Lake Victoria Environmental Management Project

A report on the Impact of Fisheries on the Resources along the shores of Lake Victoria

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The study attempted to cover an extensive area and by its very nature, it had to be consultative and dependent not only on structured interview instruments but also on the experience and memories of people who have lived and worked in the area.

Thus we are obliged to acknowledge all the respondents and village leaders who responded to many of our questions. We extend our gratitude to all the District Authorities and especially Regional and District fisheries, forestry and agricultural and livestock officials who provided valuable information and support during fieldwork.

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Expected Outputs: Deliverables.

At the outset this study was expected to come up with findings in five areas and these are as follows:

- Quantify the level of utilization of forestry resources for smoking fish, construction of fishing crafts, floats and other wood products that are used in fishing.

- Assesses the level of degradation of forestry, particularly around fish landing sites.

- Examine the interaction of lakeside communities with wetland resources.

- Examine the degradation of the environment through the lack of sanitary/waste processing and disposal facilities.

- Investigate the socio-economic factors leading to environmental degradation.

Terms of Reference (ToR)

OBJECTIVES OF THE STUDY AND TERMS OF REFERENCE

The main objective of the proposed study is to make an assessment of and trace the implications on the local natural resources as a result of local economic activities that pertain to artisanal fisheries around Lake Victoria.

The secondary objectives include identifying the critical problems and links between the activities of riparian communities and the lake environment. The study also aims to identify current lakeshore livelihood practices that are detrimental to the lakeshore environment. In the process, the study will generate data that will be used both as a baseline, but also to formulate policies and practices governing the management and utilization of the resources of Lake Victoria.

Specifically, the study will focus on:

- Quantifying the level of utilization of forestry resources for smoking fish, construction of fishing crafts, floats and other wood products that are used in artisanal fishing.
- Assessing the level of degradation of forestry, particularly around fish landing sites.
- Examining the interaction of lake-side communities with wetland resources.
- Examining the degradation of the environment through the lack of sanitary/waste processing and disposal facilities
- Investigating the socio-economic factors leading to environmental degradation, and.
- Disseminating information to stakeholders (to be extended by LVEMP at end of study).

Summary of Results

Summary of research Findings: Impacts of Fisheries Activities on resources along the shores of Lake Victoria (Tanzania).

The field study covered a huge area and has come up with a number of observations and several of these are linked. The results are summarized as follows:

Indicators of consumption were identified and observations of activities that exploit and consume such resources were made and these also support the sharply growing wood utilization figures. While local fish processing uses a lot of wood, over time the amount of fish that is processed using this method has been declining due to the existence of fish factories and cold storage facilities.

Over time there has been a significant increase in the level of wood utilization that is progressing from the lakeshores outwards and particularly towards the southwestern sides from Sengerema and Geita districts in Mwanza and Kagera Regions. Considerable timber is sources as south as far as Tabora region. This level of utilization is, among others, linked to the growth of the fishing industry in terms of timber for boat building, but also other uses such as building materials for settlements and wood for domestic and fish processing energy. The amount of wood or timber that is used for boat construction alone is around 30,000 M^3 in 2002 and expected to approach 60,000 m^3 by 2004 if the volume of fishing also increases. In 1998 some 15,236 m^3 of timber was felled to make boats and within two years (2000) the volume doubled to 30,982m^3. It requires clearing some 150 ha of a good forest to produce the volumes for 1998 and 300 Ha in 2000 and some 600 ha for 2002. Since the forests around the Lake are already considerably degraded, and given the mix of species, much larger areas (up to five times) are being harvested to obtain these volumes of wood and this figure excludes the amount of timber required for boat repair. This also explains two things, one is the fact that timber is now sources further away from the immediate vicinity, and two even soft woods are

There is a geographical divide in terms of how fish processing is taking place. In the eastern side of the lake there are seven large fishing factories, which use fresh fish and

process fish for markets further away e.g. the European Union and an internal market that consists of other urban areas of Tanzania. These factories do not use wood energy for processing and their locations tend to be based on a combination of access to electrical energy, labour, the raw material (fish) and access to good transport infrastructure. On the southern and western sides, fish processing is of a different nature and causing a different impact on the in shore areas. Over many years there has been extensive harvesting of forestry resources taking place for fish processing, to fulfill demand for processed (smoked and sun-dried) fish that is coming from the immediate vicinities and inland Tanzanian markets, and even as far as Uganda, Rwanda, Burundi and the Eastern Congo. This has had considerable impacts on woody vegetation in the surrounding areas, to the extent that there is a gradual but visible wave of deforestation moving in concentric circles westwards, reflecting the intensity of forestry resources depletion over time. This is not confined to inland lakeshore areas, as forest depletion is also taking place in the remaining unprotected and even protected forested islands. About 68,000m^3 of wood/biomass per annum, is used to process fish, and this is equivalent to clearing a forest stand of about 600 ha per annum. Thus the combination of fish processing and boat building would require clearing a good forest of almost 900 Ha per annum. More recently however, with the proliferation of fish factories, and difficulties of obtaining biomass, fish smoking has declined considerably.

In contrast, there is a large and growing demand for timber for boat. This is in response to the growth of fishing activities (artisanal and industrial) and lake transport. Even before the rapid growth of fishing and related activities, geographically and historically, the eastern and part of the southern sides of the lake were already deforested as part of the reduction of trees to allow livestock keeping and reduce tsetse fly. The southern and western sides were covered with much more woody vegetation and forests. This was a reflection of inland economic activities such as agriculture and livestock keeping and much less to do with fishing and fish processing. Over the last 15 years to eastern sides are showing much more extensive depletion of forests and the southern and western sides are also showing growing signs of forest depletion. While there are other causal factors that come into play, e.g. the economic liberalization has led to major exploitation of

natural resources for export and general economic gain, the role of fisheries and growth of lake side settlements are equally pronounced.

The life span of most fishing vessels is shorter and quality of boats has been falling. In all local boat yards visited it was reported that there is growing frequency of repair of old boats and construction of new boats through increasingly using less and less hardwoods. What led to this situation is the high costs and scarcity of preferred hardwoods, so less durable species of wood/timber is being utilized for boat construction, implying poorer quality and shorter lifespan of boats in general. This is yet another indicator of forest resources depletion, in which even species hitherto not preferred are now used for boat making and repair.

The socio-economic factors that contribute to environmental degradation are numerous and complex. The growth and proliferation of lakeside settlements, has also led to a growing demand for construction materials for housing/shelter, various buildings and other socioeconomic activities. Tiny fishing villages just 15 years ago have grown to become small and medium sized towns. What were once small temporary fishing settlements have become more permanent. While larger lakeshore towns such as Bukoba, Mwanza and Musoma have grown in size, it is important not to lose sight of what is happening in the hundreds of smaller lakeshore and island settlements. In aggregate they have equally pronounced impact in terms of solid, liquid and other wastes that are deposited into the lake, as well as consumption of woody materials.

The growth of lakeside settlements is a consequence of the growth of the fishing industry, but it is also a reflection of the poor performance of agriculture, limited and poorly performing alternative economic opportunities around the Lake Basin (with the exception of large scale mining). There is also the growing fragmentation of landholdings passing from one generation to the next, leaving a growing landless generation of youth. The most attractive economic opportunity therefore lays in fisheries and related activities e.g. transport, various services e.g. repairs, maintenance, provision of various supplies and generally the spread effects of fisheries.

Population growth in this area stems not only from natural increase, but also from high in-migration rates attracted by the fishing and ancillary activities. Data shows that during

the early 1980s there was a major movement towards the lake and this peaked during the 1990's. The incoming populations originate mainly from adjacent inland areas, islands, and from outlying areas within the Lake Basin. The migrants are engaged in a wide range of economic activities that are linked directly and indirectly to fishing, as fishers, builders, offering repair services, as well as other services and businesses.

The unreliable rainfall for rain fed agriculture, shortage of grazing lands and water in the outer rims of the lake basin have caused livestock keepers to move towards the lake for both water and pasture (including wetlands). In almost all sites where there were substantial livestock, there are frequent incidences of land-use conflicts between livestock keepers and cultivators and in recent years threat to fish breeding areas, such as wetlands when they are accessed for fodder. Both cultivators and livestock keepers are affecting fish production by modifying or "reclaiming" wetlands. There is considerable and widespread human interference with the lake ecology.

In most sites where wetlands exist, lakeside communities increasingly exploit wetland resources unsustainably, and many wetlands have been and continue to be depleted. While some seek to exploit wetland resources to the fullest, other perceive wetlands as wastelands. Most wetland areas suffer from these two outlooks i.e. as wastelands and as common pools resources, which basically "belong to no one". All wetlands are under severe threat, stemming from land pressure emanating from agriculture and grazing needs. Other pressures on wetland resources are a result of demands for building materials and production of various weaving products (from reeds, papyrus etc.).

Although the attitudes of most local communities reflect poorly on wetlands and other biotic resources, giving only attention to fish and the fish economy, some local officials, especially at village and ward levels, also lack awareness and appreciation of the functions and importance of wetlands and other biotic resources, such as trees, bushes and grasses. So although there already are campaigns on raising awareness of wetlands and their functions, much more work needs to be done in this area.

Almost all lakeside settlements, ranging from those engaged in fishing and fish processing, collection centers, ferry-crossing points or simply long established settlements, all are supporting much larger populations compared to 20 years ago. The

large populations also attract a wider range of support services, many of which are waste generators, e.g. fish processing, restaurants and hotels, boat building, repair shops and various other services. Most of these either lack or have inadequate sanitary facilities and so both solid and liquid waste is simply dumped into shallow open pits or if it's a liquid waste directed into the ground into shallow pits or discharged directly into the lake as it is. For many the lake is considered to be a huge and free waste depository, regardless of the health consequences. Human and animal waste contains considerable fecal matter that pollutes and contaminates the shoreline water, which is normally collected for washing and drinking and even for preliminary fish processing.

Most houses are overcrowded and lack adequate sanitary facilities. Others are too temporary and little attention is given to sanitation or sanitary disposal of waste. In the few areas that there are sanitary facilities, it is mainly attributed to effective campaigns and the activities of Beach Management Units (BMUs). The proliferation of haphazard settlement arrangements has meant that space for sanitary facilities such as toilets are limited or are not considered important because of outdated local customs, lack of knowledge of the importance of toilets or the transient nature some of the people residing in these areas. The situation is further complicated by the geology and geomorphology of most of the lakeshore areas, which consist of hard rock. Thus many people perform ablutions in the lake, next to areas where they wash clothes and fetch water. Apart form the fact that many areas of the lake are infested with bilharzias, other water borne diseases are also prevalent. The incidence and frequency of waterborne diseases such as gastro-enteritis, dysentery and other illnesses in these areas are extremely high and widespread. There is a low level of awareness of the relationship between sanitation and good hygiene on the one hand and water related diseases on the other. This is not simply a matter of ignorance, as cultural factors and taboos of most of the tribes residing in these areas contribute to this state of affairs.

The degradation of the environment through lack of sanitary/waste processing and disposal facilities is a complex problem. Despite the fact that the areas visited are home to almost a dozen different ethnic groups and sub-groups, their respective traditions, beliefs and norms are still strong, and are still being practiced. However, one of the most disturbing taboos is the one that does not consent to certain members of the family to

share a toilet, when there is one. Moreover, the construction of toilets is expensive, thus to have two or more toilets is a significant investment, that is simply not affordable for many. Moreover, many homesteads do not have even a single toilet thus ablutions and defecations are done in the lake.

As mentioned in an earlier section, one reason that partially explains why many homesteads do not have toilets is the geology of the area. Much of the geology of the area is comprised of hard rock that lie very close to the surface and thus if one would have to dig a pit latrine, they will have to contend with breaking up the rock, which is an expensive, time consuming and onerous task.

Linked to the preceding explanation, there is also a widespread attitude, or outlook that is borne by most individuals that their existence in their respective areas is only for a short time, and therefore many see no reason for undertaking any long-term investments on local resources. On the contrary, the reality is very much different. Those who arrived during the early 1980s and are still there, contributed to a localized population explosion that is taking place in an increasingly unhygienic and dangerous environment.

The socioeconomic impacts of continued pollution and degradation of the lake shores is already significant and will have profound and long term health and economic implications to both the riparian communities and the local fisheries economy. If pollution and contamination rates reach high proportions a repeat of the ban on Lake Victoria fish is imminent with disastrous result on local livelihoods.

Against this backdrop, it would be imprudent to permit the status quo to continue, i.e. the "business as usual" scenario, for it is a highly unsustainable path with immense environmental repercussions in terms of vegetation depletion, loss of wetland resources, damage to the lake and immediate inland ecology, water contamination, and a wide range of health repercussions and all these translate into considerable medium and long term costs.

Furthermore this is a real threat to the sustainability of the fishing industry itself, the very foundation for the livelihoods of millions working directly and indirectly in fisheries. At the end of the report a number of areas for both further applied research and implementation are suggested.

Methodology

The field survey commenced on 22/10/2000 and was done in two phases. The team arrived in Mwanza on the 22nd of October 2000 and was temporarily housed at the LVEMP/TAFIRI offices at Nyegezi, Mwanza South. Here the final preparation for fieldwork was done and much of this work focused on identifying the sample sites and planning for the fieldwork. Some relevant and information about lakeside settlements was obtained and this guided the selection of appropriate and representative sites that reflect the issues raised in the Terms of Reference (ToR) of the research. Extensive in-depth discussions were made with knowledgeable and experienced local field officers from various institutions and local communities.

The sampling procedure was subsequently amended (stratified) to take into account the various types of lakeside settlements and range of activities. Coverage included all Districts around the Lake, all the agro-ecological conditions that exist in the area and all the different types of socioeconomic activities occurring around the lakeshore ranging from fishing, to services, livestock keeping, agriculture, horticulture, extraction and exploitation of various natural resources such as fuel wood and timber. Settlement growth and the situation of islands were also taken into account.

The first field questionnaires were taken to Kayenze village in Magu District, and Kamanga Ferry in Missungwi District for field-testing, after which amendments were made. Three general sets of survey instruments were made. These included the main structured questionnaire, a filed guide/open ended prompt for issues to look out for, and an open ended questions guide for District and Local level fisheries, agricultural, livestock and natural resources officers/practitioners.

A total of 37 sites were identified, and these included small to large fishing settlements/islands/landing sites and issues such as wetland depletion, ferry crossing points, fish processing areas, sources of fuel wood, fish processing and collection points. In the majority of these areas (33 sites) structured interviews were dispensed and 4 sites were selected for focused observation studies (no structured interviews, but where special/pronounced issues emerge). In all Districts (14), open-ended interviews were held

with the principal functional managers of the fisheries, livestock, agriculture and forestry sub-sectors.

A total of 759 persons were interviewed, most being adults engaged in various socio-economic activities along the lakeshores. These were selected randomly and if one was selected and ready to respond then the interviews proceeded, if there was any reluctance in taking part, and then the next person was selected and so on. After the structured interviews, a small selection of knowledgeable people was made based on their experiences; these included male and female, young and old. This group was consulted through focus group discussions (FGDs). The idea was to cross check and triangulate the responses that were being obtained through the main questionnaire, and to seek clarification on various local issues. These groups also served as 'calendars of events' and their long term memory recalls were consulted to assess the degree of change in their respective areas.

Table 1. **Sites selected and visited for interviews**

	District	Study site
1	Sengerema	Kamanga Ferry
2		Juma Island
3		Kijiweni
4		Busisi ferry (observation study)
5		Kome Island
6	Geita	Kome Mchangani
7	Muleba	Rwazi Island
8		Nyarugusu Island
9		Kabunyora
10		Kitua (Bambile) island
11		Kitua Island
12		Ruhanga
13	Bukoba Rural	Igabiro
14	Bukoba Urban	Nyamkazi Land Site
15	Biharamulo	Nyabugera
16		Katete/Kasenyi
17	Tarime	Nyagabo
18		Sota
19	Musoma Rural	Bwai
20		Bwira (for wetland observation study)
21		Burungu
22		Rukuba (Kubwa) Island
23		Rukuba (Ndogo) Island
24	Musoma Urban	Nyarusorya
25		Nyabangi (observation of a dying land site)
26	Bunda	Guta landing site
27		Kisorya Ferry and landing site (also wetland observation)
28	Ukerewe	Kakukuru (fish and firewood market)
29		Kweru island (denuded area)
30	Magu	Kigangama
31		Ihale
32		Simiyu wetland (for wetland observation)
33		Kayenze
34	Missungwi	Mbarika (done during the second phase)
35		Kigongo Ferry (trans-shipment area)
36	Mwanza Urban	Igombe (urban area)
37		Kirumba (urban area)

1. Introduction

As mentioned in the Terms of Reference, the main objective of the study was to try to make an assessment of and trace the implications on utilization the local natural resources as a result of local economic activities that pertain to artisanal fisheries around Lake Victoria.

The secondary objectives include identifying the critical problems and links between the activities of riparian communities and the lake environment. The study also aimed at identifying existing lakeshore livelihood practices that are detrimental to the local environment. Some baseline data is generated that can be used both as a baseline, but also to formulate policies and practices governing the management and utilization of the resources of Lake Victoria.

The study area is the Tanzanian part of the basin of Lake Victoria (figure 1). The study area covers roughly between 1-2 kilometers from the lake-shores. Lake Victoria is the second largest fresh water lake in the world and the largest in Africa. It is rich in biodiversity and fisheries are the major resource for the livelihoods of the riparian communities and also for export. From the 1980s the lake has experienced many problems associated with extensive resource exploitation, which is now threatening productivity and the ability of the lake to sustain a whole range of economic opportunities. The lake and its fisheries is showing evidence of the dramatic changes in the lake basin over the past century, such as intensive non-selective fisheries, extreme changes in the drainage basin vegetation, agricultural expansion, mining in adjacent areas, industrialization and pollution in lake shore towns, rapid growth of human settlements of all sizes, and the introduction and invasion of exotic species, have all contributed to the destruction of native and endemic components of the lake. Lake Victoria is under growing threat and the problems are profound and cannot be ignored.

Before the 1970s, Lake Victoria had more than 350 species of fish from the cichlid family, of which 90 percent were endemic. The introduction of Nile Perch and Tilapia caused a collapse in the lake's biodiversity. It also contributed to the process of deforestation since wood was needed to dry the oily perch, compared with the cichlids,

which could be air-dried. Forest clearing around the lake is increasing siltation and eutrophication in the lake, putting in jeopardy even the Nile Perch and Tilapia fishery.

Lake Victoria's Nile Perch fishery generates as much as $400 million in export income, but few of the villagers around the lake benefit from it (Jansen, 1997). According to The World Resources (2000) report, people have focused too long on how many goods they can take from lakes and other ecosystems, with little attention to the services that the lakes provide. Yet, they provide essential services - like habitat for other species, climate control, and nutrient recycling - that cannot be replaced at any reasonable price. Eventually it is the poor, who often depend directly on ecosystems for their livelihoods, who will suffer most when ecosystems are degraded and depleted. This is certainly true for the Lake Victoria ecosystem.

The problem lies with the people and especially the considerable changes in production activities that have occurred in recent years. The problem in the surrounding basins stems through human activity, and the process went largely unrecognized amid the major socio-economic changes that have occurred over the last 30 years in the region.

Some of the more apparent and severe problems include polluted streams and rivers draining into the lake. The shoreline is particularly polluted by various municipal and industrial discharges (ICLEI, 1996; LVEMP 2002, Mnyanga, 2002) Some information has been collected by local and national authorities on the scale and location of polluting industries, and there are a number of basic industries that are common to most of the major urban areas, for example, breweries, tanning, fish processing, agro-processing (sugar and coffee) and abattoirs that have been generating and depositing their waste into the lake. Many urban areas have implemented some pollution management measures and these are beginning to take effect.

Artisanal mining, which over the last 10 years has been replaced by large mining companies was considerable had contributed to depositing pollutants into the lake is no longer significant The type of pollution was through contamination of the local streams by mercury, a heavy metal which is used to amalgamate and recover the gold Kahatano et. al (1995), Ikingura and Akagi (1996). Traces of heavy metals, such as chromium and lead, are also found in the lake, and in wetlands, and this is cause for concern.

Finally, the lakeshore is used as a source of food, domestic energy, drinking and irrigation water, shelter, transport, and as a repository for human, agricultural and industrial waste. With the populations of the riparian communities growing at rates among the highest in the world, the multiple activities in the lake basin have increasingly come into conflict. This has contributed to rendering the lake environmentally, economically and even politically unstable. The lake ecosystem has undergone rapid and substantial changes, particularly over the last three decades.

The consequences of these the negative environmental impacts pertaining from fisheries on the lake ecosystem will be profound for the livelihoods of over 30 million people who live around the whole lake. The future of the riparian population and their offspring are at stake here as the clock is ticking. The implications to the East African States, linked to the lost opportunities should be reason for serious concern and timely action. This is basically because the human welfare of the whole basin is intimately linked. Thus the need for appreciating and acting upon ecosystem integrity through good conservation practices and enhancing the sustainability of the fisheries and related socio-economic activities must be of utmost priority. This basically re-affirms the need for better management and utilization of resources.

There is a need for an ecosystems approach to manage this important regional resource, (this also means evaluating decisions on land and resource use based of how they affect the capacity of ecosystems to produce goods and services, for this is the road to sustainability), it is also pertinent to take into account the need to address critical livelihood concerns of the local populations. Most important is to be able to strike a balance between maintaining the resource base and exploiting it in a sustainable manner. This is the challenge in the management of Lake Victoria resources.

The Economic Importance of Lake Victoria

The gross economic product in the lake basin is of about US$ 3 to 4 million annually and supports over 30 million people at average incomes in the range of US$ 90 to 270 per annum. Population density in the Lake Basin in Tanzania (Kenya and Uganda as well) is well above the national average in all countries and the populations of the riparian

communities grow at rates that are expected to be among the highest in the country, mainly resulting from in-migration and the existence of a youthful population. The population of the whole of the Lake Victoria Basin, including Kenya and Uganda, is almost the same as the population of the whole of Tanzania, all concentrated within a very small area. A population distribution map of the lake basin (1995) shows very clearly the major areas of population concentration, are those within five kilometers of the lake shore and in Kenya and Uganda this extends even further (figure 2). The projections for 2025 indicate that the area will be under much greater population densities with concomitant repercussions to the physical environment, especially is the current scenario of 'business as usual" is allowed to prevail.

Tanzania has the biggest shoreline and basin area and second largest tributary area (table 2), implying that it likely to experience a greater amount of degradation within its area, and therefore also has a greater responsibility in the form of good management practices.

Figure 1. Lake Victoria Regions of Tanzania

Table 2. Lake Victoria surface area, shoreline and basin area per country

	Lake Surface Area		Catchment Area		Lake Shoreline	
Country	sq km	%	sq km	%	km	%
Tanzania	33,756	49	79,570	44	1150	33
Uganda	31,001	45	28,857	15.9	1750	50
Kenya	4,113	6	38,913	21.5	550	17
Rwanda		0	20,550	11.4		
Burundi		0	13,060	7.2		
Total	**68,870**	**100**	**180,950**		**3,450**	

Source: East African Community (http://www.eac.int/LVDP/basin.htm)

Natural Resources Utilization Models

An understanding of the utilization of natural resources around Lake Victoria can be understood through the application of one or two resource use models. For example, using the **IPAT** model of Ehrlich and Ehrlich (1990), where I = Environmental Impacts; P = Population; A = Affluence and T = Technology, it can be demonstrated that the combination of population and levels of development have a considerable impact on resource utilization in a given area. While affluence is strongly related to levels of development, it can lead to over utilization, or abuse of resources though given the case of Lake Victoria, widespread poverty also undermines the capacity of the population to have sustainable management of resources. The situation is critical in much of sub-Saharan Africa where there is agricultural stagnation that is closely interrelated and mutually reinforcing, in terms of utilization of natural resources. The large population brings to bear pressure on the natural resource base, thus pressure on fuel wood, land, fisheries and livestock keeping.

First proposed in the 1970s by Commoner, Ehrlich and Holdren, the IPAT formula is often referred to in discussions on environmental impacts of human action. The letters I, P, A and T are the initial letters of the quantities that appear in the equation:

Impact = Population × Affluence × Technology

The general IPAT formulation has been used to indicate how humans cause an impact on the environment. For example, Ehrlich and Ehrlich state that, doubling a population size

will essentially double its impact on the environment, all else being equal. Likewise, even if a population is kept at a constant size, if the amount of consumption (number of goods consumed) per capita is doubled, one will again see essentially a doubling of the impact on the environment. Finally, if the kind of production technology being used to generate a product becomes more polluting or more extractive, there will be an increase in the impact on the environment, even if the number of people and amount of goods consumed do not change. The IPAT model thus seeks to "unpack" the interrelated effects on the environment of production technologies, level of consumption, and number of people. Applying even crudely this model to the case of the consumption of fish, forest products and even impacts on the Lake environment, we should see an impact that is most likely to be considerable and even more so with time.

The IPAT model has been used on an international level to examine the main drivers of environmental change across various countries. Ehrlich and Ehrlich (1991), for example, use the model to point out that in terms of energy consumption, an average American has 140 times the impact on the environment of an average Bangladeshi (280 gigajoules of energy used annually versus 2 gigajoules). When this per capita value is combined with the U.S.'s relatively large population, it results in an overall environmental impact (in terms of current energy use) of 300 times that of the country of Bangladesh. Therefore, they conclude that continuing population growth (and presumably consumption/technology choices) in rich nations poses the gravest threat to the world's life support systems (perhaps even with high demand for Nile Perch and other fish and a supply situation that is not controlled as in the case in Lake Victoria). Meanwhile, Ehrlich and Ehrlich also point out that given the large populations of most developing countries, economic growth in these countries – to the extent it follows the patterns of consumption and technology use of the developed world – will lead to enormous future environmental impacts (the local causes and effects around lake Victoria, taking the regional populations of the East Africa countries).

However, as with any model, IPAT has certain limitations as well as strengths. Most notably, IPAT ignores some of the very details that are being highlighted in this report; that is, characteristics of population structure and dynamics that will affect a population's impact on the environment. In addition, IPAT ignores issues of both social variability

(e.g., how different cultures may act differently, given the same population size and affluence) and environmental variability (e.g., how different environments may have different sensitivity to the same impacts).

A more recently introduced "ImPACT identity" takes into account consumption patterns, which should also be included in sustainability studies, beyond population, affluence and technology. In the ImPACT identity,

Impact = Population × Affluence × Consumption × Technology

In both the IPAT and ImPACT formulas, *Impact* is expressed as a product of factors. Each factor contributes to the overall impact. Over time, growth in the factors determines growth in the impact. What is relevant to Lake Victoria fisheries is the fact that the consuming population resides not only around the lake, but also throughout east African countries and the overseas markets. It can be argued that it is the affluent populations that place a growing demand for fish, and the fact is they reside both around and further away from the source areas* large cities and towns in East Africa, and Europe and Asia. Although there degree of affluence around the lake is not considerable (with more poor people around than the rich), it is poverty and the need to escape poverty that is also driving the fishing industry. The degree of affluence exists not only locally but also elsewhere in the country and especially where the factory-processed fish is exported. By all means if these populations were not affluent, the fish catch effort would have not gone up nor the number of fish processing factories grown.

The main impact here are the falling size of the fish, the increased fish catch efforts (including illegal fishing methods) the growing number of fishers and fishing vessels. For example according to the Frame Surveys the number of fishing crafts experienced a 23.5% increase between 2002 and 2002 alone (42,483 to 52,479) and 42% of these operate in Tanzanian waters (2002). The culture of the people around the lake is one of fishing consuming communities, and even if these were not affluent, they still consume fish and take part in the fishing activities.

In Tanzania, the Lake basin has experienced a well above average population growth and the survey showed that 60% of adults were not people from the area that they were found in and came from other areas. So this is not only a case of high population growth in the

country as a whole but also one in which the region is experiencing a uniquely high growth rate.

The population of Tanzania is 34,569,232 (2002). Almost a similar number of people reside around the whole of Lake Victoria Basin (East Africa). The populations of the three regions of Tanzania surrounding the Lake are: Mwanza Region 2,942,148 Kagera Region 2,033,888, and Mara Region 1,368,602.

Between 1967 and 2002, the population of these regions has almost tripled from 2.2 million to 6.1 million (table 3). The growth rates between 1988 exceed that of 1978-1988 (2.93 and 2.73 respectively). Such numbers tell us that the increased population is contributing to the demand for fish and the fishing industry as a whole. For a further discussion and understanding of these models see appendix 2.

Finally the growing catch efforts is not only a function of more people engaged in fishing, it is also a function of improved boats with engines, fishing technology (efficiency), processing and transport (the cold storage and marketing aspects). This is the technological dimes ion of the equation. It is against the explanations offered by this equation that can help explain the degree of environmental degradation that is occurring in and around the Lake basin.

Table 3 Lake Region population

REGIONS	**ACTUAL POPULATIONS IN '000**				**PROJECTED POPULATION**	**GROWTH RATES**	
	1967	**1978**	**1988**	**2002**	**2002**	**1978-1988**	**1988-2002**
Mwanza	1,055	1,443	1,876	2,942	2,665,956	2.6	3.2
Mara	544	723	946	1,368	1,432,476	2.9	2.5
Kagera	658	1,009	1,313	2,033	1,957,921	2.7	3.1
	2,257	3,175	4,135	6,343	6,056,353	2.73	2.93

Source: URT Census reports 1978, 1988, 2002

2.0 Field Research Results

Following are the results of the observations and interviews done with members of local communities in settlements located within a kilometer of the lakeshore and on some of the islands. The results are presented in such a manner as to address the ToR of the research study, but also bringing up a number of issues relevant to the fishing industry in general.

2.1 Population

Population movements in the Lake Basin.

As the case often is in many resource endowed and productive riparian areas, the population distribution around Lake Victoria tends to be concentrated close to the lakeshores and islands, and particularly in urban areas. However, with the rapid growth of the fishing industry what can be seen is the growth of numerous small settlements that are engaged in fishing and related activities. For example in the map showing population distribution in Kagera region, it can be seen quite clearly that population density is skewed towards the lakeshores (figure 3). The situation is generally the same in all the surrounding regions. What is depicted on the maps is something that was clearly noticed during the fieldwork, and the field survey captured this movement of people towards the lake, and the 2002 Tanzania Populations Census results will reflect this.

From the survey it was established that 39 percent of the respondents interviewed were born in or around the respective study areas (villages and small settlements), and the remaining 61 percent were born elsewhere. Extrapolating from the interview, over 60% of the adult population within the immediate vicinity of the shores of Lake Victoria and outside the large urban centres has migrated into these areas only in recent years. This degree of in-migration is consistent more with rural urban migration than rural-rural or even urban-rural migration, which is the case for the lakeshore area. It also suggests that this area has experienced a very high level of in-migration in just a few years, with the concomitant pressures on lake and shore resources. A survey by Mnyanga (2002) arrives at similar finding where it was established in a survey of 280 shore settlements that many

people resident in such settlements had shifted to the area because of fishing and other business activities (op.cit:6).

Fishing in Lake Victoria was always relatively important; it was not simply a livelihood but a way of life (Owino, 1999). Both indigenous and other people have over the years been moving towards the lake in search of economic opportunities linked directly and indirectly to the lake. With the advent of the Nile Perch boom, it can be discerned that many people came into the inner lake basin quite recently as can be seen from table 4. It was during the mid-1980s that the first major movement occurred. The field survey results show clearly two such movements. The first large group of people came into the area first between 1986 and 1995; that is during the emergence of the Nile Perch economy. Subsequently a larger group arrived during post-1996 and this can be explained by two factors. First because of the dominance of the Nile Perch based fishing economy and the opportunities that it presented, i.e. the "pull factor" and second, it was in response to several other factors external to the Nile Perch economy, i.e. the "push factor".

These include the declining economic opportunities elsewhere in the country, the wave of redundancies, expulsion of small scale miners around the lake basin, failure in agriculture due to poor rainfall, particularly around 1997-1999, and collapse of cotton prices during the same period. There was also the continued shortage of arable land and inadequate economic opportunities within the lake basin. Thus there were a range of push and pull factors that influenced this considerable movement of population into this area. Basically the lakeshore became an area of hope against a backdrop of economic gloom. The value of Lake Victoria between the 1980s and today is that it has managed to offer a wide range of economic opportunities based on fishing and consequently it is supporting a growing population.

Figure 2. Areas of population concentration around lake Victoria

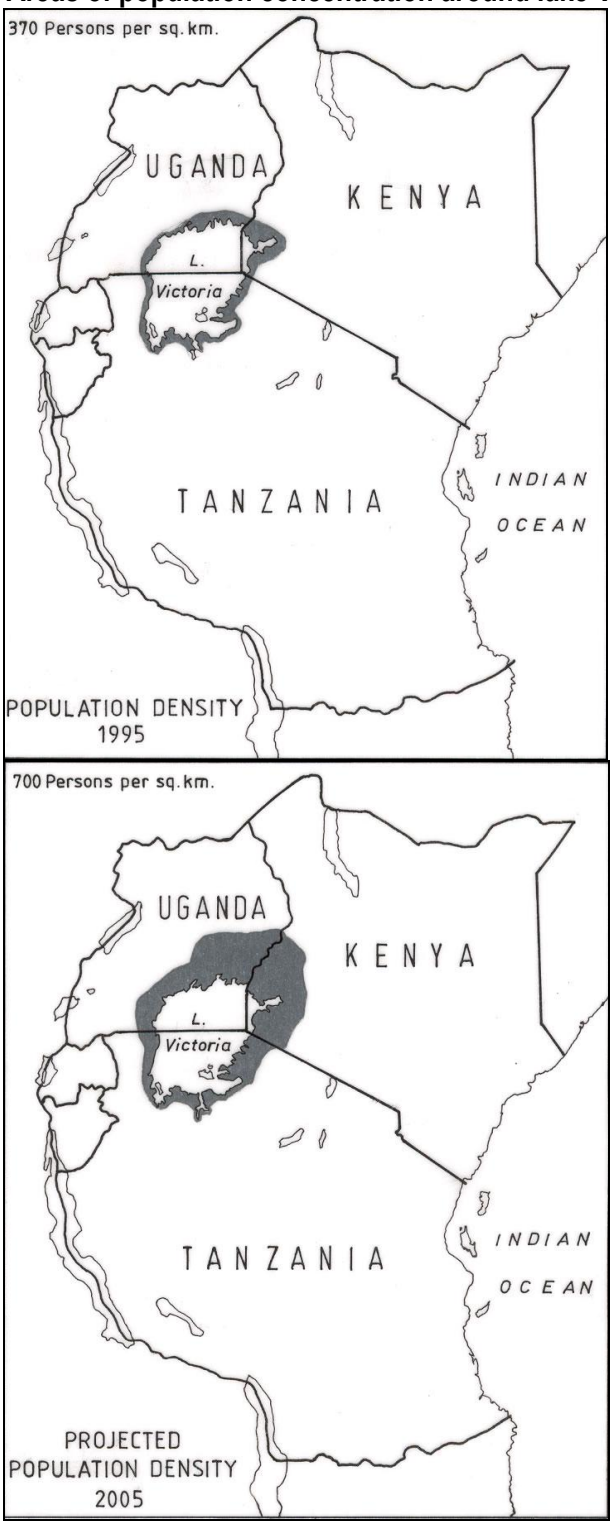
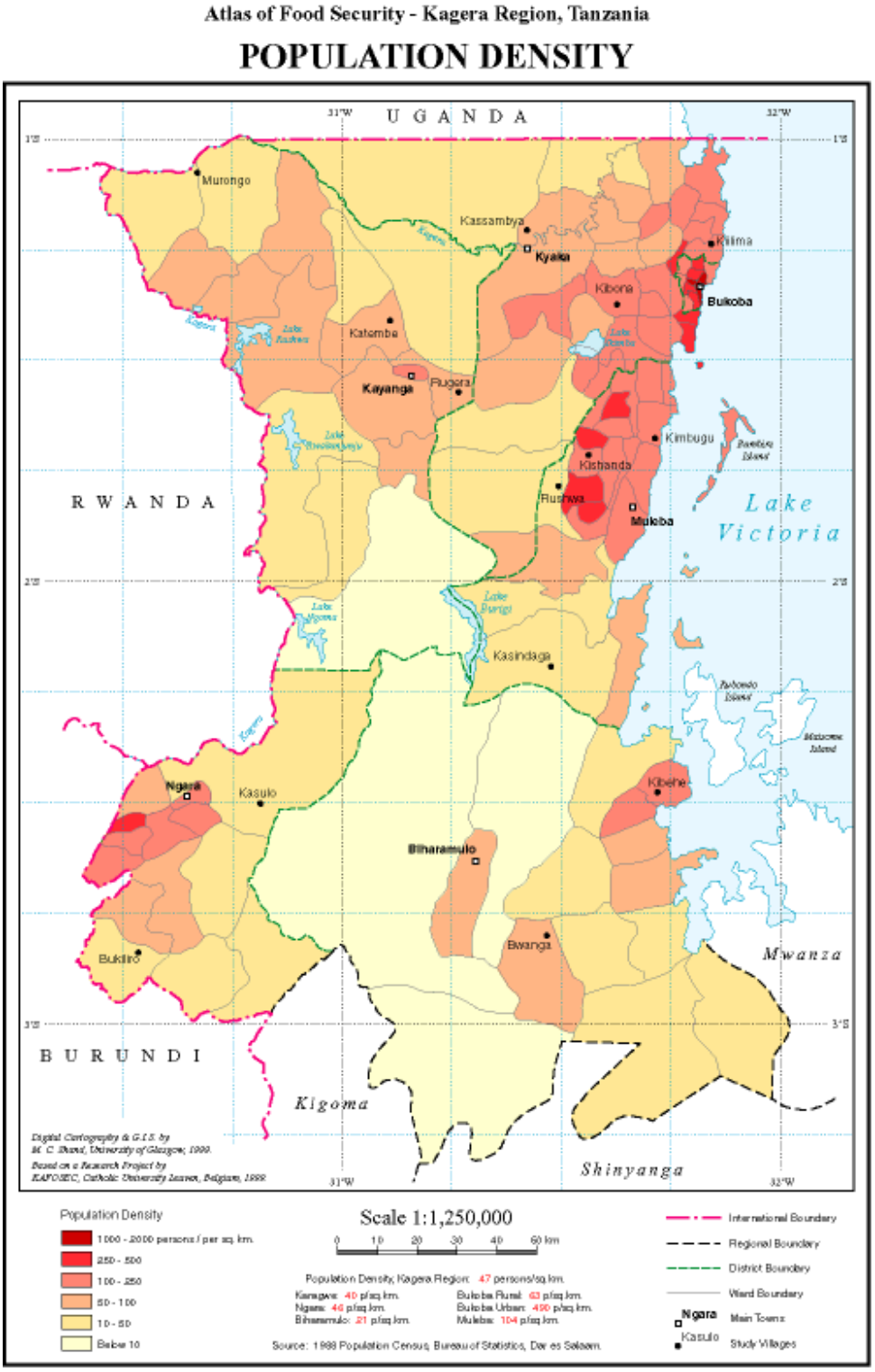


Figure 3. Population Density in Kagera Region



Source: Mike Shand and University of Glasgow (1999)

Table 4. When the migrants came into the riparian areas

Period	% of respondents coming into the lake shore area	Explanations for migrating
Prior to 1974 =	2.2	In search of land and economic opportunities
Between 1975-85	2.2	In search of land and economic opportunities
Between 1986 –1995	33.7	In response to the Nile Perch boom
1996–2000	59.1	In response to the Nile Perch boom and other factors e.g. economic liberalization and it impacts, collapse of crop prices and limited opportunities elsewhere.
	97.2	

Source: Survey N= 759, (2.8% - no response)

Why people migrated to their respective areas

Anecdotal evidence and also from group discussions held in the field revealed some common features and help explain the reasons as to why people moved into the lakeshore areas particularly during the two relatively recent waves.

First it is important to note that it is not only fishers who came into the Lake basin; there are other groups that are not fishers. The main reasons for the respondent coming into the area was to engage in fishing (67%) and fish processing (11.4%). Fishing and the direct opportunities that it offers is clearly the main attraction of population into the area (table 5) and the combination of the two accounts for a total of 78.4% of respondents who moved into this area mainly in response to fishing. Other reasons include looking for other job opportunities, joining family; farming or simply a combination of reasons.

Table 5. Reasons for coming to this place:

Reasons for migrating into lake shore areas	Percentage
Fishing	67
Fish processing	11.4
Other reasons	21.6
Total	100

Source: Survey N= 759

Another study by Mnyanga (2002:11) also establishes that dominant economic activities are in order of frequency; fishing, selling of fish and petty businesses, boat repair, mending of nets and fish processing. Agriculture and livestock keeping are secondary activities.

Growth of Human Settlements

One area that almost all studies have not given due attention is the explosion and growth of human settlements other than the large towns and cities of lake Victoria. Most of the once small fishing villages have grown significantly to more than double their sizes over less than 20 years. This is a growth rate that is rapid and approaching urban growth rates. What has happened over the last 20 year is a localized population explosion in the riparian areas and much of this population is concentrated in the hundreds of such small settlements.

If one takes a look at the population densities figures of mainland Tanzania (figure 4), for example, besides Dar es Salaam region (which does not appear on the figure and whose density is 1793 persons per sq km) and Kilimanjaro, the next regions with high population densities are Mwanza (170 persons per sq km), followed by Kagera (72 persons per sq km) and Mara (70 persons per sq km).

A comparison of population growth rates between 1978 and 1988 and 2002, also shows interesting trends (table 6). For the lake regions, with the exception of Mara, the growth rates for the latter period (1988-2002) exceed those of 1978-1988. Of the 20 mainland regions, the only other regions following this trend are Arusha, Pwani, Mtwara, Tabora Kigoma (refugee factor) and Shinyanga. The average population growth rate for Tanzania increased only slightly from 2.8 in 1978-1988 to 2.9 in 1988-2002. Only Mara region is below the national average.

The higher growth rates for the lakes regions have something to do with the lake resources. From the survey it was reported by the new settlers/fishers that the main attraction was fisheries. Fisheries also have important direct linkages, such as fish processing, storage, marketing, transport, boat and engine repair and so on. All these linkages serve to attract additional populations. Then there are other indirect linkages,

such as service and commercial activities like shops, restaurants and bars, hairdressing, and entertainment. Yet further attraction of population.

Figure 4 Tanzania: Population Densities of Mainland Regions

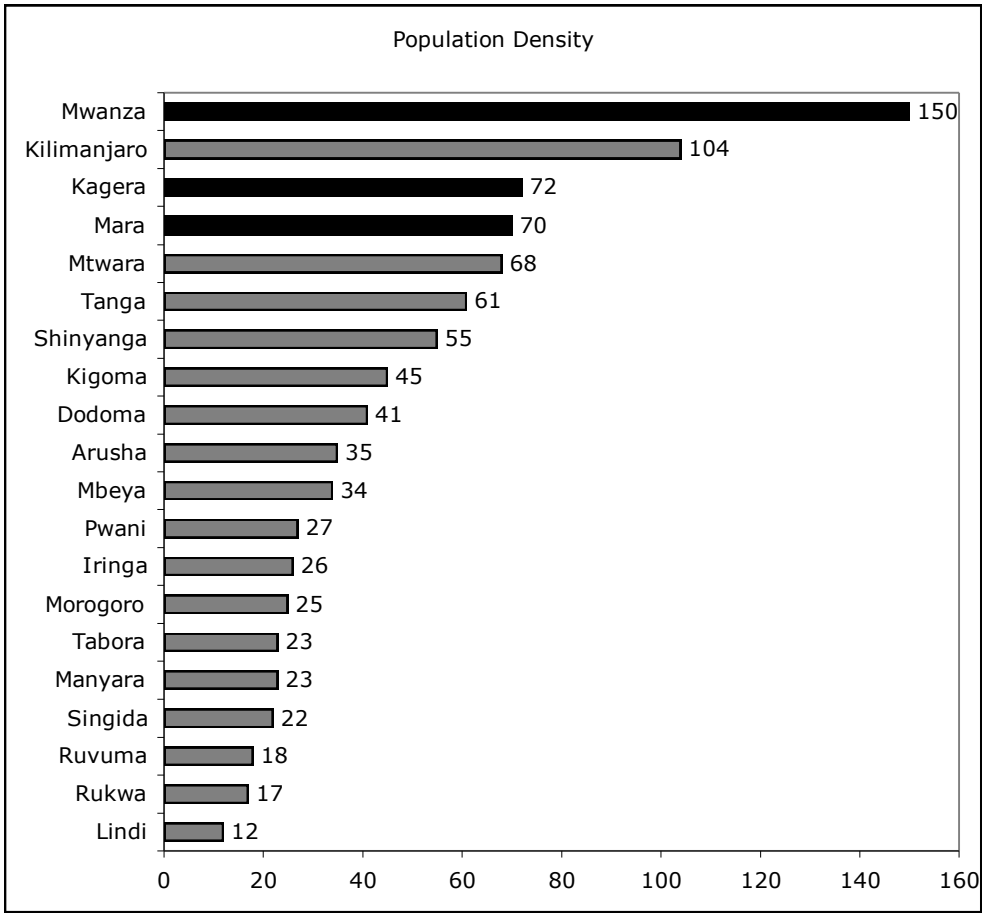


Table 6. Population growth in the Lake Regions

REGIONS	ACTUAL POPULATIONS IN '000				PROJECTED POPULATION	GROWTH RATES	
	1967	1978	1988	2002	2002	1978-1988	1988-2002
Mwanza	1,055	1,443	1,876	2,942	2,665,956	2.6	3.2
Mara	544	723	946	1,368	1,432,476	2.9	2.5
Kagera	658	1,009	1,313	2,033	1,957,921	2.7	3.1

Source 2003 Population Census Main Report

Much of this newly arriving population is youthful in the 14–45 age groups, both male and female. This population growth is also changing the characteristics of these rural settlements making them appear to be increasingly urban in appearance and function (box 2).

The problem of many of these is not only that their growth is very rapid; it is also that the growth is spontaneous and unplanned. Thus their expansion has often been towards to the lakeshore than elsewhere. In some areas the distance between buildings and even toilets is barely a few meters.

Plate 1 Settlement expansion next to lake shores

Plate 2 A Street in a fishing village

Box 1. The Fishing Village: Past and Present

One of the researchers had visited the then tiny village of Kijiweni in Sengerema District, nearly 15 years ago as a young assistant preparing for the 1988 Census. He recalls the barely motorable track he used coming to the lakeshore village. The village by then had a population of barely a couple of hundred people, mostly fisher with some farmers and few livestock keepers. There were still a number of trees around, which was very different from the eastern sides such as in Magu, Mwanza rural and parts of Kwimba District. The arrival of the vehicle signaled an important event; clearly this was a place not accustomed to vehicles. The usual crowed converged, children women carrying crying children and the curious men. Soon the village authorities arrived and realizing that after the long dusty drive on a very bad road and arriving in the midday heat, they offered the visitors some refreshments. There was really one 'major' shop and they did have some Cola drink. There were only two crates of the drink, and it has to be consumed 'as is' - warm. The shopkeeper wiped with a rag the dusty bottle and opened the corroding cap for the customers. There was no beer. There were hardly any streets and the village comprised of maybe tree dozen houses. On the lakeshore there were half a dozen boats and the usual crowd of people. The women were washing clothes, children playing in the water and at the edges a few people taking a bath.

Arriving nearly 15 years later the village has grown more than four times and is now comprised of a huge permanent population but also a significant a fair sized transient population of fishers. Many of the houses and huts are new and made of permanent materials. Several streets have emerged with lines of shops on either sides selling clothes, foods, and many other household items and fisheries equipment. It has about 3 large bars and several smaller ones, several small restaurants and teashops. It has two drug stores and two hairdressing salons and boasts of a private dispensary. There are at least two large boat-making yards and a motor repair shop along the beach. Clearly fishing in the main economic activity here followed by a plethora of support activities that have made this a rapidly growing settlement.

This is a far cry from the small sleepy settlement of the 1980s, barely 14 years ago. This is no longer a small village it conforms more to a small town. This is not an isolated case, in the lake area, this is more the rule rather than the exception, and can no longer be ignored, as it has profound ecological and economic implications not only to fisheries but also to the lake itself.

2.2 Impact of Extractive Activities

As it can be seen from the preceding section, the lake Victoria Basin is an area that has attracted a large population in recent years mainly because of the socio economic opportunities that occur within the basin but more importantly along the lakeshores. These include fishing, fish processing, fish marketing, boat making, agriculture, livestock keeping, petty trading, mining and numerous other activities. The rapid growth of population has also led to the expansion of most human settlements along the lake shores. This is ongoing process and over the next few years more and more people are going to continue to move into the area and make use of the resources available.

Although fishing is the main extractive activity, it is not the only one. There are several others such as harvesting of wood and timber, agriculture, livestock keeping and so on. Depending on the rate and manner of extraction, all of them have an impact on both the immediate physical environment and the fishing industry itself, both on the short and long term. This section delves into the extractive activities.

Fishing

To be able to fish legally, fishers acquire licenses for the fishing vessels and for conducting fishing in the lake. Long lines (migonzo), gill nets or hand-lines are used in fishing. Other gears include beach seines (kokoro) and hook and line, of which the former is illegal. The fisheries officers usually inspect all the equipment - tools and fishing gears to ensure that the required standards are met. The regulations are mainly to ensure that the resource base is maintained at a sustainable level.

However, given that fish are 'fugitive resources'[1] most fishers are often more interested in the profits that they could accrue in selling more fish than in managing the fishing activity for sustainability. It was observed and reported by informants that in the islands and remote waters some fishers practice illegal fishing[2], which will have both short and long term detrimental effects on the fishing industry in terms of over fishing and destroying fish breeding areas. In these areas it was established that small nets of less than three inches are used to harvest tons of small fish. This has led to over fishing and not allowing juvenile fish to grow and breed, even worse some of the breeding sites are destroyed in the process. During the survey such problem were reported in Ihale, Kakukuru, Nyalugusu, and Bwai.[3] Also due to the excessive use of beach seining (Makokoro) in Butata, Bukima and Lyasembe, in Majita bay, the whole area has become stripped of vegetation and become a sandy beach. All the reeds on the beach and

[1] An open access resource, common pool resources, or resources that belong to no one until someone gets to it first e.g. fish, pasture, wetlands etc.

[2] The use of various poisons such as Thiodan, an agro-chemical, is one of the most detrimental means of fishing, though enforcement has helped reduce this type of fishing considerably.

[3] While lake-wide it appeared that such illegal fishing practices were under control, it appears that there are pockets where people still engage in such practices. Generally in most areas people tend to police themselves, following the campaign against such practices.

shallow waters were cut and water channels entering the lake from this area have gradually disappeared. This is not an isolated event, indeed there are several other areas outside the survey villages, where such type of fishing still prevails.

As an indication of such local level increased catch efforts, it was revealed in an interview with a several groups of fishers in Tarime that fish catch has decreased due to the increase of immigrant fishers to the area and the resulting over-fishing. It was reported by most fishers on all sides of the lake that fish sizes have been getting consistently smaller comparing to the sizes of fish caught just 10 years ago. The concern here is that what happens to the livelihoods of the thousands of fishers once this resource is depleted? Obviously it's either that they move to other areas or focus on extracting other natural resources with equally disastrous results.

Fish Processing

Various methods of processing fish are employed along the landing sites and the processing plants. With the emergence of the Fish Processing Plants in Mwanza and Musoma over the last 15 years, most of the fishers sell fresh fish to the collectors who send or sell to the processing plant where fish is processed and preserved under cold storage facilities. Prior to the establishment of the processing plants, most of the fish was processed through smoking or sun drying (plate 3). So in recent years the eastern sides of the lake has seen a proliferation of fish processing plants, and a major shift in processing methods. By 2001 there were seven factories are located in Southern Lake Victoria side (Tanzanian section). Although the fish processing plants is likely to have helped in the reduction of use of bioenergy, the processing of by-products of fish still consumes considerable amounts of bioenergy given that that area already suffers a shortage of bioenergy.

Plate 3. Fish being prepared for sun drying and smoking

In the recent past, smoking of fish has caused significant environmental degradation over a number of Islands and landing sites. In a study on the Kenya side, it is reported that these fish processing methods place enormous pressure often valuable and scarce timber stocks but also rich indigenous plant species including trees, shrubs and grasses which constitute the neighbouring terrestrial and wetland resources (Okeyo-Owuor ,1999) and from the survey it is notes that the situations is no different on the Tanzania side. Artisanal processors predominantly occur on the south and south western sides of the Lake and this correlates with the availability of fuel wood and absence of fish processing factories.

Since smoking entails the use of firewood, over the years many forests have been depleted of trees and other vegetation. Kauzeni et. al. (1998) in a study on fish processing in Nyumba ya Mungu Dam note that in the absence of adequate cold storage facilities, especially in the rural areas, drying or smoking is the best means of preserving fish.

Between 0.2 and 1.1 m^3 of firewood or 20 kg of charcoal are required to smoke 1 ton of fish (depending on species). The average being 0.5 m^3 of wood is used to process one metric tone of fish. Current annual catch from the Lake is estimated at 500,000 metric tones of fish equivalent to 1,500 metric tones daily. Earnings from the Lake's fish catch are in the region of US$ 400 million per year or slightly over US$ 1 million per day. Tanzania produces about a half of this, implying a catch of 750 metric tones a day. If a half of this is processed by smoking/frying, it would imply that 13,600 metric tones of fish are processed using biomass. At an average of 0.5 m^3 per tone this translates into almost 68,000 m^3 of wood/biomass per annum, which is equivalent to clearing a forest stand of about 600 ha per annum. Thus the combination of fish processing and boat building would require clearing a good forest of almost 900 Ha per annum.

The physical evidence of such large volumes of biomass being consumed for fish processing manifest themselves in the following forms: for example, Gweru island one of the Ukerewe islands has been stripped of trees and all that remains are huge gullies that have been caused by erosion. Three quarter of the forest in Bambile Island (Kitua) has been depleted due to the same reason, mainly by the immigrant fishers from Mwanza, Musoma and Ukerewe who, over the years camped in the area to fish. To cater for fish processing in local and adjacent areas, there has emerged a flourishing business of selling firewood to other areas. Firewood has been sold to Nyaburo, Kinagi, and Kitobofu areas. Indeed many areas process some fish through frying and smoking, and both processes consume a considerable amount of bioenergy and rarely did the survey encounter any energy efficient systems in use.

Agriculture

Mwanza and Mara regions have semi-arid climates with maximum rains occurring between November and April, while Kagera region has more of an equatorial climate with maximum rains occurring between March and May. Table 7 shows that between 9 and 29% of the land in the three lake regions is under cultivation, with more land under cultivation in Mwanza region and less in Mara, where livestock keeping is more prominent.

On the western sides of the lake basin bananas, bambara nuts, groundnuts, maize, sweet potatoes and beans are grown, and on the eastern sides cassava, sorghum and sweet potatoes, basically crops that can survive on less rain, are grown. Similar crops are grown in Mwanza including maize, paddy and chickpeas. The main cash crops for the eastern part include coffee and tea, while cotton is the main cash crop in the western and southern areas of the basin.

Agriculture production is dependent on good land, and the fact is that despite the booming fish industry and other economic activities, people will continue to produce crops as the population grows. Some 68% of the population in the study is engaged in fishing and other activities including cultivation. As a coping strategy, many households have multiple economic activities that also include cultivation and livestock keeping.

Table 7. Lake Victoria Regions - Proportion of Land area under different land uses (Area in 000 Hectares)

	Forest	Woodland	Bush land	Grass land	Cultivated	Open	Water	Other
Kagera (Ha)	65.5	609.7	734.8	490.1	864.8	0.1	1158.3	2.1
%	1.7	15.5	18.7	12.5	22.0	0.0	29.5	0.1
Mara (Ha)	11.5	289.4	707.2	869.8	270.2	1.7	899.5	1.4
%	0.4	9.5	23.2	28.5	8.9	0.1	29.5	0.0
Mwanza (Ha)	37.4	294.9	257.1	349.9	1013	0	1577	2.4
%	1.1	8.4	7.3	9.9	28.7	0.0	44.7	0.1

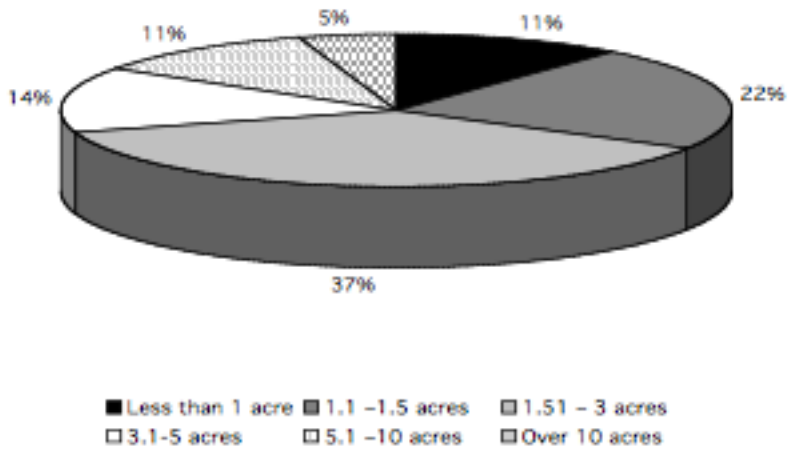
Source: Ministry of Agriculture: Agriculture and Livestock Census Report. May 2000

Throughout the area crops are grown on small plots around the homesteads, on the lakeshores and on farms away from the homesteads. Some of the smallholder farmers own more than one farm plot but the sizes of the plots differ considerably from area to area. Most farms (70%) are less than 3 acres (figure 6) and are considerably fragmented. Few farms are more then 3 acres (30%). Because of extensive cultivation over many years and low use of fertilizer, much of the land is exhausted, and so the farmers in the riparian areas are not getting much in terms of crop outputs. Fluctuating crop prices further exacerbates this situation. Under these circumstances most cultivators remain as

subsistence farmers. Naturally many of the very small plots (1.5 acres and less) tend to be those cultivated along the lakeshores and in wetlands.

In the study sites it was generally observed that most cultivation takes place on hillsides and in valleys (figure 5). However some 6 percent of the farmers interviewed conduct what is known as lakeshore cultivation, which consists of growing yams, sweet potatoes, cassava, maize and vegetables such as tomatoes, and cabbages.

Figure 5. Distribution of farm plot sizes



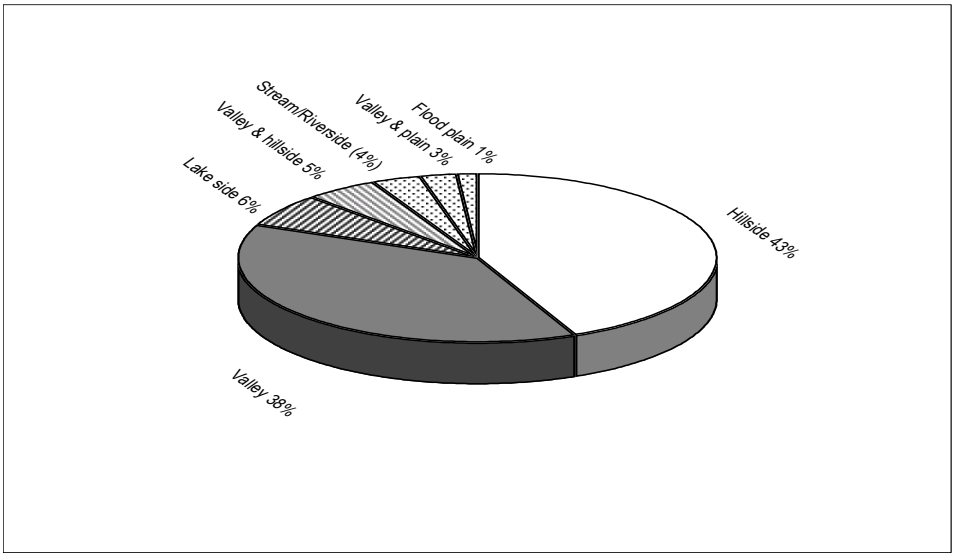
Source: Survey n = 385

Lakeshore cultivation is indicative of both land shortage for agriculture, but also the need for growing crops all year round under some form of irrigation (plate 4). This type of cultivation is also practiced with insecticides and fertilizers, though not yet on a significant scale. Many of the marshes and reeds are being cleared for this type of cultivation.

Apart from the use of fertilizers and insecticides, and the clearing of potential breeding sites for certain varieties of fish, it is not clearly known what other environmental damage this type of cultivation can bring about.

Plate 4. Lakeshore cultivation and landing area in conflict

Figure 6. Riparian farming areas



n = 370

Box 2 Crop production trends in the Lake Zone

Cotton is the main cash crop in Mwanza and Mara regions. In Kagera region, Biharamulo is the only district that relies on cotton as a cash crop. Between 1995/96-1998/99 the area under cotton production has been decreasing and the yield per acre has dropped from 5.5 tons to 0.5 tons, 0.55, and 0.44 tons respectively. During 2000/1 in anticipation of good crop prices, farmers doubled the acreage under cotton.

Coffee production has been on the increase in Bukoba Rural district, while there is a sharp decline recorded in Bukoba Urban district. Like cotton, coffee production in the area has been set back by declining coffee price in the world market.

There was a bumper food crop production in 1997/98 for almost all the districts in the basin and there has been a significant increase in maize and paddy production in Geita and Missungwi districts in the subsequent years while the production of maize declined in Mwanza district due to less acreage planted.

The overall picture emerging from agricultural production is one that is subjected to the vagaries of climate and price changes. Although the large majority of the population is dependent on agriculture, the agriculture economy is fraught with uncertainties and thus many of the youth abandon agriculture in favour of other more immediate rewarding and better paying economic activities such as fishing and fish processing.

Source: Various unpublished district reports, Sengerema, Geita, Biharamulo. Muleba and Bukoba Rural Districts (2000)

Generally almost all the crops are produced exclusively under rain-fed agriculture. There are a few areas where irrigation was once carried out, but the evidence on the ground shows that many of these schemes had failed, e.g. in Magu district. The new form of irrigation is what is being practiced right along the lakeshores, though utilizing the moisture in the soils, but also by actually ferrying water to irrigate.

The expansion of farms that is occurring has less to do with cash crops and is done mainly to increase food production. The type of land preparation, however often has negative effects on the physical environment. Before the onset of rains, the land is cleared by setting fire so as to remove grass and brushes. The effect is detrimental as the soil that is left bare succumbs to water and wins erosion. Moreover, the trees that are still small at the time of burning often get scorched and may never be able to recover and so the potential for trees to grow on farm is drastically reduced. The detrimental effects of burning can be viewed at Mbarika where the land has been left without any trees cover, while in Magu, Burungu, Bwira, and Gweru enormous gullies have been formed by rain and wind impacting on the soils, causing reel erosion, and eventually huge gullies.

The methods of cultivation also affects the quality the soils. Smallholder farmers have been tilling the land by using hand hoes for successive years. The breaking of the soil into smaller and smaller particles expose it to wind and rain erosion, especially if left bare for long periods.

There are some good agricultural practices, for example in some parts of Tarime district tie ridges are used to conserve moisture while at the same time checking erosion. In areas without the ridges, the soil has been washed out by wind and rain. This problem can be viewed throughout the basin and particularly in areas with semi arid climate, such as in parts of Musoma, Mwanza, Bunda, Tarime, Missungwi, and Magu districts.

Cotton is an important cash crop in the lake basin and most of the country's cotton is produced here. To control pests that adversely affect the yield and quality of the lint, pesticides are sprayed on the crop in the fields. Thiodan is a very poisonous insecticide and is commonly used in areas very close to the riparian areas. One common problem in recent years is that unscrupulous individuals have used Thiodan to kill fish. The poison has harmful effect on the fish and other living organisms in the water, and it eventually gets into the food chain, causing harm to humans and in turn the fishing industry itself.[4] A widespread campaign against the practice, close monitoring of fish coupled with strict legal measures has reduced this malpractice significantly. During the fieldwork extensive campaign posters were seen and almost all respondents were aware of the problem and the campaign to stop it.

Livestock keeping

The main types of livestock that are kept on the basin include cattle, poultry, pigs, goats and sheep. Mixed farming is a common practice in all the districts of Mwanza and Mara

[4] In 1999 scientists of the Tanzania Fisheries Research Institute in Mwanza and of the Kenya Fisheries Research Institute in Kisumu, who have studied the fish-poisoning problem, found the practice most serious in Tanzania, where a greater variety of poisons are used, especially around Musoma. It is only slightly less severe in Uganda and Kenya. Tanzanian fishermen commonly use Thiodan and Diazinon and plant extracts from Euphorbia tirucalli and Tephrosia vojeli. Fish killed by Diazinon and Thiodan are mainly Nile tilapia and Alestes [fish]. The chemicals kill within 6 hours of being consumed by human beings (Source East African News agency [edited] Date: 15 April, 1999)

region. Most of the households keep large numbers of indigenous cattle under extensive systems. These animals are kept both for economic purposes and prestige. For most keepers, the animals are a live reserve bank. Medard et. al (2002:159) and Mnyanga (2002:12) also note that the keeping of livestock has more to do as a way of keeping assets and as a means savings. The long term outcome however is overstocking which has lead to overgrazing and trampling or compaction of the pastures to a point of subjecting it vulnerable to soil erosion by wind and rain and also degradation of the soil nutrients through leaching. Erosion due to overstocking of animals is indeed extensive and is common in Mwanza, Magu, Musoma, Tarime, Bunda, Geita, Biharamulo, and Missungwi districts.

Almost all livestock keepers near the lakeshores water their animals in the lake and the repeated trampling by animals of the lakeshore area lead to soils being loosened and washed into the lake. There are also problems of environmental degradation that is caused by the herders frequently burning the grass in order to regenerate new growth. If the arrival of the rains delays, the soil is carried away by wind and later the exposed soil is also subjected to erosion with the onset of rains. This situation is very common is all livestock keeping areas around the lake.

Intensive livestock production is practiced for dairy animals in the western and eastern parts of the basin. While livestock keeping is important for the local economy, the problems that arise with this system is a degraded and polluted environment caused by the improper disposal of animal generated wastes, some of which also drains directly into the lake. This is practice is unnecessary because much of the land needs the animal generated nutrients and it can also be an important source of bioenergy. For example, despite the attempts by various agencies and projects over recent years to introduce biogas digesters to generate gas in the area, very few such installations were noticed.

Because much of the riparian area is under considerably high human and livestock densities, land use conflicts between livestock keepers and cultivators and even fishers[5] are quite common and serious, sometimes resulting into physical clashes. Numerous

[5] Especially when livestock go to graze in wetlands that fishers also want to maintain or exploit.

conflicts were reported during the focus group discussions and these conflicts are even more pronounced during extended dry seasons and localized droughts.

The issue of land use in these riparian areas has to be focused and acted on sooner rather than later or else both land degradation and physical injuries or even loss of lives and property is likely to occur.

Mining

There are two main types of mining activities in the lake basin, and these are the large-scale industrial type that combines open cast and deep shaft mining, and the second is artisanal mining. At the moment there are three large-scale gold mining and one diamond mining operation in the basin. The artisanal miners were once dominant is gold mining but the situation has since changed and now only the large scale companies mine gold. Of the three, only one is close to the lake and offers a high degree of threat to the fisheries environment.

The mine is one of the largest in East Africa, opened in 2000 near the Nyamalembo River, in Mara region, almost 20 kilometers from Lake Victoria's southern shore. Representing a $165 million investment by Anglo-American of South Africa, the world's largest gold producer, and Ashanti Goldfields, the mine uses cyanide to extract gold from lower grade ore than would be profitable by conventional methods. The process, called cyanide heap leaching, involves piling crushed rock on the ground and then spraying it with a cyanide solution to separate out the gold.

Overflow spills of cyanide-laced waste water from the mine can wipe out all life in rivers for many miles downstream. Environmentalists are concerned that its only a matter of time before cyanide spilled from the mine washes downstream to Lake Victoria. It is reported that cyanide has overflowed during heavy rains from a dam at the mine, killing a woman who bathed in a nearby steam and cattle that drank from it. Government officials have warned villagers not to use water from steams near the mine for drinking or bathing, and not to harvest crops planted along the water's edge. The mining company has since taken on a more stringent environmental management and monitoring approach, however, since this a significant threat, additional monitoring and mitigation measures are required.

2.3 Sources of Degradation of forestry around the Lake Shores

According to a report by IRA and LVEMP (2001:66-7) human induced vegetation cover changes are one of the remarkable features observed in the Lake Victoria basin. Deforestation is not a new phenomenon here, for it is reported (op.cit.) that around the lake basin the deforestation processes started since the early 1860s, as land was being cleared and this process has continued unabated. What is relatively new is that over the last two decades fishing has become yet another important economic activity that contributes to accelerated deforestation and degradation of the marine environment. The use of illegal fishing gears and inefficient fish processing techniques necessitate the consumption of a huge amount of wood, often from the surrounding natural vegetation.[6]

It is common knowledge that deforestation in recent years has become much more visible in the western and southern sides of Lake Victoria, and is one of the environmental concerns in the area. The eastern sides had already undergone an advanced stage of deforestation. The rapid growth of the fishing industry has further accelerated the process, particularly through the exploitation of wood products that are required for a whole variety of activities connected directly and indirectly to the fishing industry. Among the major ones include, for example, boat construction, fish processing, domestic energy consumption and settlement construction.

As it was pointed out in an earlier section, the huge population movement towards the lakeshore from the beginning of the 1980s coincides with the first appearance of the Nile Perch. As the Perch catch increased, a whole range of job opportunities rose, and this was followed by the in-migration of youthful population into the area. The rising demand for forest products is in response to the demand generated by the fast growing population for which the sources have been local forests and woodlands.

A closer observation of land cover supports the preceding observation regarding falling supply of hardwoods. Table 8 shows quite clearly shows how little of the surface area is under forest and woodlands – this is where hardwoods are obtained. For example, by

[6] Note that this study could not establish the degree of forest loss/degradation around the lake basin. To do so would require considerable resources, time and different methodologies. Given the gravity of the problem, this type of study, though expensive is still begging.

2000, the three regions had an average of only 1.07 percent of the land under forest and 11.13 percent as woodland. What aspect was noted during the field survey and is supported by the data on table 8, in that Mara and Mwanza are most denuded of forest and the situation in Kagera is not really that much better.

Table 8. Proportion of Regional Land area under different land cover

	Forest	Woodland	Bush land	Grass land	Cultivated	Other
Kagera %	1.7	15.5	18.7	12.5	22.0	29.6
Mara %	0.4	9.5	23.2	28.5	8.9	29.6
Mwanza %	1.1	8.4	7.3	9.9	28.7	44.7

Source: Ministry of Agriculture: Agriculture and Livestock Census Report. May 2000

Taking stock of the woodland areas, more or less the same situation arises. Mwanza region is most denuded followed by Mara and then Kagera. Taking the combination of forests and woodland, Kagera has almost twice the stock of Mara or Mwanza.

What is abundantly clear from the table is that the overall picture of forest cover is not encouraging. All regions in the basin just have small amounts of forest and woodland cover and with an average forested area of just over 1 percent and degraded woodland cover of around 11 percent. These figures confirm what is already well known that all the riparian regions have suffered serious deforestation, a process that had already commenced way before the fisheries boom joined to accelerate it.

Boat building

Along with the growth of the fishing industry, there has also occurred a concomitant growth in utilization of timber for boat construction. Most boats are built for the fishing industry directly and indirectly. Directly for fishing and indirectly for allied activities e.g. transport of goods and people.

Between 1998 and 2000 there was a 103% increase in the number of wooden boats that were built (from 7,618 to 15,491 boats) and most of these are directly and indirectly linked to the fisheries industry. This sharp increase was in response to the need for crafts to engage in fisheries activities and lake transport. Information from boats builders suggest that an average boat of 6-8 metres in length requires about 2 cubic metres of

timber (see plate 5). This is equivalent to 4 trees of 35 to 50 cm diameters at breast height (Dbh) per boat, which is about the size of hardwood species that occur around the area.

In 1998 some 15,236 m3 of timber was cut just to make these boats and within two years the volume doubled to 30,982m3, and if the trend in expansion of fishing and catch effort remains the same then by 2002 the volume might also increase to nearly 60,000M^3 (table 9). It would require clearing some 150 ha of a good forest to produce the volumes for 1998 and 300 Ha in 2000 and some 600 ha for 2002. The forests around the Lake degraded and so much larger areas are being harvested to obtain these volumes.

The increase in the number of boats is linked to the increase in catch effort and so a considerable amount of hardwood and such volumes are no longer available within close proximity to the lake.

Table 9. Amount of wood utilized for boat building

Year	No. of Vessels	% increase	Volume per vessel	Approx number of trees	Total volume (m3)
1998	7,618		2	61,024	15,236
2000	15,491	103	2	123,928	30,982

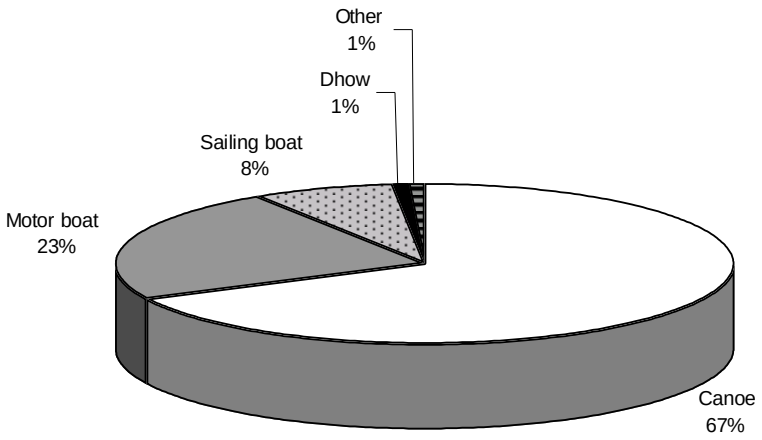
Source: URT: Fisheries frame Surveys 1998, 2000.

These calculations do not take into account the amount of timber that is wasted in the course of making planks, thus the amounts shown here are conservative estimates.

Boat building is an activity that consumes considerable amounts of timber and especially the types of small boats that are used for fishing (figure 6). The field survey also looked at the types and sources of timber required for boat building (n= 520). The small canoes, both dug out and plank construction of average size of 6-7 metres, are by far the most commonly used vessels, though use smaller amounts of wood and timber, followed by the slightly larger boats fitted with either outboard or inboard motors The large wind powered (sail) boats that require a lot more timber are fewer in number.

Traditionally the local boat builders would source the timber locally, e.g. within proximity to nearby forests. However, what has happened over the years is the as more and more timber was being demanded, the sources have been diminishing and yielding less and less of the desired hardwood species. The fact is that the rates of extraction has been very high to the extent that many forests on islands have been depleted and even those under protection are under severe threats and still people harvest logs illegally despite the laws that are meant to deter them.[7] Moreover, with the declining availability and risks associated with illegal harvesting, prices have also gone up, making such timber

Figure 6. Percentage of timber used for making different types of boats 1995-2001



Source: Survey n = 492

Consequently, the boat builders have had to source timber from further afield. In this case both distance and transport factors affect the prices of timber. This is a clear indicator of local sources being unable to meet the demand.

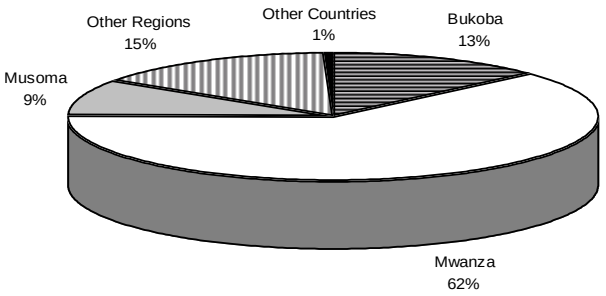
[7] From discussions with forestry officers in Geita, Biharamulo, and Bukoba urban and rural districts.

The survey shows clearly where most boat owners and builders are currently obtaining their hardwoods. In places where they indicate using locally available woods, the boat owners and builders are using softer and less sturdy woods and this means that the life expectancy of such boats is much shorter (now only 3-4 years against 7 years) and the time span needed for repairs are much more frequent. From the point of view of the economics of boat ownership and management, this means that the owners have frequent or recurring repair costs, which cumulatively make owning and managing a boat expensive. In terms of the impact on the physical environment, clearly both the physical evidence and the reports by all the district forestry officers, reflect the contribution of fisheries in the depletion of forest stocks around the lake basin.

Sources of Timber

In general most of the timber used for boat building and presumably for construction of houses and other uses is still obtained locally. However, what is also clear is that a growing supply is coming from outside the lake basin regions i.e. from regions such as Tabora and Kigoma. As mentioned in the preceding section, this is a clear reflection of dwindling local sources resulting from the ongoing deforestation around the lakeshores. Figure 7 shows where boat owners and builders were obtaining timber for making boats between 1995 and 2001.

Figure 7. Sources of timber for boat making 1995-2001



Source: Survey n = 492

It is important to note that there is a considerable variation of timber demanded and supplied even within regions of the basin. For example, the percentage represented by Mwanza is largely derived from the fact that Mwanza city is one of the major commercial centres of the lake basin, and thus some of the timber obtained in Mwanza comes from the western sides of the Lake and even as far as Tabora and Kigoma. The figure however does not provide a clear picture because it obscures that fact that some timber is sources from other areas both within and outside the lake basin, but sold mainly in Mwanza. What is important to note is that at least 16 % of timber is sourced directly from areas outside the lake basin and this is indicative of high demand for timber in the basin and decreasing supply from the same area.

Table 10 attempts to disaggregate timber source areas within the Lake Basin. From the table it is clear that Mwanza urban serves as a commercial centre that collects timber from various sources and the boat builders from all over the lake come to buy there. This explains why Mwanza region is the biggest source of timer for the fishing industry and especially for boat construction. Within Mwanza region for example, Maisome and Ukerewe Islands are the main sources of timber. In Musoma and Tarime districts are the main suppliers, while in Bukoba it is Muleba district.

Bukoba region (13.4%) ranks third as a source of timber, and especially Bukoba urban and Rural and Muleba Districts. The share of Bukoba as a source of timber indicates that the western side of the lake has of late become important. This also means that the deforestation processes is creeping westwards.

The eastern sides of the lake are the most depleted areas and this explains why only a small share of timber comes from this area. The builders and boat owners in this area often buy the hardwoods from Mwanza, other regions and Bukoba or otherwise as a last resort utilize inferior timbers available locally.

A spatial pattern of timber sources is clearly discernible, in which the eastern side of the lake show a dearth in forested areas, and some islands and the western areas a relative abundance. The southern side is now also on the verge of losing their forest resources.

Table 10. Sources of Timber for Boat Building

Source	Frequency reported	Percentage
Bukoba	27	5.5
Muleba	39	7.9
BUKOBA	**66**	**13.4**
Mwanza Urban	184	37.4
Geita	14	2.8
Ukerewe	34	6.9
Kome	6	1.2
Maisome Is	61	12.4
Missungwi	1	0.2
Sengerema	5	1.0
MWANZA	**305**	**62.0**
Musoma	15	3.0
Tarime	18	3.7
Kisorya-Bunda	3	0.6
Shirati	8	1.6
MUSOMA	**44**	**8.9**
Tabora	73	14.8
Kigoma	1	0.2
OTHER REGIONS	**74**	**15.0**
Kenya	1	0.2
Uganda	2	0.4
OTHER COUNTRIES	**3**	**0.6**
N = 492	**492**	**100**

It is interesting to note that among the other regions, Tabora and Kigoma rank second in terms of supplying timber to the lake area and accounts for 15% of the total supplies. Between the two, Tabora is supplying the bigger share of the timber. To add to a previous indication, the point to note here is that the timber merchants would not go that far to source hardwoods had there been a dependable and affordable supply of timber locally. Many of the boat builders mentioned that timber from Tabora is more mature and bigger in size compared to locally obtained hardwoods. In districts that lie close to Kenya and Uganda, some merchants cross borders to source timber. All these are clear indicators of the growing shortage of timber within the lake zone.

Types of timber used for boat making

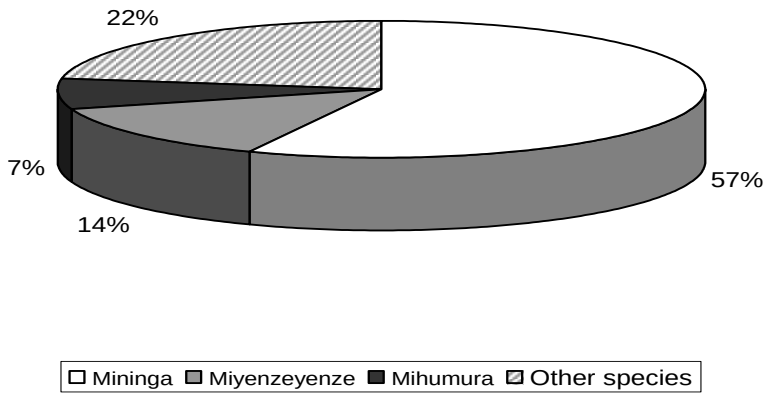
From the survey, boat builders and owners reported that the most commonly preferred and used timbers are the hardwoods (figure 7), especially the sturdy and durable mninga (*Pterocarpus angolensis)* (56.4%) variety, followed by miyenzeyenze (*Albizia gummifera)* (13.7) and mihumura (*Maesopsis eminii)* (7.2%). The remaining species are not durable enough, but the reality is that mninga (*Pterocarpus angolensis)* and the other hardwoods are increasingly in short supply locally and getting to be more expensive. This has forced most boat builders and owners to resort to using less suitable types of timber, resulting in shorter lifespan of boats and also more frequent repair work.

Boat making and repairing takes place in all the main landing sites. Over the years, many trees have been cut to supply raw materials for this important activity. The preferred species for boat making is hardwood, however this is now more difficult to obtain and has become more expensive to obtain from local sources.

The alternative is to make boats from other not so durable woods, and boats made from these alternative woods can only last only for between two to three years while those made from hard wood can last for up to ten years. This means that a lot more timber has to be cut for boat making and repair. The reasons for this are as more and more people enter into fishing and fish processing the demand for new boats increases. The physical implications of forest depletion are already evident. For example almost all the mining (*Pterocarpus angolensis)* and miyenzeyenze (*Albizia gummifera*) trees in Geita district have been depleted.[8] Currently most of the available lumber for boat making is brought in from Maisome Island whose forest is being depleted. To meet the growing demand has led to the process of sourcing timber from areas outside the lake basin. This also means that the ecological footprint of the fishing industry is not localized, and has begun to widen into neighbouring regions and even into Kenya and Uganda.

[8] Discussion with District Forestry Officials

Figure 8. Common wood species used for boat making



Source: Survey n = 492

Domestic Energy

The population growth in the area is also intricately linked to the harvesting of locally available bioenegry sources for cooking and fish processing. While on the western and southwestern sides this is not yet so much of a problem yet, on the eastern sides of the lake it continues to be a serious problem. For example in the Magu area, when fishers go out to fish, one of the things that they also bring back is firewood that they fetch on islands or shore areas that still happen to have some biomass, including wetlands. This is no longer a localized problem for Magu District but one, which is extending north and south of the district to adjacent areas of Mwanza and Mara.

The problem of firewood is one that is also closely linked to the issue of tenure and depleted forests and woodlands. Most fishers feel that they are in a place only for a short duration, and see no point in planting trees to generate future sources of energy or building materials. Likewise other people who have come into the lake shores only own very small tracts of land and use the land for house construction and to conduct businesses.

Plate 5. A boat making yard in a fishing village

Here tree planting is out of the question and the stark evidence is the use of thin sticks, reeds and grasses and even dried cow dung for cooking (plate 6). Moreover, the growing concentration of human and livestock towards the shores of the lake does not mix well with planting of trees within the same vicinity. Against this situation much of the lake area is becoming a bioenergy (especially wood) deficient area.

Energy demand for a rural household in Tanzania is estimated to range from 1.95m^3 to 2.1m^3, according to UNDP/World Bank (1988). Based on these levels of consumption, projections for fuel wood demands in Mwanza (which is an energy deficit region) for uses such as fish smoking, pottery works, brick making, tobacco drying etc. would be 4.12 million m3 of solid wood fuel by 2000. The likelihood of this level having being reached is most likely given that the factors determining the actual level and growth of aggregate consumption include: demographic changes (as we have seen here, there is

rapid population growth) income growth, the physical accessibility of the fuel woods, and fuel wood price changes (op.cit:8).

Plate 6. Firewood collect to be sent to energy deficient areas

Given that there is very little inter-fuel switch, no substitution or move into more energy efficient stoves in the Lake region, there is unlikely to be significant reduction in per capita consumption. Yet another indicator of the severity of the energy demand situation is the witch to use of dry manure, grass and food processed waste such as husks as a main means of cooking and heating energy in Mara and Mwanza regions.

Wood fuel requirements for fish smoking in Kagera and Mwanza regions is 1986/87 were 30,412m^3 and 121,009m^3 respectively and that by 2000 the projected demand would be 48,720 m^3 and 167, 465 m^3 respectively (UNDP/World bank, 1988). While on the western sides of the lake (from Geita district towards Kagera), it is most likely that this estimate will have been exceeded. In contrast on the eastern side, the situation is likely to

be around the projection, given that much of the fish processing for export is processed in factories, and the required energy capacity is lacking.

One can make a quick and simple calculation that shows that wood consumption for fish smoking alone used to be considerable. Given that it takes roughly around 0.7 tons or $1m^3$ of fuel wood to smoke 1 ton of fish and 1 hectare can provide up to $50m^3$ of fuel wood, and if Mwanza region is consuming at least $170{,}000m^3$ per annum since 2000, would imply that for 2002/3, some 3,400 hectares of wood fuel is required annually - just for Mwanza region alone, and this figure excludes energy consumption for other uses, including boat building and repair. These conservative estimates plus the evidence of types of consumption on the ground, together with the large populations in the area, together with the IPAT model, can only suggest that beyond doubt, considerable amounts of wood is being consumed in the Lake Victoria Basin.

2.4 Interaction of lake-side communities with wetland resources

There are many wetlands on the fringes of Lake Victoria, on islands and even inland in all the lake regions. The wetlands are of various types, functions and characteristics. There are those associated with rivers and streams, and there are those which are more associated with the lake environment e.g. those found fringing the lake and in most cases act as breeding areas for fish. From the survey, there is no doubt that the numbers of large and small, prominent and not so prominent wetlands are under threat, and had it not been for early initiatives to conserve and protect them the situation would have been more serious.. However, it is obvious from several reports that only certain wetlands are being protected, but at the local level there is a serious problem that also requires attention.

As the well-known adage goes, “wetlands are wastelands”, and most unfortunately this is generally how wetlands are perceived by most lakeshore communities and especially in more populated settlement areas. Most are unaware of the important ecological and even economic roles that wetlands play in Lake Victoria.

The following is a summary of the field observations on all side of the lake showing the various uses and abuses of wetlands:

There are considerable, widespread and growing agricultural intrusions into wetlands and particularly during the dry seasons so as to obtain the soil moisture in wetlands and wetland adjacent areas for crop growing. The soils in wetlands are also sought after for crop nutrition.

Grazing in the wetlands is very common, especially during the dry seasons, when fresh pastures are a few and far between (plate 7). The wetlands tend to have lots of edible grasses that are suitable for fodder. The livestock keepers rarely come to cut the tall grasses, instead they walk the cattle into the wetlands and the trampling by and feeding of the animals disturbs and alters the wetlands. In several areas there have been serious conflicts between the livestock keepers, cultivators and fishers on the use of the wetland resources.

A fairly recent and growing phenomenon along many areas of the lakeshores is vegetable growing (plate 8). This has become a local growth industry, with people cultivating right up to the water line. Part of the reason for this is the shortage of suitable land and moisture for cultivation in upland areas. The population pressure further inland and along the lakeshores is considerable and this comes as no surprise. However this growth agricultural activity is also in response to the local market for horticultural foods such as sweet potatoes, cabbages, tomatoes, and the like. In some areas clearing of wetland areas has preceded the practice and so the opportunity cost is the loss of wetland services and products. Moreover, apart from reducing areas of access to the lake, a potentially serious problem associated with this type of cultivation is the use of agro chemicals that eventually leach into the lake and pollute the waters. For example a farmer in Kome explained that organic fertilizers were common in the area but also revealed that pesticides were also popular especially in tomatoes and onion cultivation (boxes 2 and 4).

The exceptional case through was found in Sanga wetland were they use papyrus for insecticide. During the rainy season though, when the wetland is flooded people switch to paddy production. In almost all the areas visited, wherever there was a wetland, there has been some degree of intrusion and in most cases very serious intrusions with some wetlands being totally converted into agricultural land, beaches or human settlements.

Plate 7. Animals grazing in a wetland area

Box 3. A historical narration of the Nyamkazi Landing site, Bukoba Urban District by Mr. Mutagubya

Many years ago there was a large wetland here. The place was just full of reeds - papyrus and some bushes and brush, there were some wild pigs in here and people hunted them. This was an area that supplied many things apart from fodder. There were many birds of many colours, wild ducks, a lot of frogs, and snakes and many other creatures and insects associated with the wetland.

All these disappeared when human encroachment began. It is sad, but also there were many incidents of people who went to harvest fodder in the wetland, drowning from slipping into the wetland. You see, parts of it were very deep and even an adult who fell in such areas would be completely immersed.

For some reason it was left intact until when we began to encroach it little by little since 1993, I think. People started by clearing and cultivating in the wetland until 1997, and when it dried up. Then people started to build houses in the area and now it is completely gone. People who were cultivating cut down all the papyrus and bushes and deposited them into the deepest parts of the wetland when these decomposed; they covered it with some soil from the banks of the wetland in order to reclaim the area. So bit-by-bit the area was reclaimed. When women went to this reclaimed field to cultivate, they usually came up with some catfish and the like.

Even as the wetland was being converted, various products from it were being exploited. The only things present now are houses and in some areas that still have enough moisture, crops such as beans, maize, yams etc. are grown. We have developed that area to the extent that we even have important utilities such as water and electricity here, but no longer get the wetland resources of the past.

Plate 8. A patch of cabbages being grown in a wetland area

Mixed farming is a common practice in almost every accessible wetland found on the edges of the lake but there is now a more threatening reality taking shape and that is the conversion of these wetlands into settlement areas (box 3). With the growth of the fish industry, more and more people are heading for the shores of the lake to seek alternative and new opportunities in the sector and hence need somewhere to settle. Nkome and Nyamkazi areas are good examples of such a situation. The results here clearly demonstrate that the situation has gone beyond wetlands simply being threatened by agricultural intrusions and now includes human settlements or both. Consequently over time numerous other small and have completely disappeared and even large ones are under threat.

Since the wetlands are found in low lying areas, observations have shown that some of those located in areas of high population densities experience pollution especially during the rainy season when solid and liquid waste from the settlements are washed into the wetlands and directly into the lake. Thus a 'silent' form of pollution is taking place here.

While it is known that wetlands are quite resilient areas and can cope with most types of pollutions and ecologically actually take part in the cleaning process, what is not known is the threshold of their capacity to do this and the limitations into what types and levels of pollution they can cope with. It is encouraging to note that the wetlands component is focusing on such ecological research but more attention and awareness is required in this quiet but disturbing process.

In Kisorya the Nambubi wetland is used as a channel wastes into the lake because the papyrus in the wetland has been removed and the remaining stock is not enough to keep or restrict the waste from entering the lake directly. This means that the removal of the papyrus for agriculture and other uses has reduced and damaged the wetland's function of purifying water and in retaining the sediments. Moreover at the Kisorya landing site, toilets (pit latrines) are situated on the banks of the wetland itself. There is also evidence of human excreta in the wetland area and all this is washed into the lake by rainwater hence affecting the quality of water and threatening people's health.

Part of the ecological importance of wetlands has a lot to do with their being breeding areas for certain fish species. Despite this situation, some fishers have a tendency of setting traps ("mbigo") for the fish that enter the wetland areas for breeding. The trap is set such that when the fish enters it, it cannot get out and so the trapper takes away the trapped fish either for food or to sell. This act in turn interferes with the reproduction process and contributes to the decline in numbers of specific fish species. Such practices have been observed in Nambumbi wetland at the Kisorya-landing site.

From the field observations the most commonly used materials in the construction of human settlements are wetland and forest products. Wetland resources are of great importance of products for riparian communities as they provide roof thatching and house construction materials, materials for mat and basket making and many others. The rapid expansion of settlements poses a great threat to the wetland vegetation that is already in bad shape. For example, Juma Island in Sengerema district and Ikuza Island in Muleba district are among the expanding landing sites where the use of wetland vegetation is very much evident. Likewise, in the Bukubmi wetland there is both papyrus and Sesbania trees that have been cut extensively by fishermen to be used for raft making, and for poles used

for holding up lanterns during sardine fishing at night. These and other exploitative activities have and continue to cause extensive degradation of wetland vegetation.

The lack of recognition of the functions and importance of wetlands is not only a problem of local communities: it also happens to be a weakness of the local authorities. It is surprising and disappointing to note that in some areas even local authorities are oblivious to the ecological importance of wetlands. Nor does there seem there to be any directives on how best to utilize wetlands. For example in the Sanga wetlands in Sengerema district people were clearing the papyrus so as to grow paddy. Here they claimed that the rains of 1964 had flooded the area making it part of the lake, then when the water began to subside in 1998, people began to cultivate the wetland area piling up the soil so as to reduce the wetness at the top.

Insofar as the local authorities were concerned, they had instructed the farmers to cultivate the area to increase crop output. There was no limitation as to how far away from the water line, or the extent of the wetland they could cultivate. The main objective was to utilize the resource through whatever means to increase crop production, regardless of the longer-term consequences to the area.

Box 4. A vegetable farmer in Kome Island on changing agricultural practices

Over the years our cultivation practices have changed as we are forced to become more innovative in response to changing conditions. On our island we cultivate vegetables, especially tomato and onions. Land is in short supply, so in order to get more space for cultivation; we cut down the reeds, mainly papyrus and burn them on the spot to ensure that fertility is retained in that area. This means that we get both good soil moisture and fertility. This type of preparation is very good for vegetable growing.

There are however, some difficulties with this type of shoreline farming. For example, some people are cultivating right up to the water line so when there is a lot of rain, the water level rise, their plots and produce (usually tomatoes and onions) become flooded and get destroyed. In other areas, there are people who use organic fertilizers and pesticides in the cultivation of tomatoes and onions. They do this to get good crops and reduce damage and waste by insects.

Over the years, the papyrus and other species of waterweeds have been greatly reduced. For example, take a look at the area that we now standing on, in 1995 if you were to be left in this area you would have been lost. It was completely filled with papyrus. At that time (1995) people just fished and processed the fish. That was the only activity here, however with the Nile Perch and the coming of the large fish factories in the 1990's local fish processing was greatly reduced. The new type of fishing for the factories attracted new people to come here and many other places. More and more people arrived year after year, such that by 1999 a big population was attracted to the area, mainly to fish for Nile Perch and sell to the factories.

Because of the growing population here, today land is very scare. Now it is difficult for one to even move their livestock freely because people's houses and small farms block most of the routes to the grazing area. Nowadays there are so many complaints and conflicts because of this situation.

This wetland area was also observed to have a lot of bait that is used for fishing Perch and if the whole area is to be reclaimed or cultivated, then an important source of bait needed for fishing will have been lost. Wetlands are also important for livestock keepers, though as mentioned in an earlier section, the manner in which they graze animals in wetlands tends to be destructive. Also about 70% of the livestock keepers interviewed indicated that they graze next to or sometimes even within wetland areas.

Clearly wetlands are very important to the fishing communities as they provide them with a wide variety of direct use resources ranging from building materials, raw materials for domestic articles, food and to some extent an alternative and or supplementary income apart from fishing. The ecological functions are equally important both in terms of the direct and indirect uses. However, despite these very evident benefits the values of the ecological and other functions of these ecosystems are not clearly understood and appreciated and perhaps because of the fact these are common pool resources, they have been and continue to be subjected to overexploitation and serious mismanagement. Such common pool resources tend to occupy a very low position in terms of importance or concern by most people. For instance in identifying areas that suffered from environmental degradation in the whole study area, only 1% of the total respondents took notice of the destruction of wetlands.

2.5 Degradation of the environment through the lack of sanitary/waste processing and disposal facilities

Many reports about pollution around Lake Victoria, refer to the degree of pollution caused by large urban areas such as Musoma, Mwanza, Bukoba, Jinja and Kisumu (LVEMP 2002, URT 2001, URT,2002). Such big towns have large populations concentrated within their borders, and the type of economic activities associated with large towns produce certain types of waste e.g. from industrial production and other domestic solid and liquid wastes. Much has been written about urban and industrial waste that is deposited into the lake (LVEMP 2002; Mnyanga and Semili, undated) and steps are already being taken to address this situation, with varying degrees of success. Relatively little however, is known about the impacts of the hundreds of small to medium sized settlements that have expanded very rapidly over the last 20 years. Mnyanga (2002)

does report of the results of poor settlement organization, unsanitary behaviour e.g. open defecation and poor waste disposal. Indeed many small settlements have seen their population increase between one and a half times and even doubling in less than 20 years. This means that there has occurred a considerable concentration of population within two kilometers from the shoreline and the cumulative impact of the pollution coming from these settlements is likely to be just as profound as that of the large towns and cities.

A major observation and finding of the survey is that there is widespread (observable) degree of lakeshore and water pollution in almost all settlements caused by inappropriate liquid and solid waste disposal practices and the impact of this on the quality of the lake is likely to be profound if left to continue unabated (plate 9). Part of the problem lies with the inadequacy of existing legal and institutional frameworks and planning requirements governing the developments of such settlements. To date their development and management is spontaneous, and the situation is made worse by elements that are not permanent, i.e. the transient populations.

At the moment it is only the strong village authorities and Beach Management Units (where they exist) that have been able to institute by-laws and regulations that control the disposal of waste and regulate the uses of the lake.[9] While this is encouraging, it is not a widespread phenomenon and indeed some are in serious structural and functional problems (Medard et. al, 2002) and is complicated by inappropriate traditions and basically lack of sanitation and hygiene.

The following sections will highlight the gravity of the situation on the ground.

The problem of lack of toilets

One widespread and persistent phenomenon in the study area is that generally there are few toilets and even where there are toilets, this is accompanied by poor use of these facilities and this occurs in all the sites visited. For fear of local by-laws, most

[9] Beach Management Units, (BMU's) are formal local level institutions organized by fisheries communities, but being provided with technical advice, to oversee environmental and fisheries matters in their respective jurisdictions. (a) To ensure the beach environment was clean., avoid and prohibit the use of all illegal gears such as beach seines and undersized nets, confiscate any illegal gear and report these to the fisheries department, ensure all new comers to their areas are good fishers and that they report to the BMU on arrival and thereafter to the fisheries department for allocation of a camp site, supervise fishing licensing at the beach level.

respondents reported that they have toilets and when challenged to show on, they either show a hole (supposedly a toilet under construction or a neighbour's toilet). Just from physical observation 60 to 70% of houses have no toilets. Mnyanga (2002) also observes the same and explain this is why human excreta along the Lake is high and accounts for 43% of waste. There are several explanations for this state of affairs, and one widespread phenomenon is linked to the culture of most of the people. For instance in many places there is a belief that a young woman or man cannot share a toilet with her in-laws. In such a situation the logical solution would be to have more than one toilet, but the relative poverty of many households and the fact that most people who arrived recently perceive that their stay is only temporary, does not encourage the construction of any toilet, let alone have more than one. Under these circumstances the option is to use bushes and reeds the lie close to the lake.

Plate 9. Doing laundry in the lake

The amount of pollution in the lake is high but will differ from place to place. According to Mnyanga (2002) a sample taken at a major water intake in Mwanza town revealed a concentration of feacal coliform of up to 820/100ml, which means a person drinking 8 glasses of water a day also takes in 1,000 feacal coliform daily

Lack of knowledge about hygiene is another major setback. For example, despite the fact that in some areas there are regulations requiring toilets to be built, these are built but rarely used, and in some instances are referred to the "authorities toilets". Mnyanga (2002:17) comes across a similar situation in which people refer to such toilets as "choo cha daktari" This is seen as ridiculing the enforcement of local authorities and yet the same people continue to incur health costs and even threaten the vary source of livelihoods that they are so dependent upon.

Meanwhile as wetlands are being converted into other uses e.g. agriculture and human settlements, and such cover is also becoming scarce, many people use the lake itself as a depository for human waste. This is the case in most areas with the exception being where the more successful Beach Management Units (BMUs) and Village Environmental Committees are operating.

If one wants to understand and deal with this situation, it is important to note that within the fishing and other lakeshore settlements there are a group of people whose tenure is very temporary. These are the migrant fishers, who come to fish around an area and attach themselves temporarily to a nearby settlement. Since they are transient and only need temporary shelter, they construct several temporary huts and stay only for short durations and then move on. In recent years their numbers have grown, and their camps have become bigger. Given that their camps are temporary, often constructed with bits of wood, sticks and thatch, they rarely see the need to construct latrines, and thus use either bushes or the lake as a depository for waste. The construction of these shelters also takes up considerable local vegetation and woody matter. Moreover they also use considerable amount of wood for cooking, processing and heating energy.

Where there are pit latrines, the traditional non-ventilated pit latrine is the most commonly used. About 86% of all those with toilets interviewed use this type of facility. What is interesting is that some 88.5 % of those interviewed reported that they had

toilets. However, a close inspection of such facilities showed that most of these were very shallow and full and catered for large numbers of people. Others, obviously not wanting to be embarrassed and in fear of contravening local regulations, declared to have toilets but hesitated to show them or simply pointed to any nearby toilet. So this figure is not an accurate reflection of the situation on the ground.

Crosschecking with village authorities confirmed that 60% of the interviewees did not have access to a basic pit latrine. Part of the reasons for this is that some of the areas close to the lake are located on hard rock. For example Kijiweni village in Sengerema virtually sits on rock and the same is true of several shoreline villages in Mwanza and Magu. In such villages, the geology of the area poses a problem for digging pit latrines.

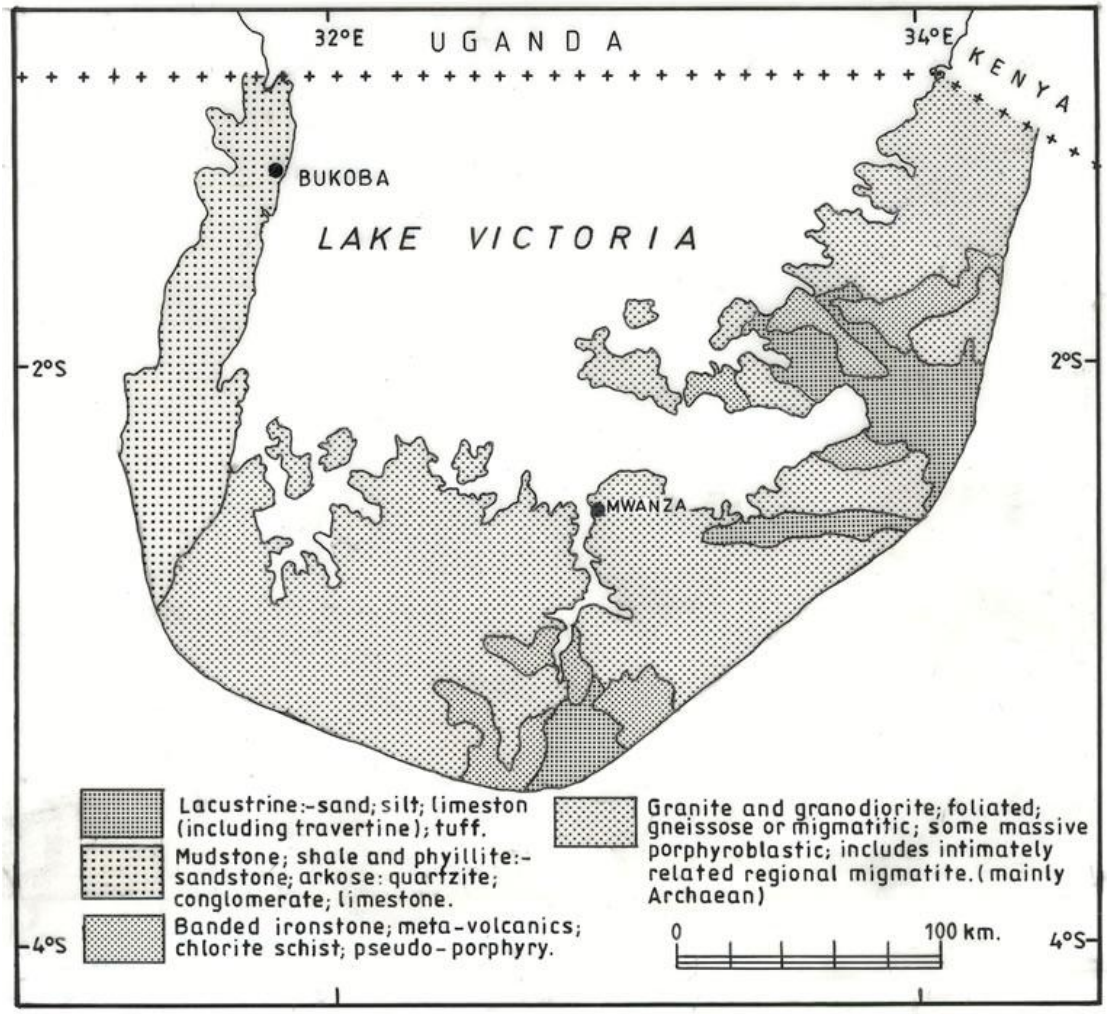
Part of the problem lies with the general geology of the lakeshore area, in that much of the surface and subsurface consists of rocky materials that makes it difficult to dig through to make pit latrines and pits for solid waste disposal (figure 8). The geology of the eastern and southern sides of the lake basin is comprised of the ***Nyanzian System*** that is mainly comprised of mafic volcanic rocks and immature sediments, which form the greenstone belts of the central craton. The Nyanzian greenstones are of major economic importance, as they host most of Tanzania's gold deposits (see figure 8). The rocks can be divided into a Lower and an Upper Series on the basis of recognizable upward transition from mafic to felsic lavas, with minor tuffs and interbedded sediments. The lower Series consists primarily of basalt, andesite and dacite pillow lavas. The sediments include banded iron formation (BIF) recrystallized cherts, and some shale and conglomerate. The Upper Series is characterized by the assemblage of felsic lavas, tuffs, ferruginous cherts, BIF and subordinate meta-pelites.

On the western side of the lake, there is the ***Bukoban System.*** The Bukoban may span the Proterozoic-Paleozoic boundary, is weakly deformed and not metamorphosed. It includes sandstones, quartzites, shales, red beds, dolomitic limestone, cherts etc. The Bukoban occurs only in the northwestern quarter of Tanzania and stretches along the shores of the lake.

The southern and part of the eastern sides of the lake comprises of Granite and granodiotrite; foliated gneissose or migmatictic, some massive porphyrolastic; incudes

intimately related regional migmatite - mainly Archean. Small shore areas on the eastern side are lacustrine area consisting of sand, silt, limestone, including travetine and tuff and even smaller areas with banded ironstone; meta-volcanics; chlirite schist; pseudo-porphyry.

Figure 9. Geology of the Lake Victoria Basin



Basically much of the lakeshore areas consist of hard materials not conducive for digging pit latrines, and even where there are softer areas, these are preferred for other uses such as cultivation. However, this does not mean that it is impossible to dig toilets at all; instead a different approach and technology might be required and certainly research on this aspect is required. One common feature in all areas is that there is overall poor use of toilets. For example in one area, Ikuza fishing village with a population of 102 fishers there are only two (2) toilets both of which are very shallow. In some few areas there are

public toilets are available, often built by NGO's. Public toilets charge people for using them so as to obtain money to maintain them, in response however, many people avoid using them and use bushes instead, thus defeating the purpose for having public toilet facilities.

Solid Waste and Sewerage

In virtually all the field sites, solid and sewerage disposal is deposited into shallow pits and unfortunately most pit latrines are located within close proximity to the lakeshore, implying that much of the liquids deposited into the shallow and sandy pits will inevitably leach into the lake waters with little effective filtration taking place. This process is polluting the inner lakeshore waters, thus explaining why the degree of water related diseases in very high all over. The degree of pollution will vary from area to area and at the moment is most likely to be limited close to shore.

Insofar as the solid waste is concerned, the decomposable solid matter is simply left to decompose or is burnt. As it gradually decomposes it allows for dogs and other vermin to delve into the open pits and spread bit and pieces of rubbish around. The waste consists of normal household/domestic waste, but increasingly also waste generated from business premises such as hotels, bars and restaurants. The volume of such waste is considerable but the manner of disposal in very inadequate.

Mnyanga (2002:13) notes that where trading is conducted the surrounding areas are filthy as various packaging materials and plastics are scattered all over. Food vendors also dispose of waste food e.g. vegetable and fruit peels in an unsanitary manner along the beaches and even in the lake.

Many of the so-called toilets and baths consist of reed wall and stones arranged on the floor. Here waste bath water and urine is channeled out into the stony surface. Some of it will evaporate, some will leach into the soil and some will drain directly into the lake (plate 10). This practice is so widespread that it is the rule rather than the exception.

The combination of the effects of poor solid and liquid waste disposal practices has and will continue to have profound impacts on health in the future. For example, almost each and every household interviewed reported intestinal disorders within the last month and a

high rate of frequent repetitive infections. This was crosschecked with dispensary, hospital records and drug store sales and is presented in a following section.

Most of the fishing sites have Village Environmental Management Committees, which are charged with, among other things ensuring proper management of liquid and solid wastes. In some of these sites, for instance Ikuza there are toilets, which have been built by the village (10 toilets) after noticing a profound problem of lack of these sanitary facilities. There is a problem however with the location of the toilets in that they are built very close to the lake (less then 20 metres) which means that if the pit is not sealed, there is a very high possibility of the waste from the toilet to infiltrate and pollute the lake.

In other areas because of the haphazard constructions of houses, there is no space for constructing toilets and thus some of the toilets have been built some distance from peoples' houses and it was reported that most of the people end-up not using them.[10] The toilets are however, used mostly during the daytime, when people are working at the beach. Thus combining these factors and the cultural dimensions, the many toilets end rarely being used and with the lake being the main depository of solid and liquid waste.

Even where Environmental Committee regulations are enforced, e.g. those that prevented people from bathing in the lake, or which prevent the waste water from the baths being channeled directly into the lake, it was observed during the field survey that the regulations were being violated, and that this was not a one off event, it was widespread though with varying degrees of infringements, implying that enforcement of sanitary/hygienic regulations is still a problem.

[10] Discussion with Village Environmental Committee members.

Plate 10. A toilet behind a tea house , with an open channel emptying directly into the lake

Fish Processing

Fish processing is yet another problem that is linked to the poor management of waste in all the fishing sites visited. In the western and southern areas, and to a lesser extent on the eastern side, the fish is cleaned before being smoked or sun dried. This cleaning is done along the lakeshores and quite often the waste is thrown back to the lake, although sometimes the waste is scavenged by the long legged Marabou Storks. Upon discussing the pros and cons of fish cleaning and disposal of fish waste in the lake, most of the processors claimed to do this because they were avoiding extra labour such as carrying water to go and clean the fish somewhere else. Attitudinally, this is also a problem, since the lake is just taken to be a depository owned by no one in particular.

Other activities

Trucks that come to collect the fish also contribute in polluting the lakes. Some of these trucks park and cleaned by the beach and thus polluting the water but also causing soil erosion. Servicing of the boat engines is also done along the beaches and the fuels and oils from the engines are finding their way into the lake waters.

Health Implications

The pollutants being deposited into the lake lead to considerable health implications since most of the local communities use the lake water and many riparian residents do not boil drinking water. The polluted water has many uses, such as drinking, washing of utensils, clothes and body, and for irrigation. Through these uses individuals come into contact with the polluted water very frequently, and especially the water close to the shores.

The improper disposal of domestic and fish waste also has serious health implications as the waste decomposes in the water and shoreline areas. Common diseases in the area are mostly bilharzias, diarrhea, malaria and typhoid, which account for 67.8% of the major incidences of disease in households over the last month (table 11). The survey by Mnyanga (2002:21) shows generally similar results with the three highest report diseases in terms of frequency of infection being dysentery, typhoid, amoeba and malaria (in that order). From the table, and discussions with the local health personnel, most of these diseases are caused by utilization of unsafe water from the lake. While this has begun to have serious short-term repercussions it is also likely to have a longer-term impact on fisheries itself in terms of affecting the quality of the fish being caught.

Although the incidence of HIV is reported as being low, it is most likely that some of the diseases reported are opportunistic infections resulting from HIV. This observation is made in connection to the lifestyles of many fishers in the areas, although an awkward plus side is noticing used condoms being disposed of improperly also along the lakeshores. This too can have serious health implications on others.

The socioeconomic implications of continued pollution will be profound to both the riparian communities and also the local fisheries economies. If pollution and contamination rates reach high proportions a repeat of the ban on Lake Victoria fish is imminent with disastrous result on local livelihoods. Experience in the past shows that

investment made to preempt the implications of pollution by far outweighs the health cost and in this case also the fish export costs.

Table 11. Reported incidences of diseases

Report illness	No.	%
Bilharzias	142	21.1
Diarrhea	124	18.4
Malaria	112	16.6
Typhoid	79	11.7
Cholera	54	8.0
STD	46	6.8
Worms	28	4.2
Dysentery	18	2.7
Vomiting	12	1.8
Incessant fevers	12	1.8
Amoeba infections	12	1.8
Hepatitis	8	1.2
Skin rashes	6	0.9
Flu	6	0.9
Coughing	5	0.7
Measles	4	0.6
Malnutrition	3	0.4
HIV	1	0.1
Fungal infections	1	0.1
	673	99.8

Finally, although most of the fishing sites visited have Environmental Committees, their (committee members') understanding of the processes of the physical environment is low. For example in some areas, the toilets are located too close to the lakeshore and therefore toilets are still polluting the lakes. Against this backdrop, there is a need of providing additional environmental management education to these committees and the communities as a whole.

Lake Shore Pollution

The type of pollution that is of concern to fisheries and the fishing communities are the non-point type, which has more to do with local impacts. In this case it has to do with faecal coliform. In a LVEMP report by Mnyanga and Semili (undated) on faecal coliform it is reported that in areas where the population growth rate is high and there are no facilities for wastewater treatment faecal coliform bacteria can be found in high levels. Faecal coliform bacteria are found in the faeces of humans and other warm-blooded

animals and these bacteria enter water bodies such as streams, rivers and lake through direct discharge, failing septic systems, from agricultural and storm runoff carrying wastes from birds and mammals and from human sewage discharged into the water. This is precisely the situation that was observed in the field. The survey could not determine the actual levels of pollution, but it would be expected that in the inner shore areas the faecal coliform levels would be high but would decrease as one moves out due to backflow dilution by the lake water.

A differing opinion however, is offered by another study. According to the Integrated Water Quality/Limnology Study for Lake Victoria (2002), waste water pollution from the rural population is regarded as non-point pollution, and as there are no sewer installations and the wastes mostly infiltrate into the solid, the waste water that discharges to water recipients must be considered as vary limited. However, it notes that the National Water and Sewerage Corporation conducted a separate investigation of the fishing villages in September 2001. Uganda has between 600 and 1000 fishing villages of various sizes on the shores and island of lake Victoria. The populations of these villages is estimated to be between 144,000 – 600,000. The report concludes that lake pollution around the fishing villages mainly represents a local public health issue and possibly not an overall pollution problem for Lake Victoria. In a situation where the populations around the lake are growing rapidly, and with no controls, the situation is likely to affect the fisheries industry itself, as it did in the recent past.

3.0 Peoples attitudes towards riparian resources

The people interviewed were asked to suggest their opinions regarding their perception of the state of the physical Lake Environment. The responses provide an interesting insight into what are the local concerns and priorities. The responses are wide and varied (table 12) but can grouped as follows:

The people who felt that there is something really wrong with the lakeshore environment and were concerned about it (n= 831) and they were asked whether they had anything to say regarding the situation. A wide array of responses followed. What is interesting however is that the most common concern was the lack of toilets and facilities for ablution. This was seen as the major cause of lakeshore environmental problems, mostly

related to health (30%). Perceptions about the over-extraction of vegetative resources were generally low and this is perhaps not so surprising.

Table 12. Perceived causes of environmental degradation

Do you have any opinion regarding environmental degradation in the riparian area?	No.	**%**
Pollution and disease is caused by not using toilets	200	**22.6**
Low level of education (is responsible for a lot of pollution)	161	**18.2**
N/A	92	**10.4**
BMUs have helped improve lake environment (positive effect).	90	**10.2**
Fishing using poison	86	**9.7**
Disposing solid waste	82	**9.3**
Cutting of trees - deforestation	53	**6.0**
Pollution and disease is caused by washing in lake	49	**5.5**
Disposing fish waste in lake	18	**2.0**
Contaminated water (lead to water bore diseases)	14	**1.6**
Water hyacinth	13	**1.5**
Cultivation on hill slopes (soil erosion)	8	**0.9**
Rapid expansion of unplanned settlements	5	**0.6**
Destruction of wetlands	5	**0.6**
Agrochemicals pollution	4	**0.5**
Burning of vegetation	3	**0.3**
Nile Perch is eliminating other fish species	1	**0.1**
Do you have any opinion regarding environmental degradation in the riparian area?	884	**100**

Medard et. al. (2002) for example note that traditionally the Wasukuma, who form a greater part of the wider interviewed community are not good conservators of resources. Perhaps what is really valid here is the attitude towards common property resources rather than simple traditions. What is interesting is that about 10% of the respondents claimed that Beach Management Units had helped improve the physical environment. Although the percentage is low, it has to be compared against to number of BMUs in existence because not all villages have BMUs and the fact that somebody at least acknowledges their roles despite their shortcomings.

When asked about activities and people who they felt to be responsible for environmental degradation around their areas, (table 13) fishers and traders who disposed of human waste into the lake were mentioned as the most common culprits (31%). Illegal beach seining and poison fishing came next (19%) followed by the felling of trees for timber and energy. Other groups of polluters include lakeshore cultivators and fish processors.

Table 13. Activities and people responsible for degradation

Which activities and people are most responsible for environmental degradation in this area	No.	**%**
Fishers and traders dispose of human and other waste in the lake and bushes	239	**37.9**
N/A	146	**19.1**
Illegal beach seining and poison fishing	94	**12.3**
People who bathe in the lake	45	**5.9**
People who fell trees for energy and timber	43	**5.6**
Lake shore cultivators	41	**5.4**
Women who process the fish	33	**4.3**
There are no problems	28	**3.7**
The rains wash down waste from the hillsides	13	**1.7**
Vehicles that come to collect fish pollute the area	12	**1.6**
Low levels of education and knowledge of the environment and irresponsible health officers	11	**1.4**
Haphazard constructions of housing	6	**0.8**
Extracting rocks from the lake	2	**0.3**
	763	**100**

Socio-economic factors leading to environmental degradation

From the preceding sections a number of observation are evident. On the one side there is the poverty-environmental resources and livelihoods nexus that is the driving force behind the exploitation of the lake resources staring from fish to bio-mass. This, for the large part affects the millions who obtain livelihood around the whole Lake. Linked to this is the apparent failure of agriculture and the growing land shortage in the lake basin. The growing unpredictability of weather is further aggravating the situation.

On the other side, there are those who see the potential of the lake and its resources, as an opportunity for generating considerable wealth, such as the fish factory owners, the large fishers with fleets of boats, transporters and many others. Furthermore the demand for fish, internally and internationally adds pressure on the resources. The combination of the two, under a situation of poor management authority over the lake resources has lead to and will continue to lead to considerable environmental degradation. The natural resources utilization model in section 1 explains this situation.

4.0 Recommendations and areas for action

Based on the finding of the field study, several areas for action are identified. While many of these areas can be linked to the current process of developing, reshaping and providing greater responsibilities to Beach Management Units (BMUs), there are areas that will need the cooperation of other actors, at village, sub-national and national levels, other than, but linked to the LVEMP. In areas where Beach Management Units are in place and functioning well, many of the problems cited and indeed potential problems are reduced and even eliminated. These however are few and far between, and there are lessons for replication.

What is important here is to note that where and when its works, the concept of BMUs is a positive one and considerable work needs to be done to make sure that they are owned by local communities, provided with technical and legal support, and gain widespread acceptability. It is important that individuals in BMUs are responsible and rewarded for their good work. BMUs must be formulated carefully, provided with the correct support by local authorities and LVEMP and at the right time. Having said this, many of the BMUs visited are enjoying some of this support but given the challenges and opportunities much more work is required for the near future. Most BMUs visited had commenced with a number of encouraging and successful environmental management activities and but this is just the start. Given the environmental management threat that exist, more needs to be done urgently. Following is a summary of the areas that need urgent attention.

The perceptions and interactions of local communities on wetland resources and other terrestrial, marine and avian biotic resources are generally poor and discouraging. Generally fishers and other people settled within the riparian areas perceive such resources as infinite and give them little value. Moreover many of the incoming populations typically perceive their existence in their respective riparian areas as only temporary, and behave accordingly with respect to the use and abuse of lakeshore and even lake resources. This is a serious threat to the existence let alone the sustainability of local biodiversity and biotic resources that form a critical base for the ecology and local livelihoods. It must also be noted that the behaviors of the poorer sections of the community and those that are richer have different motivations for resource use, but the

outcomes are the same. The only difference is that in the longer term the poor are left even poorer and more vulnerable to risk, while the rich can seek out other options locally, or elsewhere.

According to local forestry officers in all districts visited and through simple general observations, forest and woodlands resources in the immediate area surrounding the lakeshores, are on the decline. Boat construction and domestic energy needs (heating and cooking and fish processing) are largely responsible for this, but historically so is clearing of land for cultivation and livestock keeping. With the forest cover loss; there is also the loss of rich indigenous species of plants including trees, shrubs and grasses. Forest resources are being exploited to meet demands arising from fisheries, fish processing, and construction of human settlements and for domestic and traditional industrial needs. Exploiting these resources is not necessarily a bad thing, but when it is done in a haphazard and unsustainable manner, many short and long-term problems emerge e.g. widespread ecological changes and the eventual shortage of timber, building materials, wood fuel and threats to many livelihood dependent on these resources.

This implies that LVEMP and other stakeholders must put greater emphasis on the sustainable utilization of wood resources in the area. Equally important there is also the need to conserve local plant biodiversity, that is currently being sought for bio-energy and building materials or being lost through land being converted into agricultural uses. Considerable work is required with local forestry authorities to encourage afforestation and particularly through the 'ngitili' system, in which local communities plan for and implement forest and land conservation.

The management and utilization of woodland and forests within the Lake Basin needs to be given priority. This calls for inter-institutional linkages, between district authorities, Forest and Beekeeping Division, LVEMP and villages. Much as though extraction of timber is seen as a problem, it should also be seen as an opportunity. Sound management of forests and woodlands, means extending the ability to supply the demand for boats and humans settlements and other wood uses, timber and non-timber, for energy and many other uses within the lake area. LVEMP together with the Forestry and Beekeeping Division must as a matter of urgency conduct a study focusing on monitoring the

utilization of wood for boat building, other construction, fish processing and domestic energy in all lakeside settlements. It is also important to attempt to assess the depletion of trees around the lake basin over a longer period (e.g. using satellite imageries). This will give a more accurate trend over time and will allow for extrapolations, if the current trends are permitted to continue unabated.

Linked to this is the need for the introduction of energy saving stoves and kilns for fish processing. These have been particularly successful in some marine areas of West Africa, and such measure must be introduced in Lake Victoria too. This also includes more efficient solar drying methods.

Boat building and repairs need to take into account that much of the locally available hardwoods are on the decline and more judicious uses of these resources need to be considered. Thus LVEMP working with boat builders and the BMUs need to look into alternative types of boat construction that will minimize demand for local timbers. The objective should be to construct boats with a longer life span, make them affordable and easy to maintain. This could mean better boat building skills as well as maintenance of the boats so that they can last longer.

Riparian settlements are numerous and will continue to grow. LVEMP together with local authorities and working with BMUs will have to come up with land and resources use plans and regulations for riparian settlements. On the sea and ocean shores, the existing regulation from the Ministry of Lands and Human Settlements need to be enforced and implemented. On Lake Victoria many of these regulation are clearly not being adhered to. The challenge is to make use of both existing legislation (through awareness and enforcement) and create local by-laws that will protect the riparian areas. This is a legal and institutional challenge.

The growth of human settlement cannot be allowed to proceed spontaneously. Some guidelines will need to be developed regarding the management of growth of such areas. These guidelines need to be developed, adopted and supported by appropriate legislation. The guidelines, for example will want to determine the location and uses of public places such as bars, hotels, temporary fishing camps and other similar services. In areas where fishing camps are often located by local communities and fishers must construct and

make use of toilets. This can be done in conjunction with local authorities, LVEMP and the BMUs. For larger settlements, perhaps it is time for LVEMP and the Ministry of Lands and Human Settlements to come up with appropriate regulations for lakeside areas.

Linked to the preceding point is the construction of latrines and other waste disposal facilities. In different areas, pit latrines can contaminate ground water up to 40 meters in either direction. This means that such facilities need to be more than 40 meters near any water facilities that are for human use. This is yet another objective that LVEMP and the BMUs will want to follow up on. Information for the safe location and construction of affordable latrines need to be made available, but also enforcement of regulations that protect human health is urgently required. The scarcity of latrines and their use needs special attention through both environmental education and using by-laws.

Much of the geology of the area poses difficulties in some area for the construction of pit latrines. Studies will have to be done to seek practical solutions for such areas and the results disseminated quickly. This is one area where LVEMP may want to work closely in conjunction with University Collage of Lands and Architectural Studies (UCLAS) and the Building Materials Unit (agency) of the Ministry of Lands and Human Settlements, but also could work closely with NGO's such as Plan International, who have experience in such matters.

The interaction between riparian communities and the biodiversity of the lake, especially trees, shrubs and grasses, such as those found in wetlands is a contentious issue. The short-term socio-economic implications appear to be attractive, i.e. more land, more grazing areas, more agricultural output and more bio-energy. The medium and long-term impacts are more profound as fish breeding areas for particular species are drastically reduced; various plant, animal and bird species together with the various wetland ecological functions are lost. The identification of large and most significant areas for conservation has commenced, but equally important is important to identify even smaller local wetland areas and conserve them. A critical balance between immediate economic gains and longer-term ecological functions has to be realized. Thus the wetlands component will need to also devise a sub-component on smaller wetland areas.

Local communities have become considerable ‘diluted’ with the arrival of new populations and so are local rules and norms. Many are not being adhered to as settlements have become more ‘cosmopolitan’ and areas where once upon a time traditional practices that protected areas of important biodiversity and ecological functions existed, are no more as such traditions and taboos are already on the wane and difficult to enforce. Most people do not appreciate the ecological and indirect economic values of wetlands. This is the same attitude as that prevailing with other common pool resources such as fisheries. Although there are on-going efforts at making local communities understand and appreciate the values of wetland resources, it is important that these efforts are expanded and sustained over the longer-term period. A combination of education and enforcement is required.

While existing and new local legislation is being advocated in protecting such areas, mechanisms for granting rewards (benefits) for protecting such areas need to be considered. Thus economic instruments (incentives) need to be applied to areas that have well protected wetlands. The payments can be based on a combination of area and existence of certain indicator species of marine, terrestrial and avian species linked to the wetlands.

Riparian land and resource use plans will need to be formulated for the whole shoreline area and local legislation drafted and enacted to support these plans. The plans must consider the issues of riparian agriculture, the protection of wetlands and the waters of the lake. Such plans will also have to look into the design and managment of human settlements in riparian areas. The plans must be drafted with the participation of local communities.

Much as though traditions and taboos are perceived to be difficult to change, the riparian areas are undergoing change anyway. Thus LVEMP, local authorities and the BMUs need to take advantage of this process of change and advocate for changes in some inappropriate local taboos and practices that are destructive to the lake physical environment. In many of the large villages on the lakeshore and islands, one common entertainment facility is the television and videocassette player. The owners hold public shows and people pay for them. Moreover, local TV and radio stations now cover much

of the lake region. LVEMP will need to design simple and very well made programmes addressing current and new environmental management issues and how they link to poverty reduction and local livelihoods, and have them aired frequently. In addition to that several videocassettes can be distributed to the people holding such public shows. There should be environmental education campaigns aimed at school children, the next generation of resource users in the area.

Basically the issue of general environmental education both in terms of the individual and his/her health and the immediate physical environment and well as the individual and the environment in terms of the livelihood connections need to be made. This can and should be done first through the formal schooling mechanisms from primary to secondary and teacher education, through school and village demonstration units. Secondly such initiatives should also target the young and economically active population that is out of school. Such initiatives can link into other existing and new initiatives around the lake.

LVEMP with the appropriate authorities will need to focus on the health impacts of pollution but also quickly focus on looking into and acting on the implications of HIV in the riparian areas. Here there should be efforts made at linking with many on-going initiatives, but with special focus on fishers and the communities that they interact with. The analogy here is the behaviour of miners.

The socioeconomic implications of continued pollution and contamination by and through riparian settlements and activities within these settlements must be checked. If pollution and contamination rates continue unabated, a repeat of the ban on Lake Victoria fish is imminent with disastrous result on local livelihoods. LVEMP and local authorities with BMUs need to act on this as a matter of urgency. Lake Victoria's Nile perch fishery generates as much as $400 million in export income (the whole lake), during the last fish ban lasting for a few months, the local economies almost ground to a halt. The lesson is that for fish exports to thrive local health and hygiene issue must also be dealt with.

The final issues is one that threads through most of the findings and recommendations and that is the urgent need to make serious reinvestments of part of the revenues collected from various economic activities. These must be used to mitigate and improve the threats

that are occurring on Lake Victoria, in short these are the resources required to maintain the productivity of Lake Victoria.

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Appendices

Appendix 1.Types of wood commonly used for boat making (1999-2000)

Scientific name	Local name	Frequency	Percentage	Family
Pterocarpus angolensis DC.	Mninga	291	57	Papilionaceae
Maesopsis eminii Engl.	Muhumura, Mhumula, Msila. Misi	74	14.8	Rhamnaceae
Albizia gummifera (J.F.Gmel) S.A.Sm.	Myenzeyenze	70	14.0	Mimosaceae
Eucalyptus saligna Sm.	Eucalyptus saligna	18	3.5	Myrtaceae
Brachystegia spiciformis Benth.	Mtundu	8	1.6	Caesalpiniaceae
Commiphora africana (A.Rich.)Engl.	Miboyo	7	1.4	Burseraceae
Pinus caribaea Morelet	Cypress	7	1.4	Pinaceae
Afzelia quanzensis Welw	Mikoba. Mkola, Mholo Mihororo	6	1.2	Caesalpiniaceae
Milicia excelsa (Welw.)C.C.B.	Mvule, Mivule, Miboyo	6	1.2	Moraceae
Pericopsis angolensi s(Bak.) van Meeuwen	Mburumatare	5	1.0	Papilionaceae
Acacia tortilis (Forsk.)Hayne	Mianvuli	3	0.6	Mimosaceae
Acacia polyacantha Willd.	Mitundu	2	0.4	Mimosaceae
Commiphora ugogensis Engl.	Mpodo	2	0.4	Burseraceae
Phragmites mauritianus Kunth	Matete	2	0.4	Gramineae
Psychotria mahonii C.H.Wright	Msaragina	2	0.4	Rubiaceae
Syzygium owariense Benth.	Migege	2	0.4	Myrtaceae
Albizia versicolor (Welw.)Oliv.	Mkimbu	1	0.2	Mimosaceae
Cedrela mexicana M.Roem.	Msadlela	1	0.2	Meliaceae
Grewia mollis Juss.	Mpewele	1	0.2	Tiliaceae
Pterocarpus tincorius Welw.	Minginga	1	0.2	Papilionaceae
Sorindeia madagascariensis DC.	Mpilipili	1	0.2	Anacardiaceae
Tamarindus indica L.	Msima	1	0.2	Caesalpiniaceae
Terminalia cericea DC.	Mikimbwi	1	0.2	Combretaceae
Trichilia emetica vahl	Mtondoo	1	0.2	Meliaceae
		513	**100**	

Appendix 1. The Survey Instrument.

Name_____ **Occupation**_____

Name of beach_____

District_____

Region_____

Questionnaire

1. Do you process your fish prior to marketing?
2. If yes, how do you process the fish?
3. What type of energy do you use?
4. How much of this energy do you use, per day, ….., per week…, per month….?
5. Where do you obtain this energy?
6. How much do you pay per unit?

(Either in number of logs, measure or equivalent cost in case of firewood)

7. On average, how much fish do you process, per day? …. Per week? ……per month? …….
8. *How much energy of this do you use per fishing day?
9. On average how much income do you earn resulting from fishing, per day…, per week…, per month…
10. Is this sufficient for you ? 1.Yes [ ] 2. No [ ]
11. What kind of fishing gear and craft do you use for fishing?
    - Type and capacity of fishing craft_____
    - Type and size of fishing net, rod etc._____
12. What material is the fishing craft made of? _____
13. Where do you get the material for construction of your fishing craft(s)? _____
14. How do you get the materials for the construction of your fishing crafts?
15. Approximately how much material do you use in constructing a fishing craft of your capacity? _____
16. How much does this cost you?_____
17. How long does the craft last before you need a new one?_____
18. How long have you been in this area (lake area)? years _____
19. Can you describe the condition of the forest (in size and condition) when you first settled in this area?_____ _____ _____

20. Is the condition still the same? 1.Yes [ ] 2. No [ ]
21. If not, what are the changes?_____
22. What do you think has caused these changes? _____
_____
23. What other activities apart from fishing do you practice in the lake catchment? _____
_____
24. (a) If agriculture, how many acres do you have?
    - What crops are you cultivating?_____
    - Which implements do you use ?_____
    - Which inputs do you use?_____

    (b) If livestock keeping,

    - state type of livestock kept_____
    - indicate rough estimates of stock sizes_____
25. Is fishing the main activity to you?_____
26. If not, what is your main activity?_____
27. What other benefits apart from fishing do you get from the lake?
28. Do you have a toilet? 1. Yes [ ] 2. No [ ]
29. If yes, what kind of toilet do you have?
    a) pit latrine [ ]
    b) flush toilet [ ]
    c) others (specify)_____

30. Where is your toilet's drainage system directed?_____
31. Where is your domestic drainage system directed to?_____
32. How do you dispose of waste /remains resulting from fish processing?
33. How do you dispose of domestic waste?

- **NB:** investigation on the socio-economic factors leading to environmental degradation and the actual impacts will also be done using PRA and Participatory Observation Approaches.

  Likewise examination of the degradation of the environment through the lack of sanitary/ waste processing and disposal facilities will involve the same methods.

Appendix 2.

Background to the Model

Despite the growing recognition of the important linkages between population and the environment, our understanding of exactly how these linkages operate is still rather limited. It is generally assumed that human populations and their activities cause environmental change and that environmental change in turn affects the quality and condition of human lives, but the specific details of these interactions are still largely speculative.

Theories and models are simplified explanations of how reality works and are designed to enhance understanding. How theories evolve depends on what aspects of reality the proponents of the theories are most concerned about, and in a sector as diverse as the environmental sector, interested parties range from natural to social scientists. Even within social science for example, consensus within different disciplines is difficult to obtain. Economic theories of human–environment interactions with a neoclassical perspective focus on humans as economic actors, tend to ignore other ways in which humans can act and interact, such as through politics and culture. Theories in general, represent only partial images of reality. Theories of human–environment interactions are particularly sensitive to this problem, and for example, given the large number of disciplines that are relevant to the range of environmental issues pertaining to resource use and population around Lake Victoria, there is no single theory that can as yet explain or represent the complete situation occurring there.

Models, in contrast are efforts to turn general theoretical concepts into more precise relationships or mathematical equations. Models of human–environmental linkages help explain and evaluate how various population or environmental attributes might affect each other. A model of how population growth and distribution in a region might affect future water quality would be useful for those interested in water resources, or a model of how the population in an area might be affected by contaminants discharged into local rivers would be useful to regulators. Models can also help determine how to respond most effectively to various demographic or environmental issues. For example, if the aim is to maintain future water quality in an area, a model of the relationship between human

activities and water quality might help determine what responses would most effectively achieve that goal.

Three levels of modeling used to develop an understanding of human–environment interactions have been described by Machlis and Forester (1992). The first level involves developing a *theoretical framework* – or theoretical perspective – for the system. A theoretical framework provides a broad description of the system designed to identify key variables of importance, such as the aspects of human populations or the environment that are most key to understanding their linkage. On this level, the idea is to capture an overall picture of the system. The second level of modeling involves extending a theoretical framework into a *conceptual model.* Conceptual models start to indicate not only what variables are important, but how they are related (which variables affect other variables and in what direction). Finally, the third level of modeling includes refining a conceptual model into a *predictive model.* Predictive models are designed not only to indicate how variables are related, but to specify those relationships with enough detail to support predictions of future outcomes.

The following sections first discuss some of the major theoretical frameworks or perspectives being used by researchers to understand population–environment linkages.

Some Key Theoretical Frameworks

Population–environment interactions have been studied from different perspectives by a range of disciplines. Economists generally focus on how natural resources and other environmental attributes affect the human economic system. By contrast, natural scientists generally emphasize how humans – as "outside" forces – affect the natural environment. Geographers take more of a middle road, and look at patterns of interaction between humans and the landscapes in which they live. Interestingly, demographers – who study the dynamics of human population systems – generally give little attention to the relationship between populations and the environment. Formal demography has traditionally focused on the sociological conditions of demographic change (e.g., the sociology of reproduction). Little examination of the environmental causes or consequences of demographic change has occurred.

However, in the last few decades, demographers have begun to join other researchers, including economists, geographers, sociologists, and natural scientists, in articulating more precise theories of the relationship between populations and the environment. Carole Jolly (1993) provides an outline of four major theoretical frameworks – which she refers to as "perspectives" – that inform the study of human–environment linkages, each of which brings a different perspective on the role of population growth in the equation. Although her focus is on the issue of environmental degradation (specifically land degradation), the general perspectives are relevant to other issues of human–environment linkages.

Neoclassical Economics Perspective

The neoclassical economics perspective holds that environmental degradation is a result not of population pressures per se, but of economic inefficiencies and distortions of the market. This perspective holds that such things as common property arrangements such as fishing grounds or agricultural pricing policies give the wrong signals to people, leading them to misuse resources. With properly functioning markets, prices will provide appropriate signals to people regarding resource use.

Population growth is seen as a neutral factor in the cause of environmental degradation, and indeed increased population may lead to increased innovation, which in turn can act to minimize environmental impacts of humans. For neoclassical economist, allowing markets to function properly is the most important means to ensuring environmental protection.

Natural Science Perspective

The natural science perspective holds that the environment does not have an unlimited ability to meet human demands, and that growing populations will at some point reach those environmental limits. A common theme within this tradition is that each region or area – as well as the earth as a whole – has a natural carrying capacity for sustaining human populations, which cannot be exceeded in the long-term without negative consequences. Population growth is seen as a main source of environmental degradation, inasmuch as additional people will consume additional amounts of fixed resources. As a result, population control is an essential element of efforts to protect the environment.

Political Economy/Dependency Perspective

The political economy or dependency perspective shifts from a focus on economics or the environment, to a focus on political relations between people and nations, with an explicit emphasis on developing countries. This perspective holds that poverty and the unequal distribution of resources are the root causes of both environmental degradation and population growth. The historically exploitative relationship between developed and developing countries has led to inequitable distributions of power and resources among the developing countries' populations.

According to this perspective, the key to solving environmental degradation is to change political systems and alleviate poverty (e.g., promote income equality and resource redistribution). Reducing poverty (income and non-income poverty) will also have a direct effect on reducing population growth (i.e. increasing education and reducing fertility).

Combination Perspective

This perspective represents a melding of the other three perspectives. The combination perspective holds that there are a series of ultimate causes of environmental degradation that may be at play in a given area, including poverty, social relations (e.g., conflict), distortionary economic or political policies, and polluting or inadequate technologies. Population growth is therefore not the root problem, but tends to aggravate these more basic root problems.

According to this perspective, ensuring environmental protection will require identifying, on a case-by-case basis, the ultimate drivers of degradation. Meanwhile, attempts to control population growth will provide some interim reduction in the level of environmental impacts.

Although these four theoretical perspectives or frameworks are generally well developed in the literature, a significant problem is a lack of empirical evidence to test each of them i.e. the general lack of "on-the-ground" research on the links between population and the environment. Compared to the public attention it attracts, and to the general philosophical writings found in the literature, several researchers have commented on the dearth of specific studies that more closely examine the problem (Barlow et al., 1992; Davis, 1991;

Stycos, 1993; Jolly, 1993; Population Resource Center, 1992) and in the Lake Victoria Basin, such a situation exists.

Although the four theoretical perspectives presented by Jolly are as yet generally untested or only partially tested, there are elements of each that can inform environmental policy. Indeed, as Jolly (1993, p. 39) has stated, "Although these theories present very different world views, they are not necessarily mutually exclusive. Each one presents a partial picture of why [environmental] degradation occurs." Taken together, they suggest that attention to population growth and distribution, changes in technology, the sensitivity of a particular landscape, economic conditions, institutions, policies, and cultural factors may all be important to a greater or lesser degree in any particular situation.

As a practical matter, policy makers and others involved in human–environment issues may be best served by having a broad sense of how these models support understanding in this area. For example, the human ecology POET model is a broad, conceptual model that serves to bring to the forefront such ecosystem-level issues as energy demands and carrying capacity; meanwhile the IPAT model focuses on the act of pollution generation and serves to detail – in a simplified manner – some of the drivers relevant to pollution.

By and large, the models developed to date on population–environment linkages have been more oriented towards *broad conceptual models than to actual predictive models* that would support decision making. Currently, however, there are increasing efforts to develop mathematical models for specific components of the population–environment linkage. For example, Machlis and Forester (1992) are currently testing a predictive model they developed to analyze the relationship between socioeconomic factors and the loss of biodiversity. Meanwhile, several models have been developed in the global change arena to model the interconnection between population and environmental variables.