3. THE EXISTING ENVIRONMENT

A. PHYSICAL ENVIRONMENT

Location and Extent

3.1 Lake Tanganyika stretches in a generally north to south orientation between the narrow confines of the steep eastern and western escarpments of the Western Rift Valley, from 03°20'30"S to 08°48'30"S latitude. The lake averages almost 50 km in width and runs to a total length of 673 km. It drains via the Lukuga River into the Congo River basin. The countries of Burundi, the DRC, Tanzania, and Zambia, share its waters and shoreline frontage as shown in Table 1.

Table 1. Lake Tanganyika: Division of national waters and shorelines

Country	Latitude Range	Lake Area (km^2)	Lake Area (%)	Shoreline (km)	Shoreline (%)
Burundi	03°20'30"S - 04°26'40"S	2,600 km^2	8%	159km	9%
DRC	03°21'00"S - 08°13'40"S	14,800 km^2	45%	795km	43%
Tanzania	04°26'00"S - 08°36'00"S	13,500 km^2	41%	669km	36%
Zambia	08°13'40"S – 08°48'30"S (West shore)	2,000 km^2	6%	215km	13%
Lakewide totals	03°20'30"S - 08°48'30"S	32,900 km^2	100%	1,850km	100%

3.2 The Programme area generally includes all of the shoreline and its some 790 bordering villages and towns. Particular attention is to focus on a selection of fisheries co-management pilot sites that, over the five-year duration of TREFIP, will involve a total of 200 local communities representing around 20,000 fisherfolk families or around 140,000-150, 000 people (Table 2).

Table 2. Schedule of proposed TREFIP pilot co-management activity

Country	Tot. Landing Sites	Year 1	Year 2	Year 3	Year 4	Year 5	% Co-managed Sites
Burundi	54	5	10	15	15	15	28
DRC	417	5	15	30	60	95	23
Tanzania	208	5	15	25	40	60	29
Zambia	107	5	15	25	30	30	28
TOTAL	786	20	55	95	145	200	25

Geomorphological features

3.3 Lake Tanganyika was formed millions of years ago as a result of massive rifting during the Pliocene. These movements interrupted the east to west drainage of ancient watercourses towards the Congo River and caused them to fill what became an isolated basin on the floor of the Western Rift Valley. Over a subsequent period of some one million years or so, water levels in the closed lake fluctuated considerably. Volcanic upheavals during the Late Pleistocene then changed regional drainage patterns, reversing flows from the northern highlands into the lake via the Ruzizi River and raising the level of the lake and establishing the Lukuga outflow (Beadle 1981).

3.4 The contemporary lake's surface lies at an altitude of 773m. Surrounding escarpments, in some places set back behind a margin of littoral plain, and in others mounting precipitously up directly from the shore, reach elevations of between 2000 to 3000 m. Main inflowing rivers are the Ruzizi, entering the northern tip of the lake from its source in Lake Kivu, and the Malagarasi, running into the north-eastern quadrant from its source in the interior highlands of Tanzania.

3.5 Mean depth of the lake is 570m. Maximum depths are found in the 'deeps' of the major northern and southern basins (1,310m and 1,470 respectively), which may in turn be divided into the several sub-basins listed in Table 3.

3.6 In the north, the Kigoma deep extends to the depth of 1310 m. This is separated from the Kalemie sub-basin by a broad sill with a depth of 655 m. Another sill lies further to the south, at about 600 m down, and falls away into the East-Marangu deep. Here the water column reaches 1472 m, the maximum depth of the lake.

Table 3. Lake Tanganyika: Geomorphological features*

Major Basin	Latitude Range	Sub-basin	Length	Width	Max. Depth
North-Tanganyika Trough	03°20' – 05°40' S	Bujumbura	70 km	25 km	350 m
		Rumonge (Karonda area)	80 km	35 km	1150 m
		Kigoma	170 km	80 km	1310 m
South-Tanganyika Trough	06°50'S – 09°S	Kalemie	130 km	40 km	800 m
		Moba	70 km	50 km	600 m
		East-Marangu (Kipili area)	120 km	30 km	1470 m
		Mpulungu	100 km	25 km	800 m

* Adapted from Mannini (1998), after Tiercelin and Mondeguer (1991).

3.7 Tanganyika is meromictic with stable hypolimnetic waters, and the mineral contents are fairly low for a lake of this type (Degens *et al.* 1971).

Climate and hydrophysics

3.8 There are two main seasons within the Tanganyika region. The wet season from September to May is characterised by weak winds over the lake, high humidity, considerable precipitation and frequent thunderstorms. The dry season from May until end of August is characterised by moderate precipitation and strong, regular southerly winds. Seasonal changes of weather and winds result from large-scale atmospheric processes. During the dry season, the Inter Tropical Convergence Zone (ITCZ) shifts south of the equator and extends over the region. In January, during the middle of the wet season, the ITCZ is situated on the northern side of the equator.

3.9 The global El Nino-Southern Oscillation (ENSO), which is known to lengthen the dry season and decrease wet season rainfall, is now also believed to be of some importance to the regional hydrological conditions.

3.10 Regular diurnal and seasonal wind forcing provides very stable momentum input to the lake. The high and steep mountains and elongated shape of the lake affect the spatial variation of the wind forcing. Diurnal variation along with air temperature and wind speed values during the dry season are highest in Mpulungu, at the southern end of the lake (Kotilainen *et al.* 1995a, b; Huttula *et al.*, 1994).

3.11 Based on extensive wind field modelling conducted by the LTR Project, it has been determined that the offshore winds in Kigoma result from a lake-land breeze system, mountain slopes, and south-easterly trade winds (Kotilainen *et al.*, 1995a). In Kigoma the mountain slopes contributed about 50 percent, and the trades 25 percent of the diurnal variation of winds. The remaining 25 percent of wind variation is due to the lake effect. The SE trade wind enhances the lake breeze considerably at daytime and adds to down slope winds at night time.

3.12 Monthly mean wind speed is highest in the dry season at all stations, whilst monthly mean wind gust is highest in the wet season. Wind direction distribution is very similar between south and north. The proportion of the south-east winds increased at all stations during the dry season.

3.13 Bottom friction and water temperature play secondary roles in driving the hydrodynamics of the lake. Relatively high temperatures make the viscosity of Tanganyika's waters low as compared to those in temperate regions.

3.14 Tanganyika's waters are thermally stratified, although the temperature range is quite narrow. The difference between the epilimnetic and hypolimnetic waters is only 4-5 °C. Still, the density differences are clear and thermal stratification is observed throughout the year.

3.15 The stability of 70 percent of the water volume and the great age of the lake should lead to a high depth gradient of salts. However, the measurements by Degens *et al.* (1973) show that no such a gradient exists in the lake's deep waters. This indicates some kind of deep water circulation. Coulter (1968) suggested that the dense water penetration occurs every night everywhere along the lake margins. On the basis of temperature observations and theoretical analysis, he also came to the conclusion that a clockwise general circulation prevails in the lake and that strong coastal jets exist, especially near the eastern shore.

3.16 Earlier studies have noted major upwelling and its biological influences in the pelagic zone at the very southern end of the lake during the dry season in May - August (Coulter and Spiegel 1991; Hecky and Bugenyi, 1991). This pattern was confirmed by the recent LTR studies (Huttula, 1997). In Mpulungu the thermocline in the wet season is found at the depth of 70-80, but the water mass wells up to the surface layers during 2-3 months of the following dry season. In Kigoma wind forcing is too weak to bring waters below the thermocline to the surface, although upwelling of sub-thermocline waters is likely taking place there as well.

3.17 Recent LTR survey results and modelling studies also show that a high spatial variation of flow pattern exists all over the lake due to variations in the wind field. Horizontally the flow pattern is dominated by large-scale gyres; regional bathymetry and wind forcing determine their location and direction. The largest wet season gyres covered parts of the lake from the eastern shore all away to the western shore. Having a typical velocity of 10 cm/s and mean lake width, one rotation of such a gyre will last 20 days. This rotation velocity is slow, given that several parallel gyres with high speed (more than 30 cm/s) were observed next to shallow shore areas.

3.18 Several areas of up-welling and down-welling were also identified. Their occurrence was more frequent and mixing velocities were higher during the dry season. The typical range for dry season upwelling velocity was about 3- 25 m/d. Previous flow and current studies reported upwelling only along the main axis of the lake, and only during the dry season.

3.19 Observed solar radiation was higher in the south than in the northern part of the lake. In the south there was no difference between the dry (June-August) and wet (September-May) seasons; in the north solar radiation was higher during the dry season (Verburg 1997, 1998a). On average, air temperature was highest in the Mpulungu region and lowest at Bujumbura.

3.20 The flow results together with temperature and echo intensity observations provide good information about transportation of the river waters. Episodic advection can be seen both westerly and easterly directions. The observed magnitude of currents and their high variation results in an effective mixing within a fairly limited area near the river mouths. Therefore, no hypolimnetic effects by cool river waters could be seen in front of the rivers (Kotilainen *et al.*, 1995, Vandelannoote *et al.*, 1999) as has been claimed since the 1930's.

3.21 Water temperature measurements reveal tilting of the thermocline along the main axis of the lake. Transversal tilting of thermocline in the Kalemie strait during dry and wet seasons was observed in connection with uninodal internal seiching. Internal wave motion with a periodicity of 23.4 d during the dry season and of 34.8 d during the wet season was found with automatic devices for the first time.

3.22 High and variable current speeds were measured at surface waters down to 20-40 m whereas the water flows below this level were more steady but showed clear seasonal variations.

3.23 The distribution of pelagic fish larvae (*Lates stappersii*) and macro zooplankton seems to correlate with water current patterns, making the hydrodynamic model a tool with certain predictive power to estimate floating directions and distances of passive objects (Huttula, 1997; Mannini, 1998).

Infrastructure and services

3.24 Tanganyika is very remote from major centres of population in the DRC, Tanzania, and Zambia. In the case of Burundi, the capital city Bujumbura (pop. ca. 250 - 300,000) is situated directly on the shoreline in the northeast corner of the lake. From a fisheries perspective, the isolated location of most landing sites, steep escarpments along much of the shoreline, and a general lack of transportation infrastructure impose severe constraints on both processing and marketing possibilities.

3.25 Roads running parallel to the coast are only found in Burundi and along stretches of shoreline in Uvira and Fizi districts in the DRC. Other major roads link principal towns like Kigoma, Kalemie, Moba, Mpulungu, and Nsumbu with their hinterlands but are not effectively served by feeder roads from outlying landing sites.

3.26 Feeder road links around the lake generally are poorly developed and the roads that do exist generally suffer from a marked lack of maintenance. This state of affairs contributes to prolonged cargo transit times and affects the quality and hence the value of highly perishable fishery products. Rough conditions also imply high vehicle operation and repair costs for transport operators.[6]

3.27 A rail link exists at Kigoma, with goods and passenger service to Tabora (connections to Mwanza and Mpande on the Central Line) and Dar-es-Salaam. In Kalemie the railway connection to Lubumbashi and the Shaba mining districts no longer operates due to the civil war that has affected large parts of eastern DRC.

3.28 For residents of the vast majority of landing sites along the lakeshore non-existent or poor and irregular overland transport links are historical conditions that have tended to maintain reliance on the lake itself as the main 'highway' of travel and commerce.

3.29 The lake provides a critically important medium of transport for passengers and cargo, including fish, linking principal towns and transit points along the shoreline -- Uvira, Kalemie, and Moba in the DRC, Bujumbura and Rumonge in Burundi, Kigoma, Tongwe, Kipili, and Kasanga in Tanzania, and Mpulungu and Nsumbu in Zambia.

3.30 Lake cargo is carried by a fleet of some dozen small to medium sized steel ships under both state and private company ownership, barges pulled by small tugboats, and locally constructed wooden dhow-type craft equipped with outboard engines (Photos 8 – 11)

3.31 At present the ports of Bujumbura (Burundi), Kigoma (Tanzania), Mpulungu (Zambia), and Kalemie and Uvira (DRC) are the only places with fully equipped berthing and cargo handling facilities (examples, Photos 9, 12 and 13), although some of these are not adequately maintained. The recently announced COMESA proposal for a Great Lakes Regional Railway will presumably lead to substantial improvements for the ports of Mpulungu and Bujumbura, since their rehabilitation is programmed as a first phase activity of the project.[7]

3.32 The only other cargo vessel facilities found on the lake are rudimentary jetty installations at Kasanga (Tanzania) and Nsumbu (Zambia). The former installation is used by *M/V Liemba* and *M/V Mwongozo*, medium sized mixed passenger/cargo ships of the Marine Services Co. Ltd. (Tanzania), one or the other of which plies the eastern shoreline route along which the company runs a weekly service between Kigoma and Mpulungu. Nsumbu is not at present served by any regularly scheduled shipping service.

3.33 Large motorised transport dhows or 'water taxis' also carry passengers and cargo, chiefly smoked and dried fish, between larger landing sites. Principal fish trading routes for these craft are from Tongwe (60 km south of Kigoma) in Tanzania to Rumonge (70 km south of Bujumbura) in Burundi, and Uvira in the DRC.

3.34 Bujumbura has a modern airport capable of handling large passenger and cargo jet traffic, and is served by several international carriers as well as smaller charter operations.

[6] In Tanzania, for example, it was estimated at a recent transportation conference held in Dar-es-Salaam that 65% of the national road network is in poor shape, resulting in lost economic opportunities and increased vehicle operating costs amounting to TShs. 365 billion per year (speech by President Mkapa reported in *Daily News*, Dar-es-Salaam, 1 June 2000).

[7] The COMESA Kasama-Mpulungu-Bujumbura railway line proposal was announced after project meetings were held in Lusaka in the latter half of May 2000. Member states of the project include Zambia, Burundi, Rwanda, and the DRC. Initial upgrading of Mpulungu and Bujumbura ports as a first phase activity is projected to cost US$ 101 million (*Daily News* (Dar-es-Salaam, Tanzania), 22 May 2000.

Airstrips exist at Kalemie in the DRC, Kasaba Bay (near Nsumbu), Ndole (near Mpulungu), and Kasama (2 hours drive from Mpulungu) in Zambia, and Kigoma, Kipili, and Mahale Mountains National Park in Tanzania. The Kasama field is served by a regular flight service to and from Lusaka, the Zambian capital, whilst Kigoma has scheduled flights to and from Dar-es-Salaam and Bujumbura.

3.35 Electricity supplies and other amenities needed to support energy-intensive techniques of fish handling and processing (chilling or freezing) only exist in the largest towns. The most developed facilities are to be found in Mpulungu, where nine companies are currently running freezing operations. Two other Zambian-based fishing companies have facilities in Nsumbu (one in operation, one dormant -- Photo 14). Industrial processing facilities also exist at Kalemie, but they are reportedly not in operation at the present time due to the civil war.

3.36 Kigoma, Bujumbura, and Uvira are the only other lakeside towns with an electrical grid. The three tourist lodges in the Nsumbu area of Zambia (Kasaba Bay Lodge, Nkamba Bay Lodge, and Ndole Lodge) operate diesel generators independent of any grid. Also in Zambia, close to border with DRC at the settlement of Mushi, the Kapishi Geothermal Power Station was built in the mid-1980s to supply power to a nearby crocodile and ornamental fish collection farm (since abandoned), but has never been placed into service (Photo 15). At the small Leopard Hotel lodge facility being developed near Kipili, the proprietor uses a wind-generator and storage battery system. Private generators are also found occasionally in small business establishments and mission stations in some localities.

3.37 The checklist of basic commercial, social, and technical services and facilities administered during the 1997 LTR lakewide SEC survey reveals a generally weak array of amenities and infrastructure in all national sectors, with Zambian sites scoring the lowest on these measures and Burundi sites the highest.

3.38 Schools, medical facilities, retailing establishments, input suppliers and servicing agents, protected water supplies, electricity, telephone/radio links, post offices, banks, fisheries extension staff, and local fisher organisations are most poorly represented in Zambia, followed by Rukwa Region (Tanzania), Kigoma Region (Tanzania), and the DRC sites. Protected water supplies, electricity, telephone/radio links, post offices, and banks are absent at nearly all sites, including those in Burundi.

B. BIOLOGICAL ENVIRONMENT[8]

The Lacustrine Ecosystem

3.39 LTR hydrodynamic modelling and intensive field measurements have shown that the interactions between the physical environment and biotic community are more dynamic and complex than previously thought, and that the trophic structure of lake is extremely difficult to study quantitatively with conventional field methods.

3.40 Basic limnological studies of LTR have dealt with the distribution and availability of macronutrients, patterns of primary production and the seasonal changes in the physical limnology affecting the water chemistry and nutrient regime. The tilting thermocline results in

[8] This review is mainly based on the work of Coulter (1991) and recent scientific summaries of LTR investigations, including Coenen *et al*. (1998), Mannini (1998), Szczucka (1998), Lindqvist *et al*. (1998), Mölsä *et al* (1999), Kurki *et al*. (1999), Salonen *et al.* (1999), Sarvala *et al.* (1999), and Vuorinen *et al.* (1999).

a density imbalance that acts as a store of potential energy. Vertical mixing, thermocline tilting and upwelling are strongest during the dry, windy season and occurred particularly in the Mpulungu area. These changes are caused by seasonal trade winds. The degree of wind shear stress on the lake surface is strongest in the southern end of the lake. Access of nutrient rich waters to the productive euphotic layer is the primary factor affecting phytoplankton production. The level and occurrence of primary production is mainly determined by the partial mixing within the epilimnion and the relation between mixing depth and euphotic depth, i.e., by the vertical distribution of temperature relative to ambient irradiance.

3.41 Phytoplankton of Lake Tanganyika is mostly distributed in a thick water layer, generally down to 60 m. Cyanobacteria contribute significantly to the phytoplankton biomass. During all seasons, bacteria-sized picocyanobacteria are very abundant. Including heterotrophic bacterioplankton, organisms <1 micrometer in diameter were thus probably an important food source for planktonic consumers. Particularly in October-November, filamentous cyanobacteria were also common, often forming extensive blooms. This implies nitrogen limitation of phytoplankton, while particulate nutrient ratios and bioassays suggested limitation by phosphorus or nitrogen or both combined. Near the surface phytoplankton was probably under a multiple stress of nutrient limitation and high solar UV-light radiation. Combined with the hydrodynamic properties of Lake Tanganyika, these features make phytoplankton primary production highly dynamic and hence difficult to assess.

3.42 Compared to earlier estimates, the measured phytoplankton primary production was 47-128 percent higher, i.e. 426-662 g C m^{-2} a^{-1}. The concentration of dissolved organic carbon was confirmed to be low, 2-3 g C m^{-3}. Thus, although bacteria are evidently an important component of the plankton, with a production of ca. 20 percent of that of phytoplankton, the epilimnetic food chains of Lake Tanganyika are probably mostly based on phytoplankton primary production.

3.43 In macrozooplankton, peak abundance of medusae occurred randomly in the north and south; during many cruises the densities were rather evenly distributed in studied areas. Shrimp abundance was equally high both in the north and south, though fairly often their densities were highest in the south. The patchy occurrence of shrimps rendered conclusions about their areal patterns uncertain. In spite of their modest role in the planktonic biomass and production, the atyid shrimps were very important in the diet of pelagic fish. Areal differences were clearly seen in fish diet and selective predation studies.

3.44 Studies in fish biology combine results on basic population parameters of the commercially dominant pelagic species, catch assessments and stock size and distribution as conducted in catch studies, fish biology analyses, and acoustic surveys.

3.45 Historically the commercial fisheries exploited the two schooling clupeid ‘sardines’ (known variously as ‘ndagala’ (Burundi and DRC), ‘dagaa’ (Tanzania), or ‘kapenta’ (Zambia) along different sections of shoreline), *Limnothrissa miodon* and *Stolothrissa tanganicae*, together with their major predators, all centropomids of the genus *Lates* -- viz: *L. stappersii*, *L. angustifrons*, *L. mariae*, and *L. microlepis*.

3.46 Of the *Lates* species, the latter three have from the mid-1970s been incidental to the catch, reportedly as a result of heavy exploitation pressure. The lake’s commercial fishery is now essentially based on the two clupeids (ca. 65% by weight) and *L. stappersii* (ca. 30% by weight).

3.47 The catch frequency and CPUE distribution showed *S. tanganicae* stock is very unevenly distributed in the lake; during most of the survey months the stock was found in the northern half of the lake from the Kalemie area northwards.

3.48 A clear horizontal migration occurs with post-larval juveniles concentrating offshore in the open areas of the lake and thereafter the young stages recruiting first to the industrial fishery and then to lift-net fishery closer to inshore areas. The *S. tanganicae* fishery is supported mostly by a single major cohort, which is recruited during the dry season and makes the exploitable stock during the successive wet season. The availability of *S. tanganicae* resources in local fishing grounds is very irregular due to high mobility of the schools. These migrations, both horizontal and vertical, are primarily determined by predation avoidance towards *L. stappersii* and by prey preference on copepod mesozooplankton.

3.49 *Limnothrissa miodon* is more evenly distributed in the lake than *S. tanganicae.* The juvenile stock comprising the post larval stage occurs in shallow waters where the fish are subject to the unselective beach seine fishery in certain areas. Large *L. miodon* occur almost exclusively offshore outside the range of artisanal fishery.

3.50 *Lates stappersii* stocks consist apparently of several annual cohorts and therefore the sudden changes in stock size and composition are less likely than those in clupeids. Juvenile and adult *L. stappersii* stocks co-occur within the same geographical areas but the juveniles are more mobile in their distribution. Neither fish biology data nor analyses of population genetic discreteness have provided evidence for the existence of *L. stappersii* sub-populations in the lake. Fish apparently move and mix amongst sub-basins, leading into significant exchange of individuals between different parts of the lake. From a managerial point of view, *Lates stappersii* stocks can be divided into northern and southern sub components.

3.51 Production, biomass, catch composition, growth, and mortality for the three major commercial species were assessed by LTR through pelagic trawling and hydro-acoustic surveys, catch surveys, and population analyses.

3.52 Whole-lake averages for P/B ratios obtained from experimental trawl results were 4.5, 2.7 and 1.6 a^{-1} for *Stolothrissa*, *Limnothrissa* and *Lates*, respectively.

3.53 In Burundi the catch in 1995 amounted to 111.5, in Zambia to 53, in Tanzania to 40, and in the DRC to 63 kg ha^{-1} yr^{-1}. In 1995, the realised catch of the planktivorous fish for the whole lake was 23-38 percent, and in the most heavily fished Burundi waters about 43-52 percent of estimated planktivorous fish production.

3.54 Mean fish biomass (in tonnes) calculated for the four lacustrine countries in three acoustic surveys from 1995, 1997 and 1998 at the LTR project are as shown in Table 4.

Table 4. Mean fish biomass (mt), derived from LTR acoustic surveys (1995, 1997, 1998)

Country	Approx. area	Survey 02/95	Survey 17/97	Survey 19/98
Burundi	580.85	23562	1533	10509
Tanzania	4241.01	44897	82201	157493
D.R. Congo	4496.78	24482	72130	120121
Zambia	735.99	No data	14116	15522

3.55 A new view of the trophic structure of Lake Tanganyika is emerging from LTR data. Phytoplankton production and carbon biomass figures are higher than earlier estimates, and zooplankton data indicate lower biomass and production than previously estimated. Thus, contrary to earlier claims (Burgis, 1984; Hecky, 1984, 1991), recent data show that, compared to lakes in general (e.g. Pauly & Christensen, 1995), the trophic efficiency between zooplankton and phytoplankton in Lake Tanganyika is not exceptionally high; likewise, the fish yield seems to be relatively low in comparison with primary production, as in many other large lakes (Oglesby, 1977; Morgan *et al.*, 1980). According to LTR estimates, fish production in Lake Tanganyika relative to primary production falls within the normal range reported from other lakes (Morgan *et al.*, 1980; Downing *et al.*, 1990). The suggested role of bacterioplankton compares well with the literature (Cole *et al.*, 1988; White *et al.*, 1991).

3.56 In fact, low production efficiency of the crustacean zooplankton is not unexpected in a deep, clear water tropical lake with high epilimnion temperatures. The microbial loop may also have a prominent role in the pelagic food web of oligotrophic systems (Weisse & Stockner, 1993; but see Riemann & Christoffersen, 1993 for an opposite view) like that of Lake Tanganyika. This leads to inflated respiration costs to the extent that such systems act as net sources of carbon dioxide to the atmosphere (del Giorgio *et al.*, 1996).

3.57 High dependence of primary production on nutrient regeneration, as in Lake Tanganyika (Hecky, 1991), implicitly suggests low efficiency of carbon transfer through the food web, because nutrients are mainly regenerated by the microzooplankton, which have high respiration rates. Thus, in Lake Tanganyika, the temporally and regionally variable nutrient inputs from the huge hypolimnetic store, through long-range transport via the atmosphere and from land runoff, are not only crucial to the absolute levels of production; by modulating the role of the microbial loop, they may also affect the efficiency of carbon transfer through the system.

3.58 The estimated carbon transfer efficiency from crustacean zooplankton to planktivorous fish was lower than the values reported from Lake Malawi between herbivorous zooplankton and their predators (invertebrates and fish larvae; Allison *et al.*, 1995). In Tanganyika, the efficiency at this step may be partly affected by the fact that part of the fish production is based on deep-water shrimps, which may not have been caught quantitatively with the present sampling scheme.

3.59 The extremely simple trophic web structure in the open waters of Tanganyika should enhance fish production, since the food chain leading to planktivorous fish production is short. The fishery itself has simplified the food web by suppressing piscivorous fish stocks at an early stage of the commercial fishery (Coulter, 1970). On the other hand, low production efficiency would rather be expected in a high-temperature environment (Edwards, 1984). In Tanganyika, the upper, almost anoxic layers of hypolimnion may provide zooplankton with a partial refuge from fish predation. This combined with the energetic costs of extensive vertical migrations, necessary in order to avoid piscivorous fish, may lead to a relatively low energetic efficiency of planktivorous fish production.

3.60 LTR researchers have concluded that trophic efficiencies in the pelagic food web of Lake Tanganyika are not unusually high. The crustacean zooplankton production is small, but the recorded fish yields quite normal relative to the measured primary production of pelagic phytoplankton. Thus, the flourishing fisheries in Lake Tanganyika are not so much based on any exceptional productivity of the system, but on the fact that most of the pelagic production is channelled into a few fish species that have short life cycles and rapid reproduction. Those fish are furthermore easy to catch and thus suitable for an economic fishery.

Evolution of the fisheries

3.61 Fishing in Lake Tanganyika has intensified considerably over the course of the 20th century in association with the dramatic expansion of human population and settlements around the lake and the introduction of various technological innovations, such as paraffin oil (kerosene) pressure lamps for night-fishing, synthetic netting material, and motorised craft.

3.62 As noted above, modern harvest operations chiefly involve three pelagic species -- the two schooling clupeid 'sardine' species, *L. miodon* and *S. tanganicae*, and their principal predator, *L. stappersii*. Most fishing is done at night as most methods rely on light attraction. This is why pelagic fishing activities practically cease each month during full moon periods.

3.63 Annual harvest levels in recent years (up to 1995) have been estimated to vary in the range of 165,000 - 200,000 mt -- volumes that translate into annual earnings amounting to anywhere between 80 to 100 million US dollars.

3.64 The harvest is shared between the littoral States roughly in the order, if not exact proportion, of each State's share of the total lake area. Thus, based on 1995 estimates, fishers in the DRC (45% of lake area) land about 50 percent of the estimated annual pelagic catch, whilst those in Tanzania (41% of lake area) land about 31 percent, in Burundi (8% of lake area) about 12 percent, and in Zambia (6% of lake area) about 7 percent.

3.65 The lake's present-day fisheries are conventionally classified according to gear kit into 'traditional,' 'artisanal,' and 'industrial' types.

3.66 The '***traditional fishery***' is based on the use of lusenga or scoop nets (in conjunction with fire or lamp light attraction) for the harvest of clupeids, and gillnets, long lines, hand lines, traps, spears, and poisons for the capture of demersal species. It is strongly if not predominantly a subsistence activity undertaken by simple fishing units comprised of one or two persons operating with dugouts or simple plank canoes propelled by paddles and, in some cases, lateen-rigged sails (Photos 16 -18). Traditional fishing with lusenga nets has undergone substantial decline in recent decades in the face of widespread adoption of more efficient artisanal gear.

3.67 However, one traditional fishing method that has become increasingly popular in recent years around the Kigoma Region is line jigging for *Lates stappersii*. Jigging is carried out during daylight hours in deeper waters usually within 5 km of the shoreline, in units comprised of one to three persons. Canoes are sailed out to the grounds on the morning offshore wind, and return in the late afternoon with the onshore wind.

3.68 Recent studies have also demonstrated that the inshore demersal fishery, primarily prosecuted with small-sized gillnets, has been vastly under-appreciated in both its size and potentially negative effects (Lindley 2000).

3.69 '***Artisanal fishing***' is primarily carried out for commercial purposes using lift nets, 'chiromila' seines (ring nets), and beach seines. The artisanal fishery has grown immensely from the late 1950s, when the technique of liftnetting from catamaran (two wooden planked canoes lashed together with poles) or, more rarely, trimaran rigs (three hulls lashed together) was first introduced in the northern portion of the lake. Liftnet units are equipped with 4 to 8 pressure lamps and operated by a 4 to 6 person team (Photo 19).

3.70 '***Industrial fishing***' units are each comprised of a large (16-20m) steel main vessel, a smaller net-setting vessel, and 3 or more light boats, all requiring a crew of from 20 to 40 persons to operate (Photos 20 - 21).

3.71 There also exists an ornamental live capture fishery. The number of active companies has varied over the last twenty years or so, especially in Zambia. Several start-ups have failed, owing to the difficult logistics involved and/or administrative difficulties. The four principal companies now active operate from bases in Mpulungu (Zambia), Kigoma (Tanzania), and Bujumbura (Burundi). There are occasional reports of 'pirate' (unlicensed) ornamental fish collectors as well, but the extent of this practice is not known. The ornamental fish trade in general remains relatively small in scale, and provides a very modest employment base (probably involving less than 100 people lakewide) comprised of diving teams, support crew, and storage and shipping facility workers.

3.72 Crocodile farming has been attempted at two sites at least within the Zambian sector of the lake. Both of these enterprises collapsed following the take-over of their assets by a state-controlled tourism/development company in the late 1980s.

3.73 Within the past decade the introduction of so-called 'Apollo' liftnets has greatly increased the fishing power of artisanal units, to the point where they are almost as effective as the large purse seines deployed by industrial units (see below). The liftnet fisheries primarily target clupeids from the Kipili area northwards, with *S. tanganicae* accounting for the greater proportion of the catch by weight. *L. stappersii* appears to replace clupeids as the dominant target species of the liftnet fishery from Kipili southwards. In the southernmost portion of the lake, however, liftnetting has only developed in a minimal way, reportedly because of the difficulties of operating in wind-exposed offshore waters.

3.74 Most artisanal operations in Zambian waters are therefore based on the kapenta beach seine, worked at night by shore crews (net haulers) operating in conjunction with net-laying and light attraction boats. Kapenta seining is an inshore fishery that tends to capture juvenile *L. miodon*. The seine codends usually have mesh sizes of <6 mm (stretched), as compared to the 6-8 mm (stretched) mesh sizes that are standard in the lift net fishery. Beach seining is banned in both Tanzania and Burundi.

3.75 The average efficiency of artisanal units has increased remarkably from 3 mt/yr in the early years up to an overall average of 14 tonnes in the 1990s, with annual peak averages in Burundi and Zambia ranging as high as 30 mt/yr. In recent years artisanal units (mostly liftnets and, beach seines) are contributing an increasingly proportion of total production at the expense of industrial purse seine units. By the mid-1990s the maximum yields within the artisanal sector in Burundi stood at 106 mt yr^{-1} for Apollo ('super' liftnet) units, and 41 mt yr^{-1} for regular liftnet units. In Zambia they amounted to 62-68 mt yr^{-1} for kapenta (beach) seine or chiromila (boat) seine, but only 10 mt yr^{-1} for liftnet units.

3.76 The industrial fishery traces back to the mid-1950s, when Greek nationals introduced the technique in Burundian waters. Purse seine units operated from larger ports throughout the lake in subsequent years, but are now concentrated in the southern portion. This fishery mostly targets *L. stappersii*, which account for about 95 percent of the catch in recent years.

3.77 The drastic decline in industrial fishing in northern waters is reflected in the migration or retirement of many purse seine units. Of the 13 industrial units active in Burundi in 1992, only two were enumerated as active in the 1995 LTR FS and only one is known to be active as of mid-2000. The remainder have either been decommissioned or have been shifted to Zambia in the south of the lake. The DRC has witnessed a similar decline in purse seining operations based in Kalemie and Moba, though this probably owes more to political instability than to adverse fishing conditions. In Tanzania the industrial fishery never developed to the same extent as elsewhere, but here too purse seining has fallen off in recent years. Of the four operational units enumerated in 1995, none are active at the present time.

3.78 Over the last 15 years or so there has been a ten-fold growth in purse seining effort in Zambian waters (from 3 to 30 active units since 1983), almost exclusively harvesting *L. stappersii.* The development of the purse seine fishery from the 1950s soon resulted in a substantial reduction in the harvest of other *Lates* species, i.e. *L. mariae, L. microlepis,* and *L. angustifrons*, all of which seem to be particularly vulnerable to localised over-fishing. Today's simple composition of the pelagic stocks, with two clupeids and *L. stappersii*, is one very striking outcome of the selective pressures imposed by the mechanised large-scale fishery.

3.79 The production of Zambian industrial units has shown a sharp decline within the last few years. Catches have dropped from 3,089 mt in 1997 to 1,988 in 1999. Annual catch per boat was 114 mt in 1997, 84 mt in 1998, and 76 mt in 1999.

3.80 At the other end of the lake, in the waters shared by Burundi and the DRC, signs excessive exploitation pressures on *L. stappersii* have also been registered. Owing to the cumulative effects of heavy industrial fishing followed by greatly expanded artisanal fishing, *L. stappersii* now make up only around 20 percent of the commercial catch in northern waters. Furthermore, most of this proportion is comprised of juveniles.

3.81 It is notable that *S. tanganyicae* was the dominant target species of the purse seine fishery in the Zambian waters of the lake during the 1980s. Although the *S. tanganyicae* decline coincides with the expansion of purse seining in Zambia, the stock in northern waters, at least until recently, seems to have withstood decades of high fishing pressure in fairly confined areas. This strongly suggests that environmental factors have played a role in hastening the southern stock's decline. A succession of poor recruitment periods brought on by environmental perturbations can rapidly reduce the size of short-lived clupeid stocks.

3.82 LTR survey results confirm a more uniform lakewide distribution of the *L. miodon* stock in comparison with that observed for *S. tanganicae*. Catch composition observations indicate that *L. miodon* contribute less to the lift net and purse seine harvests than do *S. tanganicae* and *L. stappersii*. At the same time, *L. miodon* dominates catches in the highly unselective beach seine (= kapenta seine) fishery that operates close inshore over shallow, sandy bottoms, particularly along the southernmost coastlines. Since juvenile *L. miodon* tend to be concentrated within the inshore areas beach seine hauls are mostly comprised of immature fish. The widespread use of very fine mesh covers on the seines further intensifies pressure on the immature stock.

C. SOCIO-ECONOMIC ENVIRONMENT

3.83 The tens of thousands of boat and equipment owners/operators and crew active in the harvest sector represent a first tier of fisheries employment and income generation. Secondary fisheries-generated employment has also to be taken into account.

3.84 Local processors and traders, long-distant transporters and marketeers, and various others who provide services and support at landing sites and throughout the distribution chains are reckoned to number in the hundreds of thousands.

3.85 If individuals tied to the families and households of all of these operators and service providers are considered as well, it can be reckoned that some one million people living around Lake Tanganyika – about one-tenth of the estimated population of the entire lake basin -- are directly dependent on the fisheries for their livelihoods.

3.86 LTR 1997 SEC survey findings confirm that lakeshore communities are generally characterised by conditions of weak and deteriorated physical infrastructure, and of a critical scarcity in basic social services and amenities. The communities bordering Lake Tanganyika clearly share in the conditions that, on the basis of various 'quality of life' indices, have ranked East-Central African countries amongst the world's most poverty-stricken and underdeveloped.

3.87 Brief socio-economic profiles of the respective lacustrine countries are provided in the following paragraphs, in order to set the wider context within which Tanganyika fisherfolk and other basin stakeholders live and work.

Country Overviews

Burundi

3.88 Burundi is small (27,834 km^2) and landlocked, with relatively few natural resources and one of the highest population densities (230 persons per km^2) on the continent. The national population, estimated at 6.6 million in 1997, grows at an average of 2.6 percent per year, a rate that will almost double the number of people within the next 25 years. Pressure on the country's very limited land base thus continues to mount. Estimated GDP *per capita* for 1997 was $180, amongst the lowest of all African countries.

3.89 About 94 percent of the population lives in rural areas and the economy depends almost entirely on agriculture. Until the recent period of conflict, the country was self sufficient in food and could export within the region. Coffee provides around 90 percent of foreign exchange revenue from exports.

3.90 Economic sanctions imposed after the 1996 *coup d'état* further worsened the situation, creating hardship for the bulk of the population. Deterioration in quality of life is apparent through a variety of socio-economic indicators. Immunisation coverage and rates of primary school employment for children have declined sharply. There have been dramatic increases in malnutrition (wasting amongst children under five), reported cases of endemic diseases, and HIV prevalence. Poverty has worsened sharply: the World Bank estimates that rural poverty has increased by 80 percent in recent years, and that the incidence of urban poverty has doubled. Poverty depth is thought to be amongst the greatest in sub-Saharan Africa.

3.91 The conflict and the embargo have affected agriculture through looting and destruction of household goods and livestock, population displacement, and collapse of distribution channels for farm inputs. Fisheries activities also suffer from the current situation. The military authorities have from 1996 imposed various restrictions on the scale and location of fishing operations. Fishing was stopped altogether from 26 September 1999 to 9 February 2000. Since then, only four landing sites have been opened. Before 1996, over fifty landing sites of various sizes were in operation.

3.92 In urban areas many unskilled workers have been laid off from formal private sector enterprises, in response to a drop in industrial GDP of almost 60 percent since 1992. The urban informal sector has also suffered, as enterprises have closed due to difficulties in the supply of materials from abroad and from the interior of the country.

3.93 The national economic situation has shown some limited signs of improvement in some areas in the last few years. There have been modest gains in industrial production, and the average inflation rate has dropped from 31.1 percent in 1997 to 12.6 percent in 1998 and 7.5 percent in 1999.

3.94 Fisheries in Burundi contribute only an estimated 1 percent to the country's agricultural GDP and 0.5 percent to its global GDP. Although these figures suggest that fisheries play but a minor role in the national economy, their significance as a source of food and, particularly along the Tanganyika lakeshore, as a source of employment, is very substantial. Fish represents close to 30 percent of the total animal protein available in the national food supply, and in many areas it is of vital significance for the nourishment and indeed survival of local inhabitants.

3.95 Aquaculture development is now being greatly encouraged. It is doubtful however that production from this source will be able to compensate for the growing shortfalls that can be expected from the domestic capture fisheries over the next few decades. The country has in recent years become a net importer of fish. Resources from Lake Tanganyika are at or near a state of full development, and opportunities for developing further production from other inland waters, which are of very minor extent, appear rather limited. Based on present indications, significantly greater imports will be necessary if fish supply is to keep pace with population growth in coming years.

Democratic Republic of Congo

3.96 The DRC is a vast country of 2,364,200 km^2 extending across the Congo River basin from the Rift Valley lake region in the east to the Atlantic Ocean in the west. It has the second largest land area and the third largest population (some 48 million estimated in 1997) in sub-Saharan Africa. From 1991 through 1997 the estimated average annual rate of population growth was a relatively high 3.1 percent. At its current rate of growth the national population will more than double (to about 103 million inhabitants) over the next 25 years.

3.97 The country is richly endowed with forests, good agricultural land, rainfall, and a variety of mineral resources. Mineral and petroleum extraction have been principal sources of export revenues in the past, and formerly contributed about one quarter of the country's GDP. However, the formal economy has hardly functioned in recent decades owing to prolonged mismanagement, corruption, and civil strife. Estimated GDP *per capita* for 1997 was a mere $131.

3.98 The overthrow of the previous regime in 1997 and the coming to power of the Kabila government brought a period of some positive developments in the form of currency stabilisation measures, regularisation of revenue collections, and other reconstruction measures.

3.99 But a new outbreak of hostilities in the eastern regions of the country from late 1998, involving national factions supported by intervening forces from various regional states, has again raised questions about when the country will attain a state of good governance and socio-economic health.

3.100 World Bank assessments call for a far-reaching programme of assistance in support of reconstruction and development in the DRC, including financial and monetary reform, rehabilitation of infrastructure and social sectors, provision of credit lines and import financing to help 'jump-start' the economy, capacity building, return of expatriate Congolese, political and judicial reform, and the general restoration of civil society. Such measures will be difficult to organise and implement, however, until an enduring resolution of current hostilities is achieved.

3.101 The poor economic climate has led to physical deterioration of the fishing fleet due to lack of maintenance, spares, fuel supplies, etc. Yields from the inland fisheries are thought to be substantially depressed from previous levels due to shortage of essential inputs and marketing difficulties related to infrastructure breakdowns.

3.102 FAO Food Balance Sheet data show that, even during periods of relative political and economic stability, the DRC's capture and culture fisheries sectors have not produced at anywhere near the levels necessary to meet domestic demand. If national production/availability from all sources (capture and culture fisheries, and imports) remain at around their present levels, *per caput* supply will decline from the current 5.7 kg per annum to around 2.6 kg per annum over a 25-year period.

Tanzania

3.103 Tanzania currently (1997 estimate) hosts a population of 31.3 million inhabitants, and has an average annual population growth rate of 2.9 percent. At its current rate of growth the national population will more than double over the next 25 years. The country is very large, having an area of 945 087 km^2 (942 626 km^2 mainland; 2 461 km^2 for the islands of Zanzibar and Pemba combined). Estimated GDP *per capita* (1997 figure) is US$ 214.

3.104 The overall economic performance of Tanzania was good in 1999: GDP grew by 4 percent, compared to 3.3 the year before. The inflation rate, which declined steadily since 1998, reached 8.9 percent in April 1999 and was close to 7.5 percent at the end of the year.

3.105 Available economic indicators show that the sectors, which recorded the highest GDP growth, were mining (27.4%) followed by tourism (13.7%) and construction (12%).

3.106 Agriculture, which represents 49.1 percent of GDP, recorded a 2 percent increase, compared with 2.5 percent in 1998. The continuing weak performance of the sector overall suggests wider problems of productivity.

3.107 Main agricultural products are maize, sugar cane, coffee, tea, and cotton. Natural resources also make an important contribution to the national economy, and the forestry, fisheries, bee keeping and game/wildlife sectors all recorded moderate achievement in 1998-1999. However, the fisheries sector suffered following the European ban on importation of fish products from the East African countries imposed on March 1999.

3.108 Fisheries resources from all the major marine and inland capture fisheries are at or near a state of full development, though there appears to be potential for limited expansion of production from minor lakes, rivers, swamps, flood plains, and reservoirs. Smallscale pond culture offers another possible but modest base for expanded fish production, though significant technical obstacles will have to be overcome to increase the attractiveness of pond culture as a component of family farm enterprise.

3.109 It does not appear likely that, as presently constituted, national production/availability from all sources (capture and culture fisheries, and imports) will be able to support current *per caput* supply levels of fish. All else being equal, the outlook is for *per caput* supply to decline from the current level of around 11 kg per annum to around 5 kg per annum over a 25-year period.

Zambia

3.110 Zambia is a very large and landlocked country comprising an area of 740 720 km^2 and hosting a population of some 9.4 million people. Annual population growth is 2.7 per cent. At its current rate of growth the national population will nearly double (to 18.3 million inhabitants) over the next 25 years. GDP *per capita* is estimated (1997 figure) at US$ 404.

3.111 The economy historically is based on mining of copper and other metals, which together account for around 75 percent of export earnings. In the early 1970s, however, a combination of factors including a collapse of the international copper market, sharp spikes in the price of oil, statist economic policies, and declining agricultural production brought on a long period of economic reversal that has been crippling in its effects. Between 1974 and 1990, *per capita* income fell at an annual rate of almost 5 percent.

3.112 Despite moves by Government in recent years to introduce a series of market-oriented reforms (e.g. reduction of state ownership or control in key productive sectors, price deregulation and elimination of subsidies, removal of exchange controls, and liberalisation of import restrictions and procedures), the country still has a long way to go in recovering from this protracted economic decline.

3.113 Fishing is of major economic importance to Zambia, representing the third largest occupational sector after farming and mining. It is estimated that as many as 300,000 Zambians are involved in fisheries-related employment. Fishing is the single most important source of food and employment for all those living near major water bodies, including rivers, swamps, and floodplains. At the national level, fish provides the most important source of animal protein, and is of particular importance as a high quality food for lower income groups.

3.114 After several decades of expansion, there appears to be little room for further development of Zambia's capture fisheries. It is apparent that national fisheries planning and management policy now needs to concentrate more on efforts towards rehabilitation, environmental protection, and adoption of responsible fishing practices. Improvement of processing, distribution, and marketing procedures, including transportation infrastructure, would ensure more efficient performance in the post-harvest sector through supply of greater volumes of high quality product to the consumer.

3.115 Present annual *per caput* supply of fish within Zambia is estimated at 7.3 kg. Assuming no marked increase in supply from capture fisheries production, aquaculture, or imports, population growth will result in a halving of this supply over the next 25 years.

Fisheries and Fisherfolk

3.116 Socio-economic characteristics of Lake Tanganyika fisheries and fisherfolk as determined through the 1997 lakewide SEC survey are summarised below. Further details of survey results are broken down on a country- by-country basis in Annex 1.

Distribution of settlements and fishing activities

3.117 There are about 790 fishing communities situated around the Tanganyika coastline. Settlement sizes range from a few score inhabitants at the smaller, generally more remote landings, to populations numbering in the tens of thousands at landings adjacent to major towns and regional centres (Photos 22 - 23).

3.118 The gender structure of adult populations shows a fairly even balance within Rukwa Region (Tanzania) and DRC sites, slight to marked majorities of males within the Zambian and Burundi sites, and a majority of women at sites within Kigoma Region (Tanzania).

3.119 Nearly all sample sites within Zambia and Tanzania reportedly have experienced increases in their populations over recent five years, mostly attributed to natural growth (birth rate). Political unrest in both Burundi and the DRC is identified as the major factor behind changes in population at sites in those countries, expressed either as decreases in size due to displacement of inhabitants to other places, or as increases due to influx from areas of insecurity. (Episodes of piracy, wherein fishers are accosted out on the lake at night by gangs of armed thugs and stripped of their gear, equipment, and catch, have become rampant along many parts of the Tanzanian and Zambian coasts in recent years.)

3.120 The distribution of fishing effort lakewide and on a country-by-country basis as reflected in the results of the 1995 LTR Frame Survey and recent field observations has been summarised in the TREFIP Feasibility Mission Report. Notable points include the following.

3.121 The DRC portion of the lake, which contains the largest proportion of the total shoreline (43%), accounts also for the highest proportions and greatest densities (per 10 km of coast) of landing sites, fishers, lamps, and vessels.

3.122 Burundi, with the smallest proportion of total shoreline (9%), also hosts the smallest proportions of landing sites, fishers, lamps, and vessels. At the same time, it contains the highest densities of lamps and engines per 10 km of shoreline. Although Burundi registers as having the second highest density of vessels, it also ranks first by a wide margin as having the highest density per 10 km of shoreline of inactive/broken craft.

3.123 Out of the some 17,100 vessels in active service (1995 FS figures), wooden planked canoes constitute by far the most common (≈60%) type, followed by catamaran and dugout units (19% each). Industrial units make up less than 1 percent of the lakewide fleet. Catamarans figure most prominently in the Burundi (48%) and Tanzania (26%) fleets, and dugouts appear to be most popular in the DRC (27%). (Photos 16 - 21).

3.124 Of traditional gear, lusenga scoop nets are most commonly encountered in Tanzania, gillnets in Tanzania and Zambia, longlines and handlines in the DRC and Tanzania. Traps appear to be extremely rare according to the 1995 FS returns, although a later survey that focused more specifically on the inshore fishery showed that they are in fact fairly common (Lindley 2000).

3.125 Lift nets dominate the artisanal gear kit except in the case of Zambia, where the kapenta or night beach seine rates as the most common. The higher capacity Apollo lift net is mostly limited to Burundi waters, and the chiromilla seine (of Lake Malawi derivation) is restricted to the Zambian portion of the lake. Day beach seines represent about 30 percent of artisanal gear units in both the DRC and Tanzania, but are far less important components of the overall gear kit in Burundi (3%) and Zambia 13%).

3.126 Almost half of the industrial units enumerated in 1995 were reported as non-operational. At the present time (mid-2000), all active industrial units with the exception of one in Burundi (Rumonge area) are operating in Zambian waters, from bases in Mpulungu and Nsumbu.

Post-harvest sector

3.127 Generally speaking opportunities for trade in fresh fish are limited to localities in the immediate vicinity of landing sites except for places situated close to or within easy road access of major population centres. Thus most fish caught in Burundi waters is sold fresh in the Bujumbura market. The bulk of the catch landed at most sites, however, must be processed in some fashion in order to extend its shelf life for marketing purposes.

3.128 Simple sundrying on the beach or ground is easily managed under local conditions, as it requires little input other than labour. The use of elevated racks, which provide a cleaner product, is not widespread. Sundrying is the most common method of processing clupeids and small *L. stappersii* (Photos 24 – 25). Smoke curing is commonly used for processing larger *L. stappersii* and cichlids, but demands large quantities of fuelwood (Photos 26-27). It thus contributes significantly to deforestation around major fish landings and population centres along the littoral belt – a process that is also driven be invasive agricultural practices and charcoal production (Photos 28 - 32).

3.129 Although reliable statistics are lacking on the volume of product flow along the various marketing channels that reach beyond the lake basin, the major outlets for dried and smoked fish are long established and well known. According to statistical returns obtained by the Feasibility Study Mission from the Marine Services Company Ltd. in Kigoma and the Mpulungu Harbour Corporation Ltd, it can estimated that from 1000 to 2000 mt of dried sardines and *L. Stappersii* are shipped north along the Tanzanian shoreline every year, whilst from 2000 to 7000 mt of mainly sardines (from both Lake Victoria and Lake Tanganyika) along with some *L. stappersii* are shipped south along the same route.

3.130 In addition to the large markets in the mining districts of Shaba Province in the DRC and the Zambian Copperbelt, supplies reach the Dar-es-Salaam market through the railway connection from Kigoma. North of the lake Bukavu and Goma in the DRC and towns in Rwanda have in the recent years become very important market destinations.

3.131 Hundreds of fishmongers are involved in the trade of dried and smoked fish at different scales of operation. The largest operators have the financial capability to buy up multi-tonne consignments of fish at low prices and to transport them to distant points in the Copperbelt and Shaba mining districts where they can be sold at very substantial profit. Smaller traders operate more locally, buying modest consignments at various landing sites and selling them in nearby markets or to other traders destined for town or urban centres of demand.

Fisheries, livelihood, gender, and empowerment

3.132 As earlier noted, LTR Project SEC survey findings confirm a picture of weak and deteriorated physical infrastructure around the lakeshore, and of a critical scarcity in basic social services and amenities. At the same time, however, the data show that there is considerable variation of socio-economic circumstances within local and regional settings.

3.133 The 1997 SEC sample survey of artisanal and traditional fishers (N = 923) and post-harvest operators (N = 431) at 66 landing sites around the lake indicates that local fishers of all categories (artisanal or traditional, unit owner or crewmember) are almost exclusively men.

3.134 Women are much more active in the fisheries post-harvest sector around the lake, and even appear to constitute a majority of the small-scale processor/trader population in

Zambia and parts of the DRC. Survey data indicate that post-harvest operators, in comparison to their harvest sector counterparts, tend to be younger and to have a lower overall level of education. Poor level of educational attainment is particularly marked amongst women processors and traders. As with the fisher population, post-harvest operators are usually involved in the fish business as a main occupation, though are typically engaged in secondary jobs either in some other fishing-related activity (e.g. gear owner) or in farming.

3.135 Generally speaking, farming is a subsistence activity around the littoral belt. Soils are mostly poor, the terrain is often unfavourable (very steep and rocky), and rainfall distribution highly uneven. Crop and livestock production for commercial purposes is therefore fairly marginal. There are important exceptions, however, particularly in the rice producing areas along stretches of the Tanzanian coastline, in southern Kigoma Region and northern Rukwa Region, where rice, beans, and some horticultural crops are grown.

3.136 Estimated annual income figures derived from survey data indicate substantial discrepancies occur between different categories of harvest sector and post-harvest sector operators, and between the harvest sector operators as a whole and their post-harvest counterparts.

3.137 In Kigoma Region of Tanzania, to take a case in point, it can very roughly be estimated on the basis of survey returns that fishing-derived income for most artisanal unit owners amounts to the equivalent of some US$ 640 per year (Reynolds 1997b), or about twice as high as the estimated Tanzanian national working age population *per capita* annual income of US$290 (based on figures available in World Bank, 1999). The comparative annual income figure for most Kigoma Region artisanal unit crewmembers is only US$ 340 (just over the national working age average). On the other hand, estimated earnings for traditional fishers (whether owner or crewmember) are US$190 (about two-thirds the estimated national working age average).

3.138 For the Kigoma Region post-harvest sector, a strong gender-related discrepancy shows up in the income figures (Reynolds 1997b). It is estimated that a majority of male processors/traders earns some US$ 340 per year (similar to artisanal crew earnings), whereas a majority of their female counterparts earns about US$140 per year (less than half of the estimated national working age average; estimates based on figures reported in World Bank, 1999).

3.139 The gender dimension of socio-economic inequality in local communities can be seen not only in terms of educational attainment and estimated income measures, but in terms of civic empowerment as well. Although they have a very high profile in the Tanganyika and other regional fisheries as workers, processors, traders, and even occasionally as boat and gear owners, women do not seem to play a concomitant role when it comes to participation in local public decision-making processes. As a class they appear to be subject to some of the same disadvantages as those who serve as crew and helpers (but not boat and gear owners) in the harvest sector—namely, subordinate social status and poor pay.

3.140 In a context where the overall rural economy offers very limited opportunities for gainful employment, the attractions of fisheries work may be quite strong (cf. Skjønsberg 1982); there is the promise of moderate remuneration, depending on the job, and conditions of entry seem relatively easy (low initial requirements for skills, working capital, or investment in productive equipment and supplies). This observation is borne out by SEC survey findings related to respondents' future employment preferences (Reynolds and Hanek 1997). Strong majorities across all job categories in all four countries indicated a wish to continue with their respective present lines of work.

Increasing regional demand for fish

3.141 On the other hand, local views on the state of commercial fish stocks indicate that a degree of pessimism, or at least uncertainty, exists with regard to the ability of the lake's fisheries to sustain adequate levels of livelihood security (Reynolds and Hanek 1997). Fishers and post-harvest operators are very pessimistic in their appraisals of catch trends over recent years: majorities in all cases take the view that they have been on the decrease. Opinion as to whether future catches will be lower, higher, or the same tends to be divided or undetermined (i.e., responses of 'No opinion').

3.142 Sample respondents were also asked if they thought that the lake would always provide 'enough fish for everybody.' Here too a division of opinion is apparent. DRC and Zambian fishers and post-harvest operators all take a decidedly negative view, whereas those in Tanzania are largely uncertain and those in Burundi tend towards a positive view (Reynolds and Hanek 1997).

3.143 These survey findings on perceptions of past trends and future prospects need to be appreciated in an overall regional context where demand for fish is constantly on the increase. Fish accounts for some 25 to 40 percent of total animal protein supply for the populations of the four Lake Tanganyika states (Gréboval *et al.* 1994), so its significance for nutritional welfare is obviously considerable.

3.144 At the same time, rapid population growth within the Tanganyika basin and across East-Central Africa as a whole (World Bank, 1999) fuels an ever-increasing demand for fish products, so that over the last several decades *per caput* supply has barely kept pace with overall fish production, despite increases in the latter (Gréboval *et al.*, 1994).

3.145 The food security situation across the Great Lakes region is subject to the effects of drought and other natural disasters at all times, and so can be regarded as inherently vulnerable. In recent years, though, episodes of civil unrest and military conflict, and the ravages of the HIV/AIDS epidemic in many localities, have compounded the effects of population growth in challenging food production capabilities, including those of Lake Tanganyika and other major regional fisheries.

3.146 Demand for fisheries products can become all the more acute in situations where normal crop and livestock production and marketing activities and supportive infrastructure are severely disrupted by civil conflict and population displacements, as has been witnessed in parts of Rwanda, Burundi, eastern DRC, and western Tanzania.

3.147 In a region already subject to severe episodes of drought, prolonged political unrest has compounded the effects of population growth in ratcheting up demand for Lake Tanganyika fishery products. Crop and livestock production capabilities, marketing infrastructure, and the general state of food security have all been severely disrupted in Burundi, eastern DRC, and Rwanda due to hostilities and attendant population displacements and breakdown of public services.

Tanganyika from Fisheries Station, Nsumbu, Zambia. View north towards the DRC.

Photo 2. Example landing site/fishing village (Katunga, nr. Kigoma, Tanzania)

Photo 3. Kasaba Bay Lodge, Zambia

Photo 4. Mahale Mountains Nat'l Park, Tanzania

Photo 5. Ngombe Stream Nat'l Park, Tanzania

Photo 6. Kalambo Falls (Tanzania/Zambia Border)

Photo 7. Community Referenda Meeting, Zambia, 1998

Photo 8. MV Liemba off-loading cargo at Tongwe, Tanzania, April 2000

Photo 9. Cargo vessels and tugboats at Mpulungu Port, April 2000 (Fish being dried in foreground.)

Photo 10. Cargo dhow or 'water taxi'

Photo 11. Cargo dhow

Photo 12. Aerial view of Kigoma Bay (Tanzania), June 2000 (Oil terminal upper middle; port, railway sidings middle right.

Photo 13. Kigoma Port

Photo 14. Industrial fishing company base, Nsumbu (Zambia)

Photo 15. Kapishi Geothermal Plant, Zambia

Photo 16. Dugout canoe.

Photo 17. Planked canoe.

Photo 18. Sail-rigged canoe returning from all day trip jigging for *L. stappersii*, Kigoma (Tanzania).

Photo 19. Catamaran unit returning from all night trip fishing with lamps and liftnet.

Photo 20. Mpulungu purse seiners setting off for night's fishing, lamp boats in tow.

Photo 21. Industrial purse seiner, Mpulungu (Zambia).

Photo 22. Rumonge (pop. = 30,000) landing beach (Burundi).

Photo 23. Tongwe (pop. = 1000) landing beach (Tanzania).

Photo 24. Sun-drying 'sardines' (Rumonge, Burundi).

Photo 25. Sun-dying 'sardines' (Rumonge, Burundi).

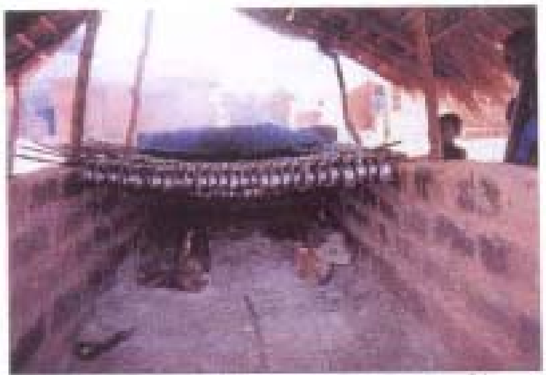

Photo 26. Smoking *L. stappersii* (Wampembe,Tanzania).

Photo 27. Firewood bulked for fish smoking (Wampembe, Tanzania).

Photo 28. Deforestation and cultivation of steep hillsides near Gombe Stream Nat'l Park (Tanzania).

Photo 29. Deforestation and cultivation on steep hillsides near Chibwensolwe (Zambia).

Photo 30. Tree felling for charcoal making and maize cultivation, forest reserve near Kamlambo Falls (Zambia).

Photo 31. Charcoal market, Mpulungu (Zambia).

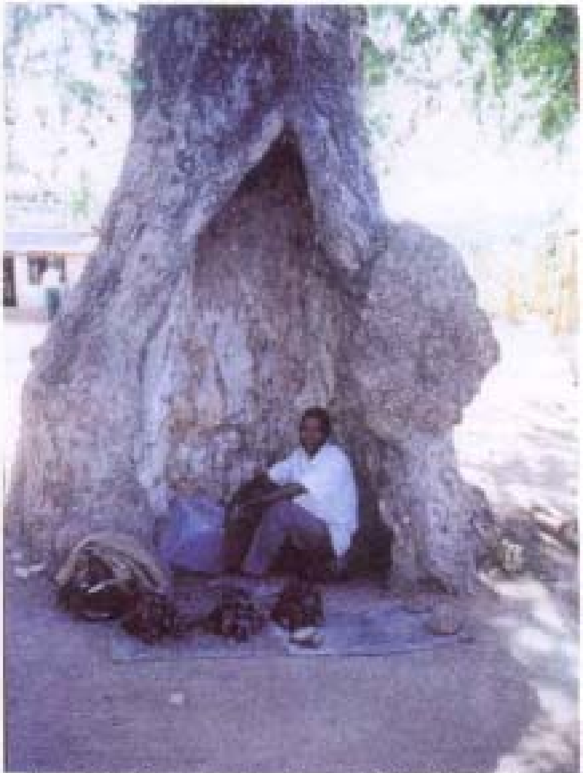

Photo 32. Charcoal trader, Nsumbu Market (Zambia).

Photo 33. Table-drying 'sardines' (Burundi).

Photo 34. Tabledrying brined *L. stappersii* (Wampembe, Tanzania).

Photo 35. Ngwenya Market, near Mpulungu Port (Zambia).

Photo 36. Central market, Kigoma (Tanzania).

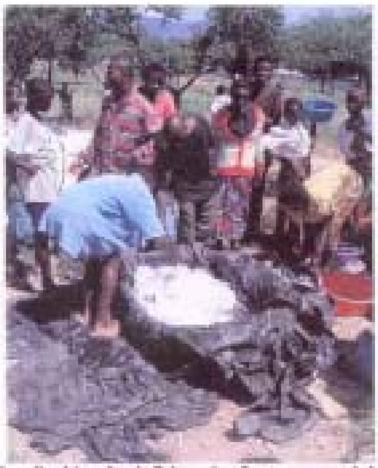

Photo 37. Packing fresh fish on ice for transport inland, Mpulungu (Zambia).

Photo 38. Same-day fish from Mpulungu, on sale at Mbala Market (Zambia).