cases technical expertise had to be imported from other parts of the countries. These were not constraints at our stations in Burundi and Congo, however, security conditions in these countries greatly impacted the teams' fieldwork and workplans had to be adjusted accordingly.

At the same time, specific conditions in each country afforded unique opportunities as well. Burundi, for example, has its capital on the lakeshore which allowed a number of high-level government officials and politicians to be closely involved in the technical programmes and increased overall public awareness of the project. Tanzania is centrally located with good security and the only country, during the life of our project, with reliable, regular transport between all the other riparian countries. As such, it served as a local hub for regional meetings and activities. Congo has a large hydrobiological institute with a broad mandate to study aquatic dynamics on the lakeshore. This institution offers special opportunities to integrate workplans and study interdisciplinary aspects of lake dynamics that would be much more difficult to achieve in the other countries. Zambia has very strong village chiefs and governments which allowed the environmental education and socio-economics teams to easily access and work with local communities through the Village Conservation and Development Committees. For a variety of historical reasons, such arrangements do not exist and/or would be unlikely to work in the other countries, but offered an excellent opportunity in Zambia.

In designing workplans for multicountry projects, it is important to create broad regional goals that the countries can work towards in different ways based on their local opportunities and constraints. This underscores the need for thorough institutional assessments in the planning stages of the project (see Section 4.4.2) and requires adaptive management and considerable flexibility on the part of the technical and implementing teams.

- Do not assume that a single workplan is appropriate for all the countries in a multi-country project. Consider the various opportunities and constraints of individual countries and tailor workplans to capitalize on the opportunities.

4.6 Other Considerations: Conservation and Development at Lake Tanganyika

In response to the UN Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992, many governments,

international aid agencies and NGOs have adopted integrated conservation and development (ICAD) programmes. These programmes are guided by the Convention on Biological Diversity (CBD) which advocates a utilitarian approach to conservation through sustainable use and equitable sharing of benefits derived from exploiting biodiversity. LTBP tried to conform to this approach, recognizing that there is a moral imperative to ensure that biodiversity conservation does not take place at the expense of social and economic development.

The theoretical basis for ICAD approaches is that there need not be a conflict between conservation and development (in the form of poverty eradication). Indeed, for development to be sustainable the two must be reconciled: maintaining 'natural capital' is integral to sustainable development, and only through development will the poor have the resources and ability to exercise choice in not having to degrade the environment in order to survive. Along the shores of Lake Tanganyika and the other African Great Lakes, where many of the world's poorest people survive by exploiting some of the world's most diverse ecosystems, the need to integrate conservation and development strategies is urgent and great.

Underpinning ICAD approaches is the assumption that the people around Lake Tanganyika can benefit more from conserving biodiversity than they can from overexploiting it. Conserved ecosystem function and proceeds from ecotourism are posited as examples of such potential benefits at Lake Tanganyika (Cohen 1991, Cohen 1992, Coulter and Mubamba 1993, Coulter 1999). However, this key assumption and these proposed benefits warrant critical examination.

There is little data on the economic value of biodiversity in Lake Tanganyika and while the Socio-Economics Special Study provided an image of livelihood strategies in the Tanganyika Basin, it lacked a rigorous livelihood analysis. Nonetheless, this information and the results of the other special studies allowed Allison ***et al***. (2001) to explore these benefits and the link between conservation and development in the Tanganyika Basin. The remaining discussion is based on ideas and conclusions presented in the BIOSS final technical report (Allison ***et al***. 2001).

Allison ***et al***. (2001) point out that conservation projects can use a mixture of different strategies or interventions. These strategies include: direct protection, economic substitution and linked incentives.

Direct protection is the current model for conservation in Lake Tanganyika and much of the early thinking in developing the Lake Tanganyika GEF initiative (Cohen 1991) was driven by this approach. In direct protection, people are excluded from areas set aside for biodiversity conservation and they benefit little from conservation activities. While this 'fines and fences' approach may work in areas with low population densities, the downgrading in status and the degazetting of land in of Rusizi National Park attest to its failure in areas under high pressure from humans. Given the levels of poverty and livelihood insecurity experienced by many in the catchment area, there is a moral imperative to prioritize development and seek compatibility between development and conservation. The direct protection approach is anachronistic given these human considerations.

The economic substitution approach is another conservation model. In this approach conservation projects attempt to implement livelihood activities such as developing rural industries that provide an alternative to livelihood options seen to threaten biodiversity, such as farming on steep rift valley slopes or fishing with beach seines. The LTBP Socio-Economics Special Study found that such alternatives were difficult to identify, though they were able to

suggest a range of development interventions to increase the value of harvested natural resources and reduce environmentally damaging activities. Providing income generating alternatives to local people that are not linked to incentives for biodiversity conservation does not mitigate against the external threats. People not benefiting from alternative income generating activities remain potential threats to the environment. Like the direct protection model, the economic substitution approach may work in areas of low population density, but again, the high population densities and large numbers of displaced people in the northern basin suggest it is unlikely to be an effective approach throughout the basin.

Finally, ICAD projects fall under the 'linked incentives' model that attempts to link biodiversity and livelihood development strategies. In such approaches both people and biodiversity benefit and are empowered by the conservation initiative. At Lake Tanganyika, the development of sport fishing, ecotourism and the aquarium trade are often cited as examples of ways in which biodiversity conservation can be linked to enhanced livelihood opportunities. While no formal costs benefits analysis has been conducted on this, we believe such thinking to be unrealistic. While other authors have assumed that parks will benefit local people as well as biodiversity in Lake Tanganyika (Cohen 1991, Cohen 1992, Coulter and Mubamba 1993, Coulter 1999), evidence from studies around the world suggests the contrary, that the benefits of protected areas accrue internationally while the costs are borne locally (Wells 1992). Consideration of the political stability, infrastructure, access, and quality of natural features compared to other locales suggests that profitable ecotourism in Lake Tanganyika is not likely in the near future. In Lake Tanganyika the benefits of establishing protected areas are likely to accrue internationally while the national costs for developing parks to promote ecotourism will be considerable (Allison ***et al***. 2001).

Linkages between the most biodiverse areas and livelihood activities in Lake Tanganyika are weak. Most fishing activity targets the species-poor pelagic system, whereas most of the biodiversity is concentrated in the littoral zone. There is a strong link between the six economically important pelagic species and livelihood activities around the lake. This strong link gives us optimism that efforts to conserve the pelagic fish stocks, through changes in livelihood activities (***e.g.*** mesh size regulations or closing certain areas to fishing at certain times) might be successful if accompanied by strong environmental education programmes. But because fishing livelihoods around Lake Tanganyika rely on just a few species, the link between Tanganyika's rich biodiversity of global interest and people's livelihoods is weak. Connections between farming livelihoods and biodiversity are even weaker as loss of the species rich littoral zone to sedimentation will have little impact on farming livelihoods in the greater catchment area. Such weak linkages between biodiversity and livelihoods are not good conditions for ICAD programmes that seek to sustain both livelihoods and diversity by enhancing the values of such linkages (Salafsky and Wollenberg 2000).

These observations lead Allison ***et al*** (2001) to conclude:

- Linkages between biodiversity and livelihoods in Lake Tanganyika are weak and indirect at best.

- Linkages between biodiversity and ecosystems function (and therefore provision of ecosystem services) are unproven but also likely to be weak.

- Financial benefits from alternative livelihoods associated with conservation activities are likely to be very limited.

And therefore:

- Self-sustaining ICAD programmes in Lake Tanganyika are not currently feasible. Funding for conservation activities will have to come from external sources if conservation is not to impose costs on those living around the lake.

External funding could potentially come from governments or international agencies. Given that the governments of Burundi, D.R. Congo, Tanzania and Zambia are struggling economies and conservation programmes compete against poverty alleviation, AIDS programmes, food security and civil war/ peace initiatives for government funding, it is unlikely the riparian nations will be able to prioritize biodiversity conservation in Lake Tanganyika in the near future.

Allison ***et al.*** (2001) emphasize that funding for biodiversity conservation should not come from the local people who value the resources but not the biodiversity. Rather, it should come from those who value the biodiversity but do not need the resources, i.e. the global community. This implies continued international funding of conservation programmes and detailed attention to ways of transferring financial resources for conservation in support of the type of poverty alleviation programmes identified by the LTBP SESS. Such a conclusion is not unique, Allison ***et al***. (2001) noted, that other authors have recently questioned the prevailing orthodoxy of development through conservation. Godoy ***et al***. (2000) argue that local forest dwellers in Central America should be paid for non-local values of rainforests as an incentive to resist deforestation. The lake dwellers of Central Africa merit the same consideration to preserve the non-local values of Lake Tanganyika's biodiversity.

EPILOGUE:
LOOKING TOWARD THE FUTURE

The Lake Tanganyika Biodiversity Project ("Pollution Control and Other Measures to Protect Biodiversity in Lake Tanganyika" [UNDP/GEF/RAF/92/G32]) concluded with a number of significant achievements, including diverse technical reports, a Transboundary Diagnostic Analysis (TDA), Strategic Action Programme (SAP) and draft Legal Convention. These achievements attest to the commitment of Tanganyika's riparian nations to conserving and sustainably managing Lake Tanganyika's resources. Considerable work remains, however, in order for Burundi, D.R. Congo, Tanzania and Zambia to fully honor this commitment. The SAP needs to be implemented at national and regional levels, the Legal Convention needs to be ratified by the four countries and the organs created therein established.

UNDP/GEF remains committed to assisting Tanganyika's riparian nations in this process. During the final months of LTBP, a Project Development Fund-B (PDF-B) document was created with consultation among the four countries, UNOPS and UNDP/GEF. This one-year project supports an interim planning and donor recruitment period to prepare for the implementation of the SAP. On 10 January 2001, GEF approved the project document, entitled "Developing Detailed Regional and National Project Proposals and Financing Mechanisms to Implement the Lake Tanganyika Strategic Action Program" (RAF01G41/A/1G/31). UNDP/GEF is contributing $595,000 US, the African Development Bank is contributing $106,000 US and Tanganyika's riparian governments are contributing $324,000 US toward this initiative for a total value of $1,025,000 US. The one-year bridging project is slated to begin 1 June 2001.

An important function of this bridging phase is to organize and coordinate donor support for interventions on Lake Tanganyika. This process has already begun, with a meeting between UNDP/GEF, FAO and the African Development Bank held in Abidjan November 2000 in which the three agencies discussed ways to coordinate and assure complementarity of their efforts in Lake Tanganyika.

The mandate of this one-year project is to develop project proposals and negotiate funding for the long-term implementation of the SAP. This will be accomplished by The Lake Tanganyika Planning Support and Coordination Unit, consisting of a team of full time senior-level planners from the region and a Chief Technical Advisor. The unit will be based in Dar es Salaam with team members travelling frequently to their countries to work with national planning teams to prepare and negotiate national project components. This includes designing and costing subprojects to address the major threats, negotiation for bilateral, multilateral, national and regional co-financing. The Unit will ensure coherence between proposals from various sectors and countries and continuity with the SAP. The output of the PDF-B project will include:

- a set of agreed proposals for national project sub-components, drawn from the priority actions listed in the SAP and developed through stakeholder consultation;
- a set of agreed proposals for public and private investment in national SAP priority interventions;
- a fully costed GEF project proposal (Project Brief and Project Document) for the implementation of the SAP which indicates agreed incremental costs, the sources of baseline funding and co-financing required to implement national and regional projects and other donor commitments.

It is anticipated that the PDF-B planning phase will be followed by a full project which will address the priority issues described in the SAP and engage the participating countries in concerted action toward finalization and ratification of the draft Convention.

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