Joseph L. Awange and Obiero Ong'ang'a

Lake Victoria

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Ecology, Resources, Environment

With 83 Figures

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AUTHORS:

PROF. DR. ING.
JOSEPH L. AWANGE
DEPARTMENT OF
ENVIRONMENTAL SCIENCES
MASENO UNIVERSITY
P.O. BOX 333
MASENO, KENYA

E-mail: jawange@yahoo.co.uk

DR. OBIERO ONG'ANG'A
OSIENALA (FRIENDS OF LAKE
VICTORIA)
P.O.BOX 4580-40103
KISUMU, KENYA

E-mail:
oonganga@swiftkisumu.com

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For along time, Professor Oyugi Aseto and the authors had a vision of writing a book on Lake Victoria. Man plans but the final say lies with our Almighty GOD. Professor Oyugi Aseto passed away before the writing of the book commenced. This book is dedicated to him in recognition to his work on Lake Victoria. Indeed, he worked tirelessly on poverty issues affecting the lake and its environs. His contribution will be greatly missed.

Joseph L. Awange and Obiero Ong'ang'a
January 2006

Preface

Recently, there has been, and continues to be, a tremendous interest on Lake Victoria and its environs, both locally and internationally. A casual browsing on the Internet indicates that the entries on the Lake have been rising phenomenally. At the same time, the issues discussed are as diverse as they are varied in their treatment of the subject, both in terms of depth and comprehensiveness. The information on Lake Victoria and its environ is scattered, isolated, and sometimes confusing even though documentation on the subject are available. Despite this situation, the fact remains that various people (e.g., secondary and university students, researchers, practitioners, etc.,) would like to access and know more about the Lake and its environs. Aware of the existing information gap about this world's second largest fresh water Lake, this book is intended to provide readers with up-to-date information pertaining the Lake.

The book gives an in-depth coverage of *environmental issues*, *resource endowment*, *poverty amidst plenty*, *development opportunities*, *challenges* and other related issues facing the Lake and its environs. It aims at providing information on the above variables, which hopefully will address the needs of various users. We have attempted to present the materials in a simple and straight forward way that will be understandable to undergraduate students as well as advanced researchers. Yet we are aware that most parameters of the Lake are changing rapidly. We have therefore attempted to provide as accurate and up-to-date information up to the time of publishing.

The motivation of this book derives from the ongoing local, national, region, and international interests in Lake Victoria and its surrounding areas. Different actors on the Lake have different reasons for their interest. While some of them are interested in solving some of the problems causing the deterioration of the Lake's environment, others are emphasizing the rich potential of the Lake and the opportunities that potentially exist for the development of the region, given the abundant resource endowment of the Lake and its region. Such interests on this wonderful Lake influenced to a great deal the recently held 11th World Lakes Conference which was held in Nairobi Kenya from 31st October to 4th November 2005. Prior to the World Lakes Conference, a pre-conference was held in Kisumu organized by Living Lakes with Global Nature Fund with the theme "*Our Lakes, our Livelihood*" between 26–30th October. This further underscores the importance of Lake Victoria as a Lake with vast endowment.

Despite these endowments however, the Lake faces a number of problems. Most important are the environmental degradation encountered as well as rampant poverty among the people in the region. In 1997, it was estimated that 63.1% of the people in Nyanza Province in Kenya, which borders the Lake, lived in absolute poverty. The region also registered one of the highest incidences of food poverty, at 58.2%, in 1997.

With serious economic deterioration since 1997, both relative and absolute poverty have increased to 67% in most rural districts in Kenya, especially in Siaya and Homa Bay Districts of Nyanza Province. The Kenya Government has labeled the Lake Victoria region of the country as a "*belt of poverty*". Other problems experienced within the Lake basin are:

- The suffocation of the Lake by pollutants from industries and factories which surround the Lake and are situated in towns and cities such as Kisumu in Kenya, Mwanza in Tanzania, and Jinja and Kampala in Uganda.
- Water hyacinths, which threatens survival of biodiversity within the Lake and its environs.
- The annual population growth rate in the region, estimated at 3%, is one of the highest in the world. The population density is currently at 350 people per square kilometer. This has posed a substantial threat to wetlands and water catchments e.g., the Nandi hills in Kenya.
- Unemployment.
- HIV/AIDs pandemic.
- Deterioration in the standards of education.

These problems have become a menace in the region, with the resultant social implications such as increase in food poverty, dependency ratio, degradation of the environment and increased crime rates.

Given the above negative factors and the importance of this Lake to the world in general, there is need for a comprehensive document which presents a total picture to readers who are unfamiliar with the Lake and its environs. At present and to the best of the authors' knowledge, no such comprehensive work has been produced on the subject. There are, of course, pieces of information here and there about the Lake region, but these are not consolidated in compendium source of information that can be readily retrieved on demand. Indeed, the authors have produced several OSIENALA (Friends of Lake Victoria) series on Lake Victoria. The present book consolidates and expands the previous work into a unified volume. It also reflects the International Lake Environmental Committee (ILEC, Japan)'s World Lake Vision which states[1]

> *The World Lake Vision is the result of a candid look at what is happening today to lakes around the world, whether natural or artificial, freshwater or saline, and what is likely to happen to them today if the current trend continues into the future. It recognizes the critical stage of many of these fragile, vulnerable, and often strikingly beautiful ecosystems. It seeks to convince people of the need to insure healthy lakes as a primary source and storehouse of the world's easily-accessible water resource, and a source of food and economic livelihoods, utilizing them in a manner that maximizes their sustainable use for humans and nature, while also preserving their quality and ecosystem integrity for current and future generation.*

This book attempts to provide the missing aspects by giving as much information as possible about the Lake and its environs, especially its natural resurges, opportunities that exist in the region, environmental, health conditions and poverty that prevails, therein. Further, the book gives simple lessons on community participation in management and suitable uses of resources. It is expected that the book will be a useful reference work for policy-makers, academicians, fishermen, and politicians in the East African region and beyond, as well as researchers in various fields.

[1] International Lake Environmental Committee and United Nation Environmental Programme, 2003: World Lake Vision. A Call For Action.

Chapter 1 introduces the book and provides a general introduction to the book. It is a motivation for those who may treasure interest in Lakes study and Lake Victoria in particular. Chapter 2 presents the background of Lake Victoria focusing on its origin, physical description and demographic issues. It opens the doors of the Lake to those unfamiliar with it. Chapters 3 and 4 gives a detail coverage of the Lake in-terms of resource potential. Chapter 3 looks at the resources within the Lake and its environs. Readers familiar with the background of Lake Victoria can move straight to this Chapter and skip Chap. 2. Chapter 4 presents a salient feature of the Lake and its environ. Its eco-tourism and its potential. It opens up the Lake and exposes its attractive features to the world for tourism purposes. For those keen on touring East Africa, Lake Victoria and its basin warmly welcome you. Through this chapter, you will get an insight on the Lake's prominent tourist attraction and cultural centers.

Chapter 5 departs from resource issue to present environmental issues pertaining to the Lake. Rather than adopting the normal convention, where the environmental issues are viewed only in-terms of pollution, *we adopt a slightly different style*. We first start by looking at the Lake's positive contribution to the environment before considering the environmental's contribution to the Lake. In this give and take approach, we felt that the *significance* of the Lake to the environment will be emphasized. The *highlight* of this chapter is the new and unexploited topic of pollution of the Lake from transportation sector and particularly the issue of car washing within the Lake's shores. Chapter 6 pays a visit to the World Bank's '*favoured topic*' of poverty. Before looking at poverty in the region endowed with plenty, the chapter begins by providing a definition of the concept of poverty and its measures.

In Chap. 7, economic development issues in the region are addressed. Chapter 8 discusses the rich wetlands endowment of the Lake, while Chaps. 9 looks at the management issues of the Lake. Chapter 10 considers the challenges facing the Lake and its environs.

The last chapter of the book departs from the rest of the chapters to discuss a modern and relatively new area applicable to Lake Victoria; the *application of satellites to the Lake*. The chapter introduces the now widely used GPS satellites and shows how they could be useful for *boundary conflict resolution* within the Lake. The applicability of GRACE satellites to monitor the Lake level is presented and the possibility to use GIS within the Lake to develop the Lake Victoria Information System (LVIS) is proposed.

The authors wish to acknowledge the hand of the Almighty GOD that enabled the grace, health and peace that enabled the completion of this book. The first author wishes to acknowledge the contribution of his undergraduate (third and fourth years of 2005) and graduate students of the Department of Environmental Studies, Maseno University. In particular, the author is very grateful to his MSc. student Mr. Benard Obera who collected the data that were used to analyze the contribution of transportation sector to the pollution of Lake Victoria in Sect. 5.5.

The present book would not have been complete without the support of various international partners. We acknowledge your efforts and valuable time. Special thanks to Prof. A. Kleusberg of Stuttgart University Germany, Prof. T. Tsuda of Radio Center for Space and Atmosphere, Kyoto University Japan, Dr. J. Wickert of GeoForschungsZentrum Potsdam (GFZ) Germany and Dr. A. Steiner of the Institute of Meteorology and Geophysics, University of Graz, Austria for the support in terms of literature and discussions on Chap. 11. The data used in Chap. 11 were provided by GeoForschungsZentrum Potsdam (GFZ). For these, the authors express their utmost appreciation.

The first author also wishes to express his utmost sincere thanks to Prof. S. Takemoto and Prof. Y. Fukuda of Department of Geophysics, Kyoto University Japan for hosting him during the period of September 2002 to September 2004. In particular Chap. 11 was prepared under the supervision and guidance of Prof. Y. Fukuda: Your ideas, suggestions and motivation enriched the book. For these, we say "*arigato gozaimashita*" – Japanese equivalent to *thank you very much.* The first author's stay at Kyoto University was supported by Japan Society of Promotion of Science (JSPS): The author is very grateful for this support.

Several renown scholars and organizations have contributed in one way or another towards the conservation and management of the Lake. We would wish to acknowledge this special input in making the Lake and its environ a better place. In this regard, we would wish to acknowledge the efforts made by the Late Professors Oyugi Aseto and Thomas Odhiambo. We appreciate the current efforts being made by Professors F. N. Onyango, Vice Chancellor of Maseno University and Erick Odada of START. Prof. Onyango has played a major role in transforming the

Lake side town into a University City. To his credit, Kisumu City boasts of the marvelous Kisumu hotel with conference facilities. Tourists and researchers in the region now have a place to rest. Prof. Odada's contribution to research on Lake Victoria stands out as some of the excellent pieces of work the Lake has received. Other reknown scholars who have contributed to the study and research of the Lake include Professor Herrick Othieno and Achola Pala Okeyo (Chairperson, Board of Directors, OSIENALA). to them we say, "*keep it up*". We would like to pay tribute to all other scientists, stakeholders, policy makers, NGOs e.g., OSIENALA, programmes, e.g., LVEMP, LVFO, EAC, etc., who have contributed in one way or another towards conservation of Lake Victoria.

Efforts made by our international collaborators Prof. Shinji Ide, Director of Koshu-Net, Mr. Udo Gattenlöhner, Executive Director, Global Nature Fund are highly appreciated. To the World Bank, SIDA, MS-Kenya, UN-HABITAT, UNEP, GNF, Living Lakes and all the other organizations that have been involved in supporting Lake Victoria, we say kudos! You are near the heart beat of the Lake.

The first author is grateful to Mr. Ken Owuor and his family for hosting him in Kampala Uganda, a period which the data for Uganda was collected. The first author wishes to thank his wife Mrs. *Naomi Awange* and his two daughters *Lucy* and *Ruth* who always brightened him up with their cheerful faces. Your support, especially family time that I denied you in-order to prepare this book is greatly acknowledged.

Kisumu (Kenya) — *Joseph L. Awange*
January 2006 — *Obiero Ong'ang'a*

Contents

1

Introduction

Of all the tropical's Lakes, Lake Victoria stands tall as the greatest fresh water body. In the entire world, it comes only second to Lake Superior. Within its surrounding, it directly supports a population of more than 30 million East Africa's inhabitants (i.e., $\frac{1}{3}$ of the combined population) while globally it is the source of Tilapia and Nile Perch. So important is the Lake such that Egypt and Sudan entered the Nile treaty for exclusive use of its waters. Just as oil is an important resource of the world, Lake Victoria and its environ plays a major role in the world such that it appears at the top of a number of lists as pointed out by [124]. Specific roles played by this Lake are:

(i) It is a source of fresh water that supports livelihood of people living within its shores. The water is used for drinking, domestic use, in industries, for transportation and sports among others.
(ii) It contributes to the river Nile, the lifeline of Egypt.
(iii) It is the habitat of Tilapia and Nile Perch, the two types of fish that are in great demand the world over together with other species of fish who reside in its waters.
(iv) Its wetlands provide homage to various bird species, insects and thus preserves biodiversity.
(v) Helps fight poverty by creating employment in fish industry and transportation for people living within its environs.
(vi) Acts as eco-tourism center.

The list could go on and on but we have chosen to mention only a few. More details on the functions of this great Lake will be addressed in detail in various chapters of the book.

Although the Lake and its environs boasts of such rich endowment, the fact of the matter is that it is a sick giant [43]. This has necessitated the establishment of several measures to help address the challenges faced by this dying Lake. Such measures include the establishment of Lake Victoria Management Environmental Programme (LVEMP) and other institutions which we discuss in Chap. 9.

The challenges facing the Lake include:

- Having as its dependants people who are faced with the health threat such as HIV/AIDs.
- Being infested with the deadly water hyacinth which is depriving it of oxygen and thus suffocating it.
- Facing people living in its surrounding languish in abject poverty although it is endowed with great resources.
- Consequences of decision and policies made in far parts of the world, i.e., ecological power, and more recently by global economic structure [43].

In general, The Lake faces three critical and mutually reinforcing problems. The first is *productivity*. The most important commercial species caught is Nile Perch. A predatory species, it has over time eaten to near extinction many species endemic to the Lake that were once important sources of food and livelihood for the local communities. The scramble for the catch has become the source of conflict between fishers from the different countries. Overfishing is attributed to the use of inappropriate gear and insufficient enforcement capacity. Open access and inappropriate exploitation increases the fishing effort against the diminishing reproduction rate. In addition, territorial boundaries tend to concentrate the fishing effort on a limited area especially in Kenya. Authorities lack the resources to effectively police the Lake.

The second set of challenges are
emphenvironmental, namely resource degradation emanating from catchment degradation and discharge of human, industrial and agricultural effluent The third set of challenges is *market related* and includes price competitiveness, quality assurance and reliability of supply. The principal export product Nile Perch, is under intense price pressure from aquaculture, in particular the new tilapia varieties. While the fishery has made substantial progress in meeting European (EU) standards, it has not yet attained the eco-labelling certification that is increasingly required by the retailers [75].

Owing to these overwhelming evidence of the importance of Lake Victoria together with its emerging threats, a comprehensive coverage is inevitable. As already mentioned, several scattered literature on Lake Victoria exists as can be evidenced by a search on the web. In recognition to the great role of Lake Victoria, Cari Meister wrote a book on it targeting primary school audience (see, e.g., [97]). That much is still not known about this Lake is captured by the controversy generated by the recently launched "*Darwin's Nightmare documentary*"[1]. The Standard Newspaper of 14th December 2005 writes

> An award-winning documentary depicting Lake Victoria as a doomed resource has angered environmentalist. ...Experts believe the film, yet to be shown in East Africa, suggests that poverty, prostitution, HIV/AIDs are consequences of greatest gain of the Lake; fishing....

Such controversy are a clear manifestation of Lack of proper information. In this pioneering book, we recognize the gap caused by lack of a comprehensive book that can be used by secondary school level students, university students and advanced researchers. This book is presented in a simple way to meet the needs of all these users.

[1]Experts protest over film on Lake Victoria by Harold Ayodo: The Standard Newspaper, Wednesday 14th, December 2005

2

Background of Lake Victoria

"Lake Victoria is a living Lake. From Kisumu (Kenya) to Mediterranean, millions of people are being fed by it!"—Pastor Martin Mbandu, Kisumu Pentecostal Church.

2.1 Features of the Lake and its Environs

2.1.1 The Origin

It is important to know, for historical and scientific purposes, the possible origins and age of Lake Victoria (Fig. 2.1 in p. 7)[1]. How old is Lake Victoria? How did it come about? Has it changed much during its existence? If so, how? Why should we be interested in knowing the age of Lake Victoria? These are some of the pertinent questions, which have occupied the attention of scientists for centuries; and rightly so. The origins and age of the Lake are still shrouded in deep mystery. Although scientists have grappled with these questions, no definitive answers have been forthcoming. As it is, the origins of Lake Victoria are still the subject of scientific dispute [4]. It seems likely that it is much more recent in its origins than the other great Lakes of Eastern Africa. But there is an interesting aspect of the direction of flow of waters into the Lake. There is a scientific contention that many of the rivers now flowing east into Victoria (including Kagera) once flowed west.

Hickman et al. [61, p. 36] suggests that Lake Victoria was formed due to warping and tilting of the land. They note that lower reaches

[1]Source: Tourist Map (K) Ltd

of some river valleys have been raised, so that they flooded, and the directions of the rivers changes. At least in the Miocene, Pliocene, and part of the Pleistocene eras (within the past 2 million years), possibly eventually into the Nile system. A more recent upthrust of the western side of the basin is thought to have however reversed these rivers, and caused Lake Victoria to form by flowing eastwards [4]. Although Fuggle [43] suggest that the Lake formed sometimes during the last 400,000 years, Aseto and Ong'ang'a [4, 119] have suggested the possibility of the Lake having formed as recently as 25,000 to 35,000 years ago and dried up completely between 10,000 and 14,000 years. Samples of Earth taken from the bottom of the Lake corroborate this suggestion by indicating that the Lake may have temporarily but completely dried up 12,000 to 14,000 years ago. But this suggestion raises a host of other questions. For instance, *what happened to make the Lake dry up? What happened to make the dry Lake become a freshwater Lake? Could it dry up again in the future?* In attempting to address the issue of the drying of the Lake, Johnson et al. [68] suggest that the Lake probably dried up entirely about 15,000 years ago due to climatic phase of extreme dryness. Be that as it may, some scientists maintain that tectonic movement that swept across the Eastern African plateau about 14,600 years ago caused the formation of shallow basins which filled with waters to become what is today ***Lake Victoria***. However, Some unresolved issues requiring further research include:

- Resolving the age of Lake Victoria since the conflicting explanations as to the age of the Lake still persists.
- Using satellite techniques (see, e.g., Chap. 11) to resolve the issue of fluctuation of the Lake's level and establish the changes in water stored within its catchment and drainage.
- Finding out whether the Lake can die under stress, as was supposed to have happened thousands of years ago?
- Establishing whether the Lake is getting deeper or shallower with the passage of time and also whether it is expanding or decreasing, thus increasing or reducing its area of coverage.
- The Lake's parameters e.g., length, area, etc., vary according to various authors as will be seen in Subsect. 2.1.2. Use of satellite techniques discussed in Chap. 11) can resolve this once and for all.

Fig. 2.1. Map of Lake Victoria

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2.1.2 Physical Description

Lake Victoria is the largest freshwater Lake in Africa (also largest tropical Lake) and the second largest in the world after Lake Superior in the United States. The Lake is also the largest in the developing world. Its surface area is approximately 68,635km^2. Its greatest length is about 400km[1] and its breadth is about 320 km[2]. The shoreline is very irregular and totals some 3,300km in length. Hughes and Hughes [63] have put the shoreline close to 3,500km in length. The shoreline on the Kenyan side is 760 km. It contains about 2,760 cubic kilometers of water with an altitude of 1135m above mean sea level. Much of the Lake is relatively shallow, reaching a maximum depth of about 80m

[1] Other sources: put the length at 337 km - Britannica Concise
[2] Other sources: put the length at 240 km - Britannica Concise

(Fuggle [43] puts the figure to 85m), and an average depth of about 40m; the deepest zone (60-90m) [5] lies toward the shore.

Because the Lake is shallow, its volume is substantially less than that of other Eastern African Lakes with much smaller surface area. The volume of Lake Victoria's water is only 15 percent of the volume of Lake Tanganyika, even though the latter has less than half the surface area. There is little annual variation in water temperatures, the mean surface being about 24°C and that of deeper water at 23°C. The Lake straddles the Equator and touches the Equator in its northern reaches. It is shared by Kenya (6%), Uganda (45%) and Tanzania (49%). The Lake's shoreline is long and convoluted, enclosing innumerable small, shallow bays and inlets, many of which include swamps and wetlands, which differ a great deal from one another and from the Lake itself.

The ***shoreline*** is comprised as follows: 17% in Kenya, 33% in Tanzania and 50% in Uganda. Of the total catchments area of 193,000 km^2, Burundi accounts for 7.2%, Kenya 21.5%, Rwanda 11.4%, Tanzania 44.0% and Uganda 15.9%. The entire drainage basin covers an area of 258,000km^2. The Lake is also the source of the Nile, the world's second longest river after the Mississippi river in the United States. The Lake's main physical parameters have been summarized by [14] in Table 2.1.

The climate of Lake Victoria catchment area is mild with small variations in monthly average air temperature between 19°C and 25°C throughout the year. Daily temperature fluctuates more widely, ranging from 15°C to 30°C. Rainfall in this catchment area averages about 1,300 mm annually, varying from 2,000 mm in highlands to 1,000 mm in the north, southwest and lowlands along the Lakeshore. Rainfall exhibits a bimodal pattern with long and short rainy seasons in the period of March to June and in October to December, respectively. There exists no remarkable dry months.

2.1.3 The Name "Lake Victoria"

We elaborate in this section how the name Lake Victoria was coined. Is the name Lake Victoria a proper name for the Lake? What is in a name? Does a name matter? If so, how and why? From time immemorial, these questions have been asked over and over again, and in different contexts. The general answer is that giving a name to an entity is an

[5] 82 m - Britannica Concise

Table 2.1. Morphoedaphic Characteristics of Lake Victoria

Characteristic	Measure
Position: Latitude	00° 20' N to 03° 00' S
Longitude	31° 39' E to 34° 53' E
Altitude [m above mean sea level]	1134
Catchment Area [km^2]	184,000
Lake Surface Area [km^2]	68,800
Lake Area as Percentage of Catchment	37
Shoreline [km]	3,440
Maximum Length, North-South [km]	400
Maximum Width, East-West [km]	240
Mean Width [km]	172
Maximum Depth [m]	84
Mean Depth [m]	40
Volume [km^3]	2,760
Inflow [km^3/yr]	20
Outflow [km^3/yr]	20
Precipitation [km^3/yr]	114
Annual Fluctuations in level [m]	0.4-1.5
Flushing time [yrs]	138
Residence Time [yrs]	21

extremely important decision that people can make, in that, it is a means of providing an identity. A good name is given to a good thing; and a bad name is usually given to a bad thing. In the Luo language in Kenya, it is taken axiomatically that "Nying' ema ichiemogo" which is translated to mean one eats by the fame of one's name. It is for this reason that human beings name their children after important persons, or give their children the names of their parents and fore parents to maintain their genealogy, or after important events, or in honour of important events or entities. It is also the reason why human beings give names to animals, hills, valleys, and stars. And even at an advanced age, individuals can acquire new names. Some are given names such as "sibuor" (lion) in recognition of one's bravery, etc.

The inhabitants around the Lake have followed suit; they always had different names for the Lake. The Lake is also known as Victoria Nyanza. This appears to have been derive from the Basuba (a tribe in Kenya) name for the Lake: "Nyancha" or "Nyanja" by certain communities in Uganda. The Luos on the Kenya side call it "Nam (Namb) Lolwe" (endless waters). The Baganda in Uganda name it "Nalubale", the Sukuma in Tanzania call it "Sukuma Lake". This being the case, why then is the Lake called Lake Victoria?

The name *Victoria* is "foreign" in that it was named in honour of an individual in a foreign land. "Foreigners" had different names for the Lake. The Arabs called it *"Ukerewe"*. But an Englishman, explorer John H. Speke, stumbled onto its southern shore and proclaimed he had discovered the fabled source of River Nile in 1858. He was the first European to sight it and decided to honour Queen Victoria of-England by naming it after her. One recalls that during 1890s, Great Britain colonized Kenya and Uganda while the Germans had a stronghold of Tanzania's mainland in 1899. In 1875, an American journalist, Henry Morton Stanley, seeking to confirm Speke's claim and looking for the British missionary Dr. David Livingston, circumnavigated the Lake. He spent two weeks spinning tales of God and England to curry favour with Mtesa, king of Buganda and ruler of the northern Lake region. Then Stanley sent word back to England, calling for missionaries. They came with soldiers and traders. He popularized the name Lake Victoria in the Western world. And the name Lake Victoria has continued to-date.

Nevertheless, African countries around the Lake have not been content with the present name of Lake Victoria. Thus, soon after the independence of the three surrounding East African states of Uganda, Kenya and Tanzania, there were attempts to rename the Lake so as to give it a proper African name; but such attempts have not yet succeeded, and the name Lake Victoria has been retained. It may be just a matter of time before the Lake is given its rightful appropriate African name that would give its true African identity and character. After all, changing the name of the Lake from a 'foreign' tag to an African name should not be a problem. Several examples of name change abound in East Africa and elsewhere in the continent and in the world. In the case of Kenya, African names have replaced foreign names. For instance, upon the country's independence on December 12, 1963, all landmarks, monuments and streets in Kenya that bore foreign names were given local, or to put it bluntly, African names. Lord Delamere Avenue in Nairobi was renamed Kenyatta Avenue. Queen's Way was renamed Mama Ngina Street. Government Road became Moi Avenue. And Duke Street became Ronald Ngala Street. Similar examples abound in the country. Thus changing the name of the Lake from a foreign one to an African name is in order and is consistent with the tradition of name changing initiated since independence. Could the name "***Nyanza***" be a good candidate for the changed name, given that originally, the natives in the Suba District called it by that name? Already, the communities around the Lake have recently expressed their desire to rename the Lake. At a cultural conference held in Mwanza, Tanzania, in 2001, the cultural leaders selected from major ethnic communities around Lake Victoria questioned the rationale for retaining the name Victoria. Following extensive discussions on the matter, the leaders recommended that the Lake be renamed. Their argument was that the current name makes their Lake sound foreign and detached from their cultures.

2.2 Population and Demographic Features

Lake Victoria basin had a population of approximately 21 million in 1997, 26 million in 1999 (above 30 million if Rwanda and Burundi are considered), with a growth rate of around 3% per annum with considerably higher rates in urban areas. The region is increasingly characterized by growing variability of ethnic composition. However the larger ethnic groups dwelling around Lake Victoria are the Luo, Samia, and the Suba people in Kenya; the Buganda and Busoga in Uganda; In Tanzania the distribution is as follow; in Mwanza region are the Sukuma, Kerewe, Jita, Kara, and Zinza. Sukuma constitute the overwhelming majority in this region. In Mara region are the Jita, Luo, Kuria, Zanaki, and Ruli. In Kagera there are Haya, Hangaza, Nyambo, Subi, and Sukuma. This means that there is a very great cultural diversity in the basin requiring a complex analytical framework as regards harmonization towards better and sustainable use of the natural resources of the basin for improving people's livelihoods.

The five countries in the Lake Region (i.e., Kenya, Uganda, Tanzania, Rwanda and Burundi) cover a total land area of 170,270km^2, and hence an average population density of about 550 persons per km^2 in 1997. However, this varies from about 25 persons per km^2 in some parts to as high as about 1,100 persons per km^2 in other parts. The Basin supports one of the densest and poorest rural populations in the world. The current estimates of the population in the region range from between 25 million to over 30 million [39, p. 10]. The distribution among the three countries are about 11 million in Kenya; about 5 million in Tanzania, and about 5 million in Uganda in 1997. Tables 2.2–2.4 present population distribution along the Lake regions (see, e.g., [4]).

Women constitute just over 50% of the population in the region. In the Lake Victoria region as a whole, population growth rate is estimated at 3% p.a. The urban rate of growth (for towns and municipalities) is

Table 2.2. Population Density of some Districts around Lake Victoria

District	Males	Females	Total	Density (People/km^2)
Siaya	220,977	259,187	480,164	316
Bondo	113,583	125,197	238,780	242
Kisumu	248,735	255,624	504,359	549
Nyando	146,635	153,295	299,930	257
Rachuonyo	145,793	161,333	307,126	325
Homa Bay	136,728	151,812	288,540	249
Migori	247,131	267,766	514,897	257
Suba	75,167	80,499	155,666	147
Busia	174,368	196,240	370,608	330

Table 2.3. Population Size and Growth on the Tanzanian side of the Lake Region, by Region

Item	Mwanza	Mara	Kagera	Average	Tanzania
Land area km^2	19,592	19,568	28,388	22,516	85,000
Population	2,929,644	1,363,397	2,028,157	6,321,198	33,584,607
Annual growth rate (%)	3.2	2.5	3.1	2.93	2.92
Ratio (males/females)	98	91	97	95.3	95.5
% (0-14 years of age)	46.6	48.1	47.3	47.8	42.2
% (15-64 years of age)	50.1	48.1	48.8	49	46.1
% (> 64 years of age)	3.2	3.8	3.9	3.6	3.9
Household size	5.9	5.5	5.2	5.5	4.9
Population density	150	70	71	97	38
Urban population	20.5	18.6	6.2	15.1	23.1

Table 2.4. Population Size and Growth on the Ugandan side of the Lake Region, by District

District	Population	Population Density	Growth Rate per Annum (%)
Rakai	456,400	99	3.0
Masaka	1,015,400	216	2.7
Kalangala	18,400	38	4.1
Kampala	878,600	4,581	4.0
Mpigi	1,121,000	202	2.7
Mukono	1,063,200	179	2.4
Jinja	397,300	428	1.8
Iganga	887,600	210	3.0
Bugiri	283,800	165	4.0
Busia	209,300	232	2.8
Total	6,331,000		

about 7% p.a. About 50% of the population in the region comprise youth who need more gainful employment opportunities to avoid the risks of social insecurity. The region already experiences some insecurity because of internally displaced persons as well as refugees from neighbouring countries.

In practically all the East African countries, increasing attention is being directed toward the status of women in society. Programmes aimed at mainstreaming gender issues in development activities are at various stages of development. To date, however, the socio-economic status of women is lower than that of men in a number of ways. For instance, women have limited access to productive resources such as land and capital. The literacy levels are lower among women than among men and the number of girls in secondary schools is considerably lower than that of boys. At the primary school level, the numbers are about the same. Women bear a heavier burden of the widespread poverty. Commercial fishing and processing factories employs more men than women and has impacted negatively on women who were previously engaged in fish processing and marketing. Moreover, when men migrate from rural to urban areas in search of employment, they leave behind women and children to bear the brunt of agricultural activities. The heavy work load women bear on farms, in their reproductive and community roles is a major source of poor health. Due to lack of money, women have limited access to health facilities [38, p. 8].

There is a strong cultural dimension to environmental degradation in the region. The dictates of cultural practices of sons inheriting their fathers' land and wives owning land to cultivate are reinforcing the need to subdivide land into small units which are uneconomic for meaningful farming. Such practices continue to generate a population of landless youth who must migrate elsewhere to earn a living and the cycle of poverty created continues to cause further environmental degradation. Population pressure on limited land leads to rapid land degradation. It is, therefore, imperative that conservation measures are adopted on a massive scale, if not then, it may not be possible to control the rate of environmental degradation.

Livelihood standards of the area have deteriorated as already noted by [5], not just because of the consequences of the population increases, but through a host of limiting factors and livestock production that lead to declining land productivity. There are also the people of Rwanda and Burundi in the wider Lake catchment region. Population density in the

Lake basin is above the national averages found in all three riparian countries and the populations within these riparian communities grow at rates that are among the highest in the world. Population density in the region ranks among the highest in the world for rural areas where the majority of the people live. Population goes with culture. In a study supported by RELMA, OSIENALA found out that culture enhances the conservation of Lake Victoria.

2.2.1 Historical Perspective of Early Settlements

East Africa is largely considered the cradle of mankind, since the first paleontologic traces of humans have been found there. Most of the present Bantu-speaking inhabitants of the Lake Victoria basin started entering the basin around the beginning of the second century. The communities presently settled around Lake Victoria were immigrants from other parts of Africa. As early as the 13th and 14th centuries, Lake Victoria was well surrounded by organized and settled communities which had and still enjoy a lot of interactions. The Luos arrived via the River Nile from the North of Africa and settled in the Lake Victoria basin in Uganda before moving to Kenya. When the Luos arrived they forced out other tribes like Elgon Masai and Bantus that had earlier settled in the Lake basin. They interacted with ethnic groups that lived in Uganda. Some of the Luos later moved to North Mara in Tanzania in search of grazing ground when drought destroyed their crops The Bantus who now occupy the Lake Victoria basin in Uganda and some part of Tanzania trace their origins in Central Africa. Their settlement developed into indigenous kingdoms in the 14th century. Among them were the Baganda, Banyoro, Toro, Ankole and Basoga. The Baganda people created a dominant kingdom that could not be penetrated until the 19th century. The other most important group was the Basoga who later established their kingdom around Jinja. Before colonization, the larger tribes that occupied the southern shores of Lake Victoria in Tanzania were the Wasukuma and Wanyamwezi. Currently their population runs into millions. Other smaller tribes like the Wanazaki, Wajita, Wakerewe of Tanzania; the Banyala and Suba of Kenya and the Samia of Uganda are some of the most important ethnic groups that live on the shores of Lake Victoria. We have among the communities the Asians who, although constituting a minority, were brought by the colonialists to build the then Uganda railway. The group is among town dwellers and still controls major businesses in the Lake Victoria port towns.

The earlier settlers brought with them distinct cultures into the basin. Through interactions, intermarriages amongst the different cultures became imminent. The cross transfers of communities were enhanced among the neighbourhood communities, through trade. The barter system amongst the communities became prominent as canoes and dhows transported goods. Trade and market centers were developed and later small towns were established in the Lake ports. This was the origin of the municipalities and cities that are now well established. The major towns include Kampala, Entebbe and Jinja in Uganda; Kisumu, Homa Bay in Kenya; and Mwanza, Musoma and Bukoba in Tanzania. These towns' populations range from 0.2 to 1.5 million. The peoples of the Lake Victoria basin share a relatively common history characterized by intensive interaction, extensive trading, intermarriage and welfare. Furthermore, they also share the historic experience of external interventions in the area, such as the slave trade and colonialism.

In 1885, Tanzania, Rwanda, and Burundi were placed under the rule of the Imperial German Government. However, after the first World War, Tanzania was placed under the British mandate until the establishment of the Trusteeship system under the Charter of the United Nations, while Rwanda and Burundi came under Belgium rule. In 1887 Kenya was placed under the Imperial British East Africa Company, but the territory was transferred in 1895 to Britain. Likewise, the British established the Uganda Protectorate in 1894. However, after 1945, various nationalist movements emerged in this region, and began a sustained and successful effort to emancipate themselves from European domination. In 1961, Tanzania became independent followed by Uganda, Rwanda, and Burundi in 1962 while Kenya gained her independence in 1963.

2.2.2 Impact of Colonialism

The establishment of colonial rule over the people of the region brought with it resource management structures that removed the power from traditional leaders to the central governments of larger territories of Kenya, Uganda and Tanganyika. This meant that people who had no interest in the Lake could be given the responsibility to manage resources such as fisheries. The ownership of the resources shifted with time. The population influx and lack of properly planned infrastructural development has brought many problems to the urban centers. These problems include non-functional sewerage systems, industrial pollution and shortage of water supply. These have become a serious headache to the citizens. Municipal councils alone cannot address these problems. The citizens have to join them with ‘own key’ solutions through organized groups such as Non-Governmental Organizations (NGOs) and Community-Based Organizations (CBOs).

2.3 Concluding Remarks

This chapter has discussed some elements of demographic features of Lake Victoria region. It is a region where the population growth rate is very high and average population density also high. These two phenomena have a direct bearing on the environment, leading to serious environmental degradation, soil erosion, pollution of the Lake and the decline in soil fertility. It is therefore imperative that measures be taken to address the issues concerning population pressure and environmental degradation.

3

Resources

"The Earth provides enough to satisfy every man's needs, but not every man's greed."—Mahatma Gandhi

3.1 Introductory Remarks

Resource endowments of a region is critically important in determining the development potential of the area, hence, the need to review the resource endowment. In Chap. 2, we discussed at length people living around Lake Victoria. In this chapter we extend the discussion to embrace the resource endowments of the Lake and its environs. The region is endowed with vast resources including natural and human resources as evidenced in the reports of Lake Victoria Environmental Management Project (LVEMP) [55, 84, 85, 87, 88, 89, 90]. The Lake basin's main natural resources include; *forests*, *minerals*, *water*, *agriculture* and *wildlife*. To get a good picture of the vast resources of the region, we factor in the region's capacity for industry. It has the potential for hydro-electric power, gold and other mineral deposits in such places as Geita in Tanzania and Macalder in Kenya. In this context, we discuss at regional level, areas that provide the richest natural resource potential within East Africa. The following sub-topics will be explored: water resources, fisheries resources, forestry, minerals, human resources, wildlife and agriculture.

Lake Victoria basin has great opportunities for sustainable socio-economic development. Prospects for future growth and the well being of its increasing population, now standing at about 30 million, are good. It is, therefore, important to make plans for sustainable development in the Lake basin, which must include socio-economic and environmental considerations. As an important pre-requisite for sustainability, the carrying capacity of the natural environment must be respected. The richness of the natural resources and a healthy environment within the basin should prevail as the fundamental basis for socio-economic development. The tools to make this possible are, however, of socio-economic nature.

3.2 Water

Essential for life, water is one of the basic necessities without which human beings cannot live! Its scarcity has often been a source of conflict. So vital is water resource such that it is difficult to discuss the environment, a water using sector, without considering the issues of water and its management. The importance of water as a resource therefore calls for sound environmental conservation measures that enhance its protection and management. It is in realization to this that the World bank, as an emerging priority of its lending, decided to broaden the development focus in its 1993 "Water Resource Management Policy Paper" to include the protection and managements of water resources in an environmentally sustainable, socially acceptable, and economically efficient manner [160].

3.2.1 Lake Water

Lake Victoria region is well endowed with a big mass of freshwater (see, e.g., Fig. 3.1) of about 2,760 cubic kilometers [5]. The Lake itself, besides the region has plenty of surface and underground water resources, including springs, precipitation and groundwater. The first striking point about the Lake Victoria region is its *vast catchment areas* covering some 193,000km^2 in Uganda, Kenya and Tanzania, including parts of Rwanda and Burundi. Within these catchment areas, Lake Victoria region is abundantly endowed with a tremendous variety of natural resources. The Lake's fresh water serves as:

- Source of domestic, agricultural, industrial, and livestock water.
- Source of the Nile river, which besides providing hydro-electric power in Uganda, supports agricultural activities in Egypt and Sudan.
- Means of transportation within the region.

Fig. 3.1. Lake Victoria water

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- Home to various biodiversity, e.g., birds, hippos, crocodiles, etc.
- Breeze provider and swimming water in tourism sites such as Munyonyo beach in Uganda.
- Source for ecosystems such as wetlands and estuaries.

Although it provides the listed services (see also [130]), the Lake's water and that of the rivers within the basin are under threat from continuous contamination. In Chap. 4, we will treat the issue of pollution in detail. It has been widely noted that pollution pressures are increasing and pollution impact by municipal and industrial discharges is visible in some of the rivers feeding the Lake and along the shoreline, such as the shallow Winam Gulf (Kisumu) and near Mwanza and Kampala in Tanzania and Uganda, respectively. Among the sources of pollution are a number of basic industries such as breweries, tanning, fish processing, agro-processing and abattoirs. Small-scale gold mining is increasing in parts of the Tanzanian catchment leading to mercury contamination of the waterway.

Increased nutrient flows originate mostly from rural areas. Fertilizer use in the farms of the region is limited and, therefore, it may be supposed that the nutrients are released from soil particles washed off the land by erosion, from burning wood-fuels, and human and animal waste in the areas surrounding the Lake. From the urban areas, the main source is untreated sewage [19].

The increased flow of nutrients into the Lake results in eutrophication. *Phosphorus* and *Nitrogen* concentrations have risen and algal growth has increased five-fold since the 1960s. A shift of algal flora composition towards blue-green algae is causing deoxygenation of water, health problems for humans and animals, clogging of water intake filters and increased treatment costs for urban centers. Deep-water fish species have sharply declined and periodic upwelling of hypoxic water has caused massive fish kills.

Besides direct pollution of water, the other threat to water resource is the contamination of water source. For instance, data obtained from the development plans of Rachuonyo and Homa Bay districts in Kenya (e.g., Table 3.1) indicate that dams are the most highly contaminated. The data indicate that water contamination is a serious problem, in that, while wells are only 40% contaminated, surface run-off (rivers) are the most contaminated.

Table 3.1. Bacteriological Contamination of Water in Lake Victoria Region

Water Source	% of Contamination
Wells	40
Lake water	50-70
Boreholes	78
Springs and rivers	80
Dams	90
Surface run-off (rivers)	90-100

Indeed, the dangers of deteriorating water quality are well known. For the Lake region, [83] already noted the direct effect on water as resources to be;

- increase of the cost of purification and treatment,
- impacts on the water available for cattle, e.g., algae blooms that renders water unsuitable for cattle and which can be fatal in extreme cases,
- loss of potential revenue from tourists who would avoid polluted Lake, and
- health risks for human beings from diseases such as *malaria*, *bilharzia*, *typhoid*, *dysentery*, and *cholera* as a result of stagnant and polluted water.

Despite the vast resource of water, it is surprising that the inhabitants of the towns and cities surrounding the Lake, e.g., Kisumu in Kenya, Mwanza in Tanzania and Jinja in Uganda suffer acute shortage of clean and safe fresh drinking water. Taps run dry and people are forced to rely on other sources of water such as ponds, boreholes or those sold by water vendors thus highly increasing the risks of water borne diseases mentioned above. The reasons for lack of clean and safe water range from poor prioritization and planning to population influx due to rural urban migration of people looking for greener pastures. Kisumu for instance was planned for 150,000 people while the population now is far over 1 million.

Towards this end, there is need to improve water quality at sources of drinking. This entails the implementation of the following activities:

- Reduction of nutrient flow especially phosphorus into the Lake by putting in place preventive measures such as buffer zones along the riverbanks and the Lakeshore line.
- Reduction of faecal coliform and municipal nutrient output into the Lake to ensure compliance with national environmental regulations.
- Regulation of industrial effluent.
- Amendment of the act regarding environmental pollution by factories with a view to including severe fines.
- Development of groundwater resources.
- Regular water quality analysis.
- The use of well designed latrines, e.g., Eco-san and dry toilets suitable for production of organic fertilizer.
- Monitor Lake circulation.
- Assess and measure sources of nutrients causing eutrophication.
- Define and measure the contaminant threat.
- Reduction of pollutants entry into water systems by;
  - Preparing and maintaining proper pond treatment plants of open wetlands for waste treatment.
  - Desludging ponds and selling the materials as fertilizers to farmers.
  - Scraping of the gaseous effluents to reduce CO_2 and SO_2.
  - Designing and producing and selling dry toilets to the communities and finally installing them.
  - Councillors and provincial administration reinforcing policies.

Enactment of the above measures would lead to:

1. Reduced solid and dissolved pollutants reaching rivers and Lakes.
2. Industries and municipalities will earn extra money from the sales of their waste products.
3. Communities utilizing wastes in agriculture will have extra income.
4. Positive environmental impact.
5. Management of Lake pollution and water quality.

Pollution aside, other water system in the basin such as that from the rivers have found use. Sondu Miriu in Kenya is currently providing water for hydro-electric power.

3.2.2 Groundwater Potential

The level and extent of sub-basin groundwater potential helps us make an estimate of total water availability in a particular region. Indeed, meaningful water conservation efforts cannot be made in the absence of sub-basin groundwater potential. This explains why the Ministry of Water Development and the Lake Basin Development Authority (LBDA) in Kenya have taken steps to estimate groundwater potential in the region. The Ministry of Water Development (MOWD) has undertaken a study of groundwater potential of the Lake basin. However, the study does not deal with groundwater potential in detail. In the MOWD study, basins were classified according to groundwater recharge potential measured as a percentage of rainfall. A percentage of more than 15% is assessed very good, 10 to 15% good, 5 to 10% moderate, and less than 5% either low or poor.

The Lake Basin Development Authority (LBDA) recently undertook groundwater development in Nyanza Province. Groundwater development activities reveal that the southern part of the Lake basin has more groundwater potential than indicated by the MOWD study. Although groundwater recharge in the southern part is not as high as in the northern part, groundwater development potential was found good to moderate in most of the southern part of the region. The highest potential of groundwater is found in Sio and Malaba basin, lower Nzoia basin, Yala basin, and Kuja basin. Low and poor potential zones are found in part of the Lakeshore and the Mara river basin. This classification of groundwater potential should be looked at tentatively and revised when detailed studies cover the whole of the Lake basin.

3.2.3 Water Balance

Changes in the water balance of a Lake or reservoir have great influences on the water quality, quantity as well as the *biotic* and *abiotic* environment, which can have serious economic and health consequences on the riparian communities. The changes in water balance are due to climatic changes and human activities in the catchment such as irrigation, deforestation and damming. These have been manifested in the frequent flooding of the low lying areas along main rivers draining into the Lake. The floods of 1960-1962 caused an increase in water levels in Lake Victoria and resulted in increased production of fish particularly tilapia. In Lake Turkana in Kenya for example, changes in the hydrological regime resulted in the drying up of a major fishing ground, the Ferguson Gulf and the abandonment of the docking facilities. In Lake Victoria, there has been the expensive shifting of beaches due to drying up of some landing beaches either due to weather or due to conversion to dry land by hyacinth. It is therefore imperative to monitor the water balance of our Lakes and resources so as to forecast future effects on fish production, water quality and the economy.

An increasing water level due to increasing precipitation would have a positive effect on hydro-electric energy production, e.g., at the Owen falls in Uganda, but at the same time may cause problems on onshore facilities. A decreasing water level or decreasing water availability would lead to losses of power production and downstream use of water.

The major inflow (85%) of Lake Victoria water budget is direct precipitation (see, Table 3.3). Therefore increase of atmospheric nutrient loading enhanced eutrophication. Thus steps should be taken to prevent atmospheric nutrient loading because they are a major source of eutrophication in Lake Victoria.

Changes in water budget are respectively accompanied by water level fluctuations and consequently in the thermal structure, nutrient and food web dynamics. Reduced inflows can lead to severe lowering of water level, cooling of the hypo-limnion, shallower thermocline, delay of turnover, increase in nutrient and Phytoplankton densities as well as suspensions in the water.

The natural variations of climate are the main reason for the alterations in the water balances of both terminal Lakes and their basins. Both development irrigation in Lake basins and in particular the reduction of Lakes leads to serious ecological and socio-economic problems of environmental origin.

The drop in Lake level brought many impacts on the ecology and economy.

Table 3.2. Water balance of Lake Victoria

Parameter	Level	%
Inflow		
Direct rainfall (10^9 m^3)	100	85
Runoff (10^9 m^3)	18	15
Sub lacustrine or ground water (10^9 m^3)	negligible	-
Outflow		
Evaporation (10^9 m^3)	100	85
Overflow (10^9 m^3)	18	15
Total inflow (10^9 m^3)	118	100

3.2.4 Management of Water Resource

The Lake Victoria basin is not just a water body shared among the three East African Community states, but its geographical location has international legal implications, especially with Sudan and Egypt, within the River Nile Basin, and with Rwanda and Burundi, due to its connection with the Kagera River basin.

The mechanisms governing the utilization of water and living aquatic resources shared by two or more states raises many concerns, partly because of the value of the resource for national policy and partly because states often invoke legislative or diplomatic interests [112]. Given the immense value of the export-oriented fishery and its nutritional importance domestically, it is understandable that protection of national interests may sometimes take precedence over the spirit of the East African Community (EAC) Treaty and Lake Victoria Fisheries Organization (LVFO) Convention [91].

All the three East African riparian countries have plans to use their waters for various purposes. Understanding the water regime in the Lake basin is a prerequisite for improving the capacity to sensibly manage the resource. Data collection efforts carried out in the 1960s and 1970s under the World Meteorological Organization (WMO)/United Nations Development Program (UNDP) Hydro-meteorological Survey Project provided a valuable crop of data but were interrupted owing to civil unrest in the region. Currently, the need to catch up with the most basic infrastructure for water management is addressed through the regional FAO/Japan "Lake Victoria Water Resources (LVWR)" Project.

This project has initiated the establishment of a sustainable skeleton network of rain gauges and river gauges for Lake management. Ground data will be integrated with remote sensing data in a geographically referenced (GIS) database (see, e.g., Chap. 11). The database will be used through a water resources simulation model for spatial estimation of the rainfall regime, rainfall-runoff and river flow simulation, and a Control/Decision Support System (DSS) for reservoir operation and water management. The DSS will assist the riparian countries in formulating a co-ordinated and mutually agreed upon management strategy for the Lake, while promoting the institutional process within which the three countries will continue co-operation and interaction in Lake Victoria water management.

A variety of options have been identified for configuring a tripartite institution for regional co-operation in the environmental management of the Lake Victoria water resources and of its catchment [20]. As the most effective approach, the Steering Committee of the LVWR project has undertaken steps to bring to the attention of the Permanent Tripartite Commission for Co-operation between Kenya, Tanzania and Uganda the need to incorporate representatives of the water administration of the three member states in any arrangement for tripartite co-operation in the water resources management of the Lake Victoria basin under the aegis of the Commission.

3.3 Fisheries

Although there are many features of Lake Victoria of intense interest to biologists, it is fish that receive the most attention. Most of the fish species also lived in the preceding westward flowing rivers before the formation of the present Lake. The cichlids in particular had a remarkable burst of speciation in response to the change from river to Lake conditions. Similar speciation happened in other Lakes but in Lake Victoria, it happened much more recently, more rapidly and with, at first sight fewer opportunities for ecological isolation in different types of habitat. This is due to the fact that cichlids are capable of rapid genetic changes and more prone to speciation than other groups of African fish [44].

Freshwater fish continues to be an important source of protein and income to the communities in the Lake Victoria basin. Fishing in the Lake is the most important economic activity. In Uganda, fishing is an important source of high quality food, employment revenue, and has led to development of infrastructure, and is currently the second most important export commodity next to coffee generating approximately US $100 million annually. The Lake Victoria fish fauna included an endemic cichlid flock of more than 300 species. To boost fisheries, Nile Perch (*lates spp*) was introduced into the Lake in the 1950s. In the early 1980s an explosive increase of this predator was observed. Simultaneously, catches of hapchromines decreased. Although fishing had an impact on the haplochromine stocks, the main cause of their decline was predation by Nile Perch. The stocks of Nile Perch in Lake Victoria (and Lake Kyoga) were introduced from Lake Turkana and Albert, despite repeated objections from scientists [42]. This has led to the fishery being dominated by three species commercially, namely Nile Perch, *lates niloticus* 63%, dagaa/ Omena, *Rastrineobola argentea* (pellegrin) 19% and Nile tilapia *Oreochromis niloticus* 9%. Other species comprise the remaining 9%.

Fishing in most countries surrounding the Lake is mainly done on canoes and many of which are nowadays propelled by out-board motors. It is mainly done in a short distance of the shore due to lack of capital to buy larger boats with refrigeration facilities, which would enable deeper fishing. Since the early 1970s total catches have increased between four and five fold, and now stand at around 500,000 tons making Lake Victoria the world's largest freshwater fishery [50]. The fish catch in 2001 in Kenyan side of the Lake was 500,000 tons with a market value of US$ 600 million, of which US$217 million was earned from exports. The Lake is also an important transport corridor and source of water for domestic and industrial use [75].

Lake Victoria's annual income from fishery in Kenya alone is estimated at about US$125 million (KSh 9.75 billion), i.e., at the present avarage exchange rate of 1 USD=Ksh 78 which we will adopt in this book. This involves handling a large volume of fish products and therefore the fishing communities have organized themselves into cooperative societies to deal with the marketing of fish on behalf of their members. Earnings from the Lake fish catch are in the region of US$1 400 millions per year or slightly over US$1 millions per day. The Fisheries production in Kenya in 2000, both from freshwater and marine, amounted to 207 thousand tons with a landed value of about 8 billion Kenya Shillings (KSh). Approximately 93% of this production was from Lake Victoria. In March 2000, there were about 38 thousand fishermen engaged and the associated number of boats recorded to be just over 11.5 thousand. A summary of the catch from the Lake are presented in Tables 3.3[1] and 3.4[2]. Figure 3.2 gives a plot of the data in Table 3.3.

Table 3.3. Fish catch from Lake Victoria (Kenya) for the period 1998-2003

Year	Lates niloticus	Rastineobola argentea	Oreochromis niloticus	Total Quantity (ton)
1998	78,663	42,336	30,000	158,876
1999	114,808	40,168	23,701	200,153
2000	109,088	38,968	23,226	192,738
2001	78,534	49,165	17,292	151,293
2002	58,432	35,455	16,251	114,812
2003	54,689	31,659	15,672	105,866

Table 3.4. Numbers of Landing Sites, Fishers and Boats in the L.V. Districts (Kenya), in 2000

District	Coastal Length (km)	Landing Sites	Fishers	Boats
Bondo		67	8,383	2,607
Busia		23	2,748	771
Homa Bay		7	568	181
Kisumu		32	3,925	1,372
Migori		27	3,649	1,101
Nyando		6	512	185
Rachuonyo		38	3,774	1,247
Suba		97	14,782	4,051
Totals	760	297	38,431	11,515

The landings for the Lake are dominated by Nile Perch (57% in 1999), tilapia (22%), and dagaa (20%). Much of the Nile Perch, up to 80-90% of adult fish are processed into fillets for export. Bladders (maws) are also exported. The frames are either consumed locally or processed to fishmeal. Tilapia are mostly consumed locally. Dagaa - a small sardine-like fish - is consumed as dried product or increasingly

[1] Source: Department of Fisheries

[2] Source: Department of Fisheries, Personnel Section; and Annual Reports for Districts

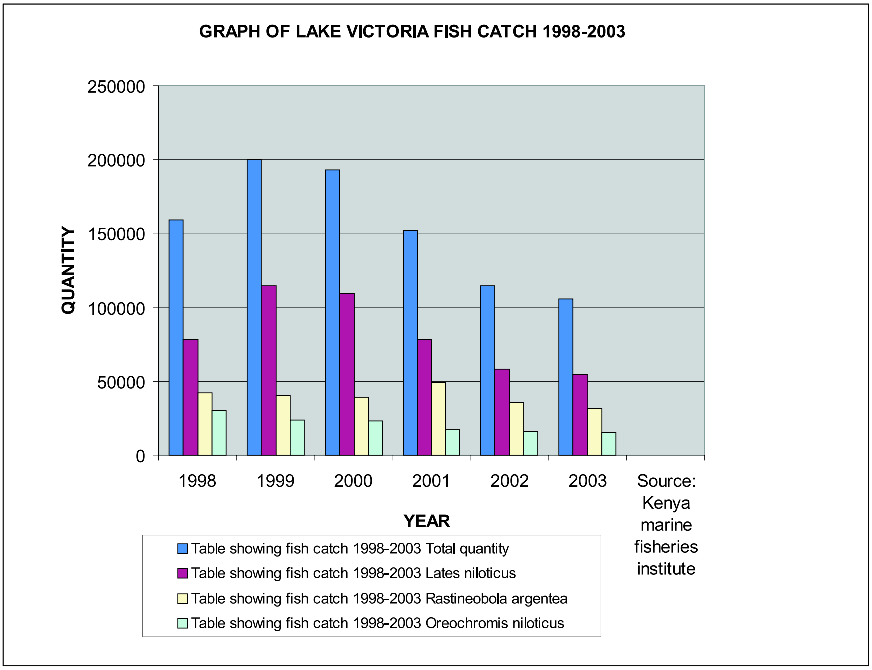

Fig. 3.2. Lake Victoria (Kenya) Fish Catch 1998-2003

used to produce fishmeal (for livestock production). Annual per capita consumption of fish is low at around 5 kg.

Total export earnings from fishery products was about KSh 2.7 billion in 2000, with the Nile Perch fillets; the main contributor at KSh 2.6 billion. Table 3.5[3] indicates the fluctuation of the price of fish per Kg from the period of 1991 to 2000, while Table 3.6 presents the mean landing prices of various fish types for the period 1998–2003. .

There is a big external demand for Lake Victoria's fish; especially filleted Nile Perch, in Europe, United States, Israel, Japan and Australia. The European Union (EU) market alone takes up 60% of the Lake Victoria fish exports. Therefore, the Lake's potential lies in the opportunities for investments in fisheries, an important resource of Lake Victoria is one of the most prolific and productive inland fisheries in Africa. At one time it harboured over 500 endemic fish species, with what the scientists call cichlids forming the bulk. Fish resource endowments of Lake Victoria have an interesting history.

[3]Source: Department of Fisheries, Statistics Section

Table 3.5. Lake Victoria Fish Prices (Species combined)

Year	Ksh/Kg
1991	8.53
1992	20.99
1993	20.13
1994	18.58
1995	25.22
1996	36.82
1997	27.44
1998	39.46
1999	35.95
2000	38.75

Table 3.6. Mean fish landing prices from Lake Victoria (Kenya) for the period 1998-2003

Year	Fish prices US$/kg		
	Nile Perch	Tilapia	Dagaa
1998	0.64	0.69	0.51
1999	0.64	0.73	0.47
2000	0.69	0.65	0.48
2001	0.83	0.68	0.47
2002	0.90	0.70	0.49
2003	0.98	0.72	0.49

Geological and fossil evidence show that fishes have lived in the world for at least 300 million years. In their long history they have become adapted to live in all sectors of the aquatic world and are found in the high seas, the inland waters, the mountain torrents and the floodplain rivers. The end product of this long history is some 20,000 species of fish of remarkably varied shapes, sizes and habits. The kinds of fish now living out-number the kinds of all other vertebrate animals (mammals, birds, reptiles and amphibians) taken together.

Despite the abundance of fish resources in the Lake, serious problems still arise. These include:

1. Over-exploitation of Nile Perch (see, e.g., Fig. 3.3 in p.31) reflected by substantially reduced catch rates and the size of fish catches. This serious situation has recently been exacerbated with Uganda patrolling its border and preventing fish caught in Uganda being landed in Kenya, as had been traditionally practiced. Similarly, there is a conflict between Tanzanian patrols whom the Kenyan fishermen have accused of intrusion into Kenyan waters and taking away their boats and charging them a fine of KSh 15,000 per boat

captured. The consequential drop in quantities landed by Kenyan fishermen has been partly offset by competing processors paying higher prices for the product. The consequence of reduced supply has been more drastic in its effect on processors. Income and costs for boat owners and crew appear modest. The estimates range between US$3333 and US$4231 per boat owner. They relate to the owner's contributions of labour, management and investment. The estimates for income per crew ranged from US$ 1410 to US$ 1667.

2. There is a big external demand for Lake Victoria fish, filleted Nile Perch especially, in Europe, United States, Israel, Japan and Australia. The European Union (EU) market alone takes up 60% of the Lake Victoria fish exports. This demand is however not met owing to the problem of overfishing and the effect of the introduction of Nile Perch. Nile Perch type of fish feeds on others species thereby reducing drastically certain species, e.g., Tilapia which are also in high demand and highly priced. There is evidence that total fish catches have increased in recent years, but these catches are concentrated on some individual species. That is, whereas some species are decreasing, other species are increasing. This situation causes uncertainty about the future trends in total catch from areas such as the Lake Victoria (Kenyan side of Lake Victoria). The key question is what kind of decision should be made to deal with this uncertain trend?
3. Fisheries in Lake Victoria are being exploited at a very high rate, due to the remarkable improvements in the capacities in fisheries such as an increase in the number of boats, improvement of communication network around the Lake, handling shades, provision of cold storage and other preservation methods such as smoking and sun drying of fish. It has been estimated that, on the Kenya side of the Lake, there are about 21,000 fishermen operating over 5,000 boats. This is the highest concentration of fishermen in the Lake. However, despite this large numbers, there is no knowledge of the magnitude of fish stocks and the maximum sustainable yields that should be exploited. In spite of this uncertainty, there are warning signs of a declining fishery in Lake Victoria.
4. Pollution of the Lake emanating from industrial and domestic wastes from large cities like Kisumu in Kenya, Mwanza in Tanzania, and big towns like Jinja in Uganda.

5. Growing threat from increased use of fertilizers and pesticides in the agricultural areas within the Lake basin. These are washed down the rivers by rainfall and eventually find their way into the Lake.
6. The cutting of the papyrus swamps for making mats.
7. Reclamation for agriculture.

Fig. 3.3. Nile Perch loaded into refrigerated van

3.3.1 Importance of the Fisheries of Lake Victoria

For several centuries, the Lake has provided a rich variety of resources to the communities living in the riparian districts. A part from providing a rich source of protein through fisheries, the Lake offers employment opportunities and generates income to thousands of people. The fish industry provides indirect employment to thousands of individuals who supply the various fishing gears and related complimentary goods, services, and those who utilize fish products and by-products. The importance of fishing in the national economies of the three riparian states has grown rapidly as reflected in the growth in foreign exchange earnings from Nile Perch fillet exports to European countries in recent years.

Commercial fishing, though somewhat artisanal, picked up in the 1950s and was well under way at independence, and increased in all water bodies. For instance, fish production in Lake Victoria has now reached 400,000 to 500,000 metric tons with Tanzania accounting for 40%, Uganda 25% and Kenya 35%. In all cases, fishing continues largely at artisanal level with very limited use of outboard engines. Most of the catch is marketed through middlemen both within and outside the areas. In the three countries, there are about 100,000 fishers using about 21,000-planked canoes on which about 270,000 fish traders depend. An estimated 3-6 million people directly depend on the Lake's fishing industry. The accompanying auxiliary services such as boat building, net manufacture, fish transportation, processing, local and export trade and fish pond construction all contribute to an even higher number of people being involved in fisheries activities.

Sustainable exploitation of a common property such as fisheries requires education of the local communities, monitoring of the resources and enforcement of regulations. Issues pertaining to biodiversity and conservation are easily acceptable to local communities only if they address immediate and tangible needs. Whereas almost all conservation practices could be enforced through legislation, additional and more appropriate approaches are required. These include dialogue, education, technical assistance and stakeholders' participation. Each of the riparian states has a government policy framework through which fisheries resources are managed. The regulation of fisheries is supported by the Fisheries Act of 1990, in the laws of Kenya, the Fish and Crocodiles Act of 1964 in the laws of Uganda, and the Fisheries Act of 1970 and Fisheries Principal Regulation of 1989 in the laws of Tanzania. The fisheries sector forms three natural divisions: *Marine capture fisheries*, *inland capture fisheries*, and *aquaculture*. It is assumed that the development of this sector should take cognizance of these divisions and of the fact that the socio-economic aspects of the industry encompass all the three divisions.

The fisheries in the three countries employ an open access system, which attracts profit motivated fishers. Their heavy investment threatens the small artisanal fishers. The Nile Perch, Nile Tilapia, and Dagaa/Omena are the three species of fish presently targeted for commercial exploitation. Most of the fishing is done by old traditional techniques such as use of canoes. This technology has relegated the fisher folks to small-scale fishing enterprizes incapable of competing with the large-scale, motorized enterprizes. There is the danger that the big fishermen are now "swallowing" the small fisher folks. Furthermore, the fishes in the Kenyan side of Lake Victoria are concentrated on the Winam Gulf.

Increasingly, there is concern that the "Mbita" causeway a bridge of concrete stones linking Rusinga Island with the mainland is wrecking havoc to the supply of fish from Tanzania to Kenya's Winam Gulf. There are other factors that have also come to the fore. For example, there is dispute among the three East African countries about the fishing boundaries in the Lake. There is also the question of the agreement between Kenya, Uganda and Tanzania about the fishing issues. It has become very clear that most large-scale fishers are people who are non-indigenous to the area. Traditionally, the indigenous people knew when and where to fish in order to allow for fish regeneration. The "foreigners", however, do not heed. It is believed that some of these 'outsiders' do not care about conservation of fishes. Their interest is only limited to exploiting the fishes immediate financial gains. This has resulted in plunder and depletion of fishes from the Lake.

Fishing is practiced almost throughout the year, except during the fish breeding season (April-August). Catch Per Unit of Effort (CPUE) has been calculated to be most substantial during August and lowest between April and July. The seasonal pattern is similar for Tilapia, R. argentea and Nile Perch. In an attempt to know more about fishing in Lake Victoria we now identify the main issues in fishing. Later sections of this chapter will examine the market for fish with emphasis on supply and demand issues.

3.3.2 Fish Species

Lake Victoria provides an abundant supply of fish. Major fish species include Nile Perch, Tilapia and *Rastrineobola argentea* or (Omena in local Luo language and Dagaa in Swahili language). A large percentage of fish produced is sold to towns within the East African region and also exported to other countries. Of the many fishes that exist in the world today, Lake Victoria has representatives of five (5) ***orders***, thirteen (13) ***families***, twenty-eight (28) ***genera***, and over 200 ***species*** of fishes, all of which are edible. Since fishes do not recognize political or administrative boundaries, they traverse the waters of Lake Victoria from one country to another. The species are too many to list by name. It is sufficient here to indicate representatives of the most important groups giving the scientific names as well as the English and local languages where applicable (see, e.g., Table 3.7 in p.36 where rare species have also been presented[4]). Fish families and groups found in the Kenyan waters of Lake Victoria and their different local names have been presented in [4, p. 37].

Like many other inland fisheries in Africa, Lake Victoria has experienced some alarming changes in recent years. The species composition of the fisheries has changed from that which prevailed at the beginning of this century when their development started. The earliest surveys of the Lake showed that the fishes of *Tilapine* species particularly *oreochromis esculentus* were then the most important commercial species.

Other fish species include *Protopterus aethiopicus*, *Barus docmac*, *Clarias Mossambicus*, *Barbus*, *Moormyrids* and *Schilbe mystus. Labeo victorianus* formed the most important commercial species along effluent rivers of the Lake Victoria Basin. *Haplochromne Cichlids* and *Rastrineobola argentea* were abundant but, because of their small sizes, they were not originally exploited on a commercial scale.

The cichlids are capable of rapid genetic change, and are more prone to speciation than other groups of African fish. There are more than 200 endemic species and 4 endemic genera of cichlids in Lake Victoria and more than 150 species, which are of the genus, *Haplochromis* type. Another major lineage is the Tilapines. From the primitive insect-eating types, mouths and pharynxes have evolved to allow feeding on plants, molluscs, fish, and even the eggs and young larvae carried in the mouths of brooding females of most cichlid species. The non-cichlid fishes have also changed, and there are at least 50 species, of which 29 are endemic, and one endemic genus.

The non-cichlids show much less divergence from the riverine stock. This is unlike the case with non-cichlid fish in Lake Tanganyika, which have had a much longer time to diversify. While most of the species remain in the Lake all year around, there are a number (at least 13 species) of anadromous (ascending) fish, especially *cyprinids*, *characids* and *siluroids*, which swim up the rivers when they are in flood, breed in a suitable place, and return with their young fish to the Lake as the water level drops.

The Nile Perch, *Lates niloticus* with several species of Tilapia, *Oreochromis niloticus*, *Oreochromis leucosicus* and *Tilapazillis* were in-

[4]fish species that were plentiful years ago but are now either absent, rare or extinct

troduced to feed on macrophytes which were not being utilized by other commercially important fish while *O. niloticus* and *O. leucostictus* were introduced to supplement stocks of the native *Oreochromis* species which had declined considerably due to fishing pressure.

Since these introductions were made, *L. niloticus* and *O. niloticus* have established themselves so much such that they now dominate the commercial fisheries of Lake Victoria. *R. argentea*, which was originally neglected, now features prominently among the commercial catches.

Prior to the introduction of the predatory Nile Perch in the Lake, the species composition of the fisheries was far more diversified. Genera such as *Oreochromis, Barbus, Mormyrus, Labeo, Gnathonemus, Rastrinebola, Synodontis, Bagrus, Schilbe* and *Alestes* were common in earlier decades but have now almost became extinct Today, only three dominant types of fishes make up 98% of the catch; the Nile Perch, the species *Rastrineobola argentea* and tilapia (*Oreochronis niloticus*). Out of a total fish catch of about 500,000 Tonnes, Nile Perch constituted about 80%, Tilapia from 10-15%, and *Rastrineobola argentea* from 5-10%.

The dominance of Dagaa or Omena (*Rastrineobola argentea*) (i.e., Fig. 3.4), Nile Perch (*Lates niloticus*) (i.e., Fig. 3.3 in p. 31) and exotic Tilapia as commercially important species in Lake Victoria is evident in Table 3.8[4]. The combined landings of these three major fresh water species accounted for 98% of all fish landed in Kenya. From the table, it is apparent that landings of Nile Perch have declined since 1996 when 97,145 tons were landed, to 77,967 Tonnes in 1998. The landings of exotic tilapia species, on the other hand, have increased for the three years under consideration.

Over the last 30 years, the composition of fish landed has changed substantially, most notably in Lake Victoria. In 1968, the dominant species landed included *Haplochromis* and *Propterus* species. In 2001, it was estimated that 26% of fish landed were *Haplochromis*, while the propterus comprised 19%. Since 1970, the importance of these species has declined dramatically and increased production of Nile Perch (*Lates niloticus*), Dagaa (*Restrineobola argentea*) and exotic Tilapia species. The reliance of the fishery on such a small number of species is causing ecologists and fisheries managers a great deal of concern. Whereas in

[4] (a) Includes ‘other’ non-major species. Source: Department of Fisheries Statistics, Kenya

Table 3.7. Fishes in Lake Victoria and Surrounding Rivers

Biological name of species	Name in Luo Language
Alestes spp. (Butter fish)	Esiyire
Protopterus aethipicus sp (Lung Fish)	Kamongo
Clarias gariepinus sp	(mudfish)
Claraus mossambicus sp (Catfish)	Mumi
Xenoclarias sp	Nyawino/Ndhira
Synodontis afrofescheires sp	Okoko
S.victorie sp	Okoko
Schilbe mystus	Sire
Barbus altrialis sp[4]	Fuani/Odhadho
B. jacksoni sp	Fuani/Odhadho
B. amphelogramma sp	Ndera
Alestes Jacksoni sp	Osoga
Labeo victorians sp	Ningu
Gnathonemus longibarbis sp	Obobo
G. victorie sp	Obodo
Momyrus kannume sp[4]	Suma/Aduoyo
Bagrus docmac sp[4] (Cat fish)	Seu
Mastecembelus fentus sp	Okunga
Oreochromis escalustus sp[4] (indigenous tilapia)	Ngege
O. niloticus sp (nile tilapia)	Nyamami
O. variabilis sp[4] (indigenous tilapia)	Mbiru
O. leucosticus sp (exotic tilapia)	Opat
Tilapia zilli sp (exotic tilapia)	Sila
T. nigra sp (exotic tilapia)	Sila
Lates niloticus sp (Nile Perch)	Mbuta
Haplochromis sp (several)	Fulu

Table 3.8. Freshwater and Marine fish catches by species and weight

Characteristic	Measure		
Key species (Tonnes)	1996	1997	1998
Fresh Water			
Clarius	405	2,049	2,586
Rastrineobola	49,670	40,316	42,336
Labeo	1,462	1,227	937
Haplochromis	3,914	2,454	2,577
Lates niloticus	97,145	73,549	77,967
Tilapia niloticus	10,903	13,953	14,652
Tilapia others	7,720	20,371	26,932
Total Freshwater (a)	174,788	157,942	173,081
Marine			
Demersal	2,296	2,117	2,132
Pelagic	1,000	936	943
Sardines	217	189	156
Total Marine (b)	4,891	4,388	5,088
Total Fish[(a)+(b)]	179,679	162,330	178,169

Fig. 3.4. Women are dominating in the processing and marketing of Omena

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1968, the three most caught species accounted for 61% of fish landed, in 1995, they represented.

The Nile Perch dominated the landings for the Lake with 57% in 1999, followed by Tilapia (22%), and dagaa (20%). Much of the Nile Perch, up to 80-90% of adult fish are processed into fillets for export. Bladders (maws) are also exported. The frames are either consumed locally or processed as fishmeal. Tilapia is mostly consumed locally, while Omena, is consumed either as a dried product and is increasingly being used in the production of fishmeal (for livestock production).

3.3.3 Exploitation of Fisheries Resources

The importance of Lake Victoria, both in terms of volume of fish and number of fishers is shown in Table 3.9. The quantity of fish landed from other fresh water bodies is considerably lower than that of Lake Victoria (see, e.g., Table 3.9[5])

It is important to note that the number of people engaged in fishing has drastically increased. In 1929, only 5,000 fishers were reported to be in the Kenyan part of Lake Victoria. While in 1973, only 10,000 fishers were active in the Kenyan part of the Lake by 2001, the number had jumped to about 36,000 with 10, 000 boats [4]. Artisanal fishers are the dominant fishers of the Lake.

An explosion in the Nile Perch fishery, following introduction of this exotic species and the expansion in the processing sector, has seen an enormous increase in the number of fishers and vessels. The most rapid

[5]Source: Department of Fisheries, Statistics Section

Table 3.9. Fish Landings in Major Lakes of Kenya, (Metric Tonnes), 1997-1998

Lake	Quantity (Tons)		Fishermen		Vessels	
	1997	1998	1997	1998	1997	1998
Lake Victoria	151,293	158,876	30,000	30,000	8,000	8,000
Lake Turkana	3,737	10,610	2,148	2,366	537	
Lake Baringo	210	374	71	81	21	27
Lake Naivasha	46	120	81	202	30	109
Lake Jipe	95	156	56	56	40	40
Tana Dams	743	655	440	503	201	225
Others	1,712	2,298				
Total	157,836	173,089	32,796	33,208	8,829	8,401

expansion in the output of fish from Lake Victoria occurred from 1980 to 1990, when production grew to 185,101 tons. Most of the growth was associated with Nile Perch landings. Other inland fisheries have not experienced a similar spectacular growth. For example, fish landings in Lake Turkana, the second most productive inland Lake have decreased from 12,384 tons in 1980 to 5,239 tons in 1999.

3.3.4 Fishing in Lake Victoria

The fisheries of the Lake Victoria have been showing signs of decline in recent times (see, e.g., Fig. 3.2 in p. 28). Throughout the 1990s the Nile Perch was the most dominant fish in landings as well as in bottom trawl catches. As exploitation continued, its total annual catches as well as mean size caught declined. In the Kenyan sector, its catches dropped from 120,000 tons in 1992 to less than 60,000 tons in 1999. This resulted in the closure of six of the fish factories while the remainder operated at less than half processing capacity.

The total fish catches have depicted a similar trend as that of Nile Perch (see, e.g., Fig. 3.3, p. 31). Initially, they increased from 19,000 tons in 1977 to approximately 253,000 tons in 1991; thereafter declining to approximately 190,000 tons in 2000 an expensive decline of about 53,000 tons (see, e.g., Fig. 3.5 in page 41 and also Table 3.10 in page 40[6]). Observations indicate that > 35% of all Nile Perch landed is immature, consisting of fish less than 20 cm. There is a very high demand for Nile Perch from filleting factories particularly for fillets from juveniles 0.5 - 1.0 kg for some export markets. This is the reason for the decline of the Nile Perch fishery in the Lake Victoria.

[6]Source: Fisheries Department Annual Reports 1975-2003; KMFRI Annual Reports 1983-2002

The current fishing effort is very high and needs to be regulated. The number of fishermen in Kenyan sector is excessive and has increased from 11,000 in 1971 to over 56,000 currently. Due to declining catches, fishermen have been forced to adopt smaller meshed nets of $> 5''$.

Estimates of fish production for Lake Victoria have not been consistent, as different values have been presented for different periods. This is partially due to lack of information on fish landings, which is needed to estimate the potential production and yields. There is also a long-standing disparity between the figures presented by various departments, e.g., fisheries department, marine and Fisheries Research Institutes on the yield estimates. Examination of data forms used in stock assessment indicates that the catch of certain species is not indicated and that others are not correctly identified. Thus with unreliable and varying estimates of potential yields, it is difficult to formulate management measures for exploitation. For example, it becomes difficult to estimate how many fishing crafts, number of fishermen or fish processing plants can be allowed to operate so as to utilize the fisheries resources profitably.

For instance, recent efforts to estimate total landings in the Kenyan sector have not been successful due to the fact that the system has not been able to assess significant quantities, which are not landed but are directly ferried to the factories for processing. It has also not been successful in separating fish originating from Tanzanian and Ugandan waters, which are brought into the Kenyan landing beaches or also taken directly to the factories. The only successful effort has been that of the frame survey which has enabled the effort characteristics in the Lake to be known. However, these also change over time.

For several centuries, the Lake has provided a rich variety of resources to the communities living in its surrounding. A part from providing a *rich source of protein* through fisheries, the Lake offers *employment opportunities* and *generates income* to thousands directly. The fish Industry provides indirect employment to thousands of individuals who supply the various fishing gears and related complimentary goods and services and those who utilize fish products and by-products.

Applied Fishing Gears

The artisanal sector is very important and can further be divided into sub-sectors by the type of fishing gear and species targeted. Results of surveys of artisanal fishers (gear and species related fishing practices)

Table 3.10. Annual fish yields from Lake Victoria in tonnes in Kenya for the period 1975-2000

Year	*L. nilot*	*Rarg*	*O. nilot*	Other tilapia	*P. aeth*	*Haplo*	*B. doc*	Others	Total
1975	51	4548	202	440	1469	4620	1389	3862	16581
1976	97	5652	421	586	935	6378	1025	3596	18690
1977	203	6704	465	970	773	5378	1141	3698	19332
1978	1066	8710	972	1634	612	6621	1396	2845	23856
1979	4286	9321	962	1777	472	6599	1769	5406	30594
1980	4310	9443	1184	3829	370	3636	642	3500	26914
1981	22834	7635	1858	2039	187	916	430	2278	38177
1982	33134	10419	2581	1894	239	2546	2532	7613	60958
1983	52337	16444	2516	1766	108	612	1243	2301	77327
1984	41319	19437	6136	1342	81	41	88	3410	71854
1985	50029	25866	7573	1869	150	90	61	3035	88673
1986	64929	31084	7853	1311	150	613	62	2289	108291
1987	86832	30803	9024	1329	58	377	40	1089	129561
1988	82019	50484	3434	625	25	415	75	4665	141742
1989	119276	82764	5777	4707	24	2246	18	10548	225360
1990	118503	82764	4494	565	84	2299	13	28061	236783
1991	122780	84663	5212	19456	81	1073	12	20464	253741
1992	105979	98232	7035			3669			219469
1993	109195	80501	12768			5223			213938
1994	60830	98745	10301			1810			174000
1995	81721	76564	9111	2149	172	978	7	2158	172920
1996	96471	49670	10765	5123	148	3914	4		166460
1997	73004	40315	13953	17838	1540	2454	82		151293
1998	76663	42336	14652	18826	1617	2577	86		158876
1999	114808	40168	23701	20202	405	528			200153
2000	109069	39967	23226	20142	404	528	2		192740

by [64] (see also similar results of Hoekstra survey in [4, Table 17 p. 63]) is provided in Table 3.11.

In the 2000 Frame Survey, it was found that there were 133,365-gill nets, 5,803 beach seines, 4,548 cast nets, and 1 million long lines hooks used by the Kenyan fishers of Lake Victoria. It is evident that the gill netting of Nile Perch is the most frequently observed fishing practice in Lake Victoria. Applied fishing gears in Lake Victoria include:

(a) **The Nile Perch Gillnet**: Fishery Nile Perch species is targeted in this fishery using nets of 7” mesh sizes although average mesh size has been decreasing in recent years [64]. Nets are typically manufactured in Kisumu, while some are imported from Uganda. An average size fishing unit deploys 20-100 nets, with a mean length and depth of 66.94m by 3.02m, respectively. Nets are commonly set on the

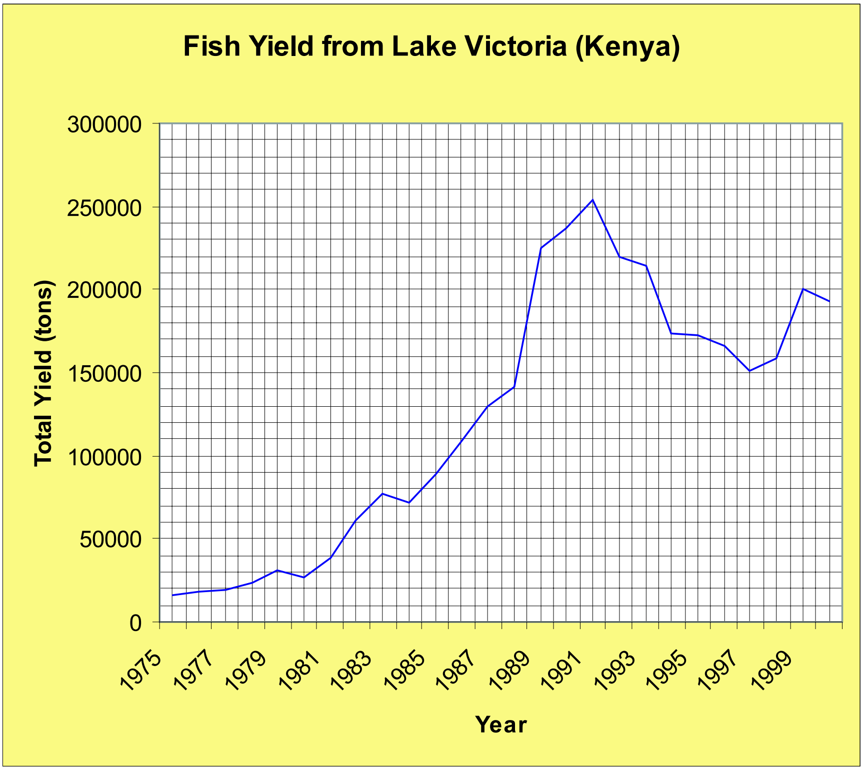

Fig. 3.5. Total fish yield from Lake Victoria (Kenya) for the period 1975–2000

Lake's surface during the night and fishers return in the morning to collect netted fish. A catch of 0.2 tons of fish per boat per day

Table 3.11. Fishing Gears Used in Lake Victoria (% of Boats), 1998

Type	Ikara Survey
Nile Perch gillnet	27.4
Tilapia gillnet	14.7
Long-line	14.7
Mosquito seine	5.8
Beach seine	12.9
Set seine	6.1
Traps	0.8
Mosquito (light)	15.5
Trawling	0.8
Hand line (hook)	0.3
Combinations	3.2

is the average catch. The operator owns most nets; and boats are Sese-type canoes of up to 13 metres with an average length of boat approximately 6m [64]. In 2000, only 6% of all boats were propelled by outboard motor, with 30% using sails.

Some new gill nets fishers obtain their gears from processors and get locked into fisher guaranteed price arrangements with agents acting for processing interests. Lower guaranteed prices curtail the profitability of fishers who operate under these arrangements. The number of days gillnet activity per year in Kenyan section of Lake Victoria have increased over the 1989-1998 period. Days of gill net fishing intensity peaked in the mid 1990s although an upward trend is evident across the charted projection. Fishing efforts for other gears (seines and long-lining) also increased throughout the 1990s. Overall, seine and long-lining efforts are not as substantial as that for gillnetting.

Outboard engines were introduced into the Lake during the 1950s. Until recently, only a few Sese canoes were fitted with outboards because the vast majority of fish could be captured within 5-10 kilometers of land [67]. The use of outboard engines has recently expanded incorporating the newly adopted method of drift gill nets or "tembea" fishing. Tembea fishing is conducted with large Sese canoes having a flat rear end. These boats operate up to 100 double gill nets, with mesh sizes of 6-9". Nets are commonly joined together to make a combined length of 1-2 km [67]. Tembea nets are set and drift throughout the night. The various investments for tembea fishing are much greater than for traditional fishing methods. A tembea style boat can cost upto Ksh600,000. Tembea fishing has been observed only with the first boats being seen around the islands of Remba and Ringiti in Kenya in 1996. By March 1998, a significant number of tembea boats were fishing from Muhuru, Uhanya, Usenge, and Sori-Karungu [67].

(b) **Tilapia Gillnet Fishery**: Exotic tilapia species are the primary species harvested in the gillnet fishery. Nets targeting tilapia have smaller mesh size compared to Nile Perch [64]. The operator usually owns gears and an average of 13 nets per fishing unit which is acceptable. The average net size is 68.27 metres long by a depth of 3.55 metres [64]. The introduction of outboard engines has also increased piracy in the Lake where fishers have lost their motorboat engines. The tilapia gill nets are always set near the beaches, especially in stony areas where tilapia breeds. After the nets are set, the fishermen then disturb the water. As a result, the nets catch fleeing fish. Tilapia fishermen sometimes catch a number of other species, with Nile Perch being the most frequently netted. Because nets for tilapia tend to be set in shallow waters, the amount of non-target species netted is not substantial. The fishers targeting tilapia and Nile Perch use similar fishing craft with an average crew size of 3 commonly observed.

(c) **Long-Line Fishery**: The main target species of long liners is Nile Perch. Instead of nets, the fishers attach a series of baits to a long anchored line. The number of hooks per line varies according to the size of the fishing craft, but an average number of 250 hooks per crew member is commonly observed [64]. Long-line fishery has gained popularity in Lake Victoria only recently and the access to quality baits is the major driver of fishing success. *Clarias* is commonly used as a bait and is caught using beach seining. A good catch for a long liner has been estimated to be 70-100 kg per canoe per fishing day [64]. Compared to gill nets, the capital costs of long-lining are much less and correspondingly, crew ownership of gear is widespread. Profitability is based on the cost of bait (Kshs2-3 per bait) and weight of fish landed. Long lining is becoming more popular.

(d) **Mosquito and Beach Seine Fishery**: Mosquito nets, commonly used in households to protect from mosquito-transmitted disease, are used in this type of fishing. Small mesh size nets are used for seining (see, e.g., Fig, 3.6). Given the small mesh size, many premature fish are landed. Typically, a fishing enterprize employs 6 nets, each having an average dimension of 33.94m long and 5.5m depth. The fisher often owns gear and an average catch of mixed species weighing 50.5 kg is common . Mosquito seine nets may be accompanied by up to about 6 lamps, which attract Dagaa (Rastrineobola argentea). Individual beach seine fishers deploy similar numbers of nets. Nets are longer, averaging 93.73m and having larger mesh sizes, compared to mosquito seines. The practice of beach seining requires a substantial labour input to cast and haul nets. Most often, fishing takes place at night, which guarantees better catches.

(e) **Traps and Set Net Fishery**: Trapping (i.e., Fig. 3.7) was the traditional method of fish harvesting in the region. Currently, relatively few fishers use traps. Most traps are manufactured from bamboo and

Fig. 3.6. Fishermen with mosquito nets in their boats

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are set in water courses flowing into the Lake to capture migrating fish. Trappers target tilapia. Set netters, who use nets of 69.3m long by 2m deep, also target this species [64].

Fig. 3.7. Traditional fish trap created at a river near Magu in Tanzania

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(f) **Trawlers**: Commercial trawlers were first introduced to Lake Victoria during the 1960s, primarily to harvest Rastrineobola argentea, with fishing efforts targeting Nile Perch. In 1988, between 5-10% of the fish processed by factories was derived from trawlers. Trawlers, however, can destroy local fishers' gears, bottom dragging of nets can interfere with the Lake's substrate , which in turn affects breeding and spawning. The use of non-selective nets can also result in overfishing [94]. Trawling has been officially banned from the Lake. Recent years, have seen a very high fishing activity in Lake Victoria especially following the introduction of Nile Perch and Nile tilapia in the Lake in the 1950s and 1960s. In Kenya the number of fish processing plants targeted to process Nile Perch has increased from none in the 1950s to about 25 in the 1990s.

3.3.5 Fish Supply and Marketing

Lake Victoria fisheries sub-sector has several components viz: fisher, agent and processor. In this section, each of these elements of the supply chain is described along with linkages and functional interdependencies. The fishery can be divided into artisanal and commercial trawler sectors. The artisanal fishermen work on a smaller scale, from open boats of 10 metres in length powered by sail or outboard motors. In contrast, the trawler sector typically uses larger vessels, powered by diesel outboard engines while participants have strong links with the processing sector.

Agents and Brokers

Agents and brokers purchase fish from fishers at the landing beaches. Market prices paid for fish are much higher at Lake Victoria, when compared to other inland water bodies. Higher prices are largely attributed to extensive export processing capacity in the region. For instance, the price paid for Nile Perch is ten times greater at Lake Victoria compared to Lake Turkana. Abila and Jensen [1] indicate that the most probable reason for higher prices for Nile Perch results from the industrial use for this species and accompanying export. Prices paid for *Rastrineobola* are lowest.

At landing beaches, fish are weighed, before being packed in layers in an insulated ice bin. The product accumulated at collection points is transported to processing plants by trucks (see, e.g., Fig. 3.3, p. 31). Most of the Perch processed locally are those that the factories are unable to collect due to delays in arrival to beaches, or arrivals without adequate supplies of ice. Factories also reject a proportion of fish on account of it being too small or stale. The rejected Nile Perch are processed by the local fishmongers as (*Mgongowazi*) which means skeleton and are sold as far as Mombasa and even to the Democratic Republic of Congo (DRC).

Fish Processing

Most locally processed fish are either sun-dried or smoked, although small quantities of frozen fillets are also produced at a few small filleting plants in Kisumu. All the fillets are made from Nile Perch and Tilapia. Nile Perch is exported as fillets although a number of other forms including smoked pieces, dried belly flaps, trimmings, 'chips' and bladders are produced. Official statistics are not published for non-fillet products and recording is difficult since these products are most often sold by piece and not by weight. There is limited data on the domestic trade in Nile Perch. There are 10 factories processing Nile Perch for export in Kenya. A significant number are not currently operating at capacity due to fish shortages.

Artisanal processors source reject fish from factories (undersize fish, less than 1 kg) and discarded fish parts from factories. The smoking process initially involves gutting, removing scales, cutting the fish into pieces, washing, then smoking the fish for 8-16 hours under a papyrus mat in multi-rack Earthen kilns. Typically, the end-product has a shelf-life of a month, though it is usually brittle and easily damaged [47].

Fish Marketing

The fish landed in the southern parts of Kenya waters of Lake Victoria is either locally marketed or sent to Nairobi and Mombasa without passing through Kisumu town. On the other hand, most fish landed in the northern part ends up in Kisumu first before further distribution. At beaches Tilapia spp have the highest value at about Kshs 6.5 per kg. The retail price of Tilapia in Kisumu market is about Kshs 25 per kg.

Consumer prices of fish in markets of major cities are almost the same as the prices of beef. Fish preserved with ice and frozen fillets made from Nile Perch and Tilapia fetch much higher prices than the beach prices. Fish prices in Kenya are not controlled by the government, and therefore differences between wholesale and retail prices are not uncommon. The disparity is more serious with Nile Perch, which is less popular among the people around the Lake. The value of smoked and dried fish production is much higher than what can be locally consumed or otherwise transported effectively to outer areas. These conditions indicate that there is a need for improving fish marketing systems for fish as well as for processing and increased use of cold storage facilities

Fig. 3.8. Fish Market at the Beach

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to expand the markets. Table 3.12 and Fig. 3.9 indicate the prices of fish from various sources in Kenya for the period 1991-2000[7]. At

Table 3.12. Fish Prices in Kenya (Species combined) (KShs/kg) for the period 1991-2000

Year	Lake Victoria	Lake Turkana	Fish Farming	Coast Districts (Fish)	Coast Crustacea
1991	8.53	9.21	43.69	11.70	79.45
1992	20.99	3.45	48.09	18.85	108.47
1993	20.13	12.45	56.03	25.15	152.07
1994	18.58	11.10	68.85	41.22	121.64
1995	25.22	10.49	95.44	45.34	137.14
1996	36.82	7.56	100.91	43.96	123.20
1997	27.44	9.03	106.89	44.21	118.49
1998	39.46	6.49	99.21	33.88	129.74
1999	35.95	14.14	100.53	49.51	109.58
2000	38.75	13.52	102.88	49.22	104.54

present, some fish companies in Nairobi and Mombasa send their own refrigerated trucks to the main fishing beaches such as Karungu, Homa Bay, Kendu Bay and Usenge (see, e.g., Fig. 3.3, p. 31) where they buy

[7]Source: Department of Fisheries (Kenya), Statistics Section

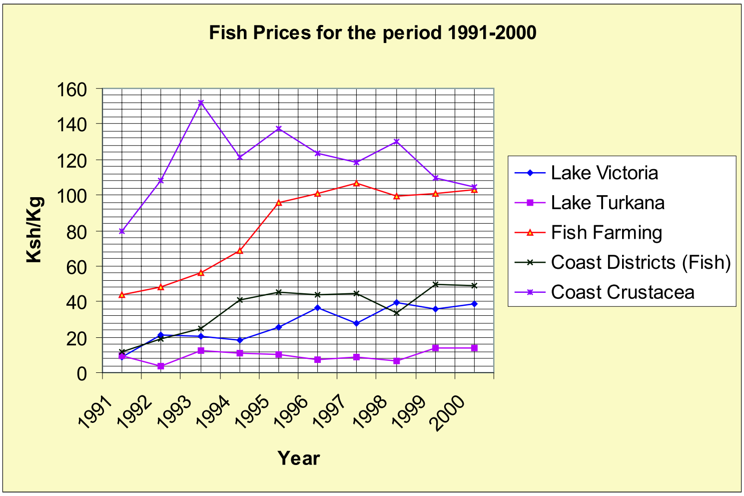

Fig. 3.9. Fish prices for 1991-2000

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fish through Fishermen's Co-operatives. Some of the fish is processed into fillets and exported to Europe, Middle East and other places while the rest is either sold in Nairobi or Mombasa as fresh fish.

Marketing Problems

The major problem in fish marketing around the Lake is that cold storage processing and transport facilities are not sufficient, with the result that excess fish supply tends to cause a drop in fish prices and to increase post-harvest losses. In order to alleviate this problem ice plants and cold storage facilities should be provided at least at some of the major fish landing beaches and access roads serving major fishing centers should be improved. A central fish processing and filleting factory should also be established. Such facilities will enhance full utilization of fish resources by producing by-products such as fishmeal and fish oil.

Fish Demand

The demand for fish stocks of Lake Victoria has increased tremendously in recent years. This phenomenal increase in fishing activity has been occasioned by the high demand by those communities that originally were not fish-eating. In addition, the increase in population around the

Lake has meant an increase in the demand for fish. The ready market for Lake Victoria fish has also played a part in this increase. In response to this escalating demand, the total number of fishing canoes has increased correspondingly. The demand for Lake Victoria fish outside and within the Lake basin region is expected to increase significantly. It is now established that human per capita fish protein requirement is 9.5kg/year. Kenya's population was estimated to have reached 30 million by the year 2002. According to this estimate, the national fish protein requirement by the year 2002 was about 300, 000 tons per annum.

This projection causes a contradiction and a paradox, while being a source of great concern. Thus, while the government estimate that fish landings from Lake Victoria have declined from 181,888 metric tons in 1995 to 155,084 metric tons in 1999. This constitutes more than 85% of the national fish production. It is unlikely that fish production from the Lake will increase significantly beyond the current production since the Lake is already showing some signs of qualitative overfishing. At the same time Kenya's population has been increasing. In view of the foregoing, the gap between fish production from the Lake and the projected national requirement by year 2005 can only be met through the development of fish farming. Emphasis should focus not only on our fisheries resources fully but also on the need to understand the factors governing fish production.

Income from Fish Export

Fish products are consumed domestically and also exported, primarily to the Middle East, Europe and Asia. These exports are an important source of foreign exchange. The destination of Nile Perch, mainly as frozen/chilled fillets, is provided in Table 3.13[8]. Figure 3.10 gives a clear illustration of the same. Israel accounted for 43% of Kenya's exports of Nile Perch in 1998 volume. The growth in export volumes to Israel has occurred largely in response to European Union's (EU) ban on Kenyan fisheries products. Other export destinations such as Singapore have become important, while fewer products are being shipped to Germany and France. 16,000 tons of Nile Perch were exported from Kenya by the year 2000. There is huge export potential for all types of fish products from Kenya to Europe. However, there are strict conditions placed on

[8]Source: Department of Fisheries Kenya, Statistics Section

Table 3.13. Destination of Nile Perch Exportsin 1998

Country	Exports (tons)
Australia	1,448
China	199
Egypt	403
Hong Kong	1,082
Israel	8,240
Japan	2,087
Malaysia	545
Singapore	961
USA	388
Other	473
Total Exports	15,826

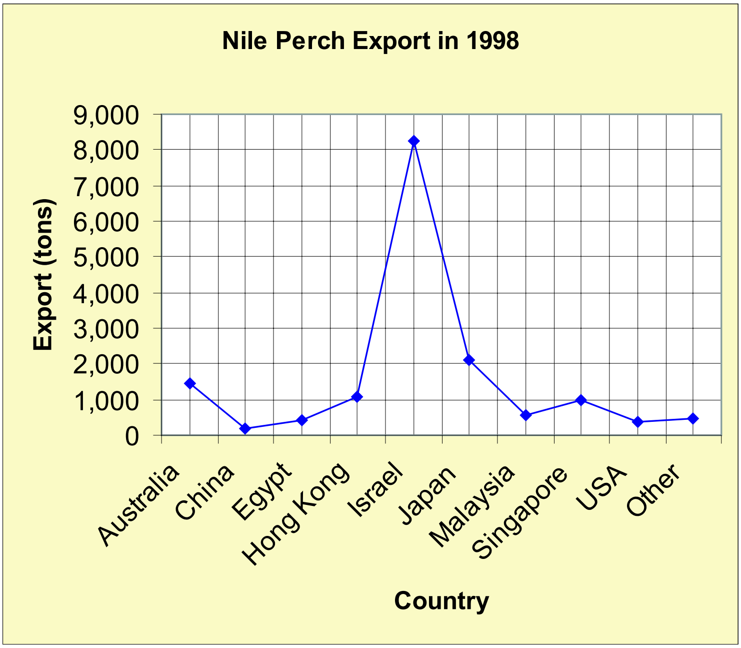

Fig. 3.10. Nile Perch Export across the World

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the fish imports from Kenya. First, the fish must be safe and secondly it must be tasty. The safety standards are required by the European Union (EU). Hygiene and adherence to EU regulations are the main issues for future trade between EU and Kenyan fish exporters. Secondly, the exports must meet the EU labelling requirements. From January

2002, fish exporters were to indicate the scientific name of the fish and the sea or Lake where it was caught. There are many specific regulations that must also be adhered to. The Department of Fisheries statistics show that Kenya exports 18,000 tons of fish annually, earning the country about Kshs 4 billion. Some 160 tons are produced from Lake Victoria[9]. A small amount of fish is consumed in the local market. In the early years of the Nile Perch fishery, locals preferred fish which was tasty and had less oil.

Fishermen Co-operative Societies

The Nordic survey of 1981 showed that there were 35 fisheries cooperatives along the Lakeshore with 8,480 member. However, by 2000, there were 46 Fishermen's Cooperative Societies servicing the Lake Victoria districts. Some co-operatives provide valuable services to their members, the most useful was the stable buying prices of fish on the beach. The co-operatives sell fish to traders, both locals and from other regions. The Co-operative Societies operate under the authority of the Co-operative Societies Act, enacted in 1968. In the 1990s, each fisherman had to pay an admission fee of Kshs 20.00 and Kshs 5.00 for administration and 10% of the catch, which is credited to an account held in their names. The co-operatives sell fish to traders, both local and from other regions. In the past, co-operatives have been the local providers of fishing gears, materials for boat maintenance, fuels, fish transport, fish preservation facilities, and channels through which fish was marketed. However, in recent times, many of these societies have ceased to function as envisaged. Consequently, fishing communities have progressively withdrawn their support, in part because some of the services rendered by the co-operatives became available from alternate suppliers, and also because of mismanagement of the co-operatives.

Problems Facing these Co-operative Societies

The availability of alternative suppliers of services to the communities is beneficial. The most aggressive of these alternative suppliers are the processors of Nile Perch for export. The exporters have played a major role in financing boats and fishing gear, as well as assisting in the procurement of supplies. In lieu of their normal activities, the societies charge a 10% Levy on the landed value of the member's catches

[9] see Kenya's Daily Nation Newspaper of June 6, 2002

(see Fig. 3.11 showing such members unload their catch). While this is high, the revenue to the societies overall is likely to be low because of their much reduced memberships. The fee is a charge for services provided. However, fishing communities complain that it is often difficult to see value for money. This has contributed to the decline in memberships. This is because the services rendered are insignificant relative to the money collected from members of the societies. In seeking to become more relevant, some societies are now providing limited banking services. Successful precedents exist in support of the coffee growing communities. The objective is to assist communities to become more aware of the importance of savings, and be able to invest in order to generate further wealth.

Fig. 3.11. Unloading of fish by co-operative members

3.3.6 Level of Fish Stocks

There is no current data on the precise magnitude of fish stocks in Lake Victoria to guide management decisions on sustainable harvest limits. The only comprehensive stock assessment survey of fish in Lake Victoria was conducted by EAFFRO/FAO with UNDP and East African Community funding in 1969-1971 [76]. At that time, total *ichthyomass* in the three riparian states of Lake Victoria was estimated at about 679,000 metric tons. The *haplochromine* species flock was the most abundant accounting for 83%, *Bagrus docmac* 5%, *Clarius mossambicus* at 4%, *Synodontis* at 3% and all other species including the *tilapiines* made up less than 1%. The Nile Perch was 0.0006% of the estimated total Lake *ichthyomass*.

There has been a dramatic decline in fish numbers in the Lake and a major drop in fish species in the last three decades. It would therefore be wrong for East Africans to continue as if all is well yet research shows that the Lake Victoria's fisheries are threatened. The fish species in the Lake have declined from about 300 in the last decade to three dominant species. As already mentioned, these are Nile Perch (*Lates niloticus*), Nile Tilapia (*Oreochromis nilotica*), and Omena.

Depletion of Fishes in Lake Victoria: A Historical Perspective

Before the arrival of the Nile Perch, there were over 500 different *haplochromines* species in a myriad of shapes, colours, and lifestyles [4]. There were insect eaters, algae scrapers, mud biters, leaf choppers, snail crushers, shrimp eaters, baby eaters, fish eaters, scale scrapers, and snail shellers, all of which found a way to live in one giant Lake by finding a different source of food.

To the scientists, this variety of diet and habits was simply astounding. Samples of Earth taken from the bottom of the Lake suggest that the Lake may have temporarily but completely dried up 12,000 to 14,000 years ago. If this is true, these hundreds of cichlid species must have evolved from a handful of ancestral species in this same relatively short span of time. So apparently changeable are the cichlids as a species that, if introduced into a new part of the Lake, they could become, for example, specialized feeders on entirely new types of food. The cichlids showed that adaptation and evolution could occur much more quickly than anybody had thought.

There are some species like *Cichlids*, which supported commercial fishing in the 1960s, but are now extinct. Between 1973 and 1998, the number of fishermen grew by 300%, increasing to 40,000. The number of fishing boats increased by 266% over the same period to reach 15,000. From available data, the biomass and the abundance of Nile Perch decreased from 790,000 tons in 1999 to about 530,000 tons in the year 2001. Most fish processing plants are operating below 50 per cent capacity due decline in fish stock Most serious, however, are discoveries that currently close to 60% of fish caught in Lake Victoria are immature and below 70 centimeters in size while the initial size of the Nile Perch caught in the Lake is about 1.8 meters long.

Negotiations on Fishing Ban

Even though the government ban on fishing in Lake Victoria was lifted in August 2002, negotiations are going between Kenya, Uganda and Tanzania on the need to enforce a fresh six-month fishing ban in the Lake. Should the three East African countries adopt this proposal for regional ban, then fishermen may once again find themselves on a collision course with scouts who patrol the Lake. Some experts feel that any other ban may only spell doom for the lucrative fish business on the Lake. However, there are those who feel this is the only sure way of replenishing the diminishing fish stocks in the Lake.

It has been argued that enforcing a regional fishing ban would cost Kshs 10 billion to the industry stake holders, fish processors, traders, exporters, and transporters. It is also estimated that export losses would be to the tune of Kshs 25 billion. This implies that the ban that is thought to make a lot of ecological sense will spur an enormous economic problem. Uganda has, however, expressed opposition to the regional ban with the country's Commissioner for Fisheries stating that Uganda would not take the proposal from Tanzania before being furnished with evidence to support the move.

The regional fishing ban will target mainly the Nile Perch, which forms the bulk of the fish export from the region to European Union (EU). The fishing ban campaign being spearheaded by the Mwanza-based Lake Victoria Fish Processors Association of Tanzania (LVFPAT), which has volunteered to stop fishing for four months every year from June to allow the fish to breed. The Association fears the Lake's fish population has declined to dangerous levels and seriously threatens the Nile Perch fish processing and packaging export industry.

The firm is demanding that a similar move be undertaken by Kenya and Uganda. The main argument of some fish traders is that small fish should be let to mature, while the big ones should be left to reproduce undisturbed. The suspension, it is argued, could also impact drastically on the livelihoods of about 32,000 small fishermen, 10 fish processing plants and over 3 million people who depend on fish for a livelihood in Tanzania. It is estimated that the Tanzanian government would lose

TSh 4.5 billion ($5 million) in taxes and loyalties during the ban. In Uganda, fish dealers say the ban could cost the country about $ 30 million in suspended export earnings and affect 500,000 people employed in the fishing industry.

Competition for Fish Harvest

Surveys carried out in Kisumu indicate a cut-throat competition for fish harvest among processors owing to the shortage of fish from the Lake. Out of the 10 fish processors situated in the Lake shore town, only four are operational. Others have closed down or been forced to relocate to neighboring countries due to an acute shortage of fish. It is now obvious that the current exploitation of the Lake Victoria's fisheries is not sustainable. The supply cannot meet the demand as can be seen from Fig. 3.12 in p.55 where the locals are scrambling for fish. The situation could get worse unless urgent measures are taken to allow fish reproduction and building up of fish stocks. The declining fisheries in Lake Victoria

Fig. 3.12. Scramble for the morning catch at Kagoro beach of Lake Victoria

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is also attributed to ecological damage inflicted on the Lake by different stake holders. Among the menaces blamed for the dwindling fish stocks is the water hyacinth. Research studies show that the Lake is suffering from diminishing oxygen supply. The problem of oxygen balance, says the report, has been exacerbated by increased siltation, and water hyacinth that settled on the Lake during the shredding campaigns.

The other factor associated with declining fish stocks is heavy sediment over-load courtesy of unabated human activities in the Lake's hinterland. Scientists believe the geological formation of Lake Victoria resembles a basin but warn that as the Lake continues to fill up with silt, we will soon have a shallow basin with tons of silt and little water. Besides the water weeds which when they die become *anoxic*, they deoxygenate water causing fish to die. Periodic algae blooms and rivers flowing into the Lake are loaded with heavy red sedimentary soils.

Studies show that human activities in far-flung areas such as the Mau Catchments, Mount Elgon, Nandi and Elgeyo escapements have direct bearing on Lake Victoria's ecosystem. At its source near Londiani, River Nyando, one of the ten rivers that drain in Lake Victoria, bubbles with clarity and rebelliousness of youth. At the start of their mating session, fish swam upriver, their course determined by a remarkable sensitivity to the quality of water. Today, many of them are near extinct, unable or unwilling to breed in Nyandos's foul waters. *Synodontis victorians* (*Okoko*) in Luo, is rare in the Lake. Another rare species is the eel, mastecebelus (*Okunga*).

The government recently introduced new regulations that criminalize the selling of certain types of nets as one way of stemming the depletion of small fish. The Director of Fisheries gazetted the new regulations in November 2001. The legal notice banned use, possession and sale of seine nets. It also prohibits use of less than 10mm net size in the Lake to catch Omena. However, some dealers in fish nets have described the new regulation as "*unfair and too restrictive*". They contend that some of the nets they sell are not specific to fishing in Lake Victoria and, therefore, it is unfair for the Fisheries Department to issue a blanket ban. They argue that the ban has affected the sale of the nets to players in the coastal region and neighbouring countries.

In a bid to address the issue of the declining fish stocks, leading scientists from the region want poverty strategies to incorporate all future operations in the Lake basin if the current trend of degradation is to be reversed. They argue that fishing on the on-shore waters should be banned since these areas serve as breeding grounds for most of the fish species in the Lake. Some scientists maintain that there is a worm that has been found in Lake Victoria which inhibits the reproduction of Omena. Research shows that the tapeworm parasite could substantially reduce the population of the indigenous fish if remedial measures are not taken. Empirical research shows that worm could infect as much as10 per cent of Omena.

3.3.7 Role of Governments in Fisheries Sector

In the preceding sections, we discussed the issue of resource exploitation. But effective resource exploitation requires efficient management in resource utilization. This section addresses the role of governments in the most important resource, the fishing industry. The need for fisheries collaboration in Lake Victoria was realized early in 1928. More recently, the three East African countries collaborated through the support of Food and Agriculture Organization (FAO) Committee for Inland Fisheries of Africa (CIFA), Sub-Committee for Lake Victoria. A Convention for the Establishment of the Lake Victoria Fisheries Organization (LVFO), drafted with FAO assistance, was signed by all three countries in 1994.

The LVFO was intended to promote better management of fisheries on the Lake, co-ordinate fisheries management with conservation and use of other Lake resources, collaborate with existing bodies and programmes dealing with Lake management, co-ordinate fisheries extension, advise on introduction of non-indigenous animals or plants into the Lake, and disseminate information on Lake Victoria. The LVFO is currently supported by the European Union through the Lake Victoria Fisheries Research project. Recently, there has been an effort in each of the three East African countries to actively pursue strategies to ensure the sustainable development of fisheries. The following is a discussion of what is being done at the level of the three states collectively, and at the level of one state, Kenya.

The East African Community Development Strategy

The Governments of Kenya, Uganda and Tanzania, recently indicated a collective approach to the solution of problems facing Lake Victoria and its environs. The East African Community Secretariat has a major project on the development of the region as an economic development bloc. In addition, the three riparian states have established major fisheries and environmental development institutions, namely the Lake Victoria Fisheries Organization (LVFO) and Lake Victoria Environmental Management Project (LVEMP). The World Bank funds the

LVEMP in each of the East African Countries. The over-riding goal in the EAC Development Strategy for 1997-2000 was to, "*promote a people-centered economic, political, social, and cultural development on the basis of balance, equity and mutual benefit of the three states*" [30, p. 5].

The main objectives of the EAC Development strategy (1997-2000) were to;

- strengthen and consolidate co-operation in agreed fields with a view to bringing about equitable development among the member states and thereby uplift the living standards and quality of life of the people;
- promote sustainable utilization of the region's natural resources and put in place measures for effective protection of the environment;
- enhance the role of women in development;
- promote peace, security and good neighbourliness in the region.

The Lake Victoria basin represents a unique opportunity to accelerate progress toward those objectives, especially as the basin is specifically highlighted in the strategy as a "regional economic growth zone" [30]. The Development Strategy emphasizes that:

> "The exploitation of Lake Victoria resources and management of its environment are crucial since it serves as a unifying factor of the three member states. There is a need to jointly exploit the Lake Victoria resources, manage its environment and develop adequate and reliable infrastructure to facilitate safe navigation on the Lake [30]."

With the renewal, coordination and harmonization of the economic, social and environmental policies and programmes among the neighbouring countries as well as more effective institutional partnerships and legal arrangements involving all key actors, the Lake Victoria basin can become a sustainable development growth zone, which can anchor and stimulate economic growth throughout the region. Moreover, as all countries can benefit by seizing the win/win opportunities in the Lake Victoria basin. The new methods of co-operation and partnerships can be used to tackle pertinent issues such as trade and economic integration. This will help accelerate progress toward the longer-term goals of the East African Community.

Project on Lake Victoria Fisheries Management

The three East African countries are to benefit from a KSh 2.3 billion (30.5m Euros) project to improve the management of the Lake Victoria fisheries. A council of ministers, directors of fisheries and top researchers from Kenya, Uganda and Tanzania have approved the project, to be funded by the European Union. The Jinja-based LVFO will help improve the erratic management of the region's $200m (KSh16b) subsector. The project is also expected to come up with a harmonized regional fisheries management plan to tackle growing insecurity on the Lake, management of beaches, surveillance, water quality, and environmental protection, among other issues.

Government of Kenya

The Department of Fisheries (DoF) undertakes the administration of fisheries. Specifically, this is the responsibility of the Director or authorized delegate, subject to the direction of the Minister. DoF Headquarters is located in Nairobi. Staff is also deployed at Provincial Fisheries Offices, as well as District Fisheries Offices. The headquarters of Department of Fisheries collects fees relating to the export and import of fish and fisheries products. The amounts collected are based on consignment weights and values as recorded by Fisheries Officers in the Provincial centers of Kisumu and Mombasa. Mostly, the information recorded is as provided by the exporters. There is considerable skepticism at DoF about the declared values. No verification is undertaken of the prices used in calculations, as might be possible from international sources such as INFOFISH. The export and import quantities and values are transcribed by hand into a ledger. Considerable effort is required to compile and tabulate the data.

The Fisheries Department actively pursues strategies to ensure the sustainable development of fisheries. These strategies include enforcing fishing legislation, which prohibits the usage of destructive fishing practices and industrial development through providing extension, research, promoting fish product marketing and infrastructure. Pursuit of these strategies involve coordination with other organizations such as the Ministry of Environment and Natural Resources (Department of Fisheries), Kenya Marine and Fisheries Research Institute (KMFRI), Lake Victoria Fisheries Organization (LVFO), and Lake Victoria Environmental Management Project (LVEMP).

Fisheries Laws: The current Fisheries Act was passed by the Kenyan parliament in 1991. Under existing Decrees, the restrictions on fishing in Kenya, include the following:

1. Fishing with explosives, poisons, any other noxious substance.
2. Electric shock devices are prohibited.
3. Trawling is prohibited within five nautical miles from the Kenyan shoreline of Lake Victoria.
4. No person shall use any vessel for fishing in Kenyan waters unless there is in force in relation to that vessel a valid certificate of registration (1991:20).
5. No person shall fish in Kenya fishery waters unless he/she is a holder of a valid fishing license, he/she is an employee of a licensee and is fishing in accordance with the Minister's order published in the gazette (1991: 21-22).
6. No person, other than a sport fisherman, shall land and fish at any point except at a fish landing station and for the purposes of this regulation, the fish landing stations shall be those specified in the Fourth Schedule (1991: 31).
7. It is forbidden to catch, process, store, buy, transport, sell or export fish which are in the reproductive stage.
8. Except for Rastrineobola argentina, fish landed from Lake Victoria must not be less than 25 cm.
9. Gill nets, with a mesh size of less than 50 mm, are prohibited.
10. Seining nets, with a mesh size of less than 50 mm, are prohibited, except in the case of Rastrineobola argentina, where a minimum size of 10 mm is allowed.

In practice, the laws and regulations for the fishery are poorly enforced in some areas due to inadequate transport resources and staff. Undersized fish are caught by many fishermen and sold locally at a lower price than fish of legal size. The use of illegal gears (undersized mesh) is an issue of major concern along with the theft of gear. The Director of Fisheries is charged with the responsibility of developing the fish industry through providing extension and training, conducting research, promoting fish product marketing, providing infrastructure and stocking waters with fish.

Fisheries Licenses and Fees: There is a vast range of levies relating to fishers and fishing vessels on the Lake. In relation to the Fisheries Act, fishermen have to be licensed and fishing craft need to be registered, as per the Act as described above. The schedule for licences and boats registration, by boat class, is provided in the Table 3.14.

As can be observed from Table 3.14, boat registration fees are as low as at Ksh 100 per year for non-mechanized vessels and increase to KSh 10,000 per year for vessels exceeding 15m.Officers of the Department of Fisheries officers and staff based in each of the fishing districts in Lake Victoria collect licence and registration fees (see, e.g., Table 3.15[10]).

[10]Source: Department of Fisheries (Kenya), Accounts Section

Table 3.14. Fees for Boat, Fisher Registration, Licences and Permits

Registration of local fishing vessels	KSh/vessel/year
Non-mechanized fishing vessels	100
Mechanized fishing vessels	
Vessels not exceeding 5m	200
Vessels 5-10m	500
Vessels 15m	10,000
Fisherman, Sport and Trout Licences	**KSh/person/year**
Fisher not using any craft	50
Fisher using non-mechanized	
Vessels not exceeding 5m	100
Vessels exceeding 5m	200
Fisher using mechanized	
Vessel exceeding 5m (1.5m beam)	150
Vessel exceeding 10m (2.5 m beam)	1,500
Vessel exceeding 15m	5,000

Due to the migratory nature of many fishers and the limited number of government officers in some districts, a number of vessels and fishers do not pay fees and registrations each year.

Table 3.15. Fees Collection From Fishermen's Licenses, Boat Registrations

Some Districts around Lake Victoria	Collection (KShs)
Bondo	202,600
Busia	18,630
Homa Bay	275,950
Kisumu	53,900
Migori	410,950
Rachuonyo	433,600
Suba	855,000
Total	2,250,630

Single Business Permit Fees: Local authorities are empowered, under the Local Government Act, to issue Single Business Permits. They are to maintain a business register enumerating the information on all businesses located in their areas of jurisdiction. The individual local authorities can choose the fee to charge for a Single Business Permit, from the 16-fee range given in the fees schedule approved by the Minister of Local Government. Its choice must be gazetted and displayed prominently at the Local Authority Council office.

The granting of a permit is not linked to other regulatory controls and clearances as might be required by the Health or Planning Departments. Nevertheless, a business must comply with all government regulations related to health, safety and public welfare. These regulatory activities are to be conducted on an on-going basis throughout the year by all relevant Central and Local Government offices. An existing permit may be canceled in the event that the business activities jeopardize health, safety, and public welfare.

The annual fees in the 16-fee range relevant to large-scale fish processing (over 50 employees) range between KSh 6,500 and KSh 97,500. For small-scale processors (up to 10 employees), the fees range from KSh 800 to KSh12, 000. It is expected that both county and town councils will choose from the lower half of the 16-fee schedule that; the municipal authorities will choose from the lower two-thirds and that large cities like Nairobi, Kisumu and Mombasa will choose from across the full range. A number of other fees and levies are borne by fishers to assist with marketing and local infrastructural development. These include:

- A “Fisherman’s Co-operative” Levy charged for each kilogram of fish landed at the various beach heads throughout the Lake areas.
- A local government, “Cess” Levy is charged on fish landed. Revenues from this Levy are supposed to support the development of fishing-industry related infrastructure such as electricity, water supplies, roads and beach huts for weighing fish. Beach Management Units (BMUs) have been established in Kenya. The key objective of BMUs is community-based co-management of the fishery in conjunction with the Department of Fisheries officers and staff. The major management objectives of the organization is observing size limits, policing of gear theft and reducing the use of illegal gears. To sustain the operation of BMUs, a Levy per kilogram of fish landed is charged.

At present, there are a number of other licenses and permits whose utility appears doubtful. They include the Fish Traders Licence, Fish Processors License, Fish Movement Permit, Camping Fee (per person per day), Aquarium Fish Dealers License, Aquarium Fish Keepers Permit, Crustacea Dealers License, Registration of Sport Fishing Club, Shell Dealers License, Shell Collectors’ License, and Oyster Collectors’ License.

Local Authorities: Fish Levy is collected by five of the local authorities in the Lake Victoria Districts. The revenue for 2000/2001 was slightly more than KSh 8.1 million. Table 3.16[11] indicates the amount of money collected during that period.

Table 3.16. Revenue From Local Government Fish Levy

Local Authority	Revenue Collected (KShs)
Bondo County Council	7,614,864
Busia Municipal Council	158,610
Busia County Council	23,000
Kisumu County Council	3,140
Migori County Council	319,910
Total	8,119,524

Management of Fisheries

The serious management issue confronting the Lake Victoria fisheries is over-exploitation of Nile Perch, as reflected by substantially reduced catch rates and the size of fish catches. This situation has been exacerbated with Uganda patrolling its border and preventing fish caught in her territory being landed in Kenya, as had previously been the traditional practice. Uganda is also substantially increasing its fleet in the hope of doubling catches over the next few years. Similarly, there is a conflict between Tanzanian patrols that the Kenyan fishermen have accused of intrusion into Kenyan waters and impounding of their boats and charging them a fine of KSh 15,000 per boat impounded. The consequential drop in quantities landed by Kenyan fishermen has been partly offset by competing processors paying higher prices for the product. The consequence of reduced supply has been more drastic in its effect on processors.

Several factors have contributed to the tremendous fish supply activity. First, there is the freedom to enter the fishing activity without restrictions. Once in the business, there is virtually no effective regulation to control the fishing effort and the size of the fish caught. Since Lake Victoria has been and still remaining an area of open fishery, it would be very difficult to limit the fishing effort by excluding some fishermen from the fishing industry. Besides, there is no scientific data on the basis of which the fishing effort could be set. Government fish scouts are expected to execute the Fisheries Act within the fishing villages and

[11] Source: Ministry of Local Government, Kenya

landing beaches. Across the 297 landing sites, fish scouts police the use of illegal fishing gears, prosecute net thieves, collect fisheries statistics and ensure boats, fishers and gears are licensed.

Since the explosion of the Nile Perch fishery, many observers indicate that the effectiveness of fish scouts has declined since they are hampered by a lack of equipment and expansion of fisher numbers. Of greatest concern is the inability of scouts to police net mesh size and harvesting in breeding areas. Under the auspices of the Fisheries Act (Section 43), it is illegal to use net mesh sizes of less than 2" for beach seine, 4" for gill nets and 0.5" mosquito nets for Omena fishing. Despite these regulations, large numbers of juvenile fish are being harvested, putting pressure on the fishery. Data from Dunga Beach in Kisumu, in 1997, indicated that 34% of Nile Perch landed were juvenile. Many illegal mesh sizes are currently being employed.

In-order to improve fisheries management in Lake Victoria basin, the following activities need to be implemented:

- Stabilization of the catch of Nile Perch.
- Increase the catch of indigenous species.
- Increase incomes of local fisher folk.
- Head off developing instability and possible collapse of valuable fisheries.
- Measure fisheries-trophic state interactions.
- Harmonize regulation and legislation.
- Monitor recovery and impact through the participation of the government and the local communities.
- Definition of current contamination of fish and prevention of any increase.
- Built capacity both at the grassroots level and relevant institutions.
- Improvement of fisheries research.
- Improvement of information base on the ecosystem and fisheries of Lake Victoria.

Boundary Conflicts and Fishing Rights

In the old days, fish was presumed to be an unlimited gift of nature. Fishing was mainly for subsistence. The inexhaustible '*fish mine*' was, therefore, hardly a cause of struggle. However, things have changed drastically. The reality is that the cash economy has thwarted the old day perspectives. Today, the use of Lake Victoria has become a source of great conflicts over the waters, the fish and even the land catchment areas [109].

The present-day conflicts are fueled by commercial motives backed by technological advancement. In addition, declining economic returns and diminishing natural fish resources contribute to conflicts in fisheries management. The conflicts involve all stakeholders from great men to the ordinary fisherfolk, angler against anglers, and nation against nation.

Lake Victoria is a shared water resource shared between Kenya, Uganda and Tanzania. Its Lakeshore line is 3,440 km long. It is highly irregular and indented. There are many isles in the Lake, some of which, especially the Sesse group, are known for their beautiful landscape, health resorts and sight-seeing places. Abundant pre-historic remains found around the Lake indicate the early development of agriculture.

A number of coastal towns such as Kisumu and Homa Bay (Kenya), Entebbe and Jinja (Uganda), Bukoba, Mwanza and Musoma (Tanzania), connect with each other by ship routes and also to the cities of the Indian Ocean coast by railways. It is unfortunate that the passenger steamer network that used to operate on the Lake is no longer functioning due to the collapse of Lake transport systems. The division of the Lake water is not egalitarian. Kenya has the least percentage, inspite of having the largest number of fishermen. To be able to obtain their livelihood, Kenyan fishermen fish in the Tanzanian and Ugandan waters. Ugandan authorities recently embarked on a mission to get rid of any Kenyan fisherman found in their waters. This has led to conflicts overfishing rights.

There have been occasional conflicts on Lake Victoria fishing boundaries disputes overfishing rights and the boundaries by fishermen from the three riparian states. Kenyan fishermen have occasionally had conflict with Ugandan and Tanzanian authorities overfishing space in Lake Victoria. This has been caused by lack of clearly boundaries in the waters. Kenyan fishermen do not understand how far into the waters they should go in their fishing activities. At the same time, the Tanzanian authorities argue that the Kenyan fishermen trespass into their territories. On numerous occasions, Kenyan fishermen have complained that their fishing boats are seized by Tanzanian authorities at the boundary and they are fined Kshs 10, 000 per boat payable before their vessels are released.

A dramatic example of the boundary problem occurred between 19th and 21st of 2003 when Tanzanian authorities arrested 87 Kenyan fishermen for violating the fishing boundaries. The fishermen were from the beaches of Gwassi, Sori, Kiwa, Nyangw'ina, Nyandiwa, Sumba and Mugabo. They were rounded up by Tanzanian armed patrol officers and taken to Sota in Tarime District. They were then jailed for three years each in Musoma and Tarime jails, after failing to pay the fine. Their fishing equipment which included 52 boats, 18 outboard engines, 300 fishing nets and 30,000 hooks, all valued at Kshs 5.5 million, (US$70,500) was also seized by the Tanzanian government[12].

The Kenyan fishermen were charged with collaborating with foreigners to "plunder" Tanzania's natural resources. They were convicted and jailed for illegal fishing and criminal trespass on the Tanzanian side of Lake Victoria[13]. Tanzanian regional authorities said they allow Kenyans to fish in Tanzanian waters on condition that they follow all licensing procedures and pay taxes due to the government. Most of the 12 fish processing plants around Lake Victoria on the Tanzanian side are owned by Kenyan-based firms.

Commenting on this incident, the then Kenyan Foreign Affairs and International Co-operation Minister Hon. Kalonzo Musyoka termed it as a "matter of great concern and we are going to move fast to secure their release"[13]. He said that an independent investigation had been instituted to establish the circumstances that led to the arrest of the fishermen. Meanwhile, an official at the Tanzanian High Commission in Kenya described as scandalous the arrest and subsequent jailing of the fishermen. He said, "It does not only sound scandalous but is also against the spirit of the East African Community ideals"[14]. Meanwhile, fishing activities grounded to a halt along several beaches in Migori and Suba Districts as fishermen demonstrated against the jailing of their 87 colleagues.

In the meantime, the Tanzanian authorities issued a statement warning that, to curb rampant illegal smuggling of fresh Nile Perch from its territorial waters, the government was planning to establish patrols on Lake Victoria. Prior to the arrests of the fishermen, the Tanzanian authorities issued a statement saying it would establish surveillance patrol on its Lake Victoria territorial waters at the Sirari, Kirongwe, and Kogaja exit points in order to crack down on smuggling of fresh Nile Perch.

Boundaries on the Lake have been controversial for many years. Ugandan authorities, for example, have frequently accused Kenyan fishermen of trespass. They have occasionally arrested the fishermen and confiscated their equipment. Recently, the Ugandan government enacted a law which defined and delineated its Lake boundaries with Kenya, but the Kenyan authorities have not done so. As a result, there has been a serious misunderstanding between the Kenyan fishermen and the Ugandan authorities. Uganda reviewed its boundaries in 1995 in its constitution. The boundaries were changed and some of the waters previously assumed to be on the Kenyan side reverted to Uganda.

[12] see, e.g., Daily Nation Newspaper of 22nd January 2003

[13] see, e.g., The East African Newspaper of 27th January–2nd February 2003

[14] see, e.g., Daily Nation Newspaper of 24th January 2003

The present Kenyan constitution is silent on the issue and the Draft Constitution of Kenya is still not clear on the matter. In 2002, District Commissioners from Bondo, Migori, Suba, and Homa Bay met with the Tanzanian authorities to discuss ways of resolving the boundary crisis[12].

There are also increasing concerns that the cases of Lake Piracy are escalating, and that these may be linked to gun running by the refugees. In Kenya, concern has been expressed over the involvement of non-riparian communities in the harvesting of fish resources. There are mounting conflicts around Suba and Migori districts on portions of the Lake. The concern is based on the fact that both refugees and other new entrants have no interest or any knowledge of traditional conservation methods used by the Lake communities.

Increased conflicts on the Lake will lead to reckless harvesting of fish, pollution and insecurity, especially through piracy. Already, there seems to be resurgence in piracy, which had gone down in the past three months. For example, in July, 2003, Kenyan fishermen around Muhuru Bay in Nyatike, Migori District, lost 10 engines, fishing gears and money to pirate, believed to have crossed over from Tanzania. None of the stolen engines has so far been recovered. Questions are being asked about the role and interests of humanitarian organizations, some of which are believed to be fomenting conflicts. Some relief agency staffs are living off the suffering of the refugees. To resolve the Lake Victoria water boundary disputes and associated problems, there is need for concerned authorities in Kenya, Tanzania and Uganda to start negotiation over the matter. At the same time, it is also necessary for the three countries to revisit history with a view to establishing some possible reasons for the problems in the Lake, and finding possible solutions. In Chap. 11 Subsect. 11.2.2, the possibility of using Global Positioning Satellites (GPS) satellites in border conflict resolution is suggested.

Unresolved Management Issues

We have already observed that the dominant fishing gears currently in use in Lake Victoria are gill nets, beach seines, mosquito nets and hooks. Of course, setting mesh sizes would go a long way to limit and restrict the types of fishing gears and the methods of fishing that would be effective in managing the fishery than merely limiting the size of fish caught.

In this regard, setting the fishing gears to limit the supply of fish may not be sufficient. Much more needs to be done. There is, therefore, need for the governments which benefit from the fishery resources of Lake Victoria to develop policies that will permit sustainability of the fish stocks so that they could continue to meet the supply of the protein demands of the increasing populations in the region and provide raw materials for the fish processing plants as well as those of other consumers of fish and fish products. Setting such policies require a tremendous amount of information and knowledge about fishes. The knowledge that we presently have is inadequate for effective policy formulation. For instance, what do we really know about the factors that determine the supply of fishes from Lake Victoria? Can the supply of Lake Victoria fishes be sustained?

The Beach Management Units (BMUs:) Beach Management Units (BMUs), each of which comprises 5 to 9 persons, exist at most or all of the 297 designated beach landing sites along the Kenya side of Lake Victoria. They are independent of government and have no legal authority. The local fishing communities determine membership. BMUs are highly accountable to their communities and are proving effective. The expenditure of these monies is at the discretion of the BMUs. There is generally no accumulation of funds. Rather, the monies are expended almost immediately after collection.

The functions of the Beach Management Units include resolving conflict, establishing beach hygiene and sanitation facilities, facilitating search and rescues in cases of Lake accidents and the establishment and maintenance of beach infrastructure. While some beaches impose a Levy of Ksh 1 per Kg on landings other less specific charging arrangements occur at other landing sites. It seems that the Levy of 1 Ksh/kg is quite high, approaching 2% of catch value. But this reflects willingness of fishermen to fund activities considered beneficial at the local level.

Current Governmental Research and Development Focus

The Government of Kenya employs a broad range of strategies to maintain the sustainability of fisheries and increase fish product quality. Strategies include improvement of basic infrastructure for fishing, enhanced fish processing, transportation and storage. Others include research leading to fisheries sustainability in inland Lakes as well as the marine coast, improving fisheries management, and developing fish quality assurance standards and codes of practice. Research programmes, environment and ecological research and development programmes are undertaken by DoF, KMFRI and LVFO. Their objectives and activities have been documented by [4, Tables 27 and 28, pp. 98–99].

Establishment of Fish Levy Trust The Kenya Government intends to establish a Fish Levy Trust to finance fisheries activities in the Lake region in addition to earning revenue to the exchequer. The rationale for establishing the Fund is linked directly with a proposal for a major change in management of the Lake Victoria fisheries. It is envisaged that a Total Allowable Catch (TAC) will be introduced for Nile Perch, with the Kenyan component being re-allocation to the districts, beaches, and then individual boat owners.

The process by which this might be achieved is through Beach Management Units (BMUs) being given the responsibility for the allocation at the beaches, and for compliance. The provision of these services is expected to attract a further 40% discount of the full-charge fisherman's license and boat registration fees. In this regard, the government has undertaken a study on feasibility of such a project. A consultancy has already submitted a report covering the riparian districts namely Kisumu, Homa Bay, Rachuonyo, Suba, Migori, Busia, Nyando and Bondo, as well as the entry and exit points of fish products of Kuria and Teso Districts. The government is still studying the recommendations contained in the consultant's report.

The above mentioned report found that the levels of compliance now standing at Kshs 2,250,630 in respect to fisherman's licences and boat registrations are poor. This is bearing in mind the number of fishermen and boats as determined by the Frame Survey of March 2000. The money that might have been collected is Ksh 7.6 million, or three-times that collected as recorded for the Lake Victoria districts.

Training Needs for BMUs and Fisheries Officers. In an effort to equip the BMUs with the necessary skills for the implementation of the Fish Levy Trust, there is need to train the fishermen members and officials of BMUs, as well as the fisheries officers in the districts. The training arrangements are expected to greatly expand the role and responsibilities of these people. The arrangements include BMUs being responsible for collections of money from licensing and TAC levies, and for systems to ensure compliance with regulations and TAC allocations. The future role of fisheries officers would shift to supporting and auditing the processes and performance of BMUs in these tasks. Considerable research is also undertaken in the fields of fish management, product development and socio-economics, as indicated in [4, Table 29, p. 101].

Establishment of the Fish Board of Kenya

On July 30, 2003, the then Minister for Livestock Development Hon. Joseph Munyao said that the Fish Board of Kenya would be established to streamline the fishing Industry. The board would operate like those covering cotton, coffee, and tea and pyrethrum sectors, which process and market the produce locally and internationally. He directed the Permanent Secretary to develop a working paper on the formation of the board. The Minister also proposed the introduction of a fish cess, which would be used to improve the roads to fish landing beaches. He announced that the Government would open up the beaches, by extending the rural electrification programme to the region.

3.3.8 Introduction of the Nile Perch and its Impact

In the preceding sections, we discussed the question of fisheries in Lake Victoria in general terms. Here, we discuss in detail the one type of fish that currently dominate the Lake; the Nile Perch. What impact does the Perch have? The wealth and diversity of fishes is currently threatened and changing. In the mid-1950s, a new kind of fish was introduced to the Lake, the giant Nile Perch (*Lates niloticus*), capable of growing to a length of 2 metres (six to seven feet) and weight of 140 kilograms (300 pounds).

At first, the giant Nile Perch did everything the officials wanted it to do. It spread far and wide throughout Lake Victoria. It could be found off the shores of Uganda, Kenya, and Tanzania, in deep waters and in shallow bays. The Nile Perch is a large predator capable of feeding on a variety of different types of fish. It is the king of the Lake's fish. There is a widely held view that Nile Perch is responsible for the disappearance of other species of fish from Lake Victoria. But other factors such as fishing pressure, and competition for available resources particularly between the native and introduced tilapine species may have contributed to the decline in stocks of certain species

The impact of the Nile Perch on Lake Victoria is not yet known. Twenty years after its introduction, the Nile Perch became established, and not only have the numbers and average weight of this fish progressively increased, but an examination of stomach contents indicate that it has been feeding vigorously on any and every fish including cannibalism on its own young. Nile Perch is a fat oily fish and when fresh does not cook when the traditional fish cooking methods are used.

As a result of its being accused by the local fishermen of having caused the disappearance of other hitherto popular species, this predator earned a bad reputation among the fishing community during the first few years after it became predominant. The progressive disappearance of *Haplochromis* and perhaps of other fish may be due to their lack of previous experience in living together with such a large and voracious predator. Nile Perch is a freshwater representative of a large family of marine group. The species *Lates niloticus* is found only within the African continent and is native to the river systems of Niger, Volta, Gambia, Senegal and the Nile. In the Lakes it is native to Chad, Albert, Turkana, Abaya and Chamo. It has also been introduced in Lakes Kyoga and Victoria.

The most detailed study of the biology and food of *Lates niloticus* were carried out in Lake Chad over a period of six years based on 5000 fish species. The study showed that food eaten varied very much with the size of the Lates, the habitat within the Lake, and the time of year. *Piscivorous* (predator) fishes such as Nile Perch are capable of eating fish up to about half their own length. Generally taken prey size, thus, bears a linear relationship with predator size.The conclusion from the study of food habit is that in Lake Victoria, as elsewhere, it would not be in the interest of the Nile Perch predator to eliminate its prey species. For the small village fishermen, the Nile Perch has eaten most of the other kinds of fishes they had traditionally caught, including lung fish, catfish, Tilapia, and the little fishes called *haplochromine cichlids.*

The loss of so many *haplochromine cichlids* had a devastating effect. Known as “fur”, “fulu” and “nkeje” in local languages, depending on whether you are from Tanzania, Kenya, or Uganda, they are called *haplochromines.* Their disappearance because of the Nile Perch not only removed an important ingredient in the medicines and culture of Lake people but also destroyed a living laboratory of cichlid evolution.

Cultural Impact: The traditional ways of life along the shores of Lake Victoria are crumbling as a result of the impact of the Nile Perch. Women from the traditional fishing communities used to buy native Tilapia, *labeo* and *haplochromines* to dry for sale. Not anymore. These days, women fry Perch scraps over charcoal fires. As the traditional fish species dwindled, the women migrated to squatter camps near the Perch-processing plants, where they buy the carcasses after filleting. The fleshy heads and tails are fried and sold by the road side pole stands. They are the only fish most local people can afford. In fact, if the Lake continues to deteriorate and the over fished Perch population crashes, it is not clear what anyone dependent on Lake Victoria will eat.

At first, official concern focused on problems that the Nile Perch created on shore. Fishermen needed bigger gear to deal with a fish that could grow to a hefty six feet. Villagers did not know how to fillet or cook the big oily fish and could not dry it in the sun. There were no markets, prices were low, and most Perch were left on the beach to rot.

With United Nations funds, a Kenya Marine Fisheries Research Institute (KMFRI) team toured Lakeside villages and Nairobi hotels, demonstrating how to fillet, freeze, smoke, and cook the fish. Foreign-aid groups and investors moved in with processing plants and refrigerated trucks. With the benefits of hindsight, it is tempting to say the effort was too successful. Today, few people who live by the Lake can match the price. Hotels and foreign customers are willing to pay for Perch; so much so that the spectre of protein malnutrition is being raised in a region exporting 200,000 tons of fish annually.

Uses of Nile Perch: No part of the Perch goes to waste. Shoes, belts, and purses are made by a Mombasa company from tanned Perch hide. Similarly, Kenya Industrial Research and Development Institute (KIRDI) utilizes Nile Perch hides to make leather products. In Nairobi, newspaper, front-page ads offer up to six dollars a pound for dried Perch swim bladders.

Through time, the promise of Perch as food for the people of the Lake was increasingly replaced by profits for businessmen selling their fish products around the world. The best parts of the Perch are sent out to the markets in Europe and the Middle East (see, e.g., Fig. 3.10 in p. 50). They pay high prices for such choice meat. The Perch's sand-papery hide made shoes, belts, and purses are sold in far-away locations. Nile Perch swim bladders, the internal organ that helps fish rise and sink in the water, are sent to England for filtering beer and wine and to the Far East for thickening soup. Only the smallest Nile Perch and left over tails and fish heads of the larger Nile Perch remained for many people of the Lake.

3.4 Forests

Natural forests of the region are logged, burned into charcoal, wood fuel and the tree foliage and barks are used for medicinal purposes. The forests associated values range from subsistence, fuel wood, wild fruit production, vegetable and wild roots, all which have also economic value that partially forms livelihoods for some communities.

Forests make up around 40% of the Lake basin area and are a habitat to numerous plant and animal species, as well as an irreplaceable repository of biodiversity. Accurate and up-to-date statistics are however of poor quality in the Lake basin due to absence of regular updating and the forest composition/cover changes are taking place at an increased pace [55]. Forests are important for preservation of water catchments areas and fuel wood supply. They also provide timber for construction and furniture making, among other uses.

In the Lake Victoria basin, forests have experienced immense human use and destruction. Forests have been used to harvest timber, provision of wood fuel and for graying. The ever increasing population have necessitated the clearing of forests for cropland. Wood also find use in drying and smoking of fish and in boat making. The use and loss of forests therefore continues to increase and remain on an accelerating trend due to expanding human population and new construction.

On the Kenyan side alone, the big forests include Kakamega forest, Mt. Elgon forest, Lambwe Valley forests, Kodera Forest, and Gwassi Hills Forests. The region is covered with hills, many of which are bare and are underutilized, thus making them ideal sites for tree planting. Some of the most important of these hills are Homa Hills, Wire Hill, Gwassi Hills, and Ruri Hills. The region is covered with a diverse set of forest products, ranging from indigenous to exotic tree species. The latter are only found on hilltops, where they have been planted by the Forest Department. The most common indigenous species are 'mvule' (ober), 'markhamia' (siala), and olwa. The demand for forest products is so high that the existing supply cannot match it. Efforts are afoot to promote afforestation. In Siaya District, the planted hilltops include Mbaga, Rambugu, Akala, Naya, Abom, Anyuongi, Regea, Nyambare, Nyagoko, and Usire.

In Uganda, forest and woodland cover comprise 24% of the total land area. The bureau of statistics has shown that wood biomass plays a more important role in energy production than all other sources combined, i.e, 90% of all the combined total energy [147]. Lake Victoria

Environmental Management Project LVEMP is spearheading afforestation program within the basin with approximately 144.6 ha of degraded land in the basin replanted. They are encouraging private investment in timber plantation, initiating afforestation programs, promote urban reforestation, implement agro-forestry practices, and secure forest conservation areas. These efforts are currently inadequate to reverse forest decline in the basin. In Mara and Mwanza regions of Tanzanian for instance, afforestation is hampered by land use conflicts [55].

Hagen [55] have shown that besides the ever increasing population, causes of increasing wood use and forest loss in the Lake Victoria region are:

- Lack of alternative energy sources due to poor transportation.
- Limited access to energy saving technologies.
- Land tenure and access rights.
- Urbanization (construction) and industrial growth.

3.5 Minerals

The general way of looking at the term *mineral* is that it encompasses a variety of substances taken from the Earth. Specifically, the term mineral can be said to be a naturally occurring inorganic chemical compound with a particular internal structure and a continuous range of composition. If the former approach is adopted, then one would also include construction materials such as stones, sand and gravel and also energy related minerals such as coal, oil, etc. The latter definition may exclude these substances.

The Tanzanian side of the Lake is endowed with minerals such as diamond, gold and tin, while Uganda has copper mines. Kenya had gold, soapstone quarrying and good quality sand as well as murram, quarry stones, fluorite, building stones extracted for economic use in construction of housing and roads. Sand is found along the rivers and hard core stones are plentiful, thus making construction comparatively cheaper in the region. Though the availability of sand makes construction cheaper, its harvesting has devastating effect on the environment.

In Musoma beach in Kenya for instance, sand mining has left degraded land (see, e.g., Fig. 3.13). The holes are often occupied by water during rainy seasons causing water borne diseases as shown in Fig. 3.14. Filled up holes also become dangerous to children and women who may drown. Besides, the land where sand has been harvested becomes completely inhabitable. In the Lake, sand is mined several kilometers inside (see, e.g., Fig. 3.15) and brought offshore by boats. This clearly interferes with the habitat of the Lake occupants. Studies done by the Lake

Fig. 3.13. Sand harvesting at Musoma beach, Kenya

Basin Development Authority (LBDA) confirm the existence of some minerals, precious stones and other rare Earth elements in the region. These include *fluorite*, *umerite*, and *iron ore*. The best-known mineral is gold that is mined on small-scale basis in Bondo, Rarieda, and Wangai while some deposits are found in Kamagambo and Kadem in Kenya. Other mineral deposits are copper, zinc and lead, although their exact quantities are not known. The deposits are substantial enough for commercial exploitation if the appropriate machinery is made available.

3.6 Human

The Lake Victoria basin is estimated to have about 30 million people. This includes Kenya, Uganda, Tanzania, Rwanda and Burundi. This is a huge resource that if well utilized, could bring about major progress to the region. The status of the population is shown to be poor and

Fig. 3.14. Water filled holes following sand harvesting

Fig. 3.15. Sand harvesting inside the Lake

mostly with low level of education. The potential for developing this resource is huge. Surrounding the Lake are reputable institutions such as Makerere University in Uganda and Maseno University which are at the forefront of research activities pertaining the Lake.

3.7 Energy

Energy resource has played a central role in the development of mankind. The Stone Age man depended on the sun as the source of energy. As early as 2500 B.C., the Babylonians used petroleum while coal and natural gas were mined in China by 1100 B.C [92, p. 245]. Petroleum, oil, gas, nuclear power and hydro-electric power are called *commercial fuels*, i.e., those that are traded in commercial market places. Biomass which comprise of firewood, charcoal, animal and plant waste is non-commercial. Petroleum, coal and natural gas require millions of years to form and are therefore non-renewable forms of energy which in general are environmental unfriendly due to their emission of Carbon components (e.g., CO_2).

Renewable sources of energy are, e.g., solar, geothermal, wind and hydro-electric power. These renewable forms of energy except biomass are generally environmental friendly as they do not emit dangerous gases that enhance global warming. Lake Victoria is endowed with these clean forms of renewable energy, notably hydro-electric power and wind energy. The Lake plays an important role either directly or indirectly to the energy and industrial developments in East African societies, especially those around it. Various forms of energy are created by the Lake itself or through other factors associated with it.

Lake Victoria has a large *biomass* potential. Biomass constitute about 11 to 14% of the total global energy consumption [92, p. 253]. There are many *phytoplanktons*, i.e., plant variety of planktons. It is estimated that phytoplanktons produce more than half of the Earth's biomass. These plants create food through photosynthesis and energy is stored in them. Other small animals –*zooplanktons*– feed on planktons and form the second web of the food, i.e., secondary consumers. Fish and invertebrates become secondary consumers, while men become the tertiary consumers. Many species of fish are found in the Lake. They provide proteins to man in form of chemicals of life stored in them, hence the communities around Lake Victoria especially those in Kisumu, Mwanza, Jinja and other towns have engaged in fishing activities to tap out these potential.

The Lake's waters, either from the rivers draining into it or from river Nile provide water to the vegetation around the Lake and also along the rivers. These plants in turn provide biomass in large quantities. Other rivers draining into the Lake, e.g., Nyando, Sondu Miriu, etc., are used to irrigate neighbouring farms. Ahero rice scheme is irrigated by Nyando rinver while Miriu provides water to Miwani sugar estate for processing sugar. Nyando river also provides water to Chemelil Sugar factory. Sugarcane waste products from these factories are then used as biomass.

As a result of Lake Victoria, thermodynamically induced winds are generated which results into wind energy. This is as a results of uneven solar heating of air masses over the Lake and the surrounding land masses to produces moving currents that blow on the shores of Lake Victoria (see, e.g., Sect. 5.3.1 in p. 120). Local geographical features such as hills cause the wind to change speed and direction as it passes around them. In comparison to the coast, the winds from the Lake are localized and decrease between April and July, especially around Kisumu and Kadenge in Kenya, while places such as Rusinga Island and Muhuru bay demonstrate usable winds year round [56, p. 98]. Wind energy is generated by windmills in the shores of Lake Victoria. Besides the wind energy that has been compressed to produce mechanical power for pumping water, grinding grains and cutting wood, wind energy is used to propel ships and boats in the Lake.

The Lake Victoria basin has significant hydro-power generation potential from the major rivers such as Kagera in Rwanda (e.g., Rusumo Falls), the Nile in Uganda, and Sondu-Miriu in Kenya. The Owen Falls hydro-electric power plant on the Nile has an installed capacity of 180MW but this can be increased to 380MW. Other potential sites include Bujagali (320MW), Kalagala (450MW), Kamdini, Ayago and Murchison Falls. The total hydro-electric power potential in Uganda between Lake Victoria and Lake Albert exceeds 2,700MW. Currently, Uganda exports power to Kenya, Tanzania (30MW), and Rwanda (30MW).

Within East Africa, Uganda has the highest and cheapest potential for hydro-electric power, which could be harnessed to benefit the whole region. The Lake also plays a role in provision of hydro-electric power through River Nile which has a source in the Lake. As the river passes in Uganda it forms Owen Falls in Jinja where a dam has been built. The dam was constructed in 1949–1954 and is 900 meters long and is situated in the more densely populated part of Uganda. This is because when power is produced, much can be sold locally. The form of power here is hydro-electric power and is taken to Kampala and Masaka in the West and to Tororo and Mbale and to Kenya in the East. Though Uganda exports hydro-electric power from Owen Falls in Jinja to neighbouring countries, there has been recent reports of frequent power blackout.

Due to this hydro-electric power though, Jinja has developed into an industrial town. Two large textile mills provide employment opportunities since the two industries together employ over 4500 workers. Steel mills and copper smelters are also found in the town. The steel mills use large quantities of power. Raw materials for other industries are thus provided by these factories. In addition, there are paper sack, fertilizer and cement factories. In general. Because of this hydro-electric power, energy for heavy industries has been created. Energy for domestic use is also available as the people around can use the hydro-electric power for lighting, heating and cooking. Imported hydro-electric power from Owen Falls dam has helped to supplement the power that Kenya is already producing through it's projects. This has also helped Kenya to be able to increase it's industrial output and thus enhancing regional co-operation.

Kenya has a potential to develop hydro-electric power on a very small scale. Estimated hydro-electric power potential in the Lake Victoria basin according to Kenya power and Lighting company in 1987 were; River Nzoia with gross capacity 60MW, Yala 60MW, Sondu 120MW, Kuja 18MW totalling to 258 MW. This will enhance development and growth of industries in those areas. Most hydro-power potential in Tanzania are in Pangani river.

Besides actual generation of energy as already discussed, the Lake plays a role of transporting energy development products across the three countries sharing it. Terminals have been built in Kisumu, Musoma, Mwaza and Jinja. Recently the Kenya Pipeline Company has started the construction of a facility in Lake Victoria to facilitate transportation of fuel products to the neighbouring countries. Once completed, the facility is expected to improve the capacity and flexibility in handling increased volumes of petroleum products which translate into improved operational efficiency and better service delivery to the economy. The Lake therefore plays an important role in the development of all forms of energy in East African counties. Though it has not been exploited fully, tidal energy is also a potential which can be tapped in the Lake.

3.8 Land

Agriculture is the major activity around the Lake, but there are also significant industrial developments within large urban areas. The comparatively good fertile land of the basin, with the added attraction of income generation from fishing, has resulted in significant population pressure.

3.9 Wildlife

The marginal areas of the Lake region have abundant wildlife. Lake Victoria is a hauntingly beautiful Lake whose shallow inlets and bays are home to giant hippopotamuses, which bathe along its shores, thick-skinned crocodiles, which lurk in the shallows, home to weaver birds, which live in cities of dropping nests, kingfishers, which make acrobatic dives into the water to snatch tiny surface-feeding fish, and a host of hundreds of different kinds of fishes, many of which are found nowhere else in the world. Chap. 4 gives a detailed presentation of eco-tourism.

3.10 Wetlands

The wetlands in Lake Victoria basin, which we cover in details in Chap. 8, constitute an important natural resource base upon which riparian communities depend. They are important in terms of food production, hydrological stability, and ecological productivity. While wetlands support significant components of biodiversity and are important for socio-economic reasons, they have continued to be under increasing pressure from human activities, such as conversion for agricultural purposes (e.g., Yala Swamp shown in Fig. 5.8, p. 145), pollution, and destruction of vegetation. Wetlands are a source of goods and services for the riparian communities which include sources of raw materials, handicrafts, fuel, support for fisheries, grazing and agriculture; outdoor recreation and education for human society; provision of habitat for wild life especially water fowl; contribution to climatic stability, a source of water and food production in dry season, e.g., *Comelina* leaves consumed as vegetables in dry season.

The papyrus that is harvested in wetlands find use in thatching houses, and the making of mats, furniture (chairs), fishing floats, rafts, etc., while both shrubs and papyrus are used for wood fuel [69]. Wetlands provide breeding places for certain species of fish as discussed in Chap. 8.

3.11 Agricultural

In the Lake basin, though fishing is undertaken, agriculture is the most complementary activity. It is evident as already discussed in Sect. 3.4 in p. 73 that intensification of agricultural activities comes at the expense of forests, river banks and wetlands in order to satisfy the increasing demand in food and cash. Though much forests are being cleared to pave way for agriculture, and wetlands destroyed, poverty still attacks the Lake basin dwellers like bandits (see, e.g., Chap. 6 in p. 179). The destruction of basins forest, cultivation and grazing of cattle has resulted in deforestation, loss of biodiversity, erosion and hence possible silting of the Lake [55].

Agriculture employs up to 75% of the nearly 30 million people living in the Lake region. While the majority of farmers in the Lake Victoria basin are small-scale, there are also large-scale maize, wheat and barley farmers. The major cash crops include rice, sugar, coffee, tea, cotton, and pyrethrum. Smallholder farms are characterized by low investment in farm inputs, small farm size, reliance on family labour, production of food crops mainly for domestic consumption and peripheral links to agricultural markets. Hagen and Larsen [55] have reported that in lowland areas, off-season production cannot be undertaken due to inadequate irrigation facilities. They further note that loss in traditional seed banking techniques affect farmers who cannot afford certified seeds and women lack access to emerging technological innovations despite being the most active in farming.

Major exports from the Lake Victoria basin countries include coffee and tea. Other regional export crops include cotton, sisal, and tobacco, and cashew nuts. Access to export markets for such crops is generally not problematic and access to the domestic markets of neighbouring countries for food crops provides ample room for improvement especially with the planned harmonization of internal regulations for export of food crops. Thus, in the future, it should be possible to export wheat flour or sugar from, say, Kenya to Uganda if it would make economic sense to do so.

There are rich and fertile lands for agricultural production of all kinds of crops, as well as flora and fauna. All the eight riparian districts surrounding the kenyan side of the Lake report that there is an abundance of rich agricultural lands in their respective districts [7]. For instance, “vertisols” - popularly known as “Black-Cotton” soils, are found mainly in Migori, Homa Bay, Suba, Kisumu and Siaya Districts in Nyanza Province [4]. These soils have moderate fertility, and support high rice yields, sugar-cane farming, sorghum and others as seen in Kana plains.

3.12 Concluding Remarks

While the Nile Perch still remains a controversial fish species, in respect to its imbalance in the fish ecosystem and while it has contributed immensely in the reduction of other fish species. It must be understood that it has contributed equally in providing food for the local community and an observable economic value to the riparian states. It now remains for those with a stake around it to study and research more on how it can be raised with minimal ecological and imbalance.

The importance of fisheries resources in the region cannot be overstated. It forms the core economic activity of many people in the region. For centuries, fishery activities were undertaken by small artisanal fisherfolk using cannoes. The fishing methods were not sophisticated. However, in recent years, things have changed dramatically. The introduction of the Nile Perch has changed the socio-economic features of fisheries. The Perch has been responsible for the seriously dwindling fish species and fish stocks in the Lake. The big fishermen have increasingly caught the Perch for foreign markets where they sell the fish at lucrative prices. At the present, there are only three species of fish used for commercial purposes (Nile Perch, Tilapia and Omena). Thus, the issue of the declining fish stock is a matter of grave concern because it has socio-economic effects.

On the role of governments on fisheries, the governments plays a critical role in the fishing industry. It provides the legal framework within

[7] See Ministry of Planning, District Development Plan 1996-2001 for each of the districts.

which fishing activities take place. It also deals with matters concerning security in and around the Lake. Moreover, it also undertakes managerial functions, research and other activities. However, given the important role which the Lake plays in the socio-economic development of the country and in the region, the government should increase its role in ensuring security in and around the Lake.

4

Eco-Tourism

"*... The mystery of the first wife" by Alphayo Otieno*[1]

4.1 Introductory Remarks

From Munyonyo beach in Uganda to hippo point in Kenya just to mention but a few, Lake Victoria basin offers enormous attraction sites. Eco-tourism is defined as *responsible* and *sustainable* tourism. It is the *environmentally responsible* travel and visitation to relatively undisturbed natural areas in order to enjoy and appreciate nature that promotes conservation of natural and cultural heritage. This kind of tourism has low negative visitor impact and provides for beneficially active socio-economic involvement of local communities. It includes;

- local and indigenous communities in its planning, development and operation and,
- lends itself better to independent travelers, as well as to organized tours for small groups.

It strengthens protected area management systems (public or private), increases the value of sound ecosystems, promotes sustainable use of bio-diversity, generates income, jobs and business opportunities in eco-tourism and related business networks, and shares the benefits of eco-tourism developments equitably with local communities and indigenous people by obtaining their informed consent.

It is regarded as a potential for salvation for some of the world's most endangered ecosystems. Examples of eco-tourism activities in-

[1] see Subsect. 4.4.4

clude bird watching in a rainforest, hiking in the mountains, participating in a traditional village celebration, taking a canoe trip down a river and tourists staying with community facilitating cross cultural exchange. Services provided to tourists by local people can go along way in alleviating poverty. Some of the services include:

- Local guides accompanying small groups of tourists on expeditions, teaching them about the local flora, fauna and culture, share their knowledge of local terrain and ecology with visitors, and develop a strong sense of ownership.
- Tourists staying at small environmentally friendly hotels called eco-lodges.
- Employing staff and tour guides from the local communities.
- Native handicrafts and souvenirs are made and sold to the tourists leading to preservation of cultural heritage.
- Businesses.
- Offer tourists a guided tour on the natural history of the area

This chapter will focus on the eco-tourism potentials of Lake Victoria. Various cultural centers of interest for the economic development of the region will be discussed. It is hoped that the chapter will provide a motivation for the sustainable exploitation of this resource for the betterment of the region and towards the overall goal of poverty reduction (see Chap. 6 for detailed discussion on poverty).

4.2 Eco-tourism: Benefits and Dangers

For the Lake basin, the benefits of eco-tourism would include:

(a) Using the obtained revenue to protect animals from poaching. This can be the case for Ruma National Park in Kenya (see, e.g., Fig. 4.4 in p. 93) and Impala Park (see, e.g., Fig. 4.16 in p.107) within the Lake basin.
(b) Using the entry fees after a village visitation to support education and health care for local children.
(c) Being an environmentally friendlier and potentially more sustainable alternative to extractive activities such as farming, logging, mining, or harvesting of wildlife.
(d) Initiating business ventures that can become self sufficient within a short time.

(e) Providing opportunities of engaging in dialogue with people from different backgrounds - a cross cultural exchange which forms a healthy bridge between industrialized and developing countries.
(f) Providing opportunities for long term protection of the land and its resources.
(g) Providing opportunities to generate revenue to support research, e.g., on scientific knowledge about the areas ecology, captive breeding, rehabilitation, reforestation, sustainable harvesting of orchids, prehistoric sites, or monitoring the effect of human impacts to ensure that visitation does not degrade the resource.
(h) Playing an important role in raising awareness of the problems facing a particular locale or its people.

To achieve these benefits, business ventures due to eco-tourism should be kept small. For example, there should be small-scale grass-root development that incorporates the desires and opinions of local people. Regulations should be put in place to ensure low consumption, efficient use, and strict recycling of resources by keeping enterprizes to manageable levels. The local community should demonstrate an up-front commitment to environmental objectives, provide quality leadership, and exploit small market niches where personalized service and unique experiences are favoured over large-scale operations. Thus there is need to educate host communities and the tourists and ensure equitable sharing of benefits accruing from eco-tourism. This entails the development of an economy that does not rely on tourism as sole source of income for the community.

The dangers include the following:

(i) Temporally increase in population puts demands on local resources which require installation of additional infrastructure, produce large amounts of waste and pollution and further the degradation of fragile ecosystems.
(ii) Tourists scaring wildlife away from their feeding and nesting sites.
(iii) Encouragement of the development of destructive economies such as markets in wildlife souvenirs(skins, bone, etc.) which can lead to further endangering or extinction of species.
(iv) May bring about social changes such as the exchange of traditional roles for unconventional ones, which disrupt the social hierarchy in the community.
(v) Tourist operations which are owned by foreigners provide little or no benefit to the locals since revenues are siphoned off to foreign

investors instead of being reinvested in the community. Besides, the environmental resources are degraded and the needs of local people are marginalized.

(vi) Eco-tourism fails when tourist needs take priority over those of wildlife and native people and can lead to monopoly of regional resources.

4.3 Successful Eco-tourism in Lake Victoria

For a successful eco-tourism in the Lake basin, the respective governments of East Africa should; provide financial backing for rural and indigenous people to develop cultural sites, provide organizational and coordinating efforts, give small communities access to knowledge about sustainable development and prevention of abuses. They should also empower rural guides and tourism operations. The communities on the other hand should implement small-scale income generating activities.

The following are possible eco-tourism activities in the Lake Victoria basin:

- Prehistoric and scenic site.
- Annual or seasonal water sports.
- Annual cultural festivals.
- Ecolodges which are manageable and environmentally friendly.
- Start up conservation efforts on forestry, fisheries, natural vegetation cover, agro forestry in the form of small scale funded projects.
- Local handicrafts and souvenirs.

Alternatively, funding for these activities can be sourced from funding agencies currently interested in alleviating poverty among poor rural communities.

4.4 Rich Cultural and Tourist Attraction Sites

There is a superabundance of rich cultural sites along the Lake Victoria region. Some of the most important of these include the following:

‘*Kit Mikayi*’ - a conglomeration of huge boulders hanging one on top of the others seemingly precariously but never falls. Underneath is a stream of rivers flowing into Lake Victoria. This attractive site is covered in more detail in Subsect. 4.4.4 in p. 98.

'*Simbi Nyaima*' - a deep depression with a well at the bottom. The well never dries up, and the water has a greenish stinking smell. Although the bottom of the bowl appears close, one cannot throw a stone from the edge to reach the bank of the deep well at the bottom of the 'bowl'. During certain seasons, migratory birds from different parts of the world pay short visits to Simbi Nyaima.

'*Luanda Magere*' is yet another cultural site. This is a legendary rock situated near Awasi in Nyando District of Kenya. The story has it that once upon a time, there was a Luo man who could kill enemies but could not be killed, despite being speared. The enemy's spears could simply not go through his body. The Kipsigis enemies then sent him a woman spy as a bride to find out the source of his strength. After many attempts, the woman succeeded when Luanda Magere was sick. He told her to cut the shadow of his head, and blood came out. She then quickly informed his enemies who quickly attacked him and speared his shadow. He died on the spot and turned into a rock. It is said that one can still see the marks on the ribs, which were speared. Luo warriors are said to sharpen their spears and knives on Luanda Magere shrine, before going to war. The weapons become lethal after being so sharpened.

Another cultural site is that of the footsteps of "*Nyamgondho wuod Ombare*" ("Nyamgondho the son of Ombare"), who was a poor man in Gwassi District. The story goes as follows: One day Nyamgondho was fishing along the Lake when a woman appeared from the Lake. He then took the woman for a wife, and they had many children. They also became very wealthy, with many animals. But he began to mistreat his wife, until the woman could not take it anymore. She took all her animals and went back into the Lake. Her husband followed and pleaded with her to return but to no avail. She went into the Lake with all the animals while Nyamgondho watched. It is said that Nyamgondho who was by then standing on one foot and leaning his chin on a walking stick, turned into a live tree. This tree only fell few years ago. The animal foot prints to keen observers can still be seen at the shore and into the waters of wadh Nyamgondho over looking Kiwa Island in Gwassi. This site, can be reached by boat from Kagoro beach.

Port Florence (presently Kisumu Airport) Port Florence which is now known as Kisumu boasts one of the old Lake harbours which connect with major port towns of Lake Victoria in East Africa. It has one of the most developed harbours in Lake Victoria. Kisumu has one of the oldest airports in East, Central and West Africa. It was, for a long time, the only airport between Cape Town in South Africa and Cairo in Egypt. Situated on the Lake Victoria Gulf, this facility offers a spectacular sight of the Lake area. Besides, the catering service within this airport is famous for its fish sandwich. Mr. Awuor Mbande, the proprietor, also known locally as "*nice to see you*" has this to say

> "It is the only one of its kind in the region. Those who have tasted it call it mind your lips".

Lake Victoria has excellent 'White sand' and 'Black sand' unpolluted beaches, with excellent hotels of international standards. Such hotels include Munyonyo in Uganda (see Fig. 4.1)which is said to have hosted the former US president Bill Clinton in 1998, Takawiri, Rusinga and Mfang'ano Islands hotels. ICIPE in Kenya also offers excellent accommodation for tourists. Besides ICIPE, Maseno University's Kisumu hotel is one of the best hotels in the city. Located near the Lake and airport, it is strategically placed such that visitors take short time from the airport and can spend long hours viewing the city and the Lake. It is equipped with modern facilities and has a modern conference hall which hosted the international conference of sugar producing countries. Eco-tourism around the Lake would be an unforgettable adventure. Lake Victoria expedition being interesting. A visit to the 16 islands would end up at the 'pyramid island' known as Migingo. One can also visit fishing villages, such as those at Remba Island, Kiwa, Pyramid (Migingo), Ngondhe, Mageta, and Ndere Islands (see, e.g., Fig. 4.2). Ndere Islands where there is a wildlife conservation in a small national parks is also a place to visit. There are several hippo points on the Lake shore where one can watch these animals getting in and out of the Lake: The most popular spot is the 'Hippo Point' in Kisumu. There are fishing spots also; as an example of this, many tourists from Masai Mara go to Rusinga Island for Nile Perch fishing. The other cultural sites include the activities of the fishermen and their canoes as they undertake fishing activities on the Lake. A more spectacular occasion is when there is a sailing competition among the fishermen. It is a display of a real cultural heritage!

These cultural sites provide excellent spots for tourism hence poverty reduction. A satellite tourist spots could be established where tourists could stay, buy works of arts, and purchase products made locally. Thus, a whole set of industrial set-up could be established, based on the tourist sites. However this has not been the case; the tourist indus-

Fig. 4.1. The Munyonyo beach hotel in Uganda which is said to have hosted president Bill Clinton of US in 1998

Fig. 4.2. Beautiful Ndere Island, Kenya

try neglected these areas, but change is apparently on the way. Already, the governments have taken the initiative to encourage people to establish such industries. The recent government's pronouncements is all the more encouraging in view of the strategic location and great potential, which the East African Community recognized. It has designated the Lake and its basin as an "Area of Common Economic interest" and a "regional economic growth zone" to be developed jointly by the partner states.

Indeed, the region has a lot of tourist attractions facilitated by the vast Lake Victoria. Its shoreline, numerous Islands inhabited by hippos, crocodiles, waterbucks, monkeys, monitors, snakes and birds of various species like the crown bird, and other crane species create an important spectre of attraction. The scenic beauty of Lake Victoria, the sport fishing on Rusinga Island and Takawiri Island and a wide variety of birds in the various island provide very important tourist attraction sites in the region. Other tourist attractions include Takawiri Musical Club. The most important national park in the region is the Ruma National Park with its wide range of wildlife, which includes buffalos, giraffes, waterbucks, leopards, hyenas, gazelles, mongoose, porcupines, and wild pigs (see Subsect. 4.4.8 in p.106). There is also the Impala Park in Kisumu. Tourism potentials within Lake Victoria also includes sport fishing, boating and cruising safaris. The numerous Islands like Mageta, Denda, Sifu, Ndere and Oyamo can be used for camping safaris. Large bird sanctuaries also exist on those islands. Overland tourism can be promoted in tourist attraction sites like Ramogi Hill, a pre-historic site regarded as the origin of the Luo, the "Gunda Buru" in Gangu, Nyandiwa, Boro, the ox-bow Lakes like Kanyaboli, Sare and Nyamboyo, the sprawling Yala Swamp and the Yala Swamp Complex, the water falls at Kongo along Yala river and Rambula along Nzoia river. There is a super abundance of rich cultural sites along the Lake Victoria region.

In the next section, attractive eco-tourism sites are discussed in detail. Suffice to say that the Lake has attractive sport sites such as the Jomo Kenyatta sports ground in Kisumu, Kenya (see, e.g., Fig. 4.3).

4.4.1 Impala Park

Impala Park is situated along the shores of Lake Victoria in Kisumu City of Kenya. The park is famous for its Impala animals (see, e.g., Fig. 4.4). Besides the Impala, the park also hosts other animals, e.g., Ostrich, Hyena, Leopard, Jackals and baboon. Figures 4.5–4.7 shows some of the other occupants of the Park.

Fig. 4.3. Jomo Kenyatta Sports ground in Kisumu, Kenya

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Fig. 4.4. Impalas in Kisumu's Impala Park, Kenya

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4.4.2 Kisumu Museum

Kisumu museum shown in Fig. 4.8 offers variety of animals. Other than the huge crocodile shown in Fig. 4.10 in p.98, the museum offers variants

Fig. 4.5. A male lion at Kisumu's Impala Park, Kenya

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Fig. 4.6. Jackals in Kisumu's Impala Park, Kenya

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of snakes, birds, tortoises (Fig. 4.9), aquarium, and the traditional Luo home (see e.g., Fig. 4.11 in p.99).

Fig. 4.7. Ostriches providing spectacular viewing to Japanese visitors at the Park
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4.4.3 Cultural sites in Tanzania and Uganda)

Cultural sites in the Kagera region in Tanzania include Kyaya, Bunukangoma in Kahororo ward, Rwamishenye Division. Kyaya has special type of soil, "inoni" which resembles ash, and was used when chiefs were being enthroned. Legend has it that long time ago, "inoni" was smeared on the face of the chief when he was being enthroned. During that process, someone stood on the side to listen whether the chief would sniff or not. In case he did so, it meant that he could not be put on the throne and the whole process had to be repeated.

The inoni was initially being used only for chiefs of Maruku and Kiziba but later was used even for Kyamtwara and Bugabo chiefs. This "inoni" is miraculous in the sense that it shifts from one place to another: - sometimes it is on the ground and sometimes it can be seen over the Lake as if ash has been spread all-over the Lake surface.

In Bunukangoma sub-village, there is a very heavy hammer (enyondo) with other accessories. These are smelt hoe, a knife and a "panga". It is estimated that "enyondo" was brought at Bunukangoma over the past 17 generations. A man called Rugomola Owolugundu who came from Uganda brought it. He passed at different places giving names within Bukoba District. On arrival in the sub-village of Bunukangoma,

Fig. 4.8. Kisumu Museum, Kenya

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he decided to leave the “enyondo” with its accessories, which are: smelt iron hoe, a knife and a “panga”. He finally settled in Maruku where he established a Kingdom. The “enyondo” was used as a very efficient detector of witch doctors because all the suspects in the community were sent to the “enyondo”. If one was not a victim, the “enyondo” could be lifted from its place but if one was, then there was no way the “enyondo” could come off the ground. Certain rituals had to be done at the site before lifting the “enyondo”.

Kerewe chiefs dug caves on hills for self - protection against invasion and for keeping things of great cultural and social values. Some of these caves are still in relatively good shapes (see, e.g., Fig. 4.12). There are other sites such as chief’s graveyards, sites for traditional rituals and other marvelous geographical locations.

The Ugandan side of Lake Victoria is endowed with the wonderful and magnificent Munyonyo beach (see, e.g., Fig. 4.13). Here, local and international tourists can find a place for holiday, honeymoon and an environment that is relaxed to accommodate them.

Fig. 4.9. A Tortoise in Kisumu Museum, Kenya

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The Luo and Abasuba of Kenya had very many legendry/cultural sites as already mentioned in Sect. 4.4, p. 88. These were places of significant historical phenomenon or mythical incidents. Sometimes, they were places of a legendary fame or ritualistic functions. Whatever the case may be, these places were, and some are, still held in awe and fear reinforced by traditional teachings of the tribes. There are sites, which in one way or another, affected or contributed greatly to the lives of the people in the community. They were sites where various meetings and practices such as sacrifices, rainmaking, and cleansing took or are still taking place. For example, Simbi Nyaima, Nyamgondho, Lwanda Magere, Kit Mikayi, Thim Iye Lich Ohinga, the islands such as Atego, Ringiti, Mbasa na Muole, Nyama ni Ware and many others.

Fig. 4.10. A Crocodile in Kisumu Museum, Kenya

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4.4.4 "Kit Mikayi" (The Stone of the First Wife)

Kit Mikayi[2] is found in Seme, about 20km from Kisumu City and six km from Kisian-Bondo Junction. To the inhabitants of rural Seme Kakelo in Kisumu District, Kit Mikayi, a cluster of rocks along the Kisian-Bondo Road, is a mystery. The magic of the imposing Kit Mikayi, which in Luo language means "stone of the first wife", still influences the lives of the residents. Apart from the spectacular shape and pattern of the rocks, visitors are usually surprised at the eerie environment at the footsteps of the cave and a huge tree that grows horizontally; which gives the impression of an unnatural feature (see, e.g., Fig. 4.14). Children marvel at how huge rocks sit on each other and how they form a 'fence' of about 20 Metres Square. Kit Mikayi rocks are so huge that no human being could have arranged them in the breath-taking style in which they appear. The rocks stand at about 40 meters high yet their tonnage has never been established. They form a cone-shape facing each

[2]see story by Alphayo Otieno on 'the mystery of the first wife', East African Standard Newspaper, April 26, 2002

Fig. 4.11. A traditional Luo home at Kisumu Museum, Kenya

Fig. 4.12. Nambi Well in Uganda with special cultural significance

Fig. 4.13. Munyonyo beach in Uganda

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other, and at the top, there is a 'roof' consisting of smaller rocks. To enter the cave, there is only one 'door', a small green ravine. On a crack on the wall of the cave is a spear, a pot and a shield. Nobody knows who, why, and when the things were placed in the cave. But there is one spot inside the cave that no one is allowed to step on. It is a holy ground, according to traditions. The holy ground, the size of a saloon car tyre, is a swamp (thidhia), with sludge-like black mud at the center of the cave. Beneath it is a river that flows to Lake Victoria. Trees have never grown in the cave. The closest one grows horizontally and its size baffles both scientists and traditionalists. But since it caresses the rocks, it serves as an altar for sacrifices by the local community.

The history of Kit Mikayi is as old as the settlement of Seme area. To avoid ill luck, visitors to Kit Mikayi pay a fee of Ksh 5 to an elder who is appointed the shrine curator. The offering appeases the spirits, says the villagers. A story is told of a visitor who was smuggled into Kit Mikayi by a villager without paying the fee. He collapsed and died seven metres away from the revered place. Another narrative claims that a woman who visited the "thidhia" without paying the required fee disappeared mysteriously. A party of villagers on a search mission discovered her body on the shores of Lake Victoria. Since then, women

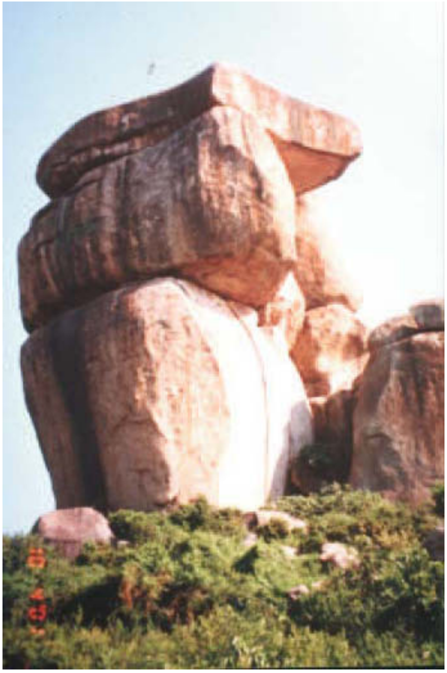

Fig. 4.14. Kit Mikaye in Seme District, Kisumu, Kenya

visiting Kit Mikayi must throw coins on the spot while shaking their shoulders in a style locally known as 'goyo otenga' (i.e., shaking of the sholders). A witch doctor, Obanga Owade, is said to have broken the rules and suffered a similar fate.

Elders trace Kit Mikayi's history to the age of inter-clan struggle for settlement. Myth has it that Seme was "gunda" (a deserted place) before the present inhabitants moved in. The first inhabitants of the area are believed to have been the Maragoli and Nyang'ori who later moved to Western and Rift Valley provinces, respectively. A short distance away was a clan called Nyikal. Gumba, one of Nyikal's sons, moved away from his birth place and settled in Seme. His brother, Dipir, is said to have remained near Asembo. The curator says that when Gumba reached Seme, the area was known as Kit Oluowa (piled stone). Mythology has it that whenever Dipir visited his brother, he always found that Gumba had gone to visit the piled rocks. Dipir then concluded that Gumba had made the stones his first wife or 'Mikayi' in Dholuo. Reaching Kit Mikayi is as strenuous as it is awesome. After trudging up a path snaking through thick bushes, one finds the ravine leading into the wide cave. The Legio Maria sect uses water from an underground stream in the cave for divine purposes. They call it Pi Hawi (holy water). Members of the sect, who have built a church next to the stones, believe the water has powers to treat gynecological complications in pregnant women.

During dry spells, villagers come with live chicken which they kill by hitting against the rock and then roasting them before feasting. This is how they 'call in rain'. One elder by the name Nyamoth recalls the days when the entire Kangeso village visited the place to drink, sing, and dance "to invite rain". One corner of the cave is called Thuon Gweno and is believed to be home to a large snake that mediates between the villagers and their ancestors. Thousands of black bats hang on the cave's walls and are said to accompany the snake on its occasional sojourns to the Lake. Nyamoth says the snake is seldom seen. When seen, it portends trouble. The snake leaves in the form of a windstorm that sweeps towards the Lake and returns in a similar style. One villager, Outa Ogingo, saw it and died instantly. His son, a teacher at a local primary school, is chairman of a committee appointed by villagers to manage the affairs of the shrine.

4.4.5 "Thimlich Ohinga" (The Haunting Forest)

Thimlich Ohinga[3] which means thicket or forest castle, is situated along the Lake Victoria basin in Migori District and covers 52 acres. The site has a complex of six skilfully constructed enclosures of stone built without the use of mortar. The enclosures have walls averaging 2.5m high. The forest castle consists of beautiful ancient stone walls, historic rock paintings and engraved sites of archaeological interest. These are believed to host some of the world's oldest fossils, dating between 17 and 19 million years. The present buildings are estimated to be at least four centuries old. Long before the government gazetted it as a national monument in 1983, a British scientist Lorna Lofgren, wrote about its picturesque landscape with its amazing stone structures in 1967. However,it remained obscure until the World Monument Watch listed this monument at position 48 among the top 100 sites threatened with extinction.

[3]see e.g., "Where great Zimbabwe got its theme" by Tom Mosoba in the East African Standard newspaper, September 27, 2002

Ruins of huts and cattle pens inside the complex provide evidence of settlements in the region that introduced a unique dry-stone wall, building tradition and a communal power system. The construction of the walls through piling of stones on top of each other without mortar displays an ingenious architectural mastery. It is believed that the first occupants were the stone-age people of Bantu origin, but Nilotic settlers are said to have later taken over and enhanced the structures into the technological enigma they are today. Archaeologists say Thimlich Ohinga served as an area for active cultural celebrations for several centuries before being abandoned in the first decades of the 20th century. The architectural artistry exhibited here is believed to have spread to Zimbabwe, through immigration in the 15th century, and led to the establishment of the Great Zimbabwe of East Africa, which is a site to behold and continues to attract thousands of tourists.

Although Thimlich Ohiga is the only one of its kind in Eastern Africa, its history remains largely undocumented. In a five-year management plan, the National Museums of Kenya (NMK) intends to preserve the cultural value of the site for the enjoyment of present and future generations. The NMK project received a Ksh 2 million grant from the World Monument Watch. The initiative is also in line with efforts by the government to open up the western Kenya tourist circuit. Served with three airstrips, other tourist attraction sites near Thimlich Ohinga include Lake Victoria, Gogo Waterfalls, and the former gold mines in Macalder.

4.4.6 Bird Watching and Sport Fishing

The Lake Victoria basin is habitat to 34 endemic waterfowl and migratory species. Conservation activities have included direct protection of bird types and habitat protection. Efforts have involved organizations for example East African Wildlife Society, National Museums of Kenya, Kenya Wildlife Services, World Wildlife Fund, Wildlife Clubs of Kenya, Bird Watch Groups and Community Based Organizations (CBOs). Protected habitats include Important Bird Areas (IBAs) such as Lake Nyamboyo and Usenge in Kenya.

Dunga wetland close to Kisumu City is one of the habitats with richest bio-diversity. Out of the 34 endemic bird taxa, 25 are found in it. However, the wetland is currently threatened with the expansion of Kisumu City and with agricultural activities. Fishing birds such as gulls, terns, pelicans, kingfishers and cormorants are abundant in the river mouths of Sondu-Miriu, Kuja-Migori, Yala and Nzoia. Rocky beaches with clear sandy waters host plenty of cormorants, little egrets and African fish eagles. This can be attributed to the fact that the visibility allows the birds to capture prey with little effort. River Yala and Sondu-Miriu are home to some of the candidate species for conservation such as the papyrus gonolek (*Luniarus mufumbiri*), the papyrus yellow warbler (*Chloropeta gracilirostris*) and the Madagascar Squaco heron (*Ardea idea*). Plovers, sandpipers and stilts dominate the water edge community on sandy beaches along the Lakeshores. Those dependent on emergent vegetation include herons, storks, cranes and passerines (warblers and weavers).

For tourists interested in bird watching, there is an ample opportunity to visit bird paradises in several areas around the Lake where there are many bird species such as comorants (osou) and, ibis (the King of Birds), a friendly bird that lands on people. Strange [140] presents an illustrative guide on the birds of Rusinga island.

Fig. 4.15. Common Birds of Lake Victoria at Muhuru Bay

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4.4.7 The Magic Of Lambwe Valley

As the sun descends slowly behind the towering hills of Ruri, Gembe, Kaksingri and Gwassi, a thick blanket of clouds speeds across the darkening sky, casting shadows over a vast patchwork of tropical savannah and thick forest. Little birds perched delicately on leafy branches pipe out wonderfully orchestrated evening music, and on the ground, monitor lizards retire lazily after a day of basking on the scattered basalt and granite rocks.[4]. Located in Kenya's Suba District, just 15 km away from Lake Victoria, the 3,100-hectare Lambwe valley is a favorite destination for tourists to the area. The hot tropical climate is moderated by gentle breezes from the Lake, creating tolerable temperatures on beautiful beaches that are easily accessible from the forest.

Visiting Lambwe valley is an unforgettable adventure. There are several ways to get there. One can take a chartered flight to the Kabunde airstrip, eight kilometres from Homabay town, then take the winding Rodi Kopany-Sori drive to the forest, which is characterized by hills and valleys and is often inaccessible during the rainy months of March, April and May. Alternatively, one can land at the Mfangano airstrip next to the home of the late Tom Mboya (one of Kenya's most reputable politicians), then drive to Mbita Point, which is about 15 kilometres from the forest. Visitors are warned, though, that journeying to the forest is rather rough and tough, hence a reliable four-wheel drive vehicle, with two spare tyres, is recommended. One can also get to Lambwe valley by Lake; a thrilling trip for which private hire boats are available. A four-hour boat trip from Asembo Bay to Mbita and Homa Bay and back costs between KSh 5,000 and KSh 7,000, depending on the weather and the amount of baggage to be carried. There are several hills surrounding Lambwe forest.

This magical forest boasts numerous species of trees, including acacia, cypress, pine and eucalyptus. Wildlife species include huge herds of the long-eared greater and lesser kudu, warthog, zebra, eland, the shy dik dik, reticulated giraffe, the mighty buffalo, waterbuck, leopards, snakes, mongooses and porcupines. There are minimal charges for nature lovers visiting this unique hideout. However, it should be taken into account that a special clearance from the forester in charge is required any time one is visiting. The forest is usually open to the public between 8 a.m. and 5 p.m. during working days. There are armed guards who provide round-the-clock security and guide visitors throughout since under the Forest Act, no visitor is allowed to roam alone in a forest

[4]see, e.g., the unspoilt magic of lambwe forest by Godfrey Olali in the Daily Nation Newspaper, September 27, 2002

especially if armed. The forest is criss-crossed by several roads, which are a bit rough and become quite muddy during the rainy season.

Magical Safaris

The magical safari to this wilderness would not be complete without visitors experiencing a number of activities besides game watching. These include bird watching, forest camping, water rafting on Lake Victoria and fishing. Keen fishermen and women are encouraged to bring their own gear and test their skills at landing Tilapia, Omena and even the giant Nile Perch. After a day loaded with activities, visitors can either camp out for the night, or check into one of several retreats near the forest which offer spectacular views of the Kanyamwa escarpment and the rugged Gembe, Ruri, Kaksingri and Gwassi hills. The hotels, for instance, are located just 15km away from the forest. Both are set in the middle of lush tropical gardens on isolated islands on Lake Victoria. The lodges are built in traditional style to reflect the rich cultural heritage of the local Suba people who are famous for their mouth-watering dishes of smoked fish, matoke (mashed bananas) and game meat.

4.4.8 Ruma National Park

Ruma National Park (NP) was established in 1966 and gazetted as Lambwe Valley Game Reserve (The River Lambwe is the area's dominant geographical feature). In 1983 it was renamed Ruma National Park after the River Ruma, a permanent stream that flows underground toward Lake Victoria. The decision to make Ruma a national park was driven by the urgent need to conserve the roan antelope (*Hippotragus equinus*), locally called "Omoro" (i.e., Fig. 4.16). Roan antelope are not endangered in the strict classification of endangered species; rather, they are classified as a low-risk, conservation-dependent species by the International Union for the Conservation of Nature and Natural Resources (IUCN) or World Conservation Union. They range across sub-Saharan central Africa from Guinea to Ethiopia and south across Angola to South Africa. In Kenya, roan antelope are only found in Ruma NP, where habitat factors could potentially enable them to thrive. However, poaching and drought have caused their population to dwindle in recent years: in 1994 research scientists from the Kenya

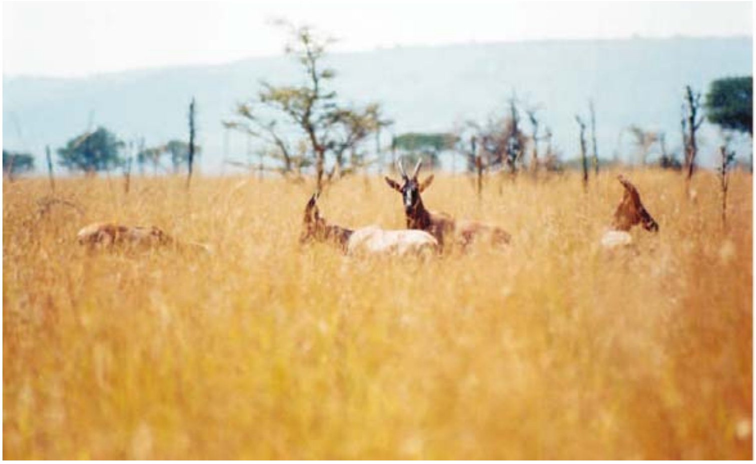

Fig. 4.16. In Kenya, roan antelope (Hippotragus equinus) are found only in Ruma National Park. Their survival, however, is threatened by poaching and drought
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Wildlife Society found only 34, and the census of September 1999 put the number at 25 (see, e.g., [12, Table 1]).

The park has a rare inland equatorial climate. Its altitude and closeness to Lake Victoria serve to modify temperatures which range between 17.1°C to 34.8°C. The little known wilderness offers an interesting menu of treats for nature lovers, ranging from bird and game watching to nature walks and camping. Visitors drive to the Kenya Wildlife Service offices for a guide, and from here, they can take one of several rough tracks that go through the park. Driving along these tracks gives visitors a fabulous view of the game this sanctuary offers. There is plenty of accommodation including the Takawiri Island Hotel, Rusinga Island Hotel, Homa Bay Tourist Hotel, Hippo Back Lodge and the Mfang'ano Island Hotel. The rates at the lodges are about Ksh 1,500 a night for residents, and Ksh 2,000 for non-residents. Visitors can also explore other interesting sites in the area; such as Thimlich Ohinga, Gogo Falls, the Kanyamwa escarpment, Mwarachi Hills, and Rusinga Island.

On the way, you might chance upon a cheetah lying in the shade, the tawny mane of a lion hiding in the yellow grass, a bat-eared fox peering from its hole, a young jackal pouncing on its rodent meal or a waterbuck standing motionless beneath a tree. One of the best times to view the lions is probably in the evening. As the chill begins to set in, the savannah lions can be seen emerging from the thickets to enjoy the dying warmth of the setting sun. They are a sight to behold, as they yawn and search the plains with their shiny yellow eyes.

The guides in Ruma National Park advice, though, that the best time to visit in order to get a good view of the game is at dawn and at midday. At dawn, visitors can follow nocturnal animals to their caves, where they retire after their nocturnal activities. A family of hippos can be seen floating leisurely in the river, while crocodiles lie lazily on the banks, their eyes and nostrils poking and protruding from the murky pools. It is at this hour, too, that one is most likely to see an ostrich threaten an intruder with a hiss, or with raised wings to assert its physical dominance. Other animals that visitors to the Ruma National Park can see are the graceful impala, usually found at the forest's edge, the dik dik, the Thomson's and Grant's gazelles and wildebeests. Its remote location makes the park an attractive site for those who want to spend some time in a quiet, peaceful setting.

In the late 1970s and early 1980s the Rothschild species of giraffes (*Giraffa camelopardalis rothschildi*) was relocated from Soi Ranch in the Rift Valley of Kenya to two national parks. This measure was taken to both conserve the giraffes, which were threatened by the spread of human settlements, and to enrich Ruma NP with new species[5]. Twenty-seven (27; five males and 22 females) of these Rothschild giraffes were relocated to Ruma National Park (NP) (see, e.g., Fig. 4.17), and 17 were relocated to Lake Nakuru NP.

In July 2002 a team from OSIENALA (Friends of Lake Victoria), a regional NGO conducted a survey at Ruma NP to determine both the current giraffe population and the impact of their introduction on the park's other animal species, on park flora, and on human habitat. The study found the giraffe population to be approximately 75. The giraffes' presence at Ruma NP was found to have an impact both on the environment and the human communities that surround the park. Awange et al. [12] present details finding of the survey.

Residents of communities just outside Ruma NP's borders occasionally start wild fires (see, e.g., Fig. 4.18) to express their dissatisfaction with the park's administration. These fires compromise environmental management efforts and destroy vital habitat.

[5] Njuguna, M. 2001. Kenya now a leader in protecting the rhino. Daily Nation, Thursday 14 June

Fig. 4.17. In 1983, 27 Rothschild giraffes (*Giraffa camelopardalis rothschildi*) were translocated from Kenya's Rift Valley to Ruma National Park (NP) as a conservation measure

Fig. 4.18. Fire at Ruma National Park (NP)

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4.5 Concluding Remarks

Lake Victoria and its environ are very well endowed with a myriad of resources for eco-tourism. Tourist attraction sites are also an added feature of the resource base of the region. The Lake shores are served with two airports that makes the region accessible. On the Kenyan side, Kisumu Airport opens the Lake to the world. Entebe Airport does the same in Uganda. Besides the air mode of transport, the Lake region can be accessed via tarmacked roads and rail. This chapter therefore sensitizes you the reader, to explore the riches of Lake Victoria's attractive sites. You will not be disappointed!

Lake Victoria region has a rich biodiversity that if not properly conserved and managed for posterity will not last in the next few years because of the systemic pressures exerted on the natural ecosystem. Finally, we leave you with a spectacular pictures of some of the lakes dweller in Fig. 4.19 and a beautiful island in Mwanza, Tanzania in Fig. 4.20.

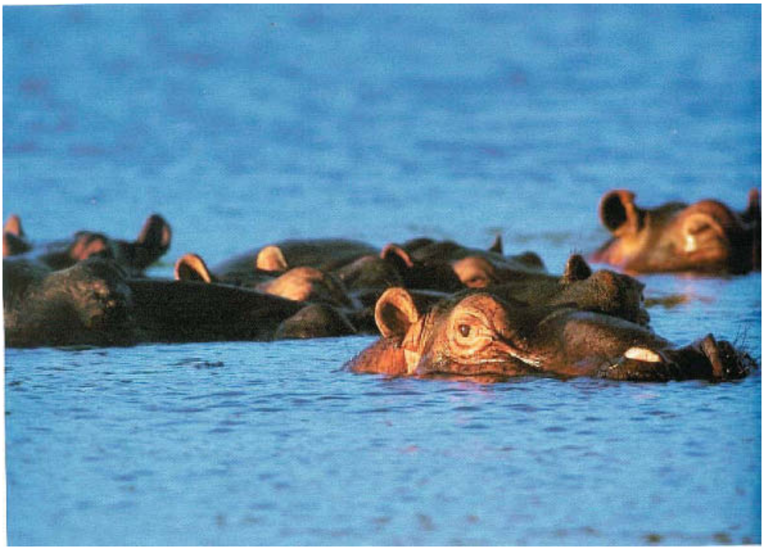

Fig. 4.19. Hippos of Lake Victoria enjoying themselves

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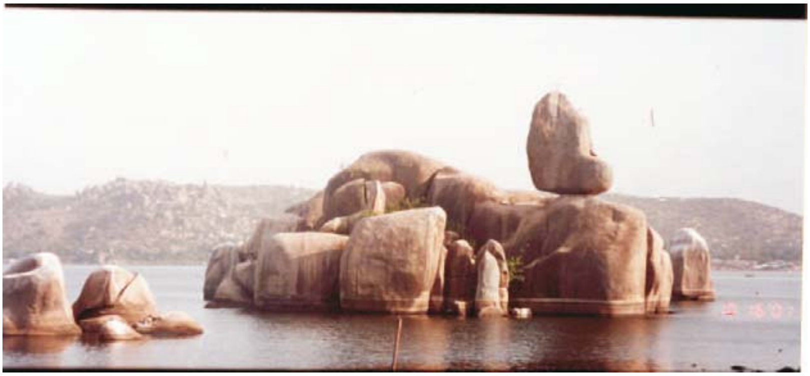

Fig. 4.20. Beautiful Island in Mwanza, Tanzania

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5

Environmental Concerns and Management

"... and the threatened fresh water Lake of 2005 is Lake Victoria" Global Nature Fund

5.1 Introductory Remarks

Lake Victoria has had significant contribution to the environment of the region on one hand, while on the other hand, it has suffered the consequences of poor environmental management. This Chapter provides an in-depth look at both the contribution of the Lake to environment and its share of burden coming from domestic and industrial pollution. First we examine the current state of the environment within the Lake and its surrounding in Sect. 5.2. We will give a comparison of its current state to that of Lake Biwa in Japan, which is almost the size of Nyanza Gulf of Lake Victoria (see, e.g., 5.1 in p.115) and also a fresh water Lake. Section 5.3 looks at the contribution that the Lake offers to the environment before considering the inverse, i.e., the impact of the environment on the Lake itself in Sect. 5.4.

5.2 Environmental State of Lake Victoria

The deterioration in environmental quality both in the land and the Lake and the associated socio-economic consequences are linked to rapid population growth and land degradation. There is little doubt that sedimentation and nutrient run-off, urban and industrial point source pollution and deforestation in the water catchment areas have induced rapid eutrophication of Lake Victoria over the last fifty years.

Further, the problem of sedimentation of the Lake is compounded by erosion following deforestation and destruction of the wetlands which normally acts as sieves. Ambient conditions in Lake Victoria now favour the dominance of Nitrogen fixing *cyanobacteria* and the spread of aquatic weeds such as water hyacinth (*Eichornia crassipes*).

Invasion of water hyacinth and loss of endemic biodiversity are interrelated and compound problems for the Lake environment and the welfare of its people (see Sect. 5.4.1 in p. 124 for an in-depth discussion of the water hyacinth). Massive blooms of algae have developed and are increasingly being dominated by the potentially toxic blue-green variety. The distance at which a white disc is visible from the surface, (a transparency index measuring algal abundance), has declined from 5m in the early 1930s to 1m or less for most of the year in the early 1990s. Water-borne diseases have increased in frequency.

Water hyacinth, absent as late as 1989, has begun to choke important waterways and landings, especially in Uganda. Over fishing and oxygen depletion at lower depths of the Lake threaten the artisanal fisheries and biodiversity. Over 200 indigenous fish species are said to be facing possible extinction. Scientists advance two main hypotheses for these extensive changes. *First*, the introduction of Nile Perch as an exotic species some 30 years ago has altered the food web structure. *Second*,the consequences of excess nutrient load into the Lake, especially from Kenya, Burundi and Rwanda catchments areas, have transformed the Lake ecology. Land degradation is a serious threat to Lake Victoria in terms of food and livelihood security of the rapidly expanding population. Soil erosion is evident in many parts of the Lake basin and declining soil fertility is of major concern.

5.2.1 Nyanza Gulf

To many scientists, Nyanza Gulf depicted in Fig. 5.1 in p.115 is an independent Lake connected to Lake Victoria by Rusinga Channel. It is a Lake within a Lake and need special attention and independent management system. At the moment no independent study has ever been done for Nyanza Gulf alone. Whatever has been done was majorly part of Lake Victoria. Yet Nyanza Gulf has its unique hydrology closets, with three main rivers flowing into it, bringing highly polluted water from the established farms and industries and also municipalities of its catchments. The rivers also bring silts, making the Gulf to continuously become shallow with the increasing risk of not being navigable in future. The Gulf is surrounded with very high population, one of the most populated areas in the Lake Victoria basin. It has very high concentration of the fishermen and yet it is prime area for fish breeding. Most of the endemic fish species of Lake Victoria are no longer found in the Gulf.

Nyanza Gulf depicted in Fig. 5.1 lies between 0 0.4'S and 0 0.6'S and 34 13'E and 34 52' East at an altitude of 1,134m above sea level. It has a surface area of 1,400km^2 constituting 38.9% of the area of the Kenyan sector of Lake Victoria. It has a maximum depth of 43 m offshore and 6 m inshore. It has a volume 13.1km^3. Water flows out into the main Lake through a narrow Rusinga channel at the rate of 0.68km^3. It has a catchment area of 12,300km^3 and has a water retention time of 19.3 years. Major inflows are rivers Nyando and Sondu-Miriu with minor contributions coming from Rivers Awach, Mogus and Kisian.

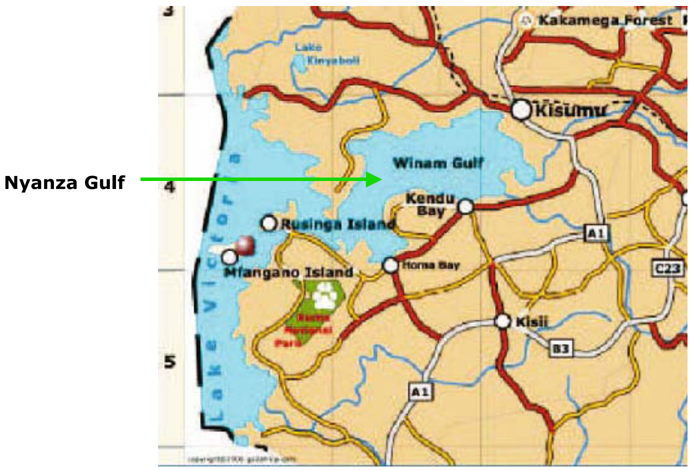

Fig. 5.1. Nyanza (Winam) Gulf

Due to recent developments in the catchment and the closure of the Mbita channel, the Nyanza gulf is the most stressed ecosystem in Lake Victoria. Agricultural and industrial activities practiced in the catchment are responsible for the recent deterioration of water quality and increasing eutrophication. Being shallow effects of environmental perturbation are expressed rapidly such as the more frequent algal blooms, reduced transparency and the most rapid infestation by hyacinth in Lake Victoria. Consequently the gulf has developed unique ecological problems. There are therefore significant differences between the ecology of the Nyanza Gulf and that of the main Lake as depicted in Table 5.1 in p. 116. It therefore needs to manage as a single ecological entity.

Table 5.1. Differences between the Nyanza Gulf and the main Lake Victoria ecosystems

Nyanza Gulf	Main Lake
Mostly shallow average 5m	Deeper; average depth 40m
Fairly well sheltered by surrounding mountains	Largely unsheltered, strong wind effects
High diversity of fish species	Low diversity of fish species except in inshore and riverine environments
Semi closed due to damming at Mbita	Open through the Nile
Algal composition largely dominated by heterocystous blue green algae	Algal composition largely dominated by diatoms
Frequent algal blooms than previously	Infrequent algal blooms
Eutrophic; most eutrophic region in the Lake	Oligotrophic to mesotrophic
Low abundance of happlochromines	High abundance of haplochromines
High abundance of tilapiines particularly O. niloticus	O. niloticus absent from the open waters except along a tiny fringe of the coastline and in bays and gulfs
Environment stressed through out; limited circulation less intense than in open Lake	Environment only stressed during stratification
anthropogenic effect: closure of Mbita causeway enhanced the stress	
Low secchi disc transparency	High secchi disc transparency
High chlorophyll *a* concentration	Low chlorophyll *a* concentration
High conductivity	Low conductivity
High nutrient concentrations	Low nutrient concentrations mouths except at major river
Seriously impacted by water hyacinth and other aquatic weeds	Not seriously impacted by water hyacinth; no other aquatic weeds except in shallow inshore areas which receive high nutrient concentrations
Highest concentration of fishermen and fishing villages in the whole Lake	Lowest concentration of fishermen
Catchments most affected by anthropogenic activities	Catchments not as much affected
Breeding ground of a wide range of species	Breeding ground of only few species

Just as other parts of Lake Victoria, Nyanza Gulf is facing serious ecological stress due to pollution from point and non-point sources. There is serious overfishing as the demand for fisheries resources is very high. The entire Nyanza Gulf is a fish breeding area and should be conserved for this purpose and yet it is over-fished with endemic fish species almost extinct. Due to its shallowness and polluted waters it has become the heaven for water hyacinth, an aquatic alien plant that is now choking some of its parts. Water borne diseases are rampant, with typhoid cases on the rise. Bilharzia and mosquitoes pose a great danger to the communities living within the Gulf's environs.

Nyanza Gulf as the most important part of Lake Victoria, Kenya, is endowed with a lot of resources (see e.g., [4, 5, 119]. Despite these endowments, it still faces a number of problems. Most important is the environmental degradation as well as rampant poverty among the people in the region. In 1997, it was estimated that 63.1% of the people in Nyanza Province (the districts which borders the Lake) in Kenya lived in absolute poverty. The region also registered one of the highest incidences of food poverty, at 58.2%, in 1997. With serious economic deterioration since 1997, both relative and absolute poverty have increased to 67% in most rural districts in the country, especially in Siaya and Homa Bay Districts, which falls within the Gulf. Consequently, the Kenya Government has labeled the Lake Victoria region of the country as a "*belt of poverty*".

Environmental degradation and poverty issues aside, Nyanza Gulf has wonderful panoramic and scenic views that can be developed into eco-tourism. It has spectacular small islands, with one of them, Ndere Island having been gazetted by the government as a National Park. It is however still undeveloped with only few antelopes roaming around it. It borders Ruma National Park at the Southern side. Ruma has an endemic endangered Roan Antelope. There is therefore an urgent need to develop the region for eco-tourism purposes (see more discussion on eco-tourism in Chap. 4).

5.2.2 Lake Biwa

In this section, we present a short review of Lake Biwa as presented e.g. in [65]. About 310 miles west of Tokyo on the Japanese island of Honshu, more than 500 rivers flow out of the Ibuki, Suzuka, and Hira mountains into Lake Biwa (Fig. 5.2), the largest of Japan's freshwater Lakes. Lake Biwa, which covers 674km^2, is 63.49km long, 22.80km across at its greatest width and less than one mile across at its narrowest. The northern portion of the Lake, which has a mean depth of 43m, accounts for 90 percent of the entire Lake area. The southern portion of the Lake has a mean depth of 4m. From this southernmost part of the Lake flows the Seta River, which later joins the Yodo River in flowing into Osaka Bay [65].

Fig. 5.2. Lake Biwa in Japan

Lake Biwa has provided critical services to the people of Shiga Prefecture for centuries. In 1995, 14 million people depended upon water from Lake Biwa and 23.7 million people visited Lake Biwa Quasi-National Park. The watershed of Lake Biwa, which lies entirely within Shiga prefecture, covers roughly 1,250 square miles. About 60 percent of this area is forested mountains, while 18 percent is in agriculture and the balance in other uses such as urban and industrial development. Lake Biwa is also one of the world's oldest Lakes. Although the present-day Lake began taking on its larger form about 40,000 years ago, Lake Biwa developed in eight stages beginning about four million years ago [65]. About one million years ago, a small Lake called Katata formed in the area now occupied by the southern portion of Lake Biwa.

About 400,000 years ago, this small Lake expanded into what is now the northern basin of Lake Biwa. Thus, Lake environments have persisted in the area for the last one million years [65].

5.2.3 Comparison: Nyanza Gulf and Lake Biwa

In the past, Lake Biwa was a typical oligotropic Lake like many others in Japan but has however tended towards eutrophic one. In accordance with the guidelines given by the Organization for Economic Co-operation and Development OECD, the northern Lake is classified as mesotropic and the southern Lake has gradually shifted from mesotropic to eutrophic [65]. Table 5.1 in p. 116 shows the Nyanza Gulf to be the most eutrophic region in the Lake while the main Lake Victoria being oligotrophic.

In comparison to the Nyanza Gulf, the quality of water of Lake Biwa has undergone rigorous monitoring from various institutions, e.g., Shiga Prefectural Institute of Public Health and Environmental Science, Lake Biwa Research Institute and several other institutes of the universities. Large scale water quality monitoring has however been carried out by Shiga Prefectural Institute of Public Health and Environmental Science in cooperation with the Kansai District Regional Construction Bureau of the ministry of Construction. Observations are carried out at 49 fixed monitoring stations once every month. Of interest are 10 automatic monitoring stations on the Lake and 8 in rivers operated by the Shiga Prefectural Government. Telemetric data from each station are sent every hour to the central office of the Shiga Prefectural Institute of Public Health and Environmental Science. Each station monitors;

- PH, water temperature, transparency, conductivity etc., as measures of water quality.
- Atmospheric temperature, humidity, direction and velocity of wind, solar radiation intensity and precipitation as weather conditions.
- Water level and the direction and velocity of water current as water conditions.

The Nyanza Gulf and by extend Lake Victoria does not enjoy such wide monitoring. Isolated efforts such as those undertaken by Lake Victoria Environmental Management Project (LVEMP) and NGOs such as OSIENALA exist. Domestic effluent and industrial effluent as well as the pollutants from agricultural sector pollute Lake Biwa, just like the Lake Victoria. For Lake Biwa however, control measures have been put in place including encouraging participatory of communities leaving in its surrounding. During specific times of the year, the community members join hand in clean up measures of Lake Biwa as part of environmental conservation. Such efforts should also be encouraged for Lake Victoria.

Due to eutrophication of Lake Biwa, about 70 kinds of water weeds have been confirmed in the Lake. The native weed species such as Biwa pondweed (*Potamogeton biwaensis Miki*) has been replaced by some invading weed species such as Florida water weed (*Elodea nuttalli* St. John) and Brazilian water weed (*Egeria densa Casp*). Nyanza Gulf on its part suffers from the increase in water hyacinth due to eutrophication.

Environmental measures employed for Lake Biwa which have succeeded are worth implementing in the Nyanza Gulf and the entire Lake Victoria. For example, there is the citizen's campaign for using soap instead of detergent and the citizen's participation in garbage clean-up activities. It will be worth evaluating what impact such measures will have on Lake Victoria.

5.3 The Lake's Contribution to Environment

Lake Victoria as already seen in the preceding Chapters carries huge volume of water in the region. It also falls along the equator and the tropics, a region which receives maximum solar radiation and rainfall. For this reason, the Lake also contributes to global weather besides regional. In this section, we look at its contribution to weather and the physical environment.

5.3.1 Influence on Weather and Climate

Lake Victoria contributes enormously to both the regional weather and climate. Lake Victoria happens to lie within the equator in the tropics, a region of maximum solar heating. Due to maximum heating by the sun, the Lake's water has played a significant role in determining the weather and climate of the surrounding regions. In regard to weather and subsequently climate, Lake Victoria has contributed the following:

(a) *Enhancement of global warming*:- Water vapour being one of the greenhouse gases, plays a significant role in trapping the long wave radiations from the Earth increasing the Earth's temperature. This has the effect of rising sea level due to melting of polar ice, an occurrence that can lead to submerging of coastal towns.

(b) *Heat transfer and balance*:- The evaporated water plays the significant role of heat balance. Using atmospheric circulation, and particularly the Hardley cells, latent heat, i.e., the heat released during the condensation of water vapour, finds its way from the tropics (e.g., Lake Victoria region) to the colder polar regions thus balancing the Earth's temperature.

(c) *Rainfall*:- Lake Victoria contributes much to the regional rainfall and subsequently the hydrological cycle. Rainfall can only occur if warm wet air is cooled and if there is sufficient water vapour in the air. The process is known as condensation and may be brought about in three ways namely;
   - when intense heat of the ground causes rising air currents (conventional rainfall),
   - when air is forced to rise by meeting higher topography (relief or orographic rain) and,
   - by meeting or convergence of two air masses.

   Of particular importance to Lake Victoria are the South-East trade winds which picks moisture from the Lake while passing. They move to the northern and western shores of Lake Victoria where they eventually condense to give heavy rainfall.

   Heat from the sun warms both the Lake and the surrounding lands causing evaporation from the Lake water and evapotranspiration from the neighbouring lands. The water vapour enters the atmosphere and circulates with air. Warm air containing water vapour rises in the atmosphere and cooler air descents. The further from the warm planetary surface the air travels, the cooler it becomes. Cooling causes water vapour to condense on small particles (cloud condensation nuclei) in the atmosphere and to precipitate as rain and fall back to the Earth's surface. Evaporated Lake's water vapour are also carried by local winds to regional highlands where they are cooled and falls back as rain. In this aspect, the Lake contributes towards the regional rain. This process contributes to the hydrological cycle of the region.

   Two explanations have also been given by Hickman et al. [61, pp. 5–12] on the Lake's influence on rainfall to its eastern and western sides. During daytime, land heats faster than the Lake's water creating a region of low pressure on the land and high pressure in the Lake. Due to the resulting pressure gradient, the Lake's cooler air moves to replace the rising warm land air masses in what is known as *Lake breeze*. On the eastern of the Lake, when the Lake breeze meets with the prevailing winds from the east or southeast, a convergence is formed resulting in the late afternoon and evening showers and clear skies at night.

During nights, the land adjacent to the Lake cools faster than the Lake's waters. Cool air from the land will thus move to replace the rising warm air mass from the Lake. This movement of the air from the land to the Lake at night is known as *land breeze*. This land breeze moves towards the Lake against the prevailing winds. A small convergence is formed with very heavy rainstorms, especially just before down.

The high rainfall experienced by Uganda, a country far from the Indian ocean could be attributed to Lake Victoria and various numerous swamps found in the country. Though the Lake's contribution to rainfall in Kenya is significant, e.g., the Lake's shores, Uganda benefits more due to the fact that winds carry more moisture to the Northwest shores of Lake Victoria. The Lake shores within Tanzania also record good rainfall as compared to other areas.

(d) *High temperatures*:- The region surrounding the Lake has experienced an average temperature of about 30°C. This high temperature is contributed partly by the high humidity in the region.

(e) *Humidity*:- Because of immense heating of the Lake and the evaporation that follows, humidity is high in the region. High humidity on the other hand has psychological effects to the people surrounding the Lake in that;
   - it leads to stuffy air resulting into people feeling sleepy,
   - perspiration becomes difficult leading to sweating and wet clothes etc., and
   - During bathing, people take long to dry when the humidity is high.

(f) *Wind*:- Formation of winds are at a local scale. Winds are formed due to differential heating of the Lake and land.

(g) *Pressure*:- When the surrounding lands heat faster than the Lake, the kinetic energy of air molecules around the heated land increases. In comparison to the Lake, a region of low pressure is created in the overheated land while a region of high pressure exists in the Lake.

The reverse is the case at night. This results into pressure gradient which triggers the movement of wind.

(h) *Clouds*:- Lake Victoria contributes towards the formation of cumulonimbus clouds through the process of convection (see e.g., [61, p. 5]).

5.3.2 The Lake and the Physical Environment

Besides its contribution to the weather and climate as we have seen in Sect 5.3.1, the Lake has several positive contributions towards the physical environment. Without the Lake, the environment could probably not be what it is today. Some of these contributions include:

- The provision of cool breeze that helps in cooling the warm surrounding land. During day time, the land heats faster than the Lake and creates a region of low pressure. Since wind moves from regions of high pressure to low due to pressure gradient, cold breeze from the Lake cools the land. The reverse process takes place during night where the land looses its heat faster than the Lake.
- Providing a reservoir for industrial and domestic effluent which could otherwise be harmful if left in the open environment. If properly treated, these can be channeled into the Lake. Unfortunately as we will see in the next section, this is not the case and the Lake itself ends up being polluted. In balancing the CO_2, the Lake provides a sink for pollutant gases. This also include sulphur dioxide which falls back as acidious rain.
- Providing habitat for different biodiversity. The plants within the Lake contribute towards the balancing of oxygen and carbon dioxide gases, while the reptiles e.g., crocodiles, provide tourists with good site seeing.
- Providing through its wetlands a sieve for substances such as sediments which would lead to other environmental catastrophes such as flooding. These wetlands also provide grazing grounds for cattle among other uses (see detailed discussion in Chap. 8).
- Providing a basin/tank for rivers to empty its contents. One can only imagine the catastrophe of flooding in the absence of the Lake.
- The Lake is the source of Nile river which provides irrigation water to Sudan and Egypt. Without Lake Victoria, therefore, Egypt would have to rely entirely on imported food.
- The Lake recharges underground water and its own water alleviates the extensive exploitation of ground water.

- With its fish and fishing career, the Lake contributes towards poverty alleviation as already noted in Chap. 3.

5.4 Choking of Lake Victoria

5.4.1 Water Hyacinth

An extensive body of knowledge on the biology, growth and control of the water hyacinth exists from studies conducted in the Americas, South Africa, Sudan, Egypt, Europe and East Asia [117]. The plant reproduces by both seeds and vegetative propagation. It has a phenomenal growth rate and can increase its surface area under ideal conditions by upto 15% per day. It has an attractive white flower tinged with shades of mauve and yellow. Following pollination, the seed capsules after ripening rapture to produce between 3 and 364 seeds [117]. It is the existence of these resistant seeds that make the eradication of water hyacinth impossible.

The time required for the plant to double its biomass ranges between 5.7 and 27.4 days. Yields of upto 250 tons per hectare are possible and the plant can contain as much as 33.5 Kg Nitrogen, 59Kg Phosphates and 615Kg Sodium per hectare. In South Africa, its production was estimated at 40 tons per hectare per day [117]. The plant is capable of absorbing and utilizing large quantities of plant nutrients and thrives under eutrophic conditions. This explains why it has been so successful in colonizing the Lake, in such a short period of less than three years.

Lake Victoria faces various constraints and threats with water hyacinth (Fig. 5.3, p. 126) being one of them. The water hyacinth, *Eichornia Crassipes*, is a large fleshy fresh water plant capable of vigorous growth. In Africa, the water hyacinth has been present in significant quantities for several decades, mostly in major rivers and in fresh coastal waterways. It first appeared in Egypt's Nile in 1890's where initial introductions were deliberate as it was used for ornamental purposes. In 1908, it was seen in Natal province, South Africa, and in the 1930's, it appeared in several Lakes in Zimbabwe. In 1950's, the hyacinth colonized rivers Congo, White Nile in Sudan and Pangani in Tanzania. In East Africa, the hyacinth was sighted in 1982 in Lake Naivasha in Kenya and in Lake Kyoga, Uganda in 1988. Reports from Tanzania indicated its occurrence in 1990. The weed was first spotted in Rwanda in 1987. The water hyacinth was reported for the first time on the Ugandan portion of the Lake in 1989. By 1990, it had spread from the Kagera river mouth to Entebbe. By 1993, the plant was already established on the Yala river mouth in the Kenyan sector of the Lake. By mid 1994, the first batches of the plant were encountered in the mid- Nyanza Gulf in the Kenyan sector. By early 1995, the water hyacinth had already become a problem in a number of beaches in the Kenyan sector of the Lake particularly Luanda- Konyango, the Nzoia and Yala river mouths. The weed is now widespread in the Nyanza Gulf, occupying about a quarter of the total surface area and has already blocked sheltered bays particularly Asembo Bay, Nyakach Bay, Kendu Bay and the inner Winam Gulf, creating serious navigation, fishing, health and recreational problems.

It has since multiplied rapidly to cover several locations of Lakes Victoria, Albert, Kyoga and on the shores of River Nile. Aerial and ground surveys and updates by FAO/UN indicate that as much as 90% of shorelines in affected water bodies are infested. Hyacinth covers up to 1% of the Lake area of 6.9 million hectares. The major source of hyacinth into Lake Victoria is River Kagera. An average of 0.8 ha of weed floats into Lake Victoria from the Kagera and outflows via Nile where it causes major problems at Owen Falls hydro-electric power station at Jinja, Uganda.

The water hyacinth *Eichhornia crassipes* (Mart) *Solms* is an obnoxious surface-floating weed of the tropics. A large body of literature addresses its growth and methods of control whilst relatively little investigates its ecological interaction [93]. Kateregga [71] has considered the issue of abundance of water hyacinth during the 1990s and analyzed its effect on the catchability of fish, estimated the elasticity of catch with respect to various efforts in Lake Victoria fisheries, and estimated the cost of electricity outages. The water hyacinth has 7 genera constituting of 28 species. It reproduces by use of small daughter plantlets known as stolons. It produces large quantities of long-lived seeds that can survive up to 30 years. Weed populations can double up in every 5-15 days at temperatures of between 25°C and 27.5°C. Growth ceases at temperatures of below 10°C and above 40°C. Proliferation is encouraged by nutrient enrichment.

Water hyacinth brings with it diseases such as *Bilharzia*, while *dangerous reptiles* such as poisonous snakes, crocodiles and monitor lizards luck in the hyacinth mats and are a threat to human and livestock. Disease transmitting insects, e.g., *mosquitoes*, which transmit malaria and yellow-fever are also found among the weeds.

Attempts have been made to quantify the spread of hyacinth in East Africa. In Kenya about 17,000 ha are covered by water hyacinth. The hyacinth is concentrated inshore where it has the greatest impacts on the ecology of the Lake the health and the economy of the riparian communities.

Water Hyacinth has had several direct and indirect impacts on Lake Victoria. The following subsections discusses some of these impacts.

Fig. 5.3. Water hyacinth in Lake Victoria

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Ecological Impact

Water Hyacinth has had the following impacts on the Ecology of Lake Victoria.

1. **Evapotranspiration**: The rate of evapotranspiration may increase adversely affecting water balance. The rate of water loss due to evapotranspiration can be as much as 1.8 times that of evaporation from the same surface but free of plants. The hyacinth is also promoting successive growth of other weeds like hippo-grass.
2. **Eutrophication**: The hyacinth causes eutrophication through release of nutrients from rotting hyacinth mats. The mats reduce light penetration and impede photosynthetic activities due to shading,

thus reducing primary productivity and in the process affecting fish dependent on it. This affects the bio-diversity. Together with other aquatic macrophytes they form floating islands and obstruct water transport as well as change the structural complexity of the habitat. It is very likely that sedimentation and nutrient run-off, urban and industrial point source pollution and biomass burning, have indeed induced the rapid eutrophication of Lake Victoria over the latter part of the 20th century. Ambient conditions in Lake Victoria now favour the dominance of Nitrogen fixing cyanobacteria and the spread of aquatic weeds such as water hyacinth (*Eichornia crassipes*). Algal concentrations are three to five times higher now than during the 1960's, and much of the Lake bottom currently experiences periods of prolonged anoxia that were uncommon 50 years ago. The result has been the loss of deep-water cichlid species and continued threat to fish in shallower waters since the periodic upwelling of highly toxic water is responsible for massive fish deaths. Decomposition and sedimentation of rotten water hyacinth and other organisms accentuates the process of eutrophication.

3. **Reduction of Biodiversity**: There appears to be a cause-effect link between land degradation and loss of biodiversity in the Lake. However, there is no evidence to ascertain this at this point in time. Since Lake Victoria emerged from a dry landscape 12,000-14,000 years ago, it has experienced rapid evolution of endemic species of cichlid fish, providing one of the most diverse flocks of fish species on Earth. However, by the 1980s, some 400 endemic species were approaching extinction. The introduction of Nile Perch into Lake Victoria in early 1950 has been blamed for dramatic shifts in algal populations and the near extinction of cichlids. With water hyacinth mats covering parts of the Lake, light penetration is impeded and photosynthetic activities of primary producers. Phytoplankton growth is interfered with resulting in reduced quantity of fish. Transparency and clarity are also interfered with. This results in interference with food webs and life cycles in the Lake. It, in turn, affects food levels and feeding habits of fish and can lead to elimination of herbivorous ethnic fauna such as Tilapia. Such conditions in littoral zones are likely to lead to migration of young tilapia out into deep waters where they become prone to predation. The hyacinth also promotes accelerated sediment deposition and successive growth of other weeds such as hippo-grass.

Impacts on Human Activities

Over 30 million people depend on the Lake and its resources for their livelihood. It serves the Lakeshore populations in both artisanal and commercial fish exploitation. It is also an important transport medium and a source of water supplies, for domestic and industrial use. Nile water leaving the Lake powers the region's principal electricity generating plant. The hydrological cycle, to which the Lake's evaporation strongly contributes, underlies agriculture, which is the primary economic activity in the region. Its impacts to human activities therefore are:

- *Tourism*: A decade ago there was expectation of significant growth in water-focused tourism; for example in towns like Bukoba or on islands like Ssese in Uganda, the presence of the water hyacinth has greatly diminished this expectation. There is limited recreational boating, and development of beaches. Small boats cannot be reliably launched. Swimming is hazardous due to risk of bilharzia infestation in most areas, worsened by presence of hyacinth. The sight of numerous floating snail shells is a depressing warning. The rise of malaria to visitors has intensified.
- *Water Transport*: The weed has choked important waterways and landings. Commercial transportation and services for people and goods, especially movement by small boats are obstructed. Docking the large steamers are regularly delayed.
- *Water Supply*: Supply and access to quality water from the Lake for the urban and rural communities is constrained by the high treatment costs to rid the water of high concentrations of suspended, decaying organic matter due to the weed. Piped water, for both domestic and industrial use is in short supply in rural and urban areas. Acute *gastro-intestinal* complications are an increasingly common phenomenon. There is growing difficulty in accessing water in Lake side villages since traditional collection areas are choked with water hyacinth. Blocked intakes and loss of production at urban and industrial water supply systems is hindering the operations of small-scale horticultural irrigation schemes which had been implemented to help improve the incomes of women in Lakeshore areas.
- *Fishing*: Fishing Declines in fish landings are estimated at 50-75%. This is partly attributed to declines in *habitat quality* of the Lake waters and *over-fishing*. Sheltered bays have suffered nutrient reduction interfering with breeding and nursery grounds for fish, par-

ticularly tilapia. The presence of expansive mats of water hyacinth choking bays has interfered a great deal with habour and fish landing operations. Reduced accessibility to the habours has occasioned unprecedented delay in commercial water-borne transport for people and goods resulting in losses for fishermen especially when their catches rot due to delays. There's also loss of fishing time due to obstructed beaches. Fuel consumption for fishing boats and lamps is doubled or even tripled.

- *Diseases and Vermin*: Water hyacinth mats provide a suitable environment for proliferation of *biomphalaria* snail, which hosts *Schistosomiasis* (bilharzia) and breeding sites for mosquitoes which cause malaria. The *biomphalaria* and *bulinus* aquatic snail colonies build up in large numbers in aquatic weeds, which provide a good substrate and refuge from predators. Lack of access to basic sanitation provides a significant reinforcing loop in the transmission of schistosomiasis. Other diseases prevalent are *amoebic dysentery*, *typhoid* and severe *dermatological* disorders. There is therefore a proximal link between the proliferation of water hyacinth and burden of disease and morbidity in the Lake region. There are numerous *poisonous snakes*, which are difficult to spot as they are well camouflaged within mats. Life threatening *crocodiles* are also common.
- *Obstruction of utilities*: The operations of the Owen falls *hydro-electric power station*, with a potential of 2700MW are threatened. The turbines have to be shut down for cleaning and maintenance to free the cooling-system filters of trapped water hyacinth, resulting in losses of up to 15MW. This exercise, which used to be carried out twice a month, now has to be done weekly. The equipment's life span is reduced. There are power interruptions and financial losses. This has caused increased operating costs for hydro-electric power production at the station. Similar adverse effects have been seen in Kisumu city where the weed has blocked the *water outlet pumps* from the Lake to the consumers. This has resulted in serious water shortage in the city.

Controlling the Water Hyacinth

Integrated control practiced by riparian states is restricted to *manual* and *biological* control, while Uganda has taken the lead in incorporating mechanical control. The principle behind biological control is to reduce infestation load very fast as a short-term measure and apply bio-control agents for long-term effect. Under present control regimes, this principle has been overlooked in Kenya and Tanzania. In Uganda, the Uganda Electric Board of Governors spends about US$1 million annually to remove the weed, especially at the Owen Falls Hydro-power station. Kenya had been hardest hit and the government opted to give out a tender for chopping and sinking the weed in the Lake. The Kshs 100 million tender was awarded to Aquarius Systems of United States. Despite the expenditure of that huge sums of money, the weed is now back and blooming with a vengeance (see, e.g., Fig. 5.3, p.126). Tanzanians are even using trawl nets to haul out the weed for burning. These efforts are being supported by international organizations.

Physical removal-The total eradication of hyacinth is not possible. The mechanical method is the safest method to use but it is time consuming and costly. Huge amounts of money have been spent to eradicate hyacinth in different Lakes. In the Kenyan sector of Lake Victoria as already mentioned, Kshs 100 million were used in the eradication campaign. In Sudan, approximately US $ 2.5 million is spent annually to remove water hyacinth. In Louisiana and Florida in the USA, US $ 11 million is spent annually to control the proliferation of hyacinth. Fishermen need compensation for lost fishing time. The complex nature of the habitat prevents complete removal. Local communities require incentives in order to remove hyacinth. Manual removal is conducted by fishermen in a small scale around landing sites where water is also abstracted for domestic use and drinking by livestock.

Considering the level of infestation, it may not be technically effective or economically feasible to clear the weed manually. These methods would come in handy in areas where water use restrictions limit application of mechanical means. Such methods will involve using booms and barriers to restrict plants to move and keep them from infesting new areas. It requires weed disposal. An example of mechanical/manual removal is seen in countries like Mexico where the weed is chopped and left to sink to the water bottom. "Chop and sink" is undoubtedly cheaper than transporting to the shore although if badly done it may encourage vegetative regeneration of new plants. However, mechanical destruction of plants without removal to shore may have unacceptable and adverse consequences.

Biological control- is one of the methods successfully used in control of the water hyacinth. Use of host specific natural enemies is exercised to reduce population of the pest in question. In Lake Victoria, two species of weevils have been used: *Neochetina eichhornia* and *Neochetina bruchi.* There were plans to introduce a third enemy- the May Fly of the *genus Povilla.* The insects are plant specific. Extensive research has been conducted prior to the release of the weevil enemies to prevent another uncontrollable distortion of the ecosystem. The biological control appears to be most successful of all the methods. *Someodes albiguttalis* moth, a mite and three fungal genera; *Cerospora rodimani sp*, *Cerospora. piaropi sp*, *Acromonium zonatum sp* and U*reds eichornia sp* are most promising candidates for biological control. Another biological control method in use is the fungus *Cercospora rodmanii.* Alternaria *eichromiae* is also effective. However, it is yet to be developed. In Kenya, investigations are being done at the University of Nairobi using a fungus found on the hyacinth. However, although several African countries started using biological control, it appears that control brought about by the hyacinth weevil, N*eochetina spp.*, is very slow. In Kenya, biological control does not seem to have worked, as the weeds are back and blooming. There is need for further research on appropriate and efficient agents for biological control.

Chemical removal-Proposals have been advanced that the chemical method is effective in removing the hyacinth. But in Zimbabwe, spraying was stopped following a public outcry over fish deaths. This method did not prove good in Lake Chivero outside Harare, although it is recorded that the 2 4-D was successfully used on Lake McIlwaine between 1953 and 1956 and between 1969-1971 in Zimbabwe. In both periods, a reduction in water hyacinth coverage was observed. The chemical also affected other weeds such as Typha and Nymphaea and associated arthropod populations. Such effects can have serious impacts on the food chain and can change the structure of the fishery. In Lake Victoria, the Uganda Fisheries Department and the American herbicide specialist Aquatics Unlimited Company proposed the use of 2 4-D to control the proliferation of water hyacinth. They ran trials with the chemical but the proposal was rejected by the two other states of East Africa, Kenya and Tanzania. These trials were conducted without the consent of the other states.

At the International Water hyacinth Consortium sponsored by the World Bank on 18-19 March 1997, it was noted that European Union (EU) countries would stop buying Nile Perch from countries around Lake Victoria if they continued using herbicides to control water hyacinth. The EU was willing to help fund a programme that would be environmentally sustainable in the control of hyacinth weed. Chemical control using herbicides such as 2,4-D, glyphosate or diquate therefore is not option for consideration. It is impossible to combine chemical poisoning with removal of dead plants. Application of herbicides in the control of water hyacinth would trigger massive hyacinth die offs. The effects of decomposing weed are expected to release more nutrients, which will fuel growth of other algae thereby affecting water quality. These algae will replace the water hyacinth and may even cause further complications in the Lakes ecological functioning.

The long-term components of a sustainable management strategy are biological control and improved land use management of the upland sediment source areas. In the ***medium-term***, a well managed strategy is to employ biological control. Immediate quick fixes of chemical control would have a huge negative impact on the already fragile ecological balance of the Lake. Most expenditure associated with biological control occurs within five years. The technology is well developed and relatively inexpensive to implement. Management of watersheds and reduction in nutrient enrichment may require substantial changes in land use and management, improved treatment of urban sewage and drainage, and treatment of industrial effluents. Major ***long-term*** action is needed and these will require substantial financial resources. Greater use of environmentally friendly technology, passing urban industrial effluents through constructed wetlands designed to decrease nutrient load, may be more cost effective than traditional engineering solutions. East African states are opposed to using chemicals on their water bodies because they wish to maintain the highest possible quality in water used for drinking and washing, and because of fish, physical control (manual removal) is the ***short-term*** choice in many countries. It entails considerable initial investment in machinery and an on going cost of operation and maintenance. For these reasons it is used only where valuable infrastructure must be protected, that is when essential navigation channels must be kept open or water flow maintained.

Further required actions include:

(i) Reduce water hyacinth to manageable levels by utilizing it economically. There should be studies to establish the most economical ways of exploiting the weed. Currently the hyacinth is used to manufacture a variety of products some of which are expensive to produce.
(ii) Utilizing water hyacinth for energy and furniture production, lampshades, biogas, manufacture of paper, fibre boards etc.

Let us examine in more detail the economic value of this weed.

Economic Potential of Water Hyacinth

Although the hyacinth comprises 95% water and has fibrous tissue with limited nutritive value, it can still be transformed into several useful products using very simple methods and facilities. The level of hyacinth utilization in East Africa has been relatively low. Possible uses of water hyacinth, some of which have been well developed and are being practiced in Lake Victoria while others are still in experimental stages include:

1. **Composting**: Composing can be done on small scale since, it has low capital requirement although it entails high demand for labour. The weed can be used on land as a green manure by ploughing it into the ground or mulching. The weed utilization for composting and mulching can be a solution to low soil productivity in the Lake Victoria basin at very low economic and environmental cost compared to inorganic fertilizers.
2. **Fodder and Silage**: Water hyacinth with a crude protein content of up to 20% is suitable for pigs and poultry. However its high KCI makes it unsuitable for cattle and sheep. It contains about 9% crude protein to be a minimum fodder for ruminants [4, p.117]. Although this makes it possible to substitute up to 30% of the roughage by dried hyacinth, sharp needles of calcium oxalate could damage digestive tracts of animals if they are not dissolved by digestive acids.
3. **Production of Dry Fuel**: This can be achieved through drying as a pre-treatment followed by either incineration or briquetting. Briquetting or pelleting by compression gives an energy density of about 8.3 GJm-3 which is comparable to charcoal.
4. **Yarn and Rope**: Stem fibres of the weed can be used for making ropes. The stalks from the plant are shredded lengthwise to expose fibres and dried for several days. The rope making process is similar to sisal twines. The finished rope is treated with *sodium metabisulphaite* to prevent it from rotting. Rope making can provide employment and income for communities.
5. **Making of Furniture and Handicraft**: The plant is currently being used for making a variety of reinforced household furniture including chairs, tables and screens (see, e.g., Fig. 5.4). In Kenya, Kisumu Innovation Center Kenya (KICK) has taken the lead in devising ways and methods of utilizing hyacinth to produce furniture

and different kinds of handcraft. This use can be targeted to organizations like women and youth groups in Lake Victoria region. There are chances of creating employment and income generation for the community.

Fig. 5.4. Products of water Hyacinth

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6. **Biogas Production**: Methane gas produced from the weed can be used as fuel for cooking, lighting or for powering light engines for various purposes. A Ugandan industrial and plantation company is believed to be considering manufacturing biogas from the weed for feeding to an engine to generate electricity. The French Embassy in Kampala was also interested in alternative uses of the water hyacinth. They installed two locally produced biogas tanks and six stoves at Luzira prison in 1996. Food at the prison is cooked over methane gas produced from the weed and cow manure. This move has done justice to the environment by saving trees that would have been decimated for the same purpose. Its other possible use being experimented in Uganda is as a substitute to charcoal.
7. **Production of Building Boards**: One company from United Arab Emirates David J. Price Contracting Solutions had proposed to use about 20 tons of the plant to produce building boards by dewatering, drying and using small amounts of resin binding agents

to compact fibres and particles into materials of varying thickness and densities.

8. **Production of Paper**: Pulp of reasonable quality has been prepared from water hyacinth. The Mennonite Central Committee of Bangladesh has experimented with the efficacy of hyacinth for paper production for several years. There is need to blend pulp to produce good quality paper. Low-grade paper can be produced for packaging and tissue rolls. Kisumu Paper Mills that has been recycling paper has proposed to convert part of their plant to process hyacinth for pulp and paper production.

The weed's potential economic value has received very less attention in comparison to its biological, chemical, mechanical or other means of reduction. This neglect reflects two widely held but erroneous beliefs; respectively

(i) currently no economically viable use is in place, and
(ii) that utilization would always be incompatible with control objectives.

Table 5.2 summarizes the major organizations that makes use of hyacinth (see, e.g., [118, p. 82]).

5.4.2 Pollution of the Lake's Waters

Mackenzie [92, p. 314, Fig. 10.12 in p. 317] has defined water pollution as any physical or chemical change in water from both natural and anthropogenic sources that adversely affects the organisms living in it. In Sect. 3.2, we highlighted the use of Lake Victoria's fresh water. Indeed, the fact that fresh water has played a key role in agriculture, industries, municipalities, etc., has already been highlighted for instance by [92, p. 314]. Whereas the Lake's water carries natural substances and nutrients, today, in addition to these natural materials, pollutants, e.g., chemicals and excess eroded soil can also be found in the Lake's water. As discussed in Sect. 5.3.2, the Lake acts as a sink for both surface and atmospheric pollutants (see, e.g., Fig. 5.5). Surface pollutants include those produced from sugar factories within the Lake's basin, e.g., Chemelil sugar factory in Kenya, that find their way into river Nyando and eventually into the Lake. Agricultural activities in the neighbouring farms also contribute towards polluting the Lake. During rainy seasons, water carries with it chemicals from fertilizers and pesticides

Table 5.2. Major Actors in Water Hyacinth Utilization

Use	Organization	Country
Biogas Production	Luzira Prison	Uganda
Furniture Making	Luzira Prison	Uganda
	Kisumu Innovative Center Kenya (KICK)	Kenya
Organic Fertilizer	Makerere University	Uganda
	Bio Earth (U) Ltd.	Uganda
	Transform APS Danish Root Zone	Uganda
	Hyafuel and Gleeson	Uganda
	Kawanda Agricultural Research Institute	Uganda
	Industrial Tech. & Engineering Trust	Uganda
Feed/Silage	Makerere University	Uganda
	Hyafuel and Gleeson	Uganda
Fuel	Bethany Community Project	Uganda
	Joint Energy and Environment Project	Uganda
	Hyafuel	Uganda
Cement Manufacture	Chichibu Onada Cement Corporation	Uganda
Pesticide	Kawanda Agricultural Research Institute	Uganda
Cement kiln	Chichibu Onada Cement Corporation	Uganda
Fibre board	Chichibu Onada Cement Corporation	Uganda
Rope Making	Kisumu Innovation Center Kenya (KICK)	Kenya
Soil conditioner	Industrial Technological and Engineering Trust (ITET)	Kenya
Pulp and Paper	Kisumu Innovation Center Kenya (KICK)	Kenya
	Kenya Matches Ltd.	Kenya

Fig. 5.5. Pollution from the industries

from sugar and rice belts that surround the Lake together with other nutrients from the neighbouring towns.

These materials are either swept into the rivers through surface runoffs or percolate into the ground to reach groundwater flows and finally into the rivers. The rivers eventually pour their contents into the Lake. Neighbouring towns in addition pour their sewage and other industrial effluent to the Lake. From the atmosphere, precipitation may contain chemical such as *sulfur* and *Nitrogen* oxides from the activities of the people living along the Lake.

The Lake therefore undergoes pollution from both ***point*** and ***non point*** sources (see, e.g., [25]). Points sources are, e.g., factories outlet pipes and sewage treatment plant outlets. Non point sources are those that are difficult to identify, e.g., pollution from transportation sector and waste from mining operations, agricultural activities and waste carried by street runoffs and drainage. Owing to their dispersive nature, non point sources are difficult to control.

Lake Victoria basin has one of the highest population growth rate in the region. This coupled with the shortage of land based jobs, has put an increasing demand for food, housing, water and social services. The people in the region are striving for self sufficiency in food crops and increased yields from cash crops particularly sugar cane, tea and coffee. As a result, pesticides and fertilizers are being used increasingly. Despite this, their deployment has not been matched with sufficient environmental awareness among the communities involved. There are many intensive small and large scale areas of agriculture, and pollutants from these sources are carried down to Lake through the many rivers in the basin, where they affect a highly productive but delicate ecosystem. These include fertilizers rich in nutrients, pesticides and silt [117]. As more pressure is exerted on natural resources and more land is deforested, the volume of the pollutants in the surface runoff increases and their impacts on the Lake's ecosystem is even greater.

Another important source of pollutants affecting the Lake's water quality and ecosystem is sewage. Urban centers concentrated around Lake Victoria, e.g., Homabay and Kisumu in Kenya, Entebbe in Uganda, Mwanza in Tanzania, etc., have high population density. The majority of these centers do not have sewage treatment facilities and where they exist, the technology is too conventional that significant reduction in nutrients in sewage effluent is not achieved. Further, most of the sewage treatment facilities are broken down and sewage is disposed into the rivers and the Lake semi- or untreated.

The consequence of sewage contamination of water quality include outbreak of human diseases and eutrophication problem which has resulted in the proliferation of algal blooms and undesirable aquatic macrophytes, e.g., water hyacinth (see, e.g., Subsect. 5.4.1 in p. 124). The unplanned development of fishing villages without proper sanitation properties, provide yet another localized source of sewage contamination. As these continue to expand along the Lake shore, they pose a threat to water quality, human health in general and to fisheries resources. Human faeces (or night soil in civil engineering terms) are often excreted direct into the Lake or along the beaches due to lack of toilet facilities.

Urban garbage and other waste pose a serious water quality problem particularly with ground water. This is due to the fact that leachate from the garbage dumps find its way into ground water. The water table along the Lake shore is high, thus making contamination from leachate easy. This is of particular concern, when the leachate derives from sewage spills and in places where there is lack of toilet facilities.

As industrialization in the catchment increases, the rate of industrial pollution increases. Industries in the wider catchment of Lake Victoria include sugar factories, paper mills, textile mills, breweries, soft drinks and coffee pulperies. There are other industries located in urban centers particularly fish processing plants, slaughter houses, tanneries and match factories. A factor associated with these industries is the inadequate capacity of waste water treatment, resulting in the production of poorly treated effluent. Some of these industries channel their effluent to the municipal sewage treatment plants, which are not adequately designed to treat the type of effluent produced. This therefore means that semi or untreated effluent is discharged into the rivers and in some cases with the fish processing factories directly into the Lake. These effluent affect the water quality and fisheries in that most of them accumulate along the food chain.

The wetlands along the Lake shore are threatened by cultivation. These huge swamp areas covered largely with papyrus and other indigenous vegetation, work as giant filters removing silt, nutrients, heavy metals and other pollutants from the water. Concurrent with their cultivation, their filter function is curtailed and pollutants are directly carried into the Lake. A further consequence of the destruction of wetlands is the loss of rich biodiversity associated with them and which is not found in any other habitat.

There are other small scale localized sources of pollutants whose effect when summed together have a significant effects on the Lake's ecosystem, water quality and human health. These include, e.g., mining operations in Nyanza and Western provinces of Kenya, gold rush occurring east and south of Musoma, and west and south of Mwanza in Tanzania. The mining operations contaminate water with heavy metals which concentrate along the food chain and are carcinogenic. Pollution from petrol either from direct car washing in the Lake (see, e.g., Fig. 5.17 in p. 156) or waste from petrol stations which are toxic to aquatic life and are difficult to degrade in the environment thus portending a threat to the Lake.

The overall effect of aquatic pollution (i.e., both point and non point source pollutants) of Lake Victoria can therefore be summarized as:

(a) Excess nutrients enrichment leading to eutrophication.
(b) Pollution due to pesticides and other industrial toxic chemical which have an adverse effects on human health, water quality and aquatic life.
(c) Sedimentation.
(d) The Lake's pollution from transportation sector.

Next, we consider these four variants in detail. Their impacts on the aquatic environment and human health will thereafter be discussed in Subsect. 5.6 in p. 163.

Eutrophication of the Lake

Eutrophication can be defined as the enrichment of water body with plant nutrients particularly nitrates and phosphates, resulting in the nuisance of algal blooms and aquatic macrophytes [117]. Mackenzie [92, p. 318] defines eutrophication as the process of being fed too well. Eutrophication leads to water quality deterioration, taste and odour problems, oxygen depletion, reduced transparency, decline of fisheries, possible fish kills, clogging of waterways and toxic effects on animals and human beings.

For Lake Victoria, a significant eutrophication (high algae concentration) has been noticed in waters near major cities surrounding it and also in the mouths of large rivers entering it where depths of 1m have been recorded. Besides the algal blooms, eutrophication has also led to the proliferation and sustenance of water hyacinth *Eichhornia crassipes* (see e.g., Subsect. 5.4.1 in p. 124). The center of the Lake, however, shows little eutrophication with depths of 5-7m. Most of the Lake bed suffers from low dissolved oxygen at some time during the year, but the area with almost permanent anoxic conditions is limited to a small deep area in the center.

Eutrophication as manifested in surface waters through proliferation of algal booms and aquatic macrophytes is due to a disturbed balance of the trophic levels in the ecosystem, resulting in the destabilization of the normal ecosystem regulating mechanisms on species dominance and distribution. This results in the explosive growth of a few single species which in the process disturb the biochemical cycle of water giving rise to anaerobiosis. The phenomenon is a typical result of nutrient imbalances at several levels. The source of nutrients include agricultural activities which produce a nutrient rich runoff resulting from the leaching of fertilizers and manure, garbage dumps, sewage and industrial effluent. Odada et al. [108] have listed three causes of eutrophication as:

(a) Enhanced effluent discharge,
(b) runoff and storm water, and
(c) enhanced discharge of solids,

with the first two being the most important causes of eutrophication.

Studies indicate that the high *phosphorous* and *Nitrogen* loads presently choking Lake Victoria are attributed to several non-point sources. The most important of these are *agriculture*, *livestock*, *domestic* and *industrial effluents*. Most of these activities use large amounts of synthetic compounds including fertilizers and pesticides (see, e.g., [69]). Estimates show that up to 22,000 tons of phosphorous are loaded into the aquatic ecosystems of Lake Victoria basin annually. Although animal manure and domestic wastes contribute about 3000 tons and 132 tons of the total, respectively, their Nitrogen inputs are estimated at over 40,000 tons per year [4, p. 106]. This represents more than three times the amount contributed by synthetic fertilizers.

Due to the high population growth rate, and increased population pressure on land, there has been the need to intensify agricultural practices, which have, as a result, had a negative impact on the environment. For example, because of deforestation, which aims at increasing agricultural land, there has been increased soil erosion and high loads of silt and nutrients being transported through the rivers into the Lake. The wetlands bordering the Lake have been converted into agricultural land or land for industrial use and, therefore, increasingly being unable to act as natural filters for both nutrients and silt thus leaving the Lake at the mercies of the intruding nutrients and sediments.

In general, eutrophication of Lake Victoria comes as a result of (see, e.g., [108]):

(i) Use of detergents and soaps within the Lake and its surroundings. It is common to find people bathing and washing using detergents within the shores of the Lake as shown in Fig. 5.9 in p.148.
(ii) Industrial and farm activities in the surrounding. Agricultural nutrient rich runoffs from fertilizers and pesticides used in sugar belt areas and deforestation contribute to eutrophication.
(iii) Lack of legal policies that can be used to monitor and control sources of pollution.
(iv) Lack of encouragements for local industries which try to come up with measures to reduce industrial pollution.
(v) Atmospheric nutrient loadings which occur after forests burning and the resulting wind erosion.

The fifth cause has been a source of heated debate amongst scientist in recent days. Some scientists now believe that eutrophication of Lake Victoria is largely due to atmospheric pollution. Their argument is that due to atmospheric circulation, some of the pollutants are carried all the way from industrial nations and find their way to the Lake during rainy periods. It is in-fact doubted whether the local urban cities surrounding the Lake has the potential to pollute the Lake through its atmospheric emission. More studies preferably at Ph.D. level may unravel this uncertainty. For example, COWI[1] presents the nutrient pollution levels in Table 5.3 which suggests that the loads from the atmosphere are dominant.

Table 5.3. Nutrient pollution load on Lake Victoria

Source	BOD (tons/year)	Total Nitrogen (tons/year)	Total Phosphorus (tons/year)
Catchment	0	49,510	5,690
Atmosphere	0	102,150	24,400
Industrial	5,610	410	340
Municipal	17,940	3,510	1,620
Total	23,550	155,580	32,050

[1] Source: Environmental management of Lake Victoria (pdf) from www.cowi.dk

Sedimentation of the Lake

Lake Victoria is fed by several rivers. As we pointed out in Subsect. 5.4.2 in p. 135, there has been an increase in population growth of urban cities within the Lake basin. The increase in population has in-turn put pressure on the available resources, e.g., land leading to increase in deforestation (see, e.g., Fig. 5.6).

Fig. 5.6. Deforestation of the once densely forested Gwassi hills in the Lake Victoria basin

Besides clearing land for cultivation, vegetation are destroyed to pave way for settlement, infrastructure while forests are cleared to provide timber for building and fuelwood. As a result, topsoil erosion and sedimentation are enhanced leading to increased suspended solid loads in the rivers that feed the Lake. In the final analysis, these suspended solid in rivers or where erosion takes place in the Lake shores enhances the amount of the suspended solid particles in the Lake. Significantly, topsoil erosion because of human activities, particularly agriculture, is an important source of the increased sediment discharge to Lake Victoria.

Mackenzie [92, p. 322] points out that an estimated 480 billion tons of topsoil have been lost to the world's farmers by erosion in the past few decades. Of this, 18 billion tons are said to be transported by rivers to oceans annually while the rest moves to other terrestrial ecosystem.

Indeed, as pointed out by [108, 141, 152], analysis of sediments in Lake Victoria has shown tremendous increase over the past 150 years. Lake Victoria basin has very rich agricultural land with many densely cultivated areas, especially in Kenya, Uganda and Burundi (see, e.g., Table 5.4) [131]. Graphically, the data in Table 5.4 are as plotted in Fig. 5.7.

Table 5.4. Agricultural Characteristics of Lake Victoria basin (Catchment land area 1000 ha)

Country	Cultivated	Noncultivated	Total
Kenya	1470	3400	4870
Uganda	1400	2100	3500
Tanzania	1500	5540	7040
Rwanda	930	1130	2060
Burundi	670	640	1310
Total	5970	12,810	18,780

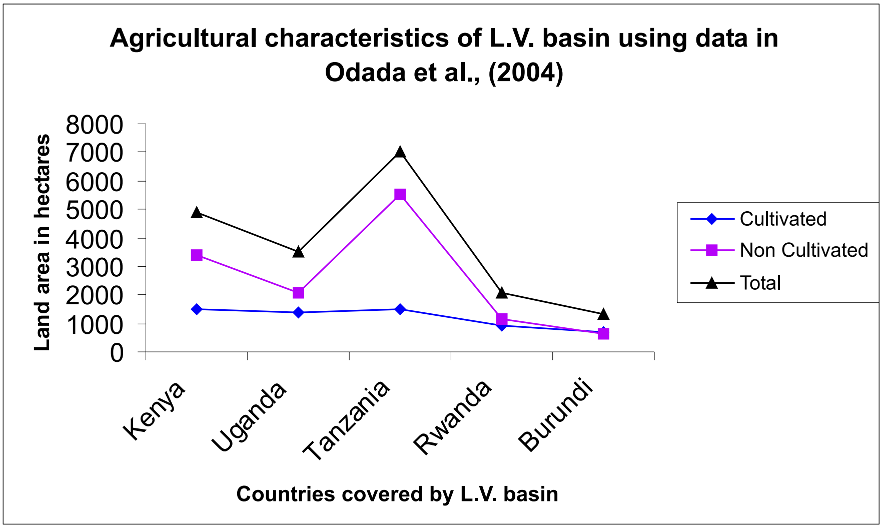

Fig. 5.7. Agricultural Characteristics of Lake Victoria basin (Catchment land area 1000 ha)

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Odada et al. [108] have cited rivers Sio, Nzoia, Yala, Sondu, Nyando and Kuja in the Lake Victoria basin of Kenya as draining highly agricultural areas with the sediment loads of river Nyando increasing by

7.5 times during the last 16 years, with turbidity measured at 527 NTU in rainy season of 2001 (see also [141]). The Nyando River Basin is a major source of sediment and phosphorus flow into Lake Victoria.

The pollution level of this river is alarming and is a threat not only to marine life but also to people who use it for domestic purposes. Municipalities, farms, both large and small, industries and markets, all empty their waste into the river. The entire weight of Ahero's waste rolls down into River Nyando, transported by rain-wash or dumped directly into the river. This water is used directly for domestic consumption. That is the sad part if it. There is no sewage treatment at Ahero. The toilets of Ahero are their banks where everybody relieves himself/herself and finally rain-washed into the river.

The state of River Nyando illustrates a widely held view: of the three East African countries that share this resource, Kenya's impact on the Lake's ecological health is by far the most severe. All the East African countries contribute to the pollution of the Lake basin in general and Lake Victoria, in particular. The Nyando River is also an important spawning ground for some of the Lake's native fish species. At the start of the mating season fish swim up-river, their course determined by a remarkable sensitivity to the quality of water.

Today, many of them are either endangered or extinct, unable or unwilling to breed in Nyando's foul waters. *Synodontis victorianus*, "Okoko" in Luo language is rare. *Barbus spp.*, "Adel" is rare. The eel, *mastecebelus spp* is near extinct. Of the 320 odd fish species native to Lake Victoria 40 yeas ago, only eight remain. Their disappearance from the Lake has been described as "*the greatest mass extinction of modern times*". Sedimentation has contributed in heavily polluting the Lake by;

- destroying the feeding grounds for fish,
- filling the Lake and,
- decreasing the light necessary for the growth of aquatic life.

Wetland habitats, fishing and eco-tourism industries that depend on the Lake are at risk due to increased sedimentation. The clearing of wetlands, e.g., Yala Swamp in Kenya (see, e.g., Fig. 5.8) to pave way for farming land as already pointed out by [48, 69] increases the deposition of sediments in the rivers and the Lake.

The effect of increased sedimentation on coral, phytoplankton and benthic marine productivity has been outlined in [92, pp. 321–322]. Other activities, e.g., sand mining within the basin, urban and industrial activities have also contributed to the increased rate of transportation of sediments and sedimentation of particulate materials in the Lake which lies far from the sediment source.

Fig. 5.8. A cleared area of Yala Swamp. Inset: Prof. Oyugi Aseto

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Toxic Chemical Pollution of the Lake

A good example of the effect of toxic chemical poisoning of water and its subsequent repercussion on human health is illustrated by the mercury poisoning of Minamata Bay in Japan [92, p. 324]. Around 1950s, mercury was discharged from a chemical plant located on a river flowing into the bay. The traces of these mercury found themselves in fish and were eventually consumed by the Japanese. The net result of eating the contaminated fish was mercury poisoning in human being, the Mad Hatter's disease, a disease that affects the nervous system. Mackenzie [92, p. 324] continues to report that older Japanese living around the bay today still exhibit evidence of the disease which has killed a number of people.

Toxic chemicals are discharged from urban and industrial areas surrounding the Lake. These are Kisumu and Homabay in Kenya, Mwanza and Musoma in Tanzania and Kampala, Entebbe and Jinja in Uganda. Scheren et al. [131] note that in Tanzania and Uganda, industrial waste water treatment facilities are generally absent while in Kenya most factories operate treatment plants. Other than urban and industrial areas, agricultural lands neighbouring the Lake also contribute pesticides to the Lake. Indeed, the abundant sugar, coffee, cotton, maize, tea and rice plantations that surround the Lake contributes heavily in this regard as use is made of agro-chemicals. The fact that the use of agro-chemicals in these plantations is increasing has been pointed out,e.g., by [105].

It is important to point out that the pollution of the Lake also comes from the atmosphere. Similar to the causes of eutrophication (see, e.g., page 139), Odada et al. [108] identify the immediate causes of chemical pollution of Lake Victoria as;

- enhanced effluent discharge,
- enhanced discharge of solids,
- runoffs and storm water and
- atmospheric deposition through the supply of nutrients such as Nitrogen and phosphorus,

and present the root causes of chemical pollution.

The major point sources of pollution in Lake Victoria basin are municipal sewerage outlets, industrial effluent and mining leachates. Odada et al. [108] have pointed out the fact that small-scale mining is increasing in parts of Tanzania catchments, leading to contamination of the waterways by mercury which finds its way into the Lake killing many aquatic organism. At the start of this section, we outlined the effect that mercury had in Japan. Increase in mercury pollution of the Lake therefore should be a cause of alarm.

Besides the mercury threat, [100] have indicated the trace of organochlorine pesticides in fish from Lake Victoria which have been traced by [108] to agrochemical residues from the farms within the catchment. Indeed, [108] writes

> "Increasing volumes of chemical effluent discharges go directly into the rivers and Lake. Leachates from mining tailings that are close to the rivers or Lakeshore, industrial waste such as barley waste and chemicals are dumped into the Lake in uncontrolled manner. There is also disposal of expired pesticides, medical wastes, petrol station wastes, bunkering wastes, etc. Some companies have stockpiles of banned substances such as DDT".

In a number of municipalities, sewerage treatment plants do not work. Raw sewerage is discharged into the water system. A 1998 SIDA-funded report[2] paints a terrifying picture of pollution from all sides of the Lake basin: For example, there was a time when Kisumu had not treated the urban wastes for almost a decade. The raw waste was dumped into the Lake (see, e.g., [4]). Similar cases abound around the urban centers surrounding the Lake on the Kenyan side, e.g., Kendu Bay, Homa Bay, Mbita and Muhuru Bay, among others.

Sugar industries and towns in Western Kenya have been cited as the heaviest polluters. Muhoroni Sugar Factory and its molasses-producing counterpart, Agrochemical and Foods Ltd., are among the worst industrial polluters in the Lake basin and pay little attention to clean technologies [4]. Effluent released from Agrochemical had a **B**iological **O**xygen **D**emand (BOD) of 95,000mgs/litre. The World Health Organization recommended level is 100 [4]. Like many other factories, they had taken advantage of weak environmental legislation and opted to pay ridiculously small fines rather than improving their treatment plants.

In Uganda, Kampala and Jinja towns bordering the Lake contain industries and factories that contribute to the pollution of the Lake through expired chemicals as well as drugs and partially treated domestic sewage as pointed out by [74, 108]. Mwanza and Musoma towns in Tanzania also contribute in polluting the Lake.

However, things have improved a little, thanks to the efforts made by OSIENALA, a regional NGO. Before OSIENALA (Friends of Lake Victoria) embarked on a campaign to extol the virtues of waste treatment to the managers of Muhoroni Sugar Factory and its molasses-producing counterpart, Agrochemicals and Foods Ltd, OSIENALA was faced with two options. First it had the choice of exposing and eventually getting them closed down leaving thousands of people unemployed. The second alternative was to work with them to steadily reduce pollution-levels.

OSIENALA chose the latter. Working with the District Development Committee, they managed to get the government of Kenya to offer them some tax breaks. Eventually, and at a huge cost to both companies Ksh300 million for Agrochemicals and Ksh120 million for Muhoroni ($3.75 million/$1.5 million) the two installed new treatment works and are gradually reducing the toxicity of their effluents.

Garages and petrol stations are some of the sources of oil and grease pollutants in the region. Specific sources include the Kenya Railways deport in Kisumu, oil companies, factories, steamers, motorized boats

[2]The Lake Victoria Basin Hot Spots Study

plying Lake Victoria, septic tanks and pit latrines. There are also metals discharged by factories (paper, matches, and batteries), tannery wastes mostly chromium; fish particles and wastes, from fish processing and filleting companies and corrosive chemicals; hospital and pharmaceutical wastes and molasses spill. Use of detergents by locals as in Fig. 5.9 also adds to the toxic chemical pollution of the Lake.

Fig. 5.9. Use of detergents in Lake Victoria

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5.5 Pollution from Transportation Sector

Lakes and rivers are fundamental parts of the natural, social and economic systems and feature prominently in policies for land, water and environmental management [49]. Lake Victoria is one such system, being one of the most important fresh water ecosystems in the world. Its hydrology has been one of the most difficult and controversial to understand [113]. As pointed out in Sect. 5.4.2 in p. 135 however, the Lake's water quality has fast been deteriorating due to pollution from point and non-point sources associated with the location of several urban centers on its shores. In combination with other factors, the increased pollution load into the Lake Victoria is blamed for the changing fresh water ecosystem. Further more the Lake's water level is said to be decreasing due to the net output from evaporation and the outlets [95, 101, 113]. This is slowly leading to the concentration of pollutants, hence threatening to convert the fresh water ecosystem into a salty Lake, with the resultant change of the ecosystem.

Natural resources on the fringes of urban areas always suffer severe depletion and degradation as urban centers create demand for goods and services thus exerting tremendous pressure on fragile ecosystems. The high rate of urbanization therefore rapidly increases the pressure on these ecosystems. The increasing population and economic growth of cities associated with urbanization create externalities due to the demand for resources and waste disposal [81].

Kisumu city in Kenya is one such urban center which sits at Nyanza gulf of Lake Victoria (see, e.g., Fig. 5.1 in p.115). Kisumu, the largest urban area on the Kenyan shores of the Lake has been blamed for the high pollutant input. The location of Kisumu on the shores of Lake Victoria poses a serious challenge to urban environmental planners as it experiences a rapid urbanization rate with the accompanying increase in the socio-economic processes. The magnitude and reality of these socio-economic processes, propelled by rapid urban population growth around the Lake has increasingly put demand for environmental goods and services, hence a potent threat to the life of the Lake [49]. Wastes from Kisumu, like from many other urban centers, have found their way into the Lake, arising from the poor environmental services and developed road and drainage infrastructure with no provision for run off treatment before release into the Lake. Under the prevailing basin's rainfall and topographic characteristics, there is a high input of pollutants through the run off from Kisumu.

Although pollution from industry, agrochemical factories and farmlands have been well documented (see, e.g., Sect. 5.4.2 in p. 135), the contribution of the transportation sector to the pollution of Lake Victoria has received little or no attention at all. Indeed, [27] had noted that in many cities, motor vehicle transport was the main cause of environmental degradation. The increase in the motor vehicle traffic experienced in Kisumu, due to its strategic location on the main transnational highway has significantly contributed to the pollution of the Lake. The city experiences relatively heavy vehicle traffic causing concern over the levels of exhaust emissions and air pollution, among other problems [27, 95].

Contribution of pollution from the vehicles takes the form of;

- litter generated at the termini and along the roads,
- vehicle repair, service and maintenance yards and garages commonly known as "Jua Kali" (i.e., open garage),

- exhaust fumes and oil spills on to the roads, which are washed into the Lake.

However, one of the emerging sources of pollution is the *direct* car washing in the Lake and run off from the urban center.

In the following sections, we contribute towards the on going studies of pollution of fresh water Lakes in general, and Lake Victoria in particular by considering the effects of transportation sector in Kisumu on Lake Victoria waters (see also [107] for more details). Section 5.5.1 starts by considering motor transportation in general, while Sect. 5.5.2 presents a special focus on car washing and urban runoff water. Kichinjio beach in Kisumu was selected for case study.

5.5.1 Transportation Sector: General Pollution of Lake Victoria

In what follows, we present means by which the Lake is suffocated by transportation sector related activities in Kisumu, Kenya. The information presented in this section has been obtained from field observations captured digitally and from interviewing a handful of selected people working in the interest areas with a direct or indirect effect on the environment to gather more knowledge on their activities as well as to gauge their environmental consciousness. Three mechanics from "Jua Kali" (i.e., open garage) and three car-washers at "Kichinjio" beach were directly interviewed.

As already mentioned, the strategic location of Kisumu on the trans-Africa highway and at the center of the East African community has seen it becoming the leading transport and communication hub in the region. The city is traversed with many roads of varying grades supporting the various different transport functional needs. It is dissected by the two major roads into three parts, i.e., the Nairobi–Busia (trans-African) road that divides the city into the North and South, while the Kakamega road further divides the Northern part of Kisumu into East and West.

The city has a total of 255 kilometers of roads and streets of which 148km are paved while the remaining 107km either Earth or gravel. The city's position has, to some extent, contributed to the confluence of major roads accompanied by the increase in the town's vehicular traffic. Following the most recent rehabilitation of the paved roads in town and its environs, the amount of traffic has drastically increased over the past few years [95, 101]. The city experiences a large mix of traffic from large trucks ferrying *oil products* from the inland container and oil deports, trucks, trans-border and cross country busses to the smaller public transport and private vehicles. These have varying degrees of contribution to pollution of the air and land finally leading to the eventual pollution of Lake Victoria.

Traffic counts conducted in 1993 by the ministry of Public Works revealed that Kisumu experiences very high traffic volumes, possibly due to its location and the fairly good roads [96, 120]. Opiyo [120] summarizes the 12h vehicle count in Table 5.5[3] indicating high volume of vehicles, more so for the private cars. Increased traffic volume for the

Table 5.5. Vehicle 12 hour Volume counts along various roads in the town

Mode	Motor cycles	Private cars	Taxis	Matatus	Buses	Trucks
Totals	1,684	58,754	16,625	22,624	1,219	7,589

town has a potential for affecting ambient air (see the vehicle left of Fig. 5.10). Most of the vehicles within the town, and indeed in Kenya

Fig. 5.10. Vehicle congestion and exhaust pollution

as a whole, are of the old generation. They cannot run sustainably on unleaded fuel, as the conditions generated during combustion con-

[3]Matatus refers to commuter (passenger) vehicles of Nissan type used in Kenya. In Tanzania, they are known as Daladala (see, e.g., the foreground vehicle on the right hand picture in Fig. 5.10)

tribute to a rapid erosion of the valve seats, resulting in loss of engine performance through poor valve sealing.

The high lead content combined with the low combustion efficiency of the old type of engines lead to the emission of high volumes of exhaust gasses, which contain semi-combusted fuels combined with worn out engine parts and waste oils [96], hence high concentration of particulate matter in the air. From their study of air pollution in Beijing, Yang et al. [162] found that the relative particulate mass and the elemental concentrations of crustal and pollutant elements in the air particulate matter collected over the urban area to be higher than rural areas. On the other hand, the increased concentration of these gases leads to a warming of the Earth's surface and the lower atmosphere. This has serious implications on the aquatic ecosystem, as it alters the water physical properties hence the trophic relations [126]. For Kisumu, for instance, the cases of upper respiratory diseases within the city have been on the increase, which is indicative of air quality [101]. This could be linked to the Lake through rain and runoff as already pointed out by [135].

The city further has a total of 60km of Earthen roads. Some of these are in the hilly areas of Kajulu and Riat hills. In some cases, there are no roads; hence vehicles cross fields to get to their destinations. On the other hand, the amount of dust raised from the Earthen roads is significant. Vehicle traffic blows up dust on these roads which are swept into the Lake in the storms, via the drainage channels.

Besides direct pollution from the large volume of vehicles, their presence has necessitated large strips of land to be cleared to make room for wide roads to accommodate their needs, thereby destroying the trees and natural vegetation therein. For the 457 km road length within the city for example, 13,716 square km of vegetation had to be cleared, using an average road width of 30m. The clearing of vegetation for road infrastructure has resulted in increased compaction and impermeability reducing the soil infiltration thereby increasing the surface runoff, with the resultant erosion of the Earthen roads and siltation of the Lake [81].

Erosion of the roads is also caused by heavy vehicles used for transport of, e.g., sand or fish from the beeches causing the formation of ruts on the roads, which fill up with muddy water and eventually end up in the Lake (see, e.g., Fig. 5.11). This is more evident on the hilly areas to the northern part of the town. The increased run off power could have contributed to the increased nutrient load into the Lake leading to siltation and eutrophication, as noted by [115] in their studies of the pollutant load into the Lake.

Fig. 5.11. Eroded Earthen roads and trenches at some of the beeches

The largest contributor to pollution of the Lake is probably the increased surface runoff. The provision for vehicle parking and transport comes with the need for provision of waste services for the passenger-generated waste. Passenger waste has resulted in severe waste problems at the Kisumu Bus Park, the highways and taxi parking. The concentration of vehicles at termini also presents lucrative business opportunities for the hawkers, and food vendors. This has seen the accumulation of both liquid and solid wastes at the termini. With the low waste services in the town, most of the wastes end up in the drains hence blocking them during rainstorms or are swept into the Lake via these drainage channels as illustrated in Fig. 5.12.

Perhaps the more serious waste is from the vehicle repair, service and maintenance yards and garages (i.e., "Jua Kali"). The yard has no provision for waste handling of any kind. This has resulted in used oils being poured on the ground at the point of change, old tires and batteries being dumped at site which eventually find their way into the Lake as illustrated in Fig. 5.13.

The efficiency of most of the vehicles, especially the public transport within the city is also questionable. The vehicles are old and unreliable, leading to frequent breakdowns. Some people use jerry cans as the vehicle fuel tank. Most of the public transport vehicles therefore spill oil as well as fuel in the period of their operation (see, e.g., Fig. 5.14). These oil spills find their way into the Lake during run offs.

Oil also finds its way into the Lake from petrol stations and depots (see, e.g., Fig. 5.15). The town has two operational oil deports and several petrol stations to supply fuel to the motor vehicles. These do

Fig. 5.12. Waste accumulation at bus termini

Fig. 5.13. Wastes from vehicle repair known as Jua Kali

not have adequate treatment mechanism for the waste water and oil spills from their sites. Their wastes end up in the common storm water drains or streams and eventually end up in the Lake, since they are not connected to the conventional sewer treatment plant. Large transit trucks also ferry petroleum products from the depots, through the city center to their destination. The filling up of the trucks and the emptying at the petrol stations are not efficient, oil spills occur at both the source as well as the destination, and are swept into the conventional drainage system.

Fig. 5.14. Oil spills

Fig. 5.15. Petrol station operations and the Caltex petrol depot at the Lake side

Spray paintings of vehicles also contribute to the metal content of the runoff from Jua Kali area. This is in the form of the fillings from the old paint-work (Enamel) before spraying, the actual spraying and washing of the sprayed vehicles (see, e.g., Fig. 5.16). Welding is the other form of pollution at the Jua Kali garage. Vehicle repairs involve some welding in the body work, as well as the making of other metal products like grills for doors and windows. Welding is done using electric arc welder, oxy acetylene gas, as well as using kerosene burners. The fumes emitted from the welding processes are not only harmful to the welders but to the general public as well as the environment.

Fig. 5.16. The spray painting process and wastes

5.5.2 Car Washing: The Emerging Threat to the Lake

An increasingly popular practice at the beaches today is the car washing (see, e.g., 5.17). The car washing history stretches back to the late 1950s. The beach records very high turn over of vehicles of different classes. Tens of vehicles are washed at the Lake every day. There are no statistics on the number of vehicles washed everyday or the amount of pollution from the car washing. Casual observations reveal that the shore waters are now dirtier and greasier. The waste oils from the vehicles, dirt accumulated in transit are all washed into the Lake. Some of the vehicles have leaking systems hence the oils or the fuels drip into the Lake, causing further problems.

Fig. 5.17. Washing of heavy petroleum vehicle in Lake Victoria

As can be seen in Fig. 5.18, the shores are no longer supporting the original vegetation or other small life forms, due to the conscious removal by the car washers or possibly due to the decrease in the oxygen levels in the water occasioned by the oil covering the water surface. In Fig. 5.18, the floral and faunal composition has also changed as can be detected by the lack of shells at the car washing area. There has been a change in the trophic relations at the car washing area, which affects the entire Lake. Kichinjio beech is one of the breeding sites for some

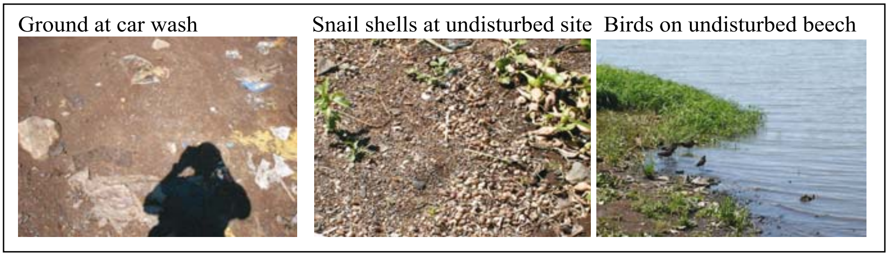

Fig. 5.18. Destroyed biodiversity due to car washing

fish species and other aquatic life forms. The disturbance accompanied with oils in the water could have adversely affected them.

In his study of the Zooplankton communities of some Tanzanian Lake Victoria basin water bodies, [157] found that the structure and composition trends of zooplankton in the surveyed water bodies may be related to both intensity of predation and limitation by environmental factors, which may include the nature of the water bodies, food quality and quantity. This could be reason for the presence of shells at a site away from the car wash and proves that pollution from point and non-point sources can significantly influence an ecosystem [81, 115].

Case Study: Kichinjio Beach

In order to ascertain the impact of car washing on Lake Victoria, we carried out a six weeks study between the months of March and April 2005 at Kichinjio beach, a famous fish eating and car washing point in Kisumu, Kenya. For each of the weeks, water samples from different spots were analyzed for conductivity, pH and phosphates. Data on the number and type of vehicles washed at the beach was also collected by counting vehicles.

Vehicle count by category was done within every thirty minutes between 7am and 7pm on each sampling day. These categories were private cars, public transport vehicles (known locally as matatus), buses, canters, lorries and tankers. Enumerators with the data sheet took the data on a twelve-hour basis. Six water-sampling points were designated along the beach line depending on the activity. The ***first point*** had an inlet to the Lake carrying urban run off, the ***second***, ***fourth*** and ***fifth*** points were car washing places. In order to act as a control study, the ***third*** and ***sixth*** points had no car washing activities. The sixth point was chosen far away from the last car washing point (i.e., a distance of 200m) to get the readings from undisturbed water area. The water samples were collected once a week for six weeks at 6 pm, so as to analyze the effect of the day's car washing activity. The Hach's water testing kit was used in the sampling.

Table 5.6 and Figs. 5.19, 5.20 and 5.21 present the daily records of the type of the vehicles washed at Kichinjio beach. The results indicate that matatus recorded the highest daily average number of vehicles washed at the beach (i.e., 114 or 42%), followed by private cars (i.e., 94 or 34%). Figure 5.20 presents the daily trend in car washing activity during the day. In the figure, it is indicated that the highest number of vehicles being washed at the beach occurred during lunch hour, with most being private cars. The highest matatus count in contrast was recorded after 6pm. Though few, buses and trailer trucks (tankers) were recorded being washed at the site. The number of vehicles being washed was fairly constant throughout the period of the study apart from 4th of April when a general low count was recorded in all categories apart from lories. The 28th of March recorded the highest vehicle counts.

Table 5.6. Daily counts of vehicles washed in the Lake from 17th March to 28th April 2005

Type of Vehicle	Total Daily Counts						Total by type	Daily averages	%
	17th/3	26th/3	1st/4	4th/4	12th/4	28th/4			
Private cars	95	101	98	66	97	96	553	92	34
Pick ups	36	34	32	16	33	33	184	31	12
Matatu	117	123	121	83	121	120	685	114	42
Canters	6	5	6	9	5	6	37	6	2
Lorries	25	23	21	24	21	19	133	22	8
Tankers	4	2	2	2	0	1	11	2	1
Buses	5	4	1	1	0	0	11	2	1
Totals	288	292	281	201	277	275	1614	269	100

The urban run off and sampling *point* 6 (undisturbed shore) posted higher conductivity values than the car washing points, which posted the lowest conductivity values. The urban drain recorded, exceptionally, the highest average phosphate values while the ***second*** car wash point recorded the lowest. In terms of turbidity, the car washing points had the most turbid water compared to the non-car washing points, which had the clearest water. The observations of the various points also indicated that the car washing points had the lowest biodiversity

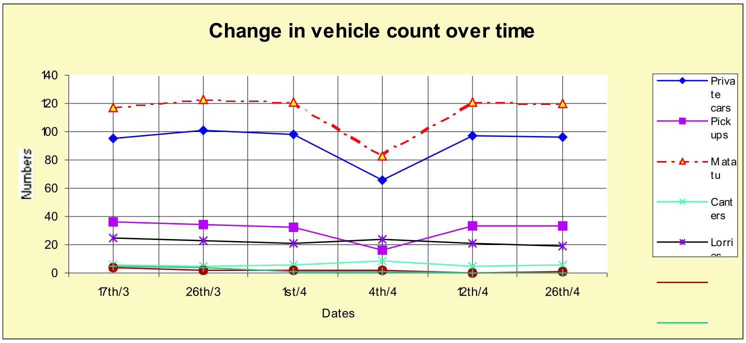

Fig. 5.19. Changes in the daily vehicle count at the car washing points

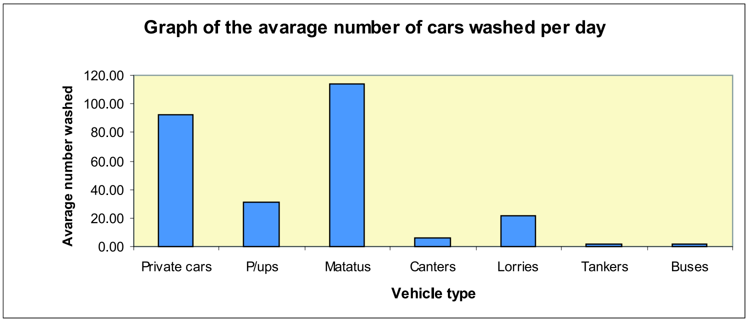

Fig. 5.20. Average daily number of vehicles washed at the beach

evident by the lack of birds, plants or water life visible at the shore. The non-car washing point (point 6) had molluscs' shells, birds and plant life.

Figure 5.22 gives a graphical presentation of the water parameters. In the figure, the phosphate and pH values had to be multiplied by a factor (100 and 50 respectively) in-order to be displayed together in one graph for easier comparison. From the Figure, it is possible to detect a correlation between the three water parameters. Sampling *point* 4 (the most active car wash point) had the lowest values for all the parameters, implying it had a higher level of acidity, while point 1 (urban run off point) had the highest values for all the parameters measured, implying a basic tendency. The figures indicate a relationship between the vehicle washing and water quality.

Figure 5.23 indicate the phosphate and conductivity values to be particularly low on the fourth of April, thus coinciding with the day when the number of cars washed was low. The average pH values stayed

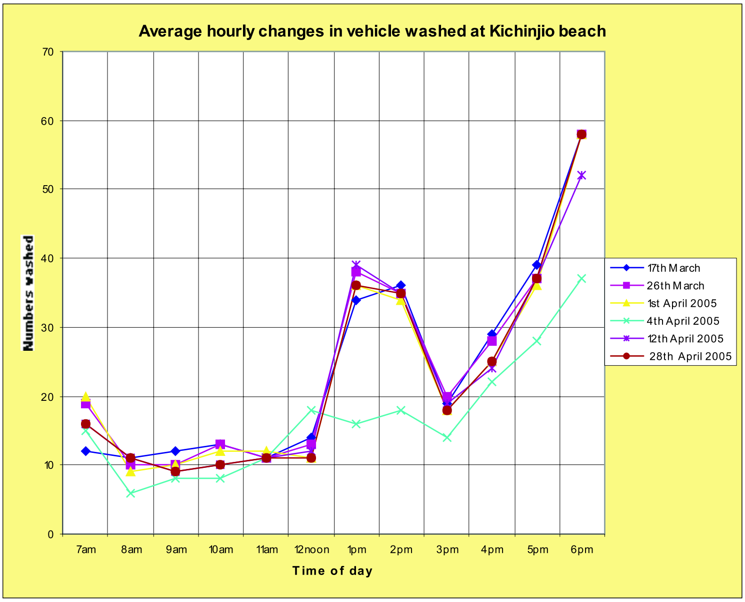

Fig. 5.21. Average hourly change in vehicles being washed at the beach

Table 5.7. Daily average water quality for the six points along the beach

Sample points	1	2 Car-wash 1	3	4 Car-wash 2	5 Car-wash 3	6
pH	7.3	6.8	7.5	6.7	6.9	7.5
Phosphates in mg/l	2.4	0.3	0.3	0.2	0.6	0.5
Conductivity in mS/cm	301.7	171.3	184.8	184.2	185.5	204.8

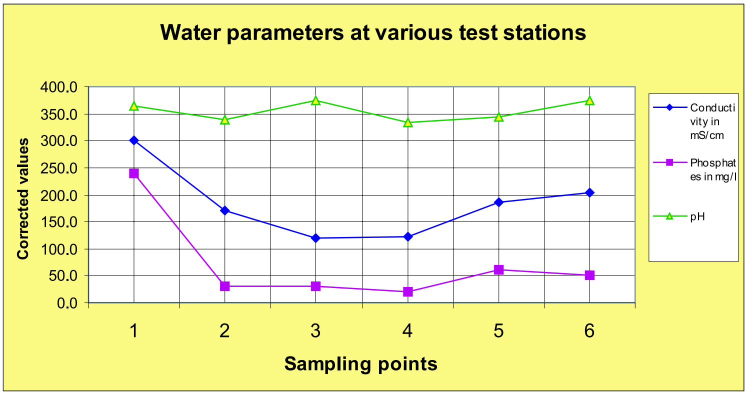

Fig. 5.22. Water parameters at various test stations

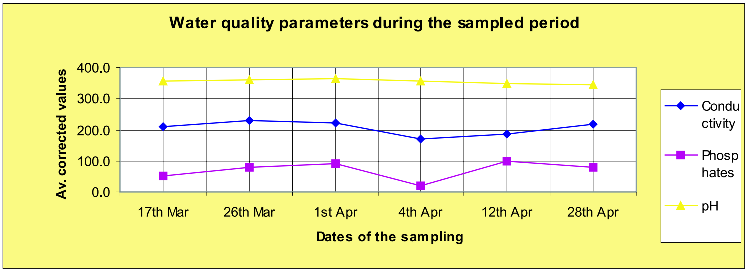

Fig. 5.23. Average daily parameters during the sampled period

fairly constant throughout the days of the study. Car wash points (see Table 5.7 and Fig. 5.22) indicated pH values lower than 7 thus slightly acidic compared to other sampled points. This is an indication of significant pollution of the Lake from the car washing activity. The wash consists of fluids such as oils, fuel, battery fluid and the dirt from inside as well as on the outer body of the vehicles.

The high phosphate levels from urban runoff (point 1) indicate the carrying of wastes from the streets and car repairing areas (i.e., Jua Kali) into the Lake. This could raise the phosphate levels. However, the high conductivity recorded at the runoff point could be an indicator that there are other sources. These are values normally recorded for sewer treatment plants. In this case, there could probably be a burst sewer releasing the effluents into the Lake. Phosphate values should be low so as to prevent the excessive growth of algae. The high levels recorded could significantly contribute to the eutrophication of the Lake (see, e.g., [60, 113].

The vehicle counts indicated higher numbers for matatus and private cars. The change in the numbers recorded throughout the day indicated that the highest private car counts were recorded at around lunch hour. The flourishing fish eating business at the beach is an indicator that most of the private cars come to the beach for lunch and only have their cars washed as a value added service. As such they do not come to the beach specifically for washing. However, the matatus (commuter vehicles) had a different pattern. The highest counts were recorded after working hours, i.e., from 5pm when apparently the vehicles come down for washing at the close of the day's business.

At the car washing point for instance, it could not be possible to get a single mollusc's shell, indicating that the car washing activity is already impacting negatively on the species composition of the beach.

The high number of vehicles recorded at the beach has also increased the bulk density at the shores; hence the ground at the car washing is impermeable. The runoff from the town therefore goes directly into the Lake without any filtration. The filter function of the natural wetland vegetation is fast being lost.

The indication of significant values of conductivity at the non-car washing point 6 could mean that there are other pollutant sources. Car washing cannot therefore be totally blamed for the high figures recorded at the beach, though it is a major contributor. Besides, car washing at the Lake with its high concentration of the vehicles at the shore has greatly compacted the beech, making it less attractive to the beech dwelling species. The ground surface is now smooth and impermeable, hence reducing its suitability for burrowing and crawling faunal species. The soil porosity has also been reduced by the increase in its bulk density. The oils washed off the vehicles (particularly petroleum vehicles, e.g., Fig. 5.17 in p. 156) floats on the water surface forming a seal hence reducing the amount of oxygen available in the water for the survival of the flora and fauna. This would interfere with the amount of food available hence the trophic relationships at the particular site [82]. This could explain the reason why there are no snail shells and predatory birds (like the Harmakop, e.g., Fig. 5.18 in p.157) at the car wash place.

In their study of the chemical constituents of surface and rain water in Sri Lanka, [135] found that rainwater collected from urban centers with high population densities had moderate concentrations of nitrate, sulphate and chloride ions, and tended to be slightly acidic. This could also be true for Kisumu. Most of the drains within the city directly empty the waste water from the urban area into the Lake. The runoff from the urban center as well as from the petrol stations and repair yards, which contain the vehicular pollutant elements, are emptied directly into the Lake. This could explain the change in pH noted by [115] in their study of pollution loads into Lake Victoria from the Kenyan catchments.

It is evident that the urban run off is probably the most significant contributor to the accumulation of elemental pollutant load into the Lake. This further increases the accumulation of toxics in the food chain [81], and could also affect the nutrient ratio, resulting in the reduction of the food and introduction of some dominating species, like the Blue green algae; result in the increase in temperature as well as the decrease in transparency, as was found out by [103] in his overview of the status of water quality of Lake Victoria on the Kenyan side. These conditions could have led to the invasion of the less nutritive blue-green algae replacing the major food for many of the fish species and affecting the Lake's biodiversity [72].

In their study of Lake Zige in Tibet, Shijie and Nanjing [133] found that the Lake could become a more typical salt Lake, due to the elemental addition and the depletion of Ca^{2+}, Mg^{2+} with concentrated Na^{+}-CO_3^{-}- SO_4^{2-}-Cl^{-}. Similarly, Lake Victoria risks being converted from fresh water Lake into a salt Lake with significant contribution from motor transportation sector.

5.6 Sanitation and Health issues

As noted in the preceding sections, water quality in Lake Victoria has been deteriorating due to increasing pollution from agricultural and industrial activities in the catchment and urban centers along the shoreline of the Lake. Only a small fraction of the population in urban and rural areas has access to treated piped water while a minute fraction has access to untreated bore hole water. A large proportion of the population uses raw water obtained from polluted sources such as rivers. The infectious agents found in raw untreated water are indicated in Table (5.8)[4].

Domestic and industrial waste management still remains a serious environmental problem in most urban areas. This is due to inadequate financial resources, *inadequate disposal vehicles*, *dumping sites* and *low participation by individual and private companies in solid waste management*. Improvement of water quality around the Lake will contribute to better health for all that rely on it, i.e., the poorer groups.

The perils of poor methods of disposal of domestic waste water are many. In Lake Victoria, these have been manifested in the frequent outbreaks of water borne diseases such as *typhoid*, *cholera*, *dysentery* and *bilharzia*. Others are *gastro-enteritis*, *chemical poisoning*, *Giardiasis*, *Shigella*, *Hepatitis*, *Salmonella*, *Typhoid fever* and *toxigenic E. coli* infections. The fraction of households with sewers in large towns is less than 30%. A small fraction of the population relies on pit latrines while a larger fraction does not have toilets, sewer pits or access to sewage

[4]Source: ETMA LBDA Workshop, Kisumu, Kenya

Table 5.8. Infectious agents in raw untreated water

Organism	Disease
Viruses	Polio Enteroviruses
Bacteria	Cholera Dysentery Typhoid
Protozoa	Giardia Amoebic dysentery
Others	Flukes Worms

treatment facilities. Table (5.9)[5] details the diseases, which occur due to contamination of drinking water sources by raw sewage.

Most of the landing beaches lack infrastructure including clean weighing sheds, piped water, toilet facilities and ice storage facilities. This is the main cause of regular outbreaks of diseases of insanitation there.

Health constitutes the physical, mental and social well being of the people and not merely the absence of disease or infirmity. A healthy population is capable of actively participating in economic, social and political development and is thus a great asset to the country. There is need to put in place plans and programs to reduce the disease incidence, including the spread of the HIV/AIDs epidemic. Nyanza province in which the Lake Victoria belong, for instance, has the highest prevalence of the HIV/AIDs in Kenya, with 26% of the rural population having the disease compared to a combined 23% for rural and urban areas for the whole of Kenya. The approach should be more on preventive rather than curative measures in the health management.

5.6.1 Effects of Algal Blooms

Algal blooms are dense growths of algae forming scum over the water surface. They are as a result of nutrient enrichment, "eutrophication" from the sources already discussed. In the Kenyan waters of Lake Victoria, algal blooms are widespread and occur throughout the year. The most intense blooms occur during April - July, during the heavy rains

[5]Source: Proc. ETMA workshop 1982, LBDA, Kisumu, Kenya: *Prevalence rates unlikely to increase:** Epidemic would change the relative proportions of different virus types.

Table 5.9. Pathogenic microorganisms in domestic raw sewage

Pathogen	Sewage concentration (organisms ml-1)	
	Typical	Maximum
Bacteria		
Escherichia coli (toxigenic and invasive)	10^7	10^8
Salonella *typhi*	10^5	10^7
Salonella paratyphi		
Other Salmonellae		
Shigella	10^4	10^6
Mycobacterium tuberculosis	10^2	10^{2*}
Leptospira	low	-
Protozoans		
Giardia lamblia	10^5	10^6
Entamoeba histolytica	10^4	10^5
coli	low	-
Helminths (worms)		
Ascaris lumbricoides (roundworms)	10^2	10^3
Necator americanus (hookwors)	10^2	10^3
Ancylostoma dudenale (hookworm)	10^2	10^3
Taenia saginata (tapeworm)	10^2	10^3
Trichuris trichura (whipworms)	10^2	10^3
Viruses (¿100 different types)	10^5	10^{5**}

and during September -November during the dry season after destratification. The major algae blooming in the Nyanza Gulf belong to the blue and green algae, the Cyanophyceae group and involve *Microcystis aeruginosa, Anabaena* spp and *Lyngbya* spp. In the open waters of the Kenyan sector of Lake Victoria, the major blooming algae are the diatoms *Nitzschia acicularlis* [45].

The environmental consequences of algal blooms in the Lake have been immense. In the open water where *Nitzschia acicularlis* is the dominant blooming algae, bottom sediments are constituted of a thick layer of green mud derived from the decomposing algal blooms. Here the greater part of the water column is permanently deoxygenated with oxygen concentrations in water depths greater than 25m falling below 3.0m/g, the lowest level tolerable to most fish species in the Lake. The net result has been the absence of fish at the bottom of these habitats.

Fish only occupy a small layer of well-oxygenated water near the surface. This means that the area suitable for fish survival has been drastically reduced due to the presence of algal blooms - hence a reduction in fish yield. This problem is even more severe in the Nyanza Gulf (see, e.g., Fig. 5.1 in p.115). The places most affected include the

Nyakach Bay, the area between Kopiata and Maboko Islands, the open water starting from Mbita Channel to the Bridge Island and beyond, the river mouths of the Nzoia and Yala. And the area to the South West and West of Rusinga and Mfangano Islands.

Another consequence associated with algal blooms in Kenya waters of Lake Victoria is fish kills [117]. Massive fish kills have occurred in two of the places with intense algal blooms, mainly the Maboko- Ndere Islands area and the river mouths of the Yala and Nzoia [45]. The Maboko- Ndere Islands area often has blooms of *Microcystis aeruginosa* while Nzoia river mouth has blooms of *Nitzschia acicularlis*. The quantity of fish killed was massive, resulting in a loss of huge amounts of income form the fishery.

Algal blooms have been known to cause a breakdown of the water treatment facilities of Kisumu municipality. This is caused by the clogging of the filters, and reducing their lifespan to about half and rendering them useless [117]. The net result is the breakdown of the water filtration process and lack of water for the supply to the town residents. This particularly happened in September 1995. In trying to combat the problem of algal blooms in water treatment facilities, increased dosages of alum are used in order to flocculate and sediment the algae. This means increased costs of producing potable water. Where the filters are damaged, particulate matter including algae pass through to the water supply.

Information obtained from fishermen in the Lake indicates that algal blooms cause itching, stomach upsets and that livestock does not readily take the water. The water is not suitable for domestic and recreational purposes, it is difficult to identify nets fished in bloom infested waters and that they become too heavy and inefficient in fishing. They have therefore to be taken out of water and washed to remove the encrusting algae and other biota on the filaments.

Elsewhere, algal blooms are known to produce toxins, which are harmful to humans, aquatic life and other wildlife [117]. One of these toxins causes paralytic shellfish poisoning PSP and occurs worldwide in the temperate and subtropical regions. A comparable algal toxin bio accumulates in the fish and has been found in over 400 species [117]. The blue- green algae (*Cyanophyceae*) are known to cause toxic water blooming. These are prevalent in the Nyanza Gulf and cause problems in the water treatment plants.

Our knowledge on the effect of algal blooms on aquatic life, humans, livestock and other wildlife is hampered due to lack of facilities for extracting and identifying the type of toxins present in the environment. Toxic strains of algae cannot be distinguished from non- toxic strains, except by isolation and by breeding in pure cultures, followed by bioassays on mice to study the effects. Both *Microcystis* and *Oscilatoria* cause severe forms of dermatitis known as "swimmers itch". Fresh water blooms have also been known to cause serious commercial losses in fish ponds and massive fish moralities in the world [117].

5.6.2 Water Pollution: Associated Human Health Problems

Chemical Pollution: Effect on Human Health

A number of harmful chemicals are used in intensive agriculture. These along with silt to which most of them are bound are carried down to the rivers during heavy rains and eventually find their way into the Lake. Their effect on water quality is more prominent in the rivers than in the Lake. The chemicals involved are those used in the manufacture of pesticides such as DDT, dieldrin, lindane and toxophene. Others include herbicides such as 2,4-D and 2,4,5-T, which contain the highly toxic compound dioxin. These are used to spray sugar plantations [117]. The major problem lies with humans consuming fish, which have been contaminated with the chemicals, as these are carcinogenic.

A number of other organic and inorganic pollutants need to be mentioned, as they are used within Lake Victoria basin. Their usage is rather restricted to large towns and intensive small and large-scale agricultural areas. Though restricted in distribution, humans do get in contact with them through contaminated water or by consuming contaminated fish. Since the use of these chemicals might increase in future and by mere fact that they pose a threat to human life, environmental awareness programs to sensitize the communities against their usage and their effects on human health should be instituted.

Harmful chemical substances originating form industrial and agricultural sources have been detected in water. Their subsequent bioaccumulations have resulted in environmental and ecotoxicological problems. The groups of chemicals of greater concern include heavy metals, metalloids and aromatic poly- chlorinated compounds. From a range of small scale mining and industrial activities in the region, lead, arsenic, cadmium, and mercury can be released into the environment.

Considerable amounts of lead can be taken from contaminated water. In children, low levels of lead affect the central nervous system resulting in decline in performance and intelligence. High levels of lead were identified at the Kisumu pier and at Homa Bay way back in 1985 [117]. The metal is hazardous to aquatic life particularly water fowl. In North America, over two million wild ducks die annually from ingesting lead originating from gun shot alone. Lead also disrupts the cycling of nutrients in the environment.

The form of mercury, which is harmful, is the methyl mercury. It is obtained by consuming fish particularly the large carnivorous fishes. It also affects the sensory and coordination functions of the central nervous system particularly in small children. The present concern over methyl mercury is concentrated on fishing communities where consumption of fish is high.

The major sources of cadmium are mining, sewage sludge and phosphate fertilizers. It causes respiratory tract (lung) cancer. Contact with arsenic is through consumption of water containing high concentrations. It causes skin and lung cancers in humans. Also food particularly fish and shellfish contain elevated concentrations. Arsenic compounds are widely used as pesticides, herbicides and desiccants.

The group of aromatic polychlorinated compounds of major concern to human health are the polychlorinated biphenyls PCBs. The highest concentrations are found in fish from inland waters and enclosed seas. Where fish constitute a major item in the diet, the total dietary intake of PCBs is higher than for populations elsewhere. The PCBs are known to cause cancer of the liver and biliary duct [117].

Certain actions need to be taken in order to curtail human exposure to chemical pollution. These include:

(a) Monitoring of exposure of people and the environment to chemical pollutants.
(b) Institution of community based education programmes to discuss the deleterious effects of industrial and agricultural pollutants on the environment and human health.
(c) The use of environment friendly chemicals in place of the ones currently used coupled with the recovery of the pollutant through recycling.

Sewage Pollution: Effect on Human Health

The Lake receives sewage from a number of larger towns and small fishing villages dotting its shoreline. Similarly, there is greater concentration of inland towns situated on the major rivers draining into Lake Victoria which discharge their effluent into them. Sewage contamination has two effects namely:

1. The contamination of the water pathogenic organisms and parasites.
2. Nutrient enrichment causing eutrophication [32, 35].

A major characteristic of the towns situated along the shoreline and in the catchments is the lack of adequate sewage treatment capacity. Most sewage is discharged raw or semi-treated, leading to contamination by pathogens.

The water borne diseases prevalent in Lake Victoria basin due to sewage contamination include: Hepatitis caused by faecal contamination of water by viruses, dysentery caused by *shigella* spp especially *Sh. Flexneri*, *Sh.shigae* and *Sh. boydi*, cholera caused by faecal contamination by the bacterium *vibrio chlolerae*, typhoid caused by bacteria *Salmonella typhi* and *Salmonella paratyphi* types A, B, C, leptosprosis, amoebiasis and helminth infections. These water borne diseases are very common in the region. Actions needed to combat water borne diseases include:

(i) The provision of sanitation facilities including piped water, toilet facilities and clean fish weighing sheds at the land beaches.
(ii) Appropriate methods of sewage treatment and disposal, e.g., by the use of waste water lagoons where towns are not very large.
(iii) The recycling of the sewage into useful products, e.g., fertilizers and biogas or pavement construction materials as done in some countries.
(iv) The preparation of communities educational programmes regarding the provision of clean water through, for example, the development of borehole water and proper planning of fishing villages along the shore line with greater emphasis on water conservation.

5.7 Hazards and Disasters around the Lake

This section addresses the threats that face the Lake and its environs. Besides poverty (discussed in Chap. 6) which afflict the inhabitants of the Lake basin, meteorological related disasters add salt to injuries. The rural poor inhabitants live in large families under crowded poor environmental conditions with little or no sanitary facilities which make them vulnerable to waterborne diseases leading to ill health and high morbidity and mortality levels and as a result, there is reduced food productivity. They lack access to information and awareness on weather and climate that affect them and are therefore vulnerable to climate and weather vagaries [122]. These in effect leads to poor timing of cultivation seasons leading to poor crop yield.

The weather system in the Lake Victoria basin manifests itself as land and Lake breezes, which develop deep convective systems as had been discussed in Subsect. 5.3.1 in p.120. These influence the weather/climate in the Lake basin.

5.7.1 Floods and Droughts

Heavy torrential rains persistent in the area result in flash floods. In Chap. 11, we will present satellite based procedures for mitigating floods. The low-lying areas of the Lake Victoria basin are prone to frequent floods during the rainy seasons [122]. During these periods, the stream flow from the high ground reach their peak levels and the rivers overflow their banks. During other years the Lake rises to unprecedented level when the major rivers reach their peaks and the Lake water flow back on to the lands to enhance flooding and exacerbate the already worse situation in the flood prone lowlands. Such a case happened during the 1997/1998 El'Nino rains.

The flood water destroy houses (see, e.g., Fig. 11.1 in p.304), infrastructure, agricultural lands, crops, and often causes direct death to humans and livestock, or indirectly through resultant stagnant water that become the source of such diseases as malaria, bilharzia, typhoid, dysentery, cholera, etc. Erosion of topsoil and leaching of the nutrients and siltation are some of the destructive phenomena associated with the heavy downpours that occur in the Lake basin during the rainy season. From the foregoing, weather/climate hazards have a devastating effect on human activities and therefore affects their capability to produce food for their families [122].

Though flooding in the Lake plains is linked to rainfall conditions such as those associated with El'Nino phenomenon, the significant reduction in vegetation cover has played a big role in enhancing the effects of flooding due to increased surface run off and reduced infiltration over most of the basin. In 1963/1964 and 1997, there ware serious El'Nino rains, which caused devastating calamities in the Lake Victoria region. As many as 46 people died in the course of the rampage brought by the rains, while more than 125,000 people were displaced. Roads, thousands of homes, schools, and other infrastructural establishments were washed away. In addition, thousands of acres of crops were destroyed. It has taken years to repair the damages brought by El'Nino, some of which are permanent.

Serious flooding in the Kenyan side of Lake Victoria region have been known to affect Kana Plains, Karachuonyo, Nyatike in Nyanza Province and Budalangi in Western Province. Thousands of homes are normally swept under water, and the road networks destroyed in these areas. Flooding has several effects some of which include:

- Transport and communication systems are rendered non-functional.
- Human lives, livestock, crops and properties are either lost or destroyed.
- Mosquitoes and snails thrive in the floods which provide ideal breeding environment.
- Flooding is responsible for cases of bilharzia, cholera, malaria, typhoid, etc.
- Further, it causes hunger and starvation, coupled with psychological trauma.
- Flooding also affect cultivation along the river, contributes to pollution through deposition of agricultural chemicals and makes provision of nutrients to water weeds.

Although flooding has been a perennial problem in the Kenyan side of the Lake basin, little attention if any has been paid to it. The Kenyan government indicated that it would address the problem of recurrent floods in the region. In his address to the Regional agricultural show in Kisumu on 31st July 2003, President Kibaki said that the Government was working on major plans to ensure floods were controlled upstream to minimize suffering in low-lying areas. This remains to be seen and one hopes that when such actions are taken, the perennial flooding will have been controlled.

5.7.2 Thunderstorms, Hailstorms and Lightning

Weather due to thunderstorms accompanied by lightning, hailstorms and strong winds have severe impact on the people causing direct physical destruction of lives and property, indirect damage to the economy through damaging the infrastructure, such as roads, schools, health center and others. Thunder is prevalent in the Lake region where thirty to forty per cent of the thunderclouds result into lightning strokes, which destroy vegetation, property and lives. Such cases build up psychological stresses on the inhabitants of the area and lower their food productivity.

5.7.3 Strong Winds

Strong winds from the cumulonimbus clouds or thunderclouds are moved inland by Lake Breezes and attain gale size wind speeds (see, e.g., Subsect. 5.3.1 in p.120). These are known to blow down trees and human settlements including physical infrastructure such as schools, health centers and other structures depending on the nature and types of houses and the exposure to the prevailing winds. They also cause wind erosion of the exposed soils and deposit it away from the source.

5.7.4 Solutions to Weather Related Problems

The unpredictability of weather and climate and their socio-economic dimensions are major causes of poverty. The reduction of the impacts of weather and climate require an approach that involves grassroots people, CBOs, NGOs, provincial administration and weather and climate forecasters working together. There is need to conduct research in order to understand the long-term trends in weather and climate. In Chap. 11, we have provided a GPS-meteorology based approach to monitoring weather parameters. Such information can be used in forecasting conditions that influence our behaviour and livelihoods. There is need to find solutions that reduce the impact of:

1. Hailstorms destruction of crops.
2. Lightning strikes.
3. Thunderstorms.
4. Seasonal floods.
5. Frost damage.
6. Strong wind.

These factors affect food security in households. Up to date research, application of modern monitoring techniques, awareness, monitoring and finance for mitigation of weather and climate hazards is therefore required to implement sustainable climate and weather mitigation initiatives.

The simplest and cheapest methods of addressing the problem almost solely take into account public awareness and information about weather and climate and their roles in poor lives. The awareness and information gap is better filled by following the weather forecasts issued by meteorological departments and other climate based NGOs. Other than weather forecasts, the following measures can be used to reduce the devastating nature of weather and climate [122]:

- Planting trees around homesteads; but single isolated trees attract lightning strikes by being centers of attraction of static atmospheric electricity.
- Reforestation to reduce the possibility of radiative frosts in agricultural lands
- Hail suppression programs-expensive. Involves injecting of fumes of silver iodide using rockets into the cumulonimbus clouds, but saves millions of shillings.
- Building of dykes along river banks-Earth banks can be constructed manually by the communities.
- Participatory bottom up approach
- Address Lake Victoria basin based on the dimensions of mitigating climate hazards and response hazards prediction.
- Linking weather/climate forecasting to development and food security.
- Integrated approach and gender sensitiveness.
- Partnership building between stake holders.
- Linking to other scientific disciplines and relevant agreements to create synergy.
- Recommendations towards community based systems of mitigating weather climate hazards.
- Adopt an integrated approach to village resource management based on daily, seasonal and annual weather climate forecasts and the steps to mitigate the impending weather climate hazards.
- Channel govt and donors assistance including finance to village institutions to mitigate the impacts of weather/climate.
- Develop a legal framework that supports local rights to manage environmentally sound resources. The framework should encourage

people to the initiative to develop their natural resource base without waiting for the govt to act.

There is a strong seasonal and inter-annual variability in the rainfall patterns that are often reflected in stream flow and Lake level fluctuations. Recurrences of floods and droughts are quite common in the Lake Victoria basin and often result in loss of life and property, mass displacement of the Lake inhabitants, destruction of crops, erosion, siltation and increase in water borne diseases as already stated. In the health sector, the location and occurrences of some diseases is weather dependent [106]. Some of the seasonal variations and extreme weather and climate anomalies in Lake Victoria basin have been associated with the El'Nino Southern Oscillation (ENSO) phenomenon [6]. Anomalous rainfall results in large losses in the economy and the effects can linger on for a long time. Weather and climate also affect the fishing industry.

Climate forecast information generated by various models will assist in the fight against poverty by early planning for the mitigation against the adverse impacts of droughts and persistent floods [114].

Recommendations

Awareness on the benefits or disasters of climate should be enhanced through workshops, seminars and demonstration pilot projects. Relevant institutions and end users should collaborate on weather and its climate research and applications for poverty alleviation. Indigenous knowledge on weather and climate prediction should be integrated for further improvement of the accuracy of forecasting. Application of weather and climate information should be included in government policies. Permanent solutions to flood problems should be sought for the communities particularly along rivers Nyando, Sondu-Miriu, Kuja and Nzoia in the Lake Victoria basin. Relevant meteorological books worth reading include [8, 7, 16, 125].

5.7.5 Regional Conflicts: The Refugee Factor

Refugees hosted by the East African countries have been identified as major contributors to the pollution of Lake Victoria. Conflicts in the Great Lakes Region as well as in the Sudan and Somalia have produced thousands of refugees whose activities at times become a threat to the environment. The refugees have invaded the fish trade and have no qualms about using illegal fishing methods, including poisoning.

Tanzanian authorities continue to grapple with the influx of refugees in the Lake Victoria basin and their virtual control of the fish trade. In Mwanza, surveys have revealed that a number of wealthy refugees have left their camps in Ngara and Kigoma in North-Western Tanzania and have set up bases in the Lake side towns of Mwanza, Bukoba ana Musoma. A Tanzanian Scholar, Mr. Nkwabi Ngiwanakillala of the St. Augustine University, told a recent environment forum at the institution that activities of the refugees had become a major source of concern to both Government and environmentalists. In a paper on "Conflict and Environment in East Africa", he said that refugees had become a burden to the host countries, creating a country within a country, with little respect for environmental conservation [4, p. 108]. He further indicated that the destructive effects of the refugees are well documented in Tanzania.

For example, the deforestation by refugees in the northwestern part of Tanzania had affected the rivers draining into Lake Tanganyika and tributaries of the Kagera River that drains into Lake Victoria. Studies in Tanzania have revealed that the deforestation by refugees both for timber and charcoal is contributing to the increasing semi-arid conditions. A European Union delegation visited the Ngara and Kigoma area to assess the impact of refugees on the local environment. The delegation promised support for reforestation.

It is worth noting that some refugees have not been entirely destructive and have made positive contributions in their host countries. For example, those in the Mpanda region in Southern Tanzania are involved in agricultural production. On the Kenyan side, the Government has announced that it acquires three vessels for security surveillance on Lake Victoria. The orders for the boats had been placed at a cost of Sh. 8.5 million and they were due to are delivered by August 2003.

5.8 Concluding Remarks

Lake Victoria and its environ is faced with the twin problems of pollution and soil erosion as well as seasonal flooding. These are the threats to the very existence of the Lake and its resources. Unless urgent measures are taken to address these threats, the Lake runs the risk of siltation and death. It is therefore important that a concerted efforts be taken by every player and stake holders within this region and beyond in the requisite measures that shall be able to adequately reduce the increase of environmental degradation. The more friendly approach of forming a consortium with factories and municipalities should be encouraged to share expertise and respond with material and financial means that shall help curb the rampant pollution that is taking toll in many areas. Several efforts have been made in achieving an environmentally clean Lake. Such experiences for the duration 1997–2001 have been documented in [88].

Water hyacinth appeared in Kenya in Lake Naivasha in 1982, and has since then spread to many Lakes in the country including Lake Victoria. The weed has both negative and positive effects. Efforts to control it have not produced the desired results. This necessitates the need to seek further means to achieve better and sustainable control of the weed so that its beneficial attributes could be enhanced while its negative effects minimized.

Trying to restore the original state of a degraded aquatic environment is a process, which takes many years and is too expensive. It is therefore important to prevent environmental degradation rather than wait to restore an already destroyed environment. Community participation in environment restoration is an effective method of achieving this. Thus, education programmes can be mounted to instil awareness on the dangers of pollution. These programmes should be part of the curricula on environmental education in schools dealing with ecological development of the Lake region. A long-term strategy of the aforesaid approach is appropriate and sustainable. However, short-term intervention measures are needed to address the situation of Lake Victoria, which is at the moment pathetic.

The contribution of the car washing to the Lake's status can be classified as both direct and indirect. The direct effect is in terms of the pollutant load through the car washing, while the indirect could be from run offs coming from vehicle repair sector (jua kali), petrol stations and main bus terminal. These two factors if not rectified, will lead to increase in the pollutant loads beyond the tolerance levels of the beach ecosystem. Already this is showing through the loss of biodiversity at the car washing point.

It is important to note, however, that the car washing has increasingly become popular due to other services offered. This includes the vibrant *food kiosks* specializing in fish business, *boat riding* and *sight seeing*. This could have an adverse effect on the long-term sustainability of the Lake, as it will experience a rise in the concentration of pollutant elements. From the vehicle counts, it can clearly be seen that the number of private vehicles to the beach is clearly highest during lunch hour. Stopping car washing in the Lake is a priority activity. This calls for relocation of the activity to a distant location or the provision of waste water treatment before release into the Lake. Relocation may negatively affect the fish eating business; hence the kiosk owners should be part of the wider strategy to rid the Lake of direct car washing. Corrective measures should therefore look at not only stopping car washing bit but also how the other sectors operate, and how they affect each other. This calls for a holistic approach to the beach management. Perhaps, the Kenyan authority could borrow a leaf from the neighbours who have dealt with a similar case at Bukoba.

It is also evident that the conventional runoff management is not environmentally friendly. This has seen the washing of pollutants directly into the Lake. There is a need for the redesigning of the urban drainage to accommodate the provision for runoff filtration, oil scrapping and organic decomposition before its release into the Lake. The provision of buffer vegetation between the urban center and the Lake could be a major step towards the achievement of this goal. The protection and revamp of the wetlands around the Lake recognizing their naturally occurring and important filter functions is key to the success of this initiative. They probably could be redesigned to include pollutant absorbing or tolerant species of plants.

It is important to note that while the direct effect of motor vehicles is manifest in the direct car washing at the Lake, the indirect pollution is probably more significant. However, it may not be seen to be so, due to the diffused nature of their occurrence elsewhere and their transport into the Lake through water and air medium. If these media are not addressed then the efforts to rid the Lake of polluting vehicles may not be successful.

The recent formation of National Environmental Monitoring Authority (NEMA) should also be commented. This body has made it possible for experts to work on Environmental Impact Assessment (EIA) and Environmental Audit (EA) pertaining to the Lake. This has safeguarded to some extend activities which could be harmful to the Lake. Currently, both authors of the present book are lead experts of NEMA.

Lake Victoria is actually ailing, diagnosis has been done and the treatment must follow immediately. Recently, the Global Nature Fund (GNF) declared Lake Victoria the 2005 threatened Lake! No other person is better suited for this purpose of saving the dying Lake, which is vital to mankind, than you, the reader! You have a part to contribute be it financial, through encouragement, or through the actual enactment of environmental conservation measures!

6

Poverty Challenges in the Lake Victoria Basin

"Poverty is the worst form of violence."—Mahatma Gandhi

6.1 Introductory Remarks

The preceding Chapters have discussed the resources and *environmental management* issues of the Lake basin. As already noted by [138], there exists a relationship between *environmental degradation*, natural resources and poverty. This chapter will therefore give an in-depth look at the poverty situations and challenges affecting the Kenyan side of the Lake Victoria basin. Future editions of the book will incorporate the cases of Uganda, Tanzania, Rwanda and Burundi. In order for the reader to be able to comprehend the poverty situation in the region, the *concept of poverty* itself has to be clearly understood. The concepts of poverty and deprivation however still remain surprisingly elusive and has become a buzzword the world over. A deeper examination of this concept reveals a litany of ambiguities, contradictions and confusion. The next Section attempts to unearth these concerns.

Poverty has been a subject of discussion in various international forums. The **U**nited **N**ations (UN) and its specialized agencies have also been concerned about poverty and how to eradicate it. The United Nations Development Program (UNDP) issues an annual report, *Human Development Report*, in which the issue of poverty is central. Other world organizations have also joined the chorus. Among the most important of these organizations is the World Bank, which has had a program on poverty eradication during the last thirty years. The major international conferences on poverty in the last decade include the *Rio Conference in 1992 on Sustainable Development, the International*

Conference on Population and Development in Cairo in 1994, and the Copenhagen Summit on Social Development in 1995. The Millennium Declaration in 2000 in New York reaffirmed the international position on poverty eradication. And there are many other conferences that have been convened to discuss poverty.

The **Copenhagen Social Summit** set the date 2015 as the time to reduce poverty by half. This date has been adopted by the international community as well as by individual countries. Kenya, for instance, set that target date for poverty reduction. In March 1999, the Kenyan Government launched the **N**ational **P**overty **E**radication **P**lan, 1999-2015 (NPEP). To implement this plan, the Government has, since 2000, launched the annual **P**overty **R**eduction **S**trategy **P**aper (PRSP), which provides the budgetary allocation for poverty reduction.

The concern expressed by the international community and individual countries or groups of countries presuppose that there is a common understanding of the concept of poverty. *This assumption is **incorrect***: This is because poverty is a difficult and controversial concept. Poverty can be defined in a *narrow* or *wide* sense. It means different things to different people. For instance, money-metric understanding of poverty is different from the *Human Poverty* concept that embraces the totality of human experience. The simple notion of poverty is that a poor person is one whose income is less than US$1 (Ksh78.00) per day. The *Human Poverty Index* encompasses other factors such as literacy and education. Thus, poverty can be amorphously defined just as it can be understood in a strict and narrow sense.

The ambiguity surrounding the term poverty has a direct bearing on policy stances adopted to fight poverty. A policy adopted to deal with human poverty is quite different from that promulgated to address poverty in the narrow sense.

6.2 The Concept of Poverty

About four decades ago, there were three pests the "***uhuru***" government of Kenya wanted to route out. These were ***poverty***, ***ignorance*** and ***disease***.[1] Over those decades, attempts have been made to route out these pests, but the "enemies" are still very much alive and kicking in Kenya in different intensities. It is possible that one of the problems inhibiting the successful extermination of these pests is a lack of

[1]Kenya African National Union (KANU) Election Manifesto, 1963

clear understanding of the concepts used in defining these maladies: particularly **poverty**.

In this Section, attempt is made to discuss the concept of poverty as well as the various types and dimensions of poverty, including problems inherent in these conceptions. Some of the issues analyzed include the following: *What is poverty? Is there a common understanding of what poverty means? Is poverty meant to be inherent in a certain small amount of goods, or is it just a relation between means and ends? Is poverty about relations among people or is it a relation between people and material goods? How is poverty measured under different conceptions? What kind of poverty reduction policies should be adopted in the light of these and other similar questions?*

The answer to these questions should be of particular interest to policy-makers, social workers, academicians, and politicians. This is so because one's *concept of poverty* determines the kinds of approaches that are likely to be adopted in seeking solutions to the problem of poverty and deprivation. Those who have tried to design and implement poverty eradication projects without knowing concretely the type of poverty they wishes to eradicate have failed lamentably. They are like doctors who treat diseases they have not diagnosed.

Poverty, as other words in human vocabulary, can be complex, ambiguous and devoid of straightforward interpretation. appears simple at first sight, but are in reality very complex and have the capacity to confuse. In light of this observation, it is necessary to explore the concept of poverty within the larger framework of words and their usage. The discussion on the concept of poverty is as interesting as it is difficult and frustrating. This is because the concept of poverty can be narrowly or widely defined. It can be textually used, and can be applied specifically or generally.

6.2.1 Definition

What is the meaning of the word 'poverty'? The answer to this question is unclear because poverty is a complex and difficult concept. The World Bank, having been in poverty analysis since about 1972 defines poverty in the following terms [5, p. 115]:

> Poverty is hunger. Poverty is lack of shelter. Poverty is being sick and not being able to see a doctor. Poverty is not being able to go to school and knowing how to read. Poverty is not having

> a job, is fear for the future, living one day at a time. Poverty is losing a child brought about by unclean water. Poverty is powerlessness, lack of representation and freedom... [159].

The Bank then continues:

> Poverty has many faces, changing from place to place and across time, and has been described in many ways... Most often, poverty is a situation people want to escape. So poverty is a call to action – for the poor and the wealthy alike – a call to change the world so that many more may have enough to eat, adequate shelter, access to education and health, protection from violence, and a voice in what happens in their communities.

The World Bank Group then concluded as follows:

> To know what helps to alleviate poverty, what works and what does not, what changes over time, poverty has to be defined, measured, and studied - and even lived. As poverty has many dimensions, it has to be looked at through a variety of indicators - levels of income and consumption, social indicators, and now increasingly indicators of vulnerability to risks and of socio-political access.
>
> So far, much more work has been done using consumption or income-based measures of poverty. But some work has been done on non-income dimensions of poverty, most notably in the Human Development Report prepared annually by the United Nations Development Programme, and new work is underway in preparation for the...

According to an academic journal; *Journal of Poverty: Innovations on Social, Political and Economic Inequalities*, "Poverty means more than 'the condition or quality of being poor, in need, indigent, or lacking means of subsistence.' The meaning of poverty also refers to deficiency in necessary properties or desirable qualities or in a specific quality, inferiority, or inadequacy."[2]

The Government of Kenya defines poverty broadly as "an absence of well being or capacities. Poverty is multi-dimensional and manifests itself in various forms making its definition using one criterion inadequate. It is also recognized that there is no single indicator that

[2] Journal of Poverty: Innovations on Social, Political & Economic Inequalities.

can adequately measure all dimensions of poverty" [36]. However this definition is not adequate, as will be demonstrated in the following paragraphs.

A close examination of the above questions reveal that poverty is a concept that has become increasingly controversial. Its measurement has also become increasingly difficult and controversial. The difficulty arises from the fact that poverty is a ***portmanteau*** term, which has distinct meanings to different people. Words such as "destitution", "ill-being", "powerlessness" and "vulnerability" are so frequently used in conjunction with "poverty" that it is difficult to make distinctions among them. Poverty may be seen in terms of people being excluded from the "living conditions and amenities which are customary, or at least widely encouraged or approved, in the societies to which they belong" [144, p. 31], or what is often referred to as a 'participation standard', but this is only part of the story. Poverty can be defined objectively and subjectively.

Subjective and Objective Definitions

While some people have argued that poverty can be defined only subjectively [121, p. 37], others have maintained the contrary position. For instance, [144] has argued,

> Poverty can be defined objectively and applied consistently only in terms of the concept of relative deprivation. The term is understood objectively rather than subjectively. Individuals, families and groups in the population can be said to be in poverty when they lack the resources to obtain the types of diet, participate in the activities and have the living conditions and amenities which are customary, or are at least widely encouraged or approved, in the societies to which they belong. Their resources are so seriously below those commanded by the average individual or family that they are, in effect, excluded from ordinary living patterns, customs and activities.

This '*objective*' definition has implications for policy that should be recognized. Although all societies have ways of identifying and trying to deal with their problems, social sciences are having an increasing influence upon decision-makers, both in providing information and implicitly or explicitly legitimizing action. A clear definition allows the scale and degree as well as the nature of the problem of poverty to be identified, and therefore points to the scale as well as the kind of remedial action that might be taken. Such an action may involve not just the general level of benefits for example, but revision of relativeness between benefits received by different types of families.

This basic problem of the *meaning of poverty* pervades debates both on its measurement and reduction policies. Although most people have an intuitive notion of what poverty is all about, the concept has been defined variously and is still a subject of much controversy in academic and policy-making circles [24]. The diversity of meanings attached to poverty render conceptualization of poverty and its operational meaning and measurement difficult as well as intractable. It has many dimensions as discussed below.

Dimensions of Poverty

While poverty can be broadly defined as an absence of well-being or capacities, it is multidimensional and manifests itself in various forms. This makes the definition of poverty inadequate, if only one criterion is used. It should also be recognized that there is *no single indicator* that can *adequately* measure all dimensions of poverty. Further, it should be noted that **poverty** and **inequality**, though related at some points, are different concepts. While poverty is concerned with absolute standard of living of a part of the society (the poor), inequality refers to relative living standards across the whole society. It is therefore difficult for one survey like the **W**elfare **M**onitoring **S**urvey (WMS) series [36], used in Kenya in recent years to capture the many dimensions of poverty. In the **WMS** analysis, poverty is defined in terms of total household consumption expenditure. A household is considered poor if it cannot attain some recommended food energy intake. The required level of nutrient intake is 2,250 calories per day per adult plus a minimum allowance for non-food consumption. The notion of what constitutes the poor goes beyond an attainment of a level of material well being to constitute a reasonable minimum by the standards of a given society. A household, which does not meet its calorific requirements, but has a relatively high income, is not considered poor.

Absolutist View of Poverty

This raises the question of whether, ultimately, it is possible to take an absolutist view of poverty. Sen [132, p. 153] has argued persuasively that ultimately poverty must be seen to be primarily an absolute notion. It is of course true that there is an irreducible absolutist core [132, p. 153] to the notion of poverty. If someone is starving, he is poor even if everyone else is starving too. But once one moves away from extreme cases it becomes much more difficult to make assertions that carry conviction or inspire confidence. For example, despite decades of work by nutritionists and physiologists we still do not know what is the minimum calorie intake necessary for adequate nutrition [53, p. 12]. More awkward for the absolutist position, we do not even know, as some claim, whether individuals really do have fixed requirements, i.e., whether the body is able to adjust to a persistent shortfall of calories and thereby in effect avoid "undernutrition" [53, p. 12].

Absolute poverty is a condition characterized by *severe deprivation* of basic human needs, including food, safer drinking water, sanitation facilities, health, shelter, education and information. It depends *not only* on income, *but* also on access to social services.

Relative Poverty

In the 18th century, Adam Smith made it clear that "necessities" were determined by "custom" and hence, that poverty was relative. He said, "By necessities, I understand not only the commodities which are indispensably necessary for the support of life, but whatever the custom of the country renders it indecent for creditable people, even the lowest order, to be without" [139, p. 693]. Theron de Montauge [142, p. 2] has said bluntly "Poverty is measured by comparisons." *It has nothing to do with physiological need for calories* [53, p. 12].

The absolutist view of poverty, however, does not depend on the results of physiological research. It is much more sophisticated than that. Emphasis is placed not only on the absolute need for adequate nutrition but also on the need for decent shelter, to live without shame and to have self-respect. The needs for *decency*, *self-respect* and *avoidance of shame* are absolute, but the commodity requirements to fulfil these socially defined needs rise with average prosperity. In this way absolute needs or capabilities are transformed into relative requirements for commodities and income [132, p. 163].

Poverty is Socially Defined

Perhaps there is enough common ground here between *relativists* and *absolutists* to make further discussion unnecessary. But once it is accepted that needs, or at least some needs, are socially defined, we are very close to accepting that poverty itself is socially defined. *That is, poverty is neither a relationship between a person and a bundle of commodities nor is it a relationship between a person and a bundle of (socially defined) needs and capabilities. It is a relationship between one person and another* [53, p. 12]. If civilization invented poverty and if social status defines it, presumably man in society, operating through the institutions he has created, or if necessary through new institutions, can abolish poverty [53, p. 13].

Historically Defined Poverty and Its Measurement

Historically, the standard economic definition of poverty in terms of income and consumption dates back to the work of [18]. Rowntree's work in Victorian England was based on the work of Booth. It has been challenged by modern social scientists looking for broader and more inclusive definitions of ill being in both developed and developing countries.

There will always be disagreement over what constitutes poverty income. Some analysts define poverty in terms of the amount of income necessary to provide a family of a certain size with the minimum essentials of food, clothing, shelter, and education. This approach provides an ***absolute poverty standard***. An absolute poverty standard establishes a specific income level for a given-size household below which the household is judged to be living in a state of poverty.

But is an absolute measure of poverty appropriate? Poverty can, after all, be relative. One's sense of poverty depends upon the incomes of others in the community. A second approach to poverty, therefore, is to measure it in relative terms. A relative poverty standard might classify a household as poor, if the household's income is, say, 25 per cent of average household's income. Thus, a relative poverty standard defines the poverty in terms of the incomes of others.

The *choice of a poverty definition* will determine to a great extent the number of poor and the rate at which poverty is perceived as being eliminated. If the *absolute standard* is selected, rising real living standards will push more and more families above the poverty line. According to a *relative standard*, only equalizing the distribution of income can eliminate poverty.

Organization for Economic Cooperation and Development (OECD): Definition of Poverty

Poverty is now understood to encompass such domains as human, rather than purely incomes. The concepts of poverty have developed rapidly over the last thirty years, and the international attention is now focused more sharply on poverty reduction than it was twenty years ago. The development committee of the **O**rganization for **E**conomic **C**ooperation and **D**evelopment (OECD) countries has proposed a reduction by half by 2015 the proportion of people living in extreme poverty. This proposal was adopted by the Summit Conference on Social Development held in Copenhagen, Denmark, in March 1995 [149]. This proposal has also been widely adopted by the international community.[3]. But exactly what this target might mean is obscured by the bewildering ambiguity with which the term is used, and by the many different indicators proposed to monitor poverty. Is the interest on *income poverty* or *human development*? or, is it on sustainable livelihood or social inclusion? or is it on current consumption or future security? Different concepts imply different interventions.

Various International Conceptions of Poverty

United Nation's Concept of Poverty:
The United Nations has addressed the concept of poverty in several forums and has reached the following conclusions: On June 14, 1992, the United Nations Conference on Environment and Development deliberated at length on the problem of poverty and inequality at both the national and international levels. The conference then said the following:

> Poverty is a complex and multidimensional problem with origins in both the national and international domains. No uniform solution can be found for global application. Rather, country-specific programmes to tackle poverty and international efforts supporting national efforts, as well as the parallel process of creating a supportive international environment, are crucial for a solution to this problem. The eradication of poverty and hunger,

[3]Department for International Development, Eliminating World Poverty: A Challenge for the 21st Century (London: HMSO, 1997)

> greater equity in income distribution and human resource development remain major challenges everywhere. The struggle against poverty is the shared responsibility of all countries [148].

In March 1995, the United Nations World Summit for Social Development, meeting in Copenhagen, Denmark, deliberated extensively on the question of, and made recommendations for alleviation of poverty. The following is a summary of what that Summit understood to constitute poverty and its many dimensions [149].

> The United Nations has estimated that over 1 billion people in the world today live under unacceptable conditions of poverty, mostly in developing countries, and particularly in rural areas of low-income countries such as Asia and the Pacific, Africa, Latin America and the Caribbean, and the least developed countries but the concept of poverty is not homogeneous.

Poverty has various manifestations; including lack of income and productive resource sufficient to ensure sustainable livelihood; hunger and malnutrition; ill health; limited or lack of access to education and other basic services; increased morbidity and mortality from illness; homelessness and inadequate housing; unsafe environments; and social discrimination and exclusion. Poverty is also characterized by a lack of participation in decision-making and in civil, social and cultural life.

It occurs in all countries: As ***mass poverty*** in many developing countries, ***pockets of poverty*** amid wealth in developed countries, *loss of livelihood* as a result of economic recession, ***sudden poverty*** as a result of disaster or conflict, the ***poverty of low-wage workers***, and the *utter destitution* of people who fall outside family support systems, social institutions and safety nets.

Women bear a disproportionate burden of poverty, and children growing up in poverty are often permanently disadvantaged. Older people, with disabilities, indigenous people, refugees and internally displaced persons are also particularly vulnerable to poverty.

In more recent times, the issue of poverty eradication has been given impetus by the United Nations and its Secretary General. Thus, poverty in its various forms is seen as representing a barrier to communication and access to services, as well as a major health risk, and people living in poverty are particularly vulnerable to consequences of disasters and conflicts. This explains why the United Nations Secretary General Kofi Annan, in his acceptance speech of the Nobel Peace Price for 2001 said that the priority of the United Nations in the 21st century will be on poverty eradication, conflict prevention and combating disease [37].

The European Community: Definition of Poverty:

The European Community[4] states that, "The poor shall be taken to mean persons, families and groups of persons whose resources (material, cultural, and social) are so limited as to exclude them from the minimum acceptable way of life in the state in which they live".

MS Definition of Poverty:

MS, which is the Danish Association for International Co-operation, is the Danish Volunteer Service whose definition of poverty includes the following crucial elements:

- *Poor people are prevented from covering basic needs in terms of food, shelter, health, education, etc.,*
- *Poor people are often deprived of their dignity.*
- *Poor people live insecure lives, and they are vulnerable to risks and crisis.*
- *Poor people have little access to vital knowledge and information.*
- *Poor people are denied their rights, are excluded from access to productive resources, and have few possibilities of influencing the political environment.*[5]

The understanding and experience of poverty vary among people according to gender, age, culture, occupation, etc. MS recognizes, for example, that gender and poverty are closely linked, with women and girls being systematically poorer than men and with gender disparities being higher in poorer countries. Thus, women and men are not likely to perceive poverty in the same way.

The MS contends that, despite the complexity of the matter, there are strong arguments for seeing the fight against poverty as basically a ***political one***. The world we live in is characterized by sufficient wealth and resources to provide all people with acceptable livelihoods. Keeping people in poverty is therefore an outright insult, and the result of narrow political interests.[5]

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[4]European Community, Council Decision, 19 December 1984

[5]MS, (undated). Solidarity through Partnership, p. 7.

[5]MS, ibid

6.2.2 Conceptions of Poverty Known to Kenyans in Different Languages

The concept of poverty is not new to Kenyans; all Kenyan communities are familiar with profiles of poverty, except those of the urban sub-culture, with no roots in the village, where the extended family imposes poverty even on those who can cope. Journalist Okech Kendo[1] has provided the following examples to illustrate the point. Poverty among the Kenyans is graded according to the perceived depth of its intensity. Among the Kikuyu, poverty is ***thi'na***. This is a state of destitution, which is not as intense as ***uthini*** among the Embu, and not as concentrated as ***bananda***, among the Kalenjin. Among the Kalenjin sub-tribes, relative poverty is ***nyalilta***. Among the Omogusi ***umaskini*** (Kiswahili word for poverty) is ***obotaka***. Among the Kamba relative poverty is ***thi'na***, but the extreme is ***ukya***.

Among the Luo poverty is classified as follows: ***Nga't morem*** is a person in dire need and does not have possessions. ***Chan*** is relative poverty, but ***dhier*** is poverty in its naked form. ***Jachan*** is a person who can hope for a better time when the environment becomes enabling, but ***jadhier*** is an individual who has reached a dead end; he owns nothing except the self. ***Jachan magururu*** is a person who is poor to the extreme, but ***Jachan ma gwonyore gi pado*** is a person experiencing the worst form of poverty. Some of these terminologies overlap and appear to have continuum in their intensity. There is also the allegorical statement that "***chan ma ka owadu ok moni nindo***" (you can not lose sleep because of the poverty of your neighbour). Another expression is "***Iyugno ka nyar jakech***" (You are as bushy as the private parts of a *starving person*).

In Kenya, poverty has been escalating at a great speed and has changed its character. For instance, people who were poor ten years ago have become ***paupers***. They have been impoverished by policies that allowed the importation of products, which Kenyans can produce, or by undermining the development of some cash crops. Cotton farmers lost out because Kenyans were importing ***mitumba*** (imported second hand items). As a result, thousands of people lost their jobs in the textile industry and became poor.

The challenge facing Kenyans is to design effective and implementable poverty reduction policies. If the blueprint for official extermi-

[1] Okech Kendo (1999): Poverty Known to Kenyans. The East African Standard Newspaper, March 18, 1999.

nation of poverty can make ***jomodhier*** to become ***jochan***, ***bananda*** to become ***nyaltilta***, and ***uthi'ni*** to become ***thi'na***, then Kenya will have begun the journey to bridging the poverty gap.

6.3 Poverty in the Lake Basin (Kenya)

The Second Welfare Monitoring Survey of 1994 shows that the incidence of hardcore poverty in Nyanza (which lies in the Lake Victoria basin), Western and Rift Valley Provinces is 50%. Malnutrition is rife, child mortality is high, and protein deficiency, is acute. In addition to the levels of poverty and malnutrition, we have to contend with the socio-economic and environmental cost of HIV/AIDs, whose incidence ranks among the highest in the world. Table 6.1 (see, e.g., [4, p. 130]) gives an indication of the poverty situation of some districts surrounding the Lake in the Kenyan side.

Table 6.1. Income and Poverty in the Districts Surrounding Lake Victoria

District	(%)Absolute Poverty 1994	(%) Absolute Poverty 1997	Monthly Mean Income (Kshs)	(%) Food Poverty	% of Population with safe drinking water
Siaya	46.90	58.02	3,041	43.64	41
Kisumu	46.91	65.44	6,493	54.99	62.80
Homa Bay	47.74	77.49	3,852	62.78	34.90
Migori	34.08	57.63	3,909	41.12	18.60
Busia	56.90	65.99	3,315	64.1	61.40

The pattern of poverty malnutrition in Uganda differs since most of their major urban centers are in the basin. In terms of poverty incidence the most dramatic increase was in Nyanza where, it increased by 50% between 1994 and 1997 and in Nairobi where poverty almost doubled, growing by 92%. On the overall, growth in urban poverty of 30% was higher than that of the rural poverty at 13%. The poverty levels in the Lake region seem paradoxical. This area is richly endowed with abundant resources, yet the people living therein are very poor. How can this paradox be explained? Given the above, poverty emerges as the most formidable challenge for Kenya. The immediate challenge for the country is to halt the increase in incidence of poverty and initiate reversals through employment, wealth creation and distribution. The fight against poverty must also tackle inequality.

Kenya's Lake Victoria region has witnessed a large number of projects since political independence in 1963. Unfortunately, a majority of them have literally collapsed. At independence, the most important project was the Rice Scheme in Kana, now part of Nyando District. The scheme disappeared into oblivion only a few years after it was started. Then there were the cotton ginneries at different locations in the region. These too collapsed. The molasses plant never took off despite an elaborate machinery and equipment put in place to produce the molasses. It is only recently that the project kicked off. Then there was the case of the new offices of the Lake Basin Development Authority, which reportedly cost Ksh 900 million ($11.25 million), but which never got past the foundation stage. The collapsed and limping sugar factories; an empty cotton mill; disused fishponds and an abandoned irrigation scheme at Yala Swamp have contributed to worsening the poverty situation in the region. The road between Homa Bay and Mbita point is officially tarmacked, the contractor paid, but it remains a dirt road, bone-shaking when it is dry, and nearly impassable when it rains. The collapse of these entities resulted in unemployment and poverty.

Waste in the Lake basin is a two-lane highway: flowing down into the Lake is the waste and pollution generated upstream. In the opposite direction, leaving the basin, flows the region's wealth in different forms: exploitation of fish, and the rich gold mines in Macalder and Kitere. Few other places in the world display such a lack of re-investment in the midst of riches. The reverse flow of the region's resources is thus a source of poverty, as the people therein do not benefit from the lack of re-investment.

For instance, Mbita Point is facing the open Lake, with its back to the Winam Gulf, its waters are rich fishing ground. So rich, is it that the brokers and agents of various, mostly foreign-owned fish processing companies, riding in fleets of two-tonne Isuzu trucks, make up to three round-trips a day from Mbita to Homa Bay, a 40km trip over the barest excuse for a road. On departure, these trucks are laden with the Lake's harvest. At the beach landing sites on an especially desperate day, the fishermen will sell a kilo of Nile Perch for Ksh20 (25 US cents). On a good day, it may go for Ksh90, (just over $1). A mature Nile Perch weighs between 30 and 180 kg, the heaviest ever recorded. The brokers, who sell to the processors, claim to make a paltry five shillings for each kilo.

The Nile Perch has been a blessing and a curse at the same time. To paraphrase the findings of a study by International Union for Conservation of Nature (IUCN), "*Rich Fisheries, Poor Fisher folk*" over the past two decades, its presence has dramatically increased the total fish harvest from Lake Victoria. It has commercialized fishing and created employment; it has also left itinerant fishermen at the mercy of wealthy industrial fish exporters, and is rapidly pushing local fish traders out of existence.

Along the Mbita causeway, female fishmongers sell dried skeletons of small, immature Nile Perch, or dried Tilapia from distant Lake Turkana. From the huge tonnage of fish caught from the waters off Mbita Point, this is what remains for local consumption. Small fry. The big fish have already been loaded onto the trucks, headed for Nairobi, Mombasa; for the export market. One problem which must urgently be addressed is that of the middleman. There is a lot of money going out but the fishermen remain poor. At times, fish prices are bid down less than Ksh20 per kilo. They sell the fish at throwaway prices because they can not store it. Once processed into fillet, a kilo will go for Ksh475 ($5.9) in Nairobi's supermarkets, and at least twice that on the international market.

There is little evidence of re-investment in Mbita; or any of the fishing towns and villages on the Kenya side of the Lake. In 1992, Kenyan fishermen landed 219,000 tons of fish. At an average of Ksh50 ($0.6) per kilo, this translates to nearly Ksh11 billion ($137.5 million). Where did all this money go? Whatever money is left behind in Mbita gets quickly fritted away, drained down the urinals of the many bars and eating places; a testimony to the fisherman's firm belief that there is always more where that came from. "*Drink today, for tomorrow we fish*". It's a trend that extends across the Lake basin, beyond borders. A fisherman is a hard person to tame. He does not understand the idea of saving. An attempt was made to implement a credit system, whereby their fish could be bought and paid for after three days, or they could be paid through a bank. The fishermen rejected that. They wanted to be paid directly and immediately on delivery of their produce. The money left over has, presumably, helped construct the many semi-permanent structures, the mabati shops, the kiosks, eating places and bars that populate the one-street townships that dot the beaches, but there is little, if any, evidence of long-term prosperity here.

From the concept of poverty discussed in Sect. 6.2.1, the Government of Kenya defines the poor as “those who cannot afford basic food and non-food items” [127, p. 3]. In 1997, the minimum cost to satisfy a daily requirements 2,250 calories was estimated to be Ksh 927 per person per month in rural areas and Ksh1, 254 in urban areas[2]. These define the *food poverty line*. When non-food necessities were added, the overall poverty line in rural areas was taken as Ksh1, 239 per person per month while for urban areas it was Ksh2, 648. Over the past decade, data on the incidence of poverty arises from three Welfare Monitoring Surveys (1992, 1994 and 1997) and two Participatory Poverty Assessments (1994 and 1996). Earlier estimates were derived from a Rural Household Budget Survey (1982-83) and the Integrated Rural Survey (1974-75).

From these surveys, it is abundantly clear that poverty, particularly food poverty in Kenya, presents a disturbing picture. According to the Government’s Interim Poverty Reduction Strategy Paper 2000-2003:

> The poor constitute more than 56% of the total population of the country. Women constitute the majority of the poor and the absolute majority of Kenyans. Three-quarters of the poor live in rural areas. The bulk of them are located within the highly populated belt stretching south to southeast from Lake Victoria to the Coast which straddles the rail and road corridors. The belt starts with a major concentration of poor families north and south of Lake Victoria in the Western and Nyanza provinces [127].

Other statistics on the magnitude and extent of poverty in Kenya reveal a shocking and equally disturbing picture. According to United Nations Development Program (UNDP) in 2000, the country was ranked the 17th poorest in the world and the 8th poorest in Africa[3]. According to the Welfare Monitoring Survey (WMS III) conducted in 1997, the overall incidence of poverty in Kenya stood at 52%. By 2000, it was estimated that the figure had risen to 56% [127]. That is to say, at least one in every two Kenyans falls below the poverty line. In 1973, the number of the poor was 3.7 million. This figure grew to 15 million in

[2] 1Ksh = 78USD or 98EUR

[3] East African Standard Newspaper (2000)

2000. The poverty figure rose much higher in 2001 and 2002, given the dismal economic performance in which the Growth Domestic Product (GDP) grew by only -0.03% in 2001 [21].

According to WMS III, 51% of the Kenyan adult population living in the rural areas only had Ksh30.90 to cater for their daily needs in terms of food, while their urban counterparts had an average of Ksh41.80. In a situation where more than half the population can hardly afford food to eat, industrialization and development of the country remains pipe dream, with the majority of the population having no purchasing power to meaningfully participate in the economy. Widespread poverty affects security, and the well being of those with surplus income. The well to do become victims of high dependency and targets of crime like robbery with violence. The Problem of poverty and inequality in Kenya has been amply discussed in the 2001 Human Development Report in Kenya; Addressing Social and Economic Disparities [150]. This report discusses the state of development of Kenyans to date. It indicates that virtually every social indicator over the past ten years, as far as human development is concerned, shows that Kenyans have regressed. The percentage of Kenyans in the "poor" category has risen from 26% in 1997 to 35% in 2001; a dramatic rise of 9% in just four years. The level of real income poverty rose from 40% in 1994 to 52% three years later. Consequently, half a million more Kenyans fall below the poverty line every year. Only 34% of the Kenyan population is expected to live beyond the age of 40 years.

The situation is grim in the water and health sectors. Only 46% of the population has access to safe drinking water. while 54% rely on rain water and unsafe water from unprotected wells, Lakes, rivers, ponds and vendors. Over half of the Kenya's population takes more than one hour to reach the nearest health service. This national statistic, as appalling as they are, hides some original rural/urban income disparities. A perusal of the Human Development Index (HDI) shows that there exist vast disparities between Central and Nairobi Provinces on one hand and North Eastern, Western and Nyanza Provinces, on the other. At the same time, Nairobi is way ahead with an HDI value of 0.783 including its nearest rival Central Province with an HDI value of 0.604. North Eastern's HDI value of 0.413 is just under half that of Nairobi's.

While gender disparities are not that great at primary school level, they get wider after that. Twice as many males have access to mass media than females and male/female university attendance ratio is three to one. Women account for 30% of total wage employment yet they constitute 70% of the labour force in agriculture.The report also bears out another alarming contrast although perhaps not as starkly as it could have; 'the bottom 20% of the population get only 2.5% of the total income whilst the top 20% receive more than 50%".

There has been a steady deterioration in the standard of living of Kenyans especially in the past ten years. Life expectancy has declined from 59.5 years in 1989 to 54.7 in 1999. Under 5-child mortality has increased from 89 per 1000 in 1990 to 105 per 1000 in 1998. Primary school enrolment has declined from 95% in 1989 79% in 1995, On the other hand, secondary school enrolment fell from 30% in 1990 to 29% in 1999. The two that remained fairly much the same were access to safe drinking water and nutrition, although the later is still below the "normative 2,250 calories".

Gender and Food Security: Studies in Kenya indicate that women are more vulnerable to poverty than men[4]. For instance, 69% of the active female population work as subsistence farmers compared to 43% of men. Given that subsistence farmers are among the very poor, this relative dependence of women upon subsistence farming explains their extreme vulnerability. These problems are most severe in arid and semi-arid areas where women spend a great portion of their time in search of water and fuel.

The release of women's productive potential is pivotal to breaking the cycle of poverty so that they can share fully in the benefits of development and in the products of their own labour. In the urban areas, the proportion of poor female-headed households was higher than male-headed households in 1997. Both rural and urban women in 1997 were severely affected by poverty.

Regional Differences in the Incidence of Poverty in Kenya: Kenya is a land of large regional and growing inter-regional inequalities in natural endowment, income, access to educational and health facilities, as well as infrastructure. While some regions are relatively well endowed with such facilities, others are extremely deprived.

According to the National Poverty Eradication Plan [127], Nyanza and Western Provinces which lie within the Lake basin constitute the "*belt of poverty*" and are the poorest region in the country alongside Eastern and North-Eastern Provinces. This means that households are

[4]Daily Nation Newspaper, October 19, 2001

disadvantaged by virtue of their residence in such places. Some households may be tempted to move elsewhere in search of greener pastures. But migration to richer regions is costly and many people cannot afford it. Consequently, most people in poor regions of Kenya are condemned to poverty, unless they migrate. Since independence, there has been simmering debate on regional income inequality and equitable distribution of development resources among the regions. The first post-independence government was based on "*regionalism*" (federalism) under the political party, the Kenyan African Democratic Union (KADU). The other political party, the Kenyan African National Union (KANU) won the elections in 1963 and formed the government. KADU joined KANU in 1964. In the last few years, however, given the increasing regional inequality, debate of regionalism (Majimboism) or federalism versus centralism has become a major public issue, with opposing sides forcefully presenting their case for or against the subject. So strong is the issue of distribution of national resources such that Kenyans on 21st November 2005, overwhelmingly and resoundingly voted to reject a draft constitution which sought to centralize resources among other issues[5]. In this context, several questions come to mind.

How did regional inequalities come about? Was it because of differences in natural endowment? Was it by chance? Was it by design? Did the people cause inequality through incorrect attitudes to development, laziness, lack of response to incentives, etc.? The answer is abundantly clear. In the past, regional inequality did not feature prominently in the allocation of public resources. The allocation of public resources was based on different criteria. The above indicators demonstrate the depth and breadth of poverty in Kenya and the magnitude of the challenge. The fight against poverty, ignorance and disease has been a major goal of the Kenya Government since independence. However, it is evident that these efforts have been inadequate and the growth of poverty has not been reversed. In response, the government is mounting a new effort, which will incorporate wider consultation and broader participation of various stakeholder.

The geographical distribution of food poor people is illustrated in Table 6.2. According to the WMS 1994 and the Participatory Poverty Assessment (PPA) 1996, the prevalence of overall poverty in 1994 was highest in North Eastern Province (58% of population), Eastern (57%), and Coast (55%), while the lowest were Nyanza (42%) and Central

[5] Resounding No: The Standard, Wednesday, November 23, 2005

(32%). However, by 1997, not only had poverty increased rapidly, but its distribution had changed with Nyanza (63%) recording the highest level followed by Coast (62%), although Central still recorded the lowest incidence (31%).

Table 6.2. Regional Differentials in the Incidence of Poverty

Rural Areas	% of food poor 1992	1994	1997	% of overall poverty 1992
Central	68	33	30	36
Coast	63	51	59	43
Eastern	62	59	56	42
Nyanza	71	41	58	47
Rift Valley	81	46	48	51
Western	78	52	58	55
North-Eastern	-	56	-	-
Total Rural	72	47	51	48
Urban Areas				
Nairobi	42	27	38	26
Mombasa	45	33	38	39
Kisumu	-	44	53	-
Nakuru	-	37	27	-
Other Towns	-	27	38	-
Total Urban	42	29	38	29
Total Kenya				45

Nyanza which falls within Lake Victoria basin is an economically distraught province. It is so relatively underdeveloped that visitors find it quite hard to reconcile the fame of the region to the reality of the place. The situation is compounded by a sometimes-hostile weather, which undercuts the produce of the hard workers. While Lake Victoria, lies there next to them undisturbed, people go without water, which they badly need to irrigate their farms and for domestic consumption. The *abject poverty* in Luo Nyanza may also be attributed to *political neglect* and marginalization owing to the outspoken nature of the Luo, who form the majority of the population of the province. No new investments have been seen here for a long time and incomplete provincial headquarters building in Kisumu town attest to this.

Even the recent upgrading of Kisumu municipality to a city was merely a political gimmick which has not led to any significant changes. The neglect first hit the water supply in the capital town of Kisumu. This resulted in such waterborne diseases as typhoid fever and amoebic dysentery, which has become the order of the day. The neglect extended to the roads, sewerage system and the environment of Lake Victoria on whose shore lies the capital town of Kisumu. The marginalization has encroached upon the transport system. So much so that, like the Indians and other Nyanza dwellers, they have resorted to the humble means of non-motorized commuter transport, known as "Boda Boda" bicycle taxis whose origin is traced to the Kenya/Uganda border of Busia District. The despicable state of Nyanza is a direct reflection of the deprived Luo community. While, at independence, they were the elite tribe, owing to their level of education and industry, both in the white collar sector and in manual employment, the community is now abysmally subdued and economically vulnerable.

The solution to the poverty problem in Nyanza is a controversial subject. Some people believe that until the political system in Kenya is totally overhauled to ensure equitable distribution of the country's wealth, Luo land, like other neglected regions in the country will never develop. A Member of Parliament cannot single handedly develop his/her constituency. Corruption has eaten into Kenya's body politic, and almost everyone is ready to sell individual pride for some kick-back. Another proposal currently being implemented is the Constituency Development Fund compelling the government to distribute 5% to 9% of the annual national income to the constituencies. Even this has been abused by the local Members of Parliament who have adopted preferential distributions that have resulted in several court cases.

Food Poverty in the Lake Victoria (Kenya): The Government has indicated that the level of poverty in Kenya increased. In 2000, the proportion of people living below the poverty level was estimated at 52%. However, in 2001, the percentage of people living below the poverty level rose to 56%[6]. Many Kenyans are unable to earn a dollar (Ksh78) a day, the world's minimum standard for every human being. Take, for example, a family of 10. It is not possible for that family to get Ksh780 daily through business, wage employment, or any other means.

Table 6.3 indicates that the percentage of food poverty in Nyanza and Western Provinces is way above the national average at 58% and 58% each in 1997. Food poverty in Kisumu rose from 44% in 1994 to 53% in 1997, while the overall poverty in the city jumped from 48% in 1994 to 64% in 1997.

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[6]Daily Nation Newspaper, April 5, 2002

Table 6.3. Socio-Economic Indicators, Nyanza and Western Provinces

Poverty Incidence Nyanza Province	Value	Rank in Kenya
Absolute Poverty (1997) (%)	63.1	7
Food Poverty (1997) (%)	58.2	5
Poverty Incidence Western Province		
Absolute Poverty (1997) (%)	58.0	5
Food Poverty (1997) (%)	58.6	6

6.4 Poverty Eradication Policies in Kenya

6.4.1 Concern with Poverty in Kenya

The concern with poverty alleviation and inequality has had a long history in Kenya. For example, soon after independence, Bildad Kaggia, one of the freedom fighters, was given a 300-acre gift from President Jomo Kenyatta. He turned down the gift, arguing that he would be uncomfortable with such a huge tract of land when ***millions of Kenyans were still landless and wallowing in poverty***. He told the president: "*We fought for independence so that our people could be free and each one of them would have a share of the national cake.*" [1]

Since independence, successive governments in Kenya have adopted policies, plans and programs for poverty eradication. The government acknowledges that "Poverty alleviation and unemployment have been the subject of National Development Plans, Sessional Papers, Presidential Commissions, Task Forces, and studies in Kenya."[2] The most recent of these is the adoption of the National Poverty Eradication Plan 1999-2015, officially launched by President Moi on 11th March 1999.[3] Despite these anti-poverty policies, poverty has, instead, increased dramatically such that the average kenyan is poorer in 1999 than he was at independence in 1963.

The question then is *what has gone wrong*? Part of the answer, of course, is the difficulty of comprehending fully and unambiguously the concept of poverty which was discussed in Sect. 6.2. The second problem is the measurement of poverty. The third concerns policies adopted for poverty eradication. And the fourth problem pertains to government commitment, or the "political will", to eradicate poverty.

[1]For a detailed account of the Kaggia story, see Daily Nation, April 6, 2000

[2]Republic of Kenya, National Poverty Eradication Plan 1999-2015, p.1

[3]Republic of Kenya, Office of the President, National Poverty Eradication Plan 1999-2015, officially launched by President Moi on 11th March 1999

It is worth recalling that Kenyans fought for independence in order to eradicate "poverty, ignorance and disease."[4] It was assumed by the 'freedom fighters' that once independence was achieved, the new post-independence regime would quickly solve the three social problems. Thus, following independence, the escalating poverty situation has been a matter of concern for the successive governments of Kenya. The policy of poverty eradication has been enunciated in the National Development Plans, Sessional Papers, Policy Framework Papers, Special Programs, and Budget Speeches. However, despite the concern expressed by the political leadership in the country, the solution to the poverty problem proved elusive. The policies adopted to deal with these problems were riddled with contradictions, ambiguities and paradoxes. For instance, while there has been too much talk about poverty alleviation, ***absolute and relative poverty*** (see e.g., Sect. 6.2.1, p. 184) have dramatically increased during the entire independence period. There has not been much corresponding progress in reducing poverty. Instead, the people have become poorer and poorer; as already noted, Kenyans were 27% worse off in 1999 than they were at independence in 1963.

This section reviews the major poverty eradication plans and programs, which have been initiated by the successive governments of Kenya since independence. The objective of this review is to attempt to gain an understanding of why the policies have failed, as well as to determine the possibilities of success of the present *National Poverty Eradication Plan* 1999-2015, where other plans have failed.

But the failure has not discouraged those interested in fighting poverty. In recent years, poverty eradication has occupied the attention of the international community, especially the international intergovernmental and non-governmental organizations. For instance, the United Nations convened a special conference in 1995 in Copenhagen that was attended by over 100 dignitaries from all over the world which included the then president of Kenya Mr. Moi who led the delegation from Kenya. The conference called for an international commitment "to the goal of eradicating poverty in the world, through decisive national actions and international cooperation". The National Poverty Eradication Plan (NPEP) outlines the basic features of what was agreed at the Copenhagen Summit. While there is no doubt that NPEP was influenced by the Copenhagen conference, it is equally true that the hard political realities have also influenced the adoption of the NPEP. This

[4]see the KANU election Manifesto of 1963

section also addresses these hard facts that led to the promulgation of the NPEP.

6.4.2 Role of the Commission for Poverty Eradication

These foregoing questions are important in the light of Kenyan historical concern with poverty eradication. Some people have argued that what is new is that the government has set up a ***Commission for Poverty Eradication***. But does this Commission have the powers to eradicate poverty by the year 2015? Given that a "commission", by its nature, is a short-term body, can it eradicate poverty? Can poverty be eradicated? Are we talking about poverty eradication, alleviation, or reduction? What kind of poverty is to be eradicated? It would be interesting to see the presently poverty-ridden Kenya turned into a Kenya in which poverty is ***eradicated***.

The answers to the above questions are not easy to give because there are many problems concerning the concept of poverty and its proposed eradication. The first problem as we have already seen in introductory remarks section is the *definition of poverty* itself: What is poverty? The NPEP does not provide a clear and concise definition of the poverty to be eradicated. The second problem pertains to *measurement of poverty*: What are the measures of poverty? There are many measures of poverty currently in vogue. While some of these measures have been used over the last several decades, others are of recent origin; these did not find their way into the NPEP. Yet, these new measures are, in many respects, more important than the ones used in terms of dealing with issues raised in the Plan. The third problem which is considered in the present section relates to *policies to eradicate poverty*: What are the strategies for poverty eradication? The strategy for poverty eradication has provoked more questions than answers. For example, What does *poverty eradication mean*? Can poverty be eradicated? What resources does it require to eradicate poverty by the year 2015? Does Kenya have the requisite resources to eradicate poverty of the magnitude found in Kenya? What precedents are there?

6.4.3 Slow Progress in Poverty Eradication

While progress on poverty reduction has been slow, there is consensus in the country and among most donors on the broad approach to poverty reduction adopted by the Kenya Government, namely, the emphasis on *employment, generating economic growth, improved social services and, when necessary, targeted assistance*. The World Bank, other donors, and non-governmental organizations (NGOs), while providing increasing support for long-term growth, appear to be still very much concerned with the short-term progress in poverty reduction. Nevertheless, as time goes on, approaches to poverty reduction appear to be converging. The common challenge is to achieve the best allocation of government and donor resources for sustained growth and poverty reduction.

Critics believed that National Poverty Eradication Plan 1999-2015 could not be implemented. They say that the government is insincere and only appointed the Commission for Poverty Eradication in response to changing donor priorities, which now prefer funding projects aimed at poverty reduction. Donors are expected to fund the programs to the tune of Ksh2.4 billion annually. Critics pointed out that similar initiatives in the past, such as those targeting environmental protection, did not stop the grabbing of such national treasures as Karura Forest. The fact that the Commission is under the Office of the President is cause for more suspicion as, say critics, some of the country's worst performing corporations and financial scandals are to be found under the Office of the President.[5]

6.4.4 Poverty Eradication Plans since Independence

At independence, the focus of Kenya's economic development was poverty alleviation. This was to be tackled through various sectoral target realizations over time. Thus, there were targets of education with indicators in literacy levels; targets in health through immunization indicators and mortality rates; and targets in economic growth that was captured through production. Unfortunately, there were no targets in governance and resource distribution.

The concern with poverty alleviation and inequality has had a long history in Kenya. The following are some of the major policies adopted by the successive Kenyan governments since independence to deal with the problem of poverty.

(1) Sessional Paper No. 10 of 1965: Increase employment and a wider sharing of the benefits of growth.

[5]Recently, the Office of the President set up an investigation unit to probe into corruption scandals in various sectors of the economy. The probe unit unearthed a large number of scams including those in the Office of the President.

During the campaign for Independence, the "freedom fighters" in the Kenya African National Union (KANU) pledged to tackle the three problems of "poverty, ignorance and disease". Soon after Independence, to keep its election promise, the politicians, now manning the new government, produced the Sessional Paper No. 10 of 1965 on African Socialism and its Application to Planning in Kenya.[6] It called for:

(a) Continued rapid expansion of the economy;
(b) a wider sharing of the benefits of expansion;
(c) an attack on imbalances and disparities in income.

Undoubtedly, this Sessional Paper had the greatest influence on the development strategy adopted in the immediate post-independence years. Although the paper stated the need for a more equitable distribution of the benefits of economic growth, it was fairly explicit about the government's priority:

> The ultimate objectives of *African Socialism* are clear... The most important of these policies are to provide a firm basis for rapid economic growth. Other immediate problems, such as Africanization of the economy, education, unemployment, welfare services, and provincial policies must be handled in ways that will not jeopardize growth.

Much was achieved in securing rapid economic growth during the first independence decade. But, over time, the "other immediate problems" began to loom more prominently in the minds of the public and its government. One of these was the problem of unemployment and poverty. Something had to be done to address these other problems.

Since the adoption of the Sessional Paper No.10 of 1965, the Government took several actions in the light of changing circumstances. The first action was the convening of the *Conference on Education, Employment and Rural Development*, which was held in Kericho in November 1966. The Kericho Conference was extremely pessimistic about the future. It noted that open unemployment at that time was 200,000 (then about 6 per cent of the labour force) and was concerned about the ability of the country to cope with the population growth, which at the time was growing at less than three per cent per annum.

The second action taken by the Government was the creation of a *Sessional Select Parliamentary Committee on Unemployment* to study

[6]Republic of Kenya, Sessional Paper No. 10 of 1965, African Socialism and its Application to Planning in Kenya (Nairobi: Government Printer 1965)

the unemployment situation in the country and to make recommendations on appropriate actions to be taken. *The Report of the Select Committee on Unemployment* was duly submitted in 1970. The Committee made many proposals regarding the alleviation of unemployment problems. These proposals included:

1. The acceleration of the rate of industrial growth and agricultural growth, and rejected family planning as an alternative to accelerated development and employment creation;
2. encouragement of viable labour-intensive construction methods as techniques for employment promotion;
3. provision of a ceiling to individual ownership of land;
4. adoption of measures to redress regional imbalances and access to such advantages as roads, educational and health facilities, and development projects. The main proposal here was to deal with the problem of tribal fears and forces, which were both a cause and a result. The Committee expressed the strong view that: "Where tribalism exists, many of the recommendations made in this report (for example, equitable distribution of development efforts geographically, equitable distribution of incomes, decentralization of industry, efficiency in the civil service) cannot be implemented."[7]

(2) ILO Mission Report: Increase Employment, Incomes and Equality

In response to the issues raised by the Select Committee, the government in 1971, invited the International Labour Organization (ILO), in collaboration with United Nations Development Program (UNDP), to carry out a study of the employment situation in Kenya and to make relevant recommendations accordingly. The ILO carried out the study and prepared a report published in November 1972, under the full title of *Employment, Incomes and Equality: A Strategy for Increasing Productive Employment in Kenya* [66].

The ILO report did not concentrate directly on the question of 'unemployment'. Instead, it covered the much wider ground of employment-generation, incomes, and inequality in Kenya. It was concerned mainly with the fact that the mass of Kenya's population, while working, was poor (it called them the 'working poor'), while a small minority enjoyed highly rewarding employment. The ILO mission thought that this sit-

[7] Republic of Kenya, Report of the Sessional Committee on Unemployment, para. 38, p.14.

uation was due to a fundamental 'imbalance' of the economy. It then went on to analyze this phenomenon in some detail.

The report pointed out that, in the rural areas, the main cause of unemployment and of unrewarding employment was the fact that many people had little or no land. Young people entering the labour force, therefore, sought work in towns, especially Nairobi. But in Nairobi, the modern sector employment grew very slowly because of the capital-intensive techniques used for production and limited markets typical of foreign manufacturing plants. Most of these plants were import-substituting in the strict sense, producing locally what had previously been imported, particularly relatively sophisticated consumption goods for the highly paid few. Employment in such concerns was well paid and, moreover, offered especially high rewards to those with advanced formal educational qualifications.

This situation created an added impetus for educational expansion. All over the country, people had been willing to pay a very high price for schooling, and there had been a massive expansion of education, accelerating the flow of people to the towns where the jobs calling for education were to be found.

The flow of educated people to towns in search of jobs did not always result in obtaining the jobs. There were few jobs for such people. Most of the young migrants eventually found work in what the report called the '*informal sector*', meaning economic activities characterized by the following: ease of entry; reliance on indigenous resources; family ownership of enterprizes; small scale operation; labour-intensive and adapted technology; skills acquired outside the formal school system; and unregulated and competitive markets. In towns, this accounted for an estimated 28-33 per cent of all African employment. The informal sector was in the Mission's view the model of the kind of economy Kenya needed because it was labour-intensive, competitive, using locally produced inputs, developing its own skills and technology, locally owned and controlled. The Mission expressed the view that, instead of being encouraged to the maximum, the informal sector was restricted and harassed so that it too failed to furnish adequate incomes to those who were engaged in it.

The report traced this complex relationships to the fact that at independence the colonial economy had been taken over largely intact, and that this economy had been structured to yield high incomes for the small white minority. It also pointed out that the school system, investment policy, and so on, reinforced this economic structure. The report says (p.11) that:

> Since independence, economic growth has largely continued on the lines set by the earlier colonial structure. Kenyanisation has radically changed the racial composition of the group of people in the center of power and many of its policies, but has had only a limited effect on the mechanisms which maintain its dominance over the pattern of government income and expenditure, the freedom of foreign firms to locate their offices and plants in Nairobi, and the narrow stratum of expenditure by a high-income elite superimposed on a base of limited mass-consumption.

The ILO Mission Report then calls for a radical change in economic strategy and policy to alleviate these problems:

> Unless there is a major change in development strategy and policies, and in the absence of effective and powerful redistributive mechanisms, the heavy concentration of income is likely to continue and may be further intensified in the future. A high degree of income inequality is a characteristic feature of private enterprize economies in an early stage of development. Further, these inequalities tend to be intensified with the growth of the economy over long periods of time. There are reasons to believe that such dynamic factors tending to perpetuate and intensify inequalities may be operative in the kenyan social and economic system (p. 97).

The basic thrust of all the recommendations was that there was need to effect a more equal distribution of income through enabling the 'working poor' to become richer. The 'working poor' so enriched would constitute a mass market for the expansion of domestic manufacturing and services on labour-intensive lines. The mission saw such an expansion as an essential alternative to an unrealistic as well as undesirable dependence, under existing plans, on further massive inflows of foreign capital.

The ILO also emphasized the role of the '*informal sector*' in employment creation in Kenya. As the mission put it, '...the bulk of employment in the informal sector, far from being only marginally productive, is economically efficient and profit-making...' [66, p. 5]. Thus, according to the mission, one of the keys to increased employment in the country lay in effecting links between the '*informal sector*' and the '*formal sector*', by increasing the latter's demand for the goods and services of the 'informal sector'.

Unlike other reports before it, the ILO mission placed public discussion of the problem, and of the wider issue of the nature of the kenyan economy and the pattern of public policy, on a new and enhanced footing. It also discussed about a group of people -a very large number of people -, who were working, and possibly working very hard and strenuously, but whose employment was not productive in the sense of earning them an income on which they could meet their basic needs. This group of people was called "***the working poor***" in the sense that they were working but were poor because they did not earn adequate income to enable them meet their basic human requirements. The ILO report thus concerned itself with the broader issues of social justice; with the need to reduce not only unemployment but also poverty and inequality as well.

The ILO report deduced from the available data that roughly 40 per cent of the rural population and 25 per cent of the urban population received inadequate incomes. Inadequate incomes were defined to be those incomes below Ksh.120 per month for rural households and Ksh.200 per month for urban households, in 1972.

In order to provide the resources essential for the implementation of proposed policies, the ILO report argued that the then prevailing GDP growth rate of 7 per cent per annum should be sustained for the rest of the decade of the 1970s. In terms of industrial composition, they envisaged a growth rate of 6 per cent for agriculture and a growth rate of 8 to 9 per cent per year for non-agricultural industries. These growth rates were expected to lead to a 3.5 per cent per year rate of increase in per capita income to be achieved.

The ILO report recommended the following measures for poverty reduction:

(a) ***Minimum household income targets should be specified***. It was suggested that the poverty-line definitions of Ksh. 120 for rural families and Ksh. 200 for urban families might make appropriate minimum household income targets for the last year of the new Plan period, 1978; other and proportionately higher targets were set for a later year, 1985.

(b) ***These targets should be made more concrete*** in terms of other targets such as access to housing, schools, water, health services and nutrition.

(c) ***The targets were to be achieved by redistribution*** of the benefits of growth from one per cent of the population earning the highest income to the 30 per cent earning the lowest incomes per capita. The incomes of those in the top one per cent will be "stabilized", i.e., have a zero rate of growth, and the per capita real incomes of those in the lowest 30 per cent will have an annual rate of growth of 7 per cent.

(d) The means for achieving these targets involve the extraction of the benefits of growth from the wealthiest one per cent and the investment of the resources gained in projects which will provide permanent jobs and permanent increases in the levels of living for the lowest 30 per cent.

The focal point of most of the specific proposals in the report was the achievement of "*redistribution through growth*", a strategy that was popularly being advocated for by a section of the international community at that time. It was claimed that these proposals would minimize the amount of investment required to create a given amount of permanent income for the poorest 30 per cent of the population.

(3) Sessional Paper No. 10 of 1973 on Unemployment: The establishment of district targets for access to housing, education, health, and water.

In response to the ILO report, the government published the *Sessional Paper No. 10 of 1973 on Employment*, which stated that 'in most cases, the proposals in the ILO report reflect, or are consistent with, current policies'. The Paper was rather general in the commitment the government made on the implementation of the mission's proposals. Most of the mission's recommendations on the informal sector would be adopted. Those on the redistribution of income and assets would be adopted wherever they did not seriously affect the established interests of capital. Finally, the government committed itself to 'those who are absolutely landless and without work and pastoralists in semi-arid and arid areas to try to provide either a wage job or land to everyone by 1980'.

One concrete action taken by the Government to implement the proposals of the ILO report, was the issuance of the first *Wages and Incomes Guidelines*, in August 1973. The guidelines were intended to enable the Industrial Court to resolve disputes ensuing from the inflationary pressures triggered by the oil crisis. The guidelines required wages to be set in relation to earnings in the informal and agricultural sectors, with the proviso that workers' share should be related to productivity and should not be consumed by price increases.

The next set of guidelines, issued in 1975, however, severed the link between wage increases and productivity and between wages and the cost of living. Henceforth, the guidelines became a means for combating inflation and unemployment. In the same manner, *Sessional Paper Number 4 of 1975 on Economic Prospect and Policies*, to which IMF/World Bank lending was linked, put forward a strategy of prices and wage restraint for coping with imported inflation and balance of payments pressures.

While the government's thinking was radically changed by the ILO report, implementation was hampered by the shocks to the economy from external sources. First, there was the oil price increase of 1973, followed by the breakup of the East African Community (EAC) in 1977, a drought in 1979, and the second oil price shock of 1979. In between was the short-lived but highly positive shock of the coffee boom of 1977/78. In consequence, the rate of growth reached 8% for the two years: 1977 and 1978, but the overall growth in the 1970s hovered around 4% per year, leaving little margin for increases in per capita income.

In a 1973 Sessional Paper on Unemployment,[8] the government accepted the recommendations of the ILO report, but with qualifications. According to Mr. Mwai Kibaki, the current president under the ruling **N**ational **R**ainbow **C**oalition (**Narc**) and the then minister of Finance and Planning, "virtually all the major recommendations of the ILO mission have been accepted by the government." The government accepted with qualifications the proposed strategy for redistributing of income in the following terms:

(a) The government accepts that those who have benefited most since independence and economic growth should bear a substantial share of the burden of financing, through taxes which they pay, services and programs which benefit low income people. This will also be one of the objectives of the new wage policy guidelines.

[8] Chapter IV of Republic of Kenya, Sessional Paper No. 10 of 1973 on Unemployment

(b) The government will continue to invest its resources in projects and programs which provide maximum benefits for the poorest income groups in the population. It should be noted that this might involve investment in projects which will probably benefit other income groups as well.

(c) The government accepts the proposals that targets be established for communities and households with respect to minimum access to social services and other amenities. The government feels that the achievement of these more specific physical targets will provide a minimum level of living for the poorest income groups. For example, the establishment of district targets for access to housing, education, health, and water will go a long way towards assuring that the worst manifestations of poverty are eliminated.

(d) Finally, the government adopts as its long-term policy that all households will have access to either wage employment or to land in order to assure that all possess a means of earning an acceptable level of living. Consistent with this policy, the new Plan will specify the number of smallholdings, which will be created during the period 1974-78.

(4) Third National Development Plan 1974-78: 'Redistribution through growth'

The Development Plan, 1974-1978, which came at the time when the ILO report was still being debated, inevitably concerned itself with the question of equity and employment promotion. The Plan adopted the strategy of '*redistribution through growth*' which had been the theme of the ILO report, and stated that the improvement of income distribution and greater employment were the primary objectives. Thus, in his introduction to the Plan, the President of Kenya said: "*This new Development Plan... continues to lay emphasis on overall growth of the economy... But the forward thrust of the economy can no longer be regarded as the only objective of our nation. Rather, it is a means of attaining other goals... These include full participation of our people in the economy, greater employment opportunities, and a more equitable distribution of resources and income.*"

The subsequent *Third National Development Plan 1974-78* was also strongly influenced by the ILO report. It incorporated a strategy for '*redistribution through growth*' as advocated by the ILO. The Plan said: "Improved income distribution and greater employment - the primary objective of this Plan - can be achieved only if economic growth occurs at a greater rate than heretofore." This strategy was outlined in the *Sessional Paper No.4 of 1975 on Economic Prospects and Policies.* It sought to shift the economy from capital intensive urban infrastructure projects to labour intensive agricultural production and basic rural infrastructure, including rural access roads and water supply projects. It was felt that such programs would increase growth rate and contribute to poverty alleviation.

(5) Fourth National Development Plan 1979-83: 'meeting the basic needs of the people'

The *Fourth National Development Plan 1979-83* was even more strongly influenced by the ILO report. Its theme was '*meeting the basic needs of the people*'. It incorporated the conclusions of the World Employment Conference of June 1976.

The premise of the fourth development plan was that the scale of poverty and inequality are such that their alleviation should be the country's top development priority. The Plan set targets for basic needs including food, education, health care, water and housing. It emphasized employment expansion and productivity enhancement to increase the income of the poor. The growing problem of the landless poor was recognized and government intervention in the land market was proposed.

(6) Fifth National Development Plan 1984-1988: 'Economic Management for Renewed Growth'. This emphasized the removal of structural and administrative constraints and promotion of rural development, employment creation, and agricultural expansion. The specific measures were set out in *Sessional Paper No. 1 of 1986: Economic Management for Renewed Growth.* Once again, economic growth was considered the most important factor in poverty alleviation.

(7) District Focus for Rural Development: Allocation of resources on a more geographically equitable basis

In October 1982, President Moi announced the creation of **D**istrict **F**ocus for **R**ural **D**evelopment (**DFRD**). The DFRD was formally launched in March 1983. Its main objective was the allocation of resources on a more geographically equitable basis. Even-handedness in a geographical sense was felt by some people to offer the possibility of social and economic equity and poverty alleviation [104, p. 6]. Funds were to be allocated to the less developed regions, which were then encouraged to submit project proposals for funding. However, due to poor preparation, the unfamiliarity of district staff with methods of participatory planning, the absence of monitoring and evaluation and the weak commitment of sector staff to inter-sectoral initiatives, a number of decentralized projects were poorly conceived and designed. Corruption also led to the procurement of unsuitable materials, equipment and machinery. High officials in the districts saw this program as providing an opportunity to loot the money, and this was done galore.

Target beneficiaries; the poor and the vulnerable, were largely excluded from direct involvement in the process of project design and implementation. The projects were therefore seen as government owned, and not community owned projects, and were not so much supported by the local people. They instead raided for benefits when there were any. Very limited efforts were made to strengthen social and administrative structures below the district level, even though these structures were much closer to the people than those at the district level. In a significant number of cases politicians and the district level staff explicitly set the priorities for district projects. Many development plans, programs and projects reflected the priorities of civil servants and not that of the local people. This led to the failure of those programs and projects. Consequently, there has been a weak local support, ownership or commitment to the projects. DFRD has not established the participatory and poverty alleviation processes it was meant to promote [104, p. 7]. The current DFRD manual, the *Blue Book*, was revised in 1995. The revised strategy now concentrates on encouraging local participation, the acceleration of development in the districts where the majority of the people live, balanced development and equity, and improved coordination.

The government is now making efforts to involve the people at the grassroots level in the fight against poverty. The government has urged the District Commissioners to adopt participatory methods in implementing the poverty eradication plan. This makes sense. History has shown that even the most astute of policy papers that disregard the person in focus is unlikely to achieve much. *Poverty eradication cannot be achieved if the poor are excluded from its implementation.* Thus, sidelining the poor, who are at the center of the focus, does not make sense. Yet, it is a practice that has unfortunately gone on locally for far too long.

The government has warned the District Commissioners (DCs) against misappropriation of project funds. These officials will be required to file accountability reports to the Poverty Eradication Commission. Furthermore, DCs are expected to present an interim poverty assessment report for their respective districts.[9] The government would then use the reports to determine what plans would be suitable for each district. The government is considering giving districts block funds, or establishing anti-poverty funds, to directly assist small community projects.[10] This is a laudable effort, but it is subject to certain provisos. The move can only be successful if such funds are properly utilized. The government must ensure that those that are left to handle such funds at the district level do not misappropriate the money as has invariably happened in the past.

This calls for the training of the target groups, which will also be involved in monitoring the progress made to eradicate poverty in their respective districts.

(8) Social Dimensions of Development (SDD): The plight of the poor and the vulnerable groups, and how they might be assisted

The National Conference on **S**ocial **D**imensions of **D**evelopment (SDD) was held in Nairobi on October 12, 1994, under the Chairmanship of Mr. Daniel Arap Moi, then president of the Republic of Kenya. The conference was attended by a wide cross section of national leadership drawn from political parties, government officials, religious groups, the private sector, and Non-Governmental Organizations (NGOs), as well as the diplomatic and the donor Community. The conference was convened to discuss the plight of the poor and the vulnerable groups, and how they might be assisted. Comprehensive proposals for income generation program, consisting of a conceptual framework and project profiles, were put before the conference. The proposals received broad approval and they constituted the Social Dimensions of Development Program for Kenya (SDD). The eventual beneficiaries of this program referred to officially as vulnerable groups included women, children, female headed households, primary and secondary school leavers, poor pastoralists, small scale farmers, the landless, the handicapped and the unemployed.

The rationale behind this program was that the Structural Adjustment Program (SAP), with the market system that it introduced, impacted negatively on weaker elements in the economy and society, who were unable to compete, and therefore sunk into greater poverty. In

[9] See East African Standard, April 29, 2000

[10] Statement by Mr. Julius Sunkuli, the then minister in the Office of the President. See East African Standard, April 29, 2000

the absence of a strong national social security system, there was need for the government to implement compensatory programs - "***safety nets***" - to assist these vulnerable groups. The SDD program presented a holistic program consisting of six sub-programs on: Welfare and Basic Services, Skills Development, Employment and Job Creation, Rural Development, Environmental Management, and Security and Public Administration. The Program envisaged a total expenditure of 2.343 billion Kenya pounds or approximately US$1.172 billion. The government of Kenya said it had committed Ksh1, 175 billion (US$ 587.5 million) and was seeking donor assistance amounting to Ksh1.169 billion or approximately US$ 584.26 million. Table 6.4 indicates the various components of the proposed **SDD** Program and the resources planned for fiscal years 1994/95 - 1997/98.[7]

Table 6.4. Summary of Proposed SDD Programme Expenditure Plans, Ksh million

Theme	1994/ 1995	1995/ 1996	1996/ 1997	1997/ 1998	Total
1. Welfare& Basic Services	184.53	210.41	242.54	256.35	893.83
2. Skills Development	95.91	156.39	78.53	39.71	893.83
3. Employment & Job Creation	32.37	105.46	92.05	56.14	370.54 (434.14)
4. Rural dev.	22.17	93.06	94.92	45.50	286.02
5. Environment management	1.32	7.92	11.50	11.41	255.65 (270.80)
6. Security & Public Adm.	191.05	162.55	152.15	505.75	32.15 (32.54)
Total	527.35	735.79	671.69	409.11	2,343.94 (2,423.08)
GOK Commitments	280.00	300.00	285.20	310.20	1,175.40
Existing Donor Commitments & Additional Funding Required	247.35	435.79	386.49	98.91	1,168.54

Note: Figures in brackets include expenditures beyond 1997/98. Ksh. 1=US$0.5

The SDD programming was further refined and recast in 1997 into three complementary components. These components are: (i) broadly

[7]**Source**: Republic of Kenya, Social Dimensions of Development in Kenya. (Document presented for discussion at Consultative Group Meeting in Paris, December 1994), p.16.

targeted, (ii) narrowly targeted, and (iii) relief and rehabilitation interventions. The SDD initiatives could make important contributions to poverty reduction, although they were not designed to offer the long-term planning and policy framework, which is now set out in the National Poverty Eradication Plan [104].

The SDD has still yet to reach an operational stage. The KANU government said that its implementation has been hampered by the lack of adequate staff, lack of programme development skills, or of appropriate institutional mechanisms and funds. However, some capacity strengthening has been gained through SDD staff's exposure visits to poverty programs in other countries.

(9) Eighth National Development Plan (1997-2001): Promotion of Industrialization in order to increase employment.

The current *Eighth National Development Plan (1997-2001)* deviates from all previous ones by shifting emphasis to private sector investment in industrial production. The aim is to transform Kenya from a largely agricultural economy to a newly industrialized country by the year 2020. Industrialization is believed to have the potential to create more jobs rapidly in order to respond to the needs of the youth and the other unemployed. The authors doubt whether Kenya will become industrialized by the year 2020 without first investing in the rail mode of transport as opposed to road. Besides, industrialization is highly enhanced by emphasizing information technology which is still at infancy stage in Kenya.

(10) Policy Framework Paper: Economic Reforms for 1996-1998 Targeted Poverty Interventions.

The *Economic Reforms for 1996-1998* contained in the Policy Framework Paper developed poverty targeted interventions intended to provide income support to those who cannot wait until the growth process gathered steam as well as those who cannot readily participate in it because of special handicaps, such as geographical isolation.[11]

(11) Land Resettlement and Reform.

The importance of land as an asset looms large in the minds of Kenyans. It was one of the reasons Kenyans fought for independence - to get back the lands taken by the colonialists. Besides resource distribution, land formed one of the major reasons a large majority of Kenyans

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[11] Republic of Kenya in collaboration with the IMF and the World Bank, Kenya Economic Reforms for 1996-1998: The Policy Framework Paper, February 16, 1996, p. 40.

resoundingly rejected the draft constitution in the recent plebiscite of 21st November 2005[8]. The land settlement scheme was one of the most important means of tackling the problems of poverty and unemployment. A resource that guarantees popular participation in the development process is land because Kenyans rely heavily on farming. At independence, the government transferred land from foreigners to indigenous hands. This was achieved very smoothly through schemes such as *the one million-acre settlement scheme* financed by British credit and by the *Ushirika* (Cooperative) land transfer program, which used a willing-buyer willing-seller framework. The government strengthened the process by providing farming loans and introducing the smallholders to advanced farming techniques through extension services. The settlement Fund Trustee (SFT); a corporate body established in 1961 under Section 167 of the Agricultural Act, Chapter 318 of the Laws of Kenya, was also used to transfer land from ex-European farm lands to Kenyans. In total, over a million acres of mixed farm land previously owned by 2,000 Europeans was transferred to 47,000 African small holders by means of land purchase and development loans. The schemes were later extended to *State* and *Trust lands* as well as *Forest land* suitable for farming. Although the land transfers were able to better integrate those Kenyans who benefited into the mainstream development process, less than 5 per cent of the rural population were included [46, p. 7]. Furthermore, corruption and administrative mistakes further reduced the schemes' overall effectiveness. Land transfer schemes were important in equity terms but also had inherent and severe limitations. The Development Plan 1970-1974 noted that the "gap between earnings of rural and urban workers is probably larger than it was a decade ago".[12]

(12) Harambee: A 'Pull-together' doctrine.

The concept and practice of "*Harambee*", a 'pull-together' doctrine, is a unique feature of Kenya's self-help movement that has been responsible for the mobilization of large capital sums of money for a wide variety of basic needs. Harambee initiatives have placed limited emphasis on economic development projects and given greater weight to social sector provision (e.g., education, health, and social welfare). During the 1965-69, social sector projects accounted for 64 per cent of total Harambee contributions. This rose to 86 per cent during the

[8]Resounding No: The Standard, Wednesday, November 23, 2005

[12]Republic of Kenya, 1969, The Development Plan 1970-1974, p.3

1980-84 period. Harambee has contributed a great deal to poverty reduction by integrating communities and individuals that had hitherto been excluded from the development process. However, the Harambee movement has subsequently been hijacked by vested interests, thereby diluting its usefulness as a social inclusion and integration initiative.

(13) Specially Targeted Projects.

Over the years, the government has adopted special anti-poverty programs, and a number of such specially targeted projects have sought to address poverty alleviation objectives. The Urban Slums Development Project of the Nairobi City Commission, the Street Children's Fund, the Education Bursary Program to assist bright children from poor backgrounds, the School Feeding Program, the Micro and Small Scale Enterprizes Program and the Essential Drugs Supply Program of the Ministry of Health have all had specific poverty alleviation aims. They are relatively recent interventions, and so the extent to which they will contribute to poverty eradication is yet to be established.

(14) Other Recent Initiatives.

Apart from the above anti-poverty programs, there have been other Government initiatives which have positive contribution to make towards poverty alleviation. The initiatives include the Rural Development Fund (RDF), the Community Development Trust Fund (CDTF), National Youth Development Fund (NYDF), Disabled Fund (DF), and National Women Development Fund (NWDF). These series of high profile fund-raising initiatives has raised sums in excess of Ksh 1 billion in contributions.[13]

6.4.5 Lessons from Previous Efforts on Poverty

The review of the previous attempts to address poverty shows that "the main problems in achieving any reduction in poverty lie in failures in implementation rather than the design of plans and aims."[14] The key lessons which have emerged from the review are:

- Basically a similar diagnosis of the problem and its causes has been repeated in the national development plans, coupled with a recurring inability to implement the remedies prescribed and a weak understanding of the real nature of poverty;

[13] Republic of Kenya, National Poverty Eradication Plan 1999-2015, p.7
[14] ibid

- There is a weak understanding of poverty reduction priorities and a very limited understanding of poverty eradication needs and an almost complete absence of accurate information surrounding the nature and causes of poverty, on the part of the sectors and districts;
- There is a policy gap between very broad national plans and frameworks and routine sector actions and projects which further contribute to low levels of policy implementation;
- Decentralized and cross-cutting poverty oriented programs have faced many difficulties because of limited resources and the weak commitment of sector staff and systems;
- Cooperative fund raising for special, urgent purposes has been preferred to alternative, more sustainable frameworks of popular participatory action against poverty;
- There have been instances of mismanagement, corruption and misappropriation of funds and the diversion of benefits away from the poor; There is need to alleviate poverty through a combination of actions to meet basic needs of the poor people with the creation of employment.

6.5 Concluding Remarks

The magnitude of poverty around Lake Victoria is a matter of grave concern both nationally, regionally and internationally. Nationally, the Kenya government has identified Nyanza, Western and some parts of Rift Valley Provinces as constituting the "Belt of Poverty" [104]. In this context, Kisumu has been identified as the poorest city in the East Africa region. Regionally, the East Africa Community has also lent its view that the Lake Victoria region is, indeed, a region of poverty. For this reason, the East Africa Community has established a programme intended to alleviate poverty in the region. Further documentation of poverty in the region has been presented in [70].

There has been concern among the International community about the poverty status of the region. The Governments of Sweden, Norway and France have expressed their concern by establishing programmes of poverty alleviation in the region. Some international institutions have also indicated their interest in instituting poverty alleviation programmes. The World Bank is presently supporting a major programme on poverty eradication in the area. Some NGOs have also made their contributions to the solution of poverty problem.

7

Economic Development

7.1 Introductory Remarks

We have noted in the previous chapters that Lake Victoria and its environs are well endowed with natural resources. Have these endowments led to economic development of the region? If not, why not? This chapter seeks to explore the economic situation in the region. Lake Victoria basin has the potential to achieve sustainable economic growth and positive social development. The soils and climate of the Lake are suited for agriculture with improvements in current land management and crop and livestock husbandry accompanied by careful consideration of environmental limitations given the fragile nature of the soils. Although threatened by ecological shifts in Lake ecology and overfishing, fishing remains an important economic activity and a source of protein to the people in the region. Fishery and agriculture as we saw in Chap. 3 already make a contribution to the local industry. Regional trade, hinged upon a more liberalized market is increasing. Tourism discussed in Chap. 4 is another area of potential growth, building on the natural resource of the Lake and its biological and cultural diversity.

Table 7.1 presents the comparison of per capita income between the countries within the Lake basin for the year 2001. One observes that Kenya has the highest per capita income at \$350 followed by Uganda with \$310 while Burundi is the poorest, with a per capita income of \$130. In terms of population growth rate, Kenya has the lowest (1.5%), while Uganda has the highest rate (3.1%) p.a. Life expectancy in Kenya is the highest in the region (51 years), while Rwanda, at 40.6 years is the lowest. None of the countries in the region has attained the minimum calorific requirement of 2,250 per day for a healthy life.

Table 7.1. Socio-Economic Data of Countries in the East African Region, 2001

Country	GNP per Capita (US$)	Population Without Safe water %	Population Growth Rate %	Annual Fresh water Withdrawals Per capita in cubic metres	Life Expectancy At birth (Years)	Infant Rate (Per births)
Burundi	140	48	2.3	20	42.7	106
Kenya	350	56	1.5	87	51.3	75
Rwanda	210	21	2.8	134	40.6	105
Tanzania	220	34	2.3	40	47.9	91
Uganda	310	54	3.1	20	40.7	84

7.2 Economy of the Lake Victoria Region

It is not possible to put a single estimate to the global value of the Lake in sustaining the regional economy. The Lake basin provides for the livelihood of about one third of the combined populations of the three countries, and about the same proportion of the combined Gross Domestic Product (GDP). The GDP of the Lake is estimated at US$3–4 billion annually; with combined annual fish export earnings at US$600 million, out of which US$240–480 million is paid directly to fishers. Other estimates put the value of the fish catch from Lake Victoria at about US$300–400 million each year [123].

With the exception of Kampala, the capital of Uganda, the Lake basin economy is principally an agricultural zone and a high level of subsistence fishing (including exports of fish). Agriculture employs up to 75% of the region's labour force. The main agricultural enterprizes, most of which are small-scale, include maize, rice, sugarcane, coffee, tea, horticulture, dairy, ranching and forestry. On the Kenyan part of the basin, the most important commercial agricultural activities are the rice irrigation schemes covering 2400 hectares of land and the sugarcane plantations. Kericho, Uasin Gishu and Trans Nzoia Districts are areas of intensive agricultural production for maize, tea wheat and dairy production.

On the Tanzanian part of the basin, about 61,000 hectares of flood land has been designated as potentially suitable for the development of irrigation. The region has an estimated 7.5 million heads of livestock. Cotton in the eastern zone of the Lake and coffee in the western zone are the export commodities. Most cotton produced in Tanzania comes from this region.

In Ugandan, the Kakira Sugar Plantation East of Jinja and horticultural and floricultural farmers practicing small-scale irrigation and smallholder rice schemes at swamp margins depend on the Lake's water for irrigation.

Fishing and fish processing for export and local markets is one of the most significant economic activities in the Lake basin, employing over 500,000 people directly and indirectly. The total landings from the three riparian countries are more than 500,000 tons per year. The estimated potential yield on the Tanzania territorial water alone is 200,000 tons per year. In Uganda, the total catch is approximately 129,000 tons per year and fisheries contribute US$ 50 million per year as exports while in Kenya, the annual fish exports are estimated to be US$ 180 million. Commercial large-scale fishing trade with exports of fish fillet overseas has developed in the last decade. The situation has led to a massive over-fishing of Nile Perch and other fish species. This has put great strain on the local fishing industry. Local fishermen, squeezed by low catch and falling fish price, have resorted to using poison for fishing and illegal nets with adverse health and environmental consequences.

The region has an active business sector. However, trade and industry is hampered by the high cost of credit, competition from cheap imports and high transportation costs occasioned by poor infrastructure. Kisumu, Homa Bay, Kakamega, Eldoret and Kericho in Kenya; Kampala, Jinja, and Entebbe in Uganda; and Mwanza, Musoma and Bukoba in Tanzania are important urban centers in the Lake basin. They all have industries involved in fish processing, sugar manufacturing, tea processing, textile production, breweries and paper manufacturing, among others. A number of heavy industries such as ginneries, sugar factories, tanneries, coffee processors and paper mills are located in this region.

The region has a reasonable network of roads, although many are poorly maintained. Telecommunication facilities such as telephone fax, and internet are concentrated in the urban areas, though most post offices in rural areas of Kenya also have internet. In general, the municipalities have not been able to provide basic urban services including water, electricity, sewerage, due to the rapid increase in population. Such services are hardly available in the rural areas. Most electric energy in the three riparian countries is based on hydro-electric power. The total installed capacity is 1,500MW and demand exceeds supply in all the three countries. Electricity accounts for only 5% of the energy consumption and the demand is increasing at a rate of approximately 6-10% annually. This is estimated to increase to over 6,000 MW by the year 2020.

Although the degree of industrialization and of urban and rural development show no great differences between areas of East Africa, significant differences can be seen in the rapid commercialization of the fishery, especially in the export-oriented activity for Nile Perch, a species introduced in the 1950s. Such commercialization has had a profound effect on the ecology of the Lake, including displacement or near extinction of many endemic species (see e.g., [4, 51, 52, 110]). Commercialization of fisheries has also affected the social fabric of traditional fishing communities and, of course, the foreign currency earnings of the riparian states.

7.2.1 Transport and Communications Infrastructure

One major factor, which has inhabited the development of the Lake Victoria region (on the Kenya side), is the lack and poor condition of communication infrastructure, especially, the road, networks. The poor road network has impacted negatively on the Kenya fishing industry. This has been compound by the shortage of power supply at the beaches, which hampers the establishment of refrigeration and processing plants. There is therefore a significant need to pay particular attention to the development of this sector, if the region's potential is to be opened up for development.

The transport system within the Lake Victoria needs to be integrated to make if more efficient and commercially viable. Linking air and Lake transport systems could, for example, make cargo transportation within the Lake region much easier. This would also help improve services, and ease communication within the Lake region. Passenger vessels are also slowly but steadily increasing. For example, the Tanzanian-based Lake First Ferries recent acquisition of two ship vessels (i.e., Lake Express I and Lake Express II), which will operate between Mwanza and Bukoba, has increased Tanzania's passenger vessels in the Lake to more than five[1].

For many years, the transport systems in the region have tended to operate as separate entities, thus missing out on the benefits of integration. For example, air transport has no linkage to the Lake transport.

[1]See, e.g., "Lake to have more Ferries" in The Standard Newspaper, Thursday, October 13, 2005

The link between road and marine transport in Lake Victoria is also absent, and need to be developed. Due to lack of these links, foods that could easily and cheaply be transported via the Lake are often transported by road to either Uganda or Tanzania. One of the effects of this has been the increased pressure on the roads with the government spending billions of shillings to repair the roads. The linkage could help promote the Western Kenya tourism industry. Indeed, integration has served other countries well and improved efficiency in the country's communication systems. Integration will assist the region to fully utilize its communication potential.

The Kenyan government has realized the importance of this sector and has consequently drawn up a plan for the development of infrastructure concerning the road network. The plan is to improve the fish roads from Sio Port in Busia through Imbo Usenge in Bondo, Kendu Bay–Homa Bay to Mbita and Sindo in Suba District. The road will run to Magunga, Sori, Lwanda, Wath Ong'er and finally to Muhuru Bay. The Government also plans to improve the Migori–Muhuru road and will link it to the Mara road in Tanzania. The road would also be improved to Kehancha in Kuria District of Kenya.

In addition to the above, the Kenyan government also announced that a number of access roads would be improved through the 2000 Roads Programme. This is labour intensive and will create employment. Furthermore, the government announced that discussions were going on between the Kenya government and the governments of Uganda and Tanzania not only to improve the roads network around the Lake, but also to open more roads. This is meant to link up the three countries and ease trade. This is in line with the vision of the three heads of state to forge closer links and eventually create an East African Union. The roads network would be a "supermarket" for the combined population of more than 100 million people.

7.2.2 Electrical Power Network

Lake Victoria's energy resource was discussed elaborately in Sect. 3.7, p. 77. At the present time, electrical power infrastructure is minimal in the Kenyan side of the Lake region. On the southern part of the region, the only power line that exists, links Kisumu, Kisii, Oyugis and Homa Bay, Rongo, Awendo and Migori townships. On the other side, the electrical line runs from Kisumu to Bondo and Siaya. Thus, electric power does not cover most areas in the region. For the promotion of development of the region, the power supply action must be taken as a matter of utmost urgency. The Kenyan government has already planned to take steps to remedy the situation. It has announced that funds were being obtained to extend the power supply to major beaches along, the Lake. Work was already ongoing to extend the power line from Rodi Kopany near Homa Bay through Ndhiwa to Karungu Bay (Sori).

When the power network is completed, the central government and the civic authorities around the Lake will get more revenue from a more vibrant fishing industry. This will reduce the fish, waste resulting from lack of refrigeration and poor road condition. During rainy seasons, fish refrigeration vans have often been stuck on muddy roads for days resulting in losses for both fishermen and processing firms.

7.3 General Deterioration of the Region's Economy

Before independence, the economy of the Lake region especially of Nyanza Province in Kenya was vibrant, if not booming. Along the Lake there were beehives of economic activities on particular spots including Asembo Bay (Kamito), Kisumu, Kendu Bay, Muhuru Bay, Kitere Mains, Huma Limes in Karachuonyo and Marindi in Kanyada. There were various programs for the development of the Lake basin area including the Ahero rice scheme, North-West Kana rice scheme, Yala Swamp, cotton ginneries etc., but all these enterprizes have collapsed since independence. why?

The failure of the Kenyan government to develop Lake Victoria region could be attributed to many factors:

(a) The first and foremost factor was political. During the first two years of independence, there was a sharp difference of opinion between the then president *Jomo Kenyatta* from the Central Province and his Vice President *Jaramogi Oginga Odinga* from the Nyanza Province in the Lake Victoria basin. These differences culminated in a major confrontation and fight in Kisumu City in 1969 when Kenyatta visited the city to open Nyanza Provincial Hospital. Subsequently, Oginga Odinga was arrested and detained. Prior to this incidence, Tom Joseph Mboya, a prominent Luo politician from Nyanza Province had been killed allegedly by a government agent. From these two incidences, the government turned against the Luo people from Nyanza. From that time on, no major development project was initiated in Luo Nyanza and some of the existing ones were stalled. This state of affairs continued during the Moi era. With the formation of the NARC government which removed the ruling party KANU from power in 2002, people in Nyanza had high hopes that alienation would be a thing of the past. This was attributed to the fact that Mr. Raila Odinga who hails from the region propelled NARC to power by his famous declaration of "*Kibaki Tosha*" meaning Kibaki, the current president, was enough to be elected. Matters changed however, when president Kibaki failed to honour a Memorandum of Understanding (MoU) which they had agreed upon before the elections. Surrounded by his kinsmen and a kitchen cabinet drawn from his region, they completely renegaded upon most of the pre-election promises. Soon animosity and mistrust between key member parties of ensued resulting in public humiliation of the government when its supported draft constitution was rejected by seven provinces out of eight[2]. Only the president's province of Central supported the draft constitution. Humiliated, president dissolved his entire cabinet and prorogued parliament. The newly formed cabinet locked out all those who had campaigned against the draft and for the first time in Kenya's history, the Luo Nyanza region was represented by only one person in the cabinet, with the other three appointees joining other 23 Kenyans in rejecting the appointments. the With this background, it remains to be seen whether meaningful development will ever come to Nyanza, the heart of opposition politics.

(b) The final cause is a historical one. There is an indication that the regions that were developed earlier by the colonialists have tended to receive the largest shares of government resources. A good example is the enormous dominance of Nairobi in terms of government expenditures per capita. This is due to the fact that central government authorities are located there. Nairobi and Mombasa are well cared for in terms of public services. Among the other provinces, Central Province gets the most money followed by Rift Valley, while Western, North Eastern and Nyanza provinces get the least per capita. These overall figures support the conclusion that the most developed regions get the largest shares of public resources. This is one of the reason why most Kenyans were agitating for the federal system of government which will ensure equity in the distribution of national resources. The failure of the recently proposed draft constitution to

[2]Resounding No: The Standard, Wednesday, November 23, 2005

capture these aspirations led to a resounding No vote and subsequent humiliation and embarrassment of the government which led to the president dissolving his entire cabinet and proroguing parliament[3].

Collapse of Economic Enterprizes

In general, the following economic enterprizes in the Kenyan side of the Lake collapsed during either the Kenyatta or Moi regime:

(a) **Collapse of the Cotton**: In the 1970s, Nyanza Province was a power base in the provision of Cotton, Sugar cane and other crops that sustained the economic activities of the region. There were Cotton Ginneries at several locations including factories at Asego (Homa Bay), Kendu Bay, etc. This unfortunately is no longer the case; the Ginneries have collapsed and the equipment are rotting. Demoralized farmers gave up the idea of cultivating Cotton due to poor remuneration by the State.

(b) **Limping Sugar Cane Industries**: Sugar plantations that provided the bulk of the Sugar cane required by the Muhoroni, Chemelil and Sony sugar factories are increasingly being abandoned by farmers in preference to subsistence farming owing to poor income from sugar crop and constant burning of the crop by arsonists.

(c) **Demise of the Rice Industry**: Similar situation has befallen the rice plantations at Kana and Ahero regions where farmers complain of preferential treatment given to their counterparts at Mwea rice scheme. The abandonment by farmers of the cultivation of these major cash crops has only helped to worsen the poverty situation in the region.

(d) **Collapse of the Mineral Resource Industry**: The region was also blessed with natural resources that could provide income to the people of the region. The Lime at Huma, Gold in Bondo region among others could provide resources that could help alleviate poverty in the region. Unfortunately these have all collapsed.

(e) **Collapsed Piers**: Piers within the Lake such as those at Muhuru Bay, Kendu Bay, Asembo Bay, Sio Port and Homa Bay that could be used for transport have all collapsed.

(f) **Lake Basin Development Authority (LBDA)**: The **L**ake **B**asin **D**evelopment **A**uthority (**LBDA**) was a noble establishment to de-

[3]Resounding No: The Standard, Wednesday, November 23, 2005

velop the Lake region. Unfortunately, the vast rice processing plant of the LBDA lies unused due to many factors.

(g) **Fisheries Industry**: Fishing being one of the major source of income of the people in the area, the ban by the European Union (EU) of fish from the region and the stringent standards normally raised contribute a great deal towards economic hardship and the rise in poverty scale. The situation is also worsened by the fact that fishermen have no direct connection to the end consumers in order to directly talk on standards and quality. Their fish always has to pass through brokers who are the major beneficiary.

7.4 Present Efforts to Develop Lake Victoria Basin

A council of ministers, directors of fisheries and top researchers from Kenya, Uganda and Tanzania have approved a Ksh2.3 billion project to improve the management of the Lake Victoria fisheries. The project will be funded by the European Union and implemented by the Jinja-based Lake Victoria Fisheries Organization (LVFO).[4]

The project is also expected to come up with a harmonized regional fisheries management plan to tackle growing insecurity on the Lake, management of beaches, surveillance, water quality and environmental protection measures, among others. This project is underway and the region's fishing industry is expected to improve tremendously. A team of scientists and administrators had visited several beaches including the Obenge beach, in Bondo District, during a tour by the directors of fisheries and senior researches from the three East African countries to find out how the government researchers and fishing communities could jointly improve management of beaches and fisheries resources. The officials opined that only closer co-operation between fishermen, researchers, and their governments would solve problems facing the Lake. The Council of ministers that met in Nairobi discussed a joint approach in tackling the Lake's problems. It is expected that, piracy on the Lake and harassment of fishermen by security officials will be reduced drastically. At the present, harassment and arrests of Kenyan fishermen by Ugandan and Tanzanian authorities continue unabated.

Some efforts have been taken by the communities and local NGOs, e.g., OSIENALA within the Lake basin to revamp the regions economy. These initiatives are discussed below.

[4] Daily Nation Newspaper, September 13, 2002

7.4.1 The Ice Plant

While the common fisherman has been the main contributor in the harvesting of fish from Lake Victoria, it is quiet disturbing that he is also the one who receives the least from the industry. This is because the middlemen in the fishing industry have become so aggressive and sophisticated beyond the grips of the common fisherman. This comes about because while the common fisherman rows or uses wind propelled boats, the middleman uses high powered feet running motorized boats to collect fish in the high Lakes. And while the ordinary fisherman rushes with his fish to reach buyers before they get bad, he can sit in the comfort of his refrigerated van for days stocking fish to his hearts desires. In attempting to alleviate this problem along the Lake, the government is encouraging fisher folks in particular to invest in the establishment of cold storages and ice plants.

A typical example is the Mbita Ice Plant built by the government of Kenya for the sole purpose of benefiting the fishing community. In line with its present move to privatize or reduce its monopoly in running industries, it decided to give it out to potential investors. The Suba community in their desire to own this Ice Plant and manage it as a local investment for the benefit of the local community have decided to buy shares in order to reach the governments Ksh. 8 million target. They have formed a committee and floated shares with a shore price of Ksh. 100 and restricted the share buying to 10 minimum and 5000 maximum. While this example is a litmus test to the potentials the local communities have if they organize themselves well, it can also be seen as a viable economic undertaking that will provide:

1. A cooling system to store fish transported from far off places to Mbita.
2. Production of ice for preserving fish at the plant or enroute for purposes of fetching good market prices.
3. Creating employment opportunity thereby reducing the level of poverty.

Because of the inability to raise the required money within the set period some Non Governmental Organizations (NGO) with interest in the fishing industry and specifically the fisher folk plight have chipped in to make this possible. In the development of Mbita Ice Plant. OSIEN-ALA (Friends of Lake Victoria), a Non Governmental Organization with such interest in the Lake Victoria has come up with Ksh. 3 million to be used by those poor fishermen who are not able to raise enough money for buying their shares. It is envisaged that this money shall be paid back to the Ice Plant management to be used for buying more shares by a worthy but resourceless fisherfolks.

7.4.2 Beach Bank Project

The Beach bank is an OSIENALA (Friends of Lake Victoria) Micro finance project with headquarters at the OSIENALA center for Research and Development, at Dunga beach in Kisumu City of Kenya.

The Beach bank was launched in April 2004, with the aim of cultivating a culture of saving, credit and investment, among the fisher folk within the Lake Victoria basin. It addresses the linkages between financial development, investment and growth in low income of the fisher folk. The Beach bank is a pro-poor strategy in a sense that it is a self-financing development innovation that offers a comprehensive package of basic services for sustainable development and poverty alleviation among the poor in the rural areas along the shores of Lake Victoria. It is demand focus, borrowing heavily on the needs and experiences of the affected communities to boost the capital base of the fisher folk in the region. OSIENALA in launching the beach bank had a vision of having a community with good saving, investment and credit understanding that will catapult them to improve their livelihood and acquire economic independence by employing sustainable techniques to utilizing Lake Victoria resources. It aimed at realizing this vision by providing meaningful economic interventions in the Lake Victoria region in order to facilitate the communities to create wealth and improve their livelihood. Specific objectives of the beach bank are:

- To provide safe custody of customers savings.
- To provide access to credit facilities for the business activities of the fisher folk.
- To provide prudent and efficient management of the fisher folk savings with the aim of maximizing returns.
- To sustain a high level of professionalism in management and service delivery at all level of operation.
- To expose the fisher folk to viable investment projects through research on investment opportunities i.e. export of fish products, eco-tourism, fish processing and storage facilities and other non-fishing activities, i.e., hyacinth, bait making, netting and boat making.

- To provide affordable health coverage to the fisherfolk through linkages with health insurance providers.
- To initiate, enhance and sustain a savings and investment culture among fisherfolk and Lake Victoria basin communities through training.
- To use quality and cost effective technology that makes the Beach bank efficient, attractive and competitive.
- To formulate policies and guidelines that are transparent, accountable and protect and empower its employees to seek growth and self actualization.

The bank established its first branch at Nyandiwa on the 11th of April 2004. The start up capital and financing was from the internal resources of OSIENALA. This was followed by the opening of two more branches at Muhuru, Got - Kachola and Sori (Karungu) in December 2004. To date the Beach bank has a client base of over 1000 customers with over Kshs3 million saved and Ksh800, 000 lent out as loans to fisher folk. The bank is due to open the doors of its new branches in 2005 to the fisher folk of Port Victoria in Busia, , Usenge in Bondo, and Mbita in Suba district.

Limited internal financial resources has slowed down the pace of reaching the fisher folk in these part of the Lake basin as quickly as they desire. The Beach bank will have to rely heavily on external financing in the form of grants, in its first three to four years of its establishment, during which it will have developed systems, policies and products to sustain itself.

There are over 134,000 fishermen on the Kenya side of Lake Victoria. The beach bank is targeting approximately 50,000 of these fishermen in the next two years. This is a lower estimate on the backdrop of the continued demand by fisher folk for financial and banking services. The Beach bank continues to conduct community surveys to determine changing trends and needs of the fisher folk served. These surveys help develop financial products that are tailor made to suit the needs of these communities.

Some of the products offered at the current Beach bank branches include: Saving accounts, Short-term/week-end loans, Development loans, School fees savings and loans, Life insurance cover and Benevolent savings. However, in order to meet the objectives above, the Beach banks will have to reckon with lack of infrastructure at the beaches, reliable efficient transport for supervision and delivery of customers' deposits to partner banks, limited start-up capital to cover administrative costs and loans to customers as some of the possible challenges.

The Beach bank has developed partnership with the Post bank. Besides the current agreement of Post Bank securing customers money, the project is moving towards entering into product sharing relationships. Such relationship will include the use of electronic banking, support for product development, sharing client base for the Micro Finance Institutions (MFI) etc. The Beach bank is also in discussion with insurance providers to negotiate comprehensive cover for the fishermen and their gear. Already, the Beach bank is providing a much-needed service to create wealth and alleviate poverty in the Lake region basin by encouraging savings, investment and credit to the fisher folk. This is being achieved through capacity building workshops, training in credit and investment provision of improved fishing gear to competitive interest rates and prices and quick financial disbursement.

Systems are in place to ensure transparent and cost effective procurement processes, general management and accounting framework and personnel management systems that ensure hiring follows established procedures with in-built standards. The Beach bank is developing activity-monitoring system to strengthen areas of weakness. It should also create linkages with experienced partners to offer training and share experiences to shorten the organizational learning curve in this field of micro finance.

Economic Considerations of the project: Under normal, environmental and ecological conditions, fishing activities are seasonal, largely weather dependent. Traditionally, rainy reasons are normally characterized by flooding and higher fish catches (March–July and September–December), while the dry seasons are characterized by lower fish catches (January - March and July to September). This climatic conditions provide the MFI with opportunities to tailor make financial products to suit customers' needs. The majority of the fisher folk have school age children. The months of January, April and September are key to the fisher folk to have access to financial resources. These are months when demands on resources are high because of school fees, while returns are low from fishing activities. The Beach bank will develop credit, investment and saving products that specifically cater for school fees.

Besides school fees programme, the beach bank has developed a credit product that will allow fisher folk access credit for the purchase of the solar lamps and driers (see, e.g., Subsect. 7.4.5 in p. 237).

Social considerations: Changes in attitudes and behaviour will emerge as individuals accumulate wealth. There will therefore, be a need to satisfy their newly acquired needs, wants and desires following accumulation of wealth. Families will improve their homes. There will be more children going to school as house holds economies become stable. The Beach bank will have to keep a breast of these emerging trends and produce financial products and other socio-economic interventions to address them. Improvement in fishing gear may increase social reforms and security measures put in place.

As fishing becomes organized there are indications that, non traditional fishing populations are beginning to shift towards the beaches and engaging in direct fishing activities or influencing the behaviour of the fisher folks, e.g., communities of Somalia origin. This is keeping the local fishermen active and in competition. There is demand for improved infrastructure to accommodate the changes in population. The new immigrants are attributed to a wave of awareness and demand on banking services and products.

Political/Legal considerations: The Beach bank will continue to operate as a project with separate and unique financial systems. However, as the Beach bank grows and expands, it needs to develop legal status and stature of a stand-alone entity. This will only occur if it is planned for at the outset and gradually implemented with the growth of the institution. Accounts will be set up for each Beach bank branch for effective monitoring of their performance individually. The interest rates are set at 20% per annum which is calculated to cover costs of doing business. However, the market is being monitored regularly with the aim of reviewing interest rates when necessary. This will keep the beach bank attractive and competitive. Research needs to be conducted to establish safe investment opportunities with high returns for a percentage of the savers moneys. This will defray some of the administrative costs while keeping the customers money relatively safe. Keen interest will be kept on government development plans and schedules of implementation of specific projects impacting the beach bank. This will aid the beach bank adjust its strategies to remain competitive and benefit from government development resources.

7.4.3 Molasses Plant

Perhaps the thorn in the flesh for the people of Kisumu in Kenya is the *Molasses Plant* (see, e.g., Fig. 7.1) that was anticipated to create employment for thousands of people in the region and improve the standards of living. The former Minister for Foreign Affairs and International Cooperation *Dr. John Robert Ouko* did champion for the revitalization of the stalled Molasses Plant with the hope that it would improve the standards of living of the people around Lake Victoria but unfortunately was killed before he could accomplish his mission. Since 1997, there was another attempt by prominent Luo politicians in the region led by the then KANU Secretary-General and former minister for Public works in the Narc government *Hon. Raila Amolo Odinga* to have the *Molasses Plant* revamped. Currently, the plant is operational. It is hoped that once fully operational, the Molasses plant will create jobs and contribute to the fight against poverty in the region.

Fig. 7.1. Molasses Plant in Kisumu, Kenya

7.4.4 Information and Broadcasting: Radio Lake Victoria

The issues facing the basin are largely specific to the lake and its environs. Many are not perceived as particularly significant from the nations' points of view. The division of Lake Victoria between the three

East African Countries has so far worked against it–and against its dependents. Recent initiatives by the EAC in this respect are very encouraging, but cannot stand alone. They need to be communicated, explained and discussed among the communities around the lake in an open and inclusive manner.

The need to inform and educate the communities, on their rights and obligations, on environmental issues, on the absolute need to resolve conflicts peacefully, on opportunities and best practices, on matters of health, on a host of issues, is crucial. FM radio is uniquely suited to the task, but currently, no media cater for the Lake Victoria Basin and its issues specifically, either at the national levels, or regionally.

OSIENALA has previously made use of existing FM stations to address and assist its beneficiaries directly, with information and capacity building programmes. The feedback from the beaches, from individuals and organizations involved in utilizing the lake, has been uniformly positive. It has, however, also been very costly. It is in this endeavor that OSIENALA launched the *Radio Lake Victoria FM 92.2* in order to build and maintain strong national, regional and international links, and to stay in close contact with the ground at the same time. OSIENALA's universally recognized role, as the coordinating body of the region requires that the organization can handle and disseminate large amounts of information.

The requirement goes well beyond partner organizations, authorities, etc. An ongoing informational effort towards the fisher folk and the general public is a prerequisite for its involvement in – and influence on – the solutions to the issues of the Lake Victoria Basin. With its experience in capacity building on the ground, long-standing commitment to the issues at hand, independent position, international and regional network, regional perspective and vertical approach, together, OSIENALA and its Radio Lake Victoria FM are in a unique position: to facilitate dialogue, to collect and process a multitude of information, and to disseminate the result to its constituency specifically, as well as to the broader public of the region.

Radio Lake Victoria

Radio Lake Victoria (RLV) FM (Fig. 7.2) is an independent, non-partisan and non-profit community radio. As such, it reserves the right to comment and criticize any matter of public importance in a fair and balanced manner. It operates from Lake Victoria Centre for Research and Development, located at Dunga Beach near Kisumu, Kenya. AFEW (USA) has kindly provided most funding for this initial set-up. A license to broadcast was provided by Communications Commission of Kenya (CCK) and a broadcast frequency. RLV FM allocation covers the nine Kenyan Districts bordering Lake Victoria and even extends to neighbouring districts Uganda and Tanzania.

Fig. 7.2. OSIENALA's Radio Lake Victoria Mast at Kiboswa, Kisumu

The initial setup will give RLV FM valuable experience in community FM radio operation, and initiate the ongoing dialogue with its constituency about its services. However, it will not allow full scale radio production, with the separate recording and editing facilities this entails. Developing the facilities further – both to professional level of operations and to ensure long-term sustainability – is therefore a priority. RLV FM hopes to extend its operation to the whole Lake Victoria Basin. This will be achieved through extending RLV FM's own area of broadcast, and through co-operating and networking with relevant radio stations and other media operators around the lake, a process that has already been initiated with promising results.

7.4.5 Renewable Energy for Fisherfolks of Lake Victoria

Paraffin is a Lake Victoria environment pollutant. Continued use of this fuel is not recommended. High fuel prices, especially of paraffin, which is widely used in Omena fishing, have a multiplied effect on the economy. It increases the price of Omena consumed by the poor and Omena and it's bi-products in the livestock feed industry. There is need to look for alternative sources of energy. OSIENALA has introduced solar lamps and driers technology for the fisher folk. This project, which

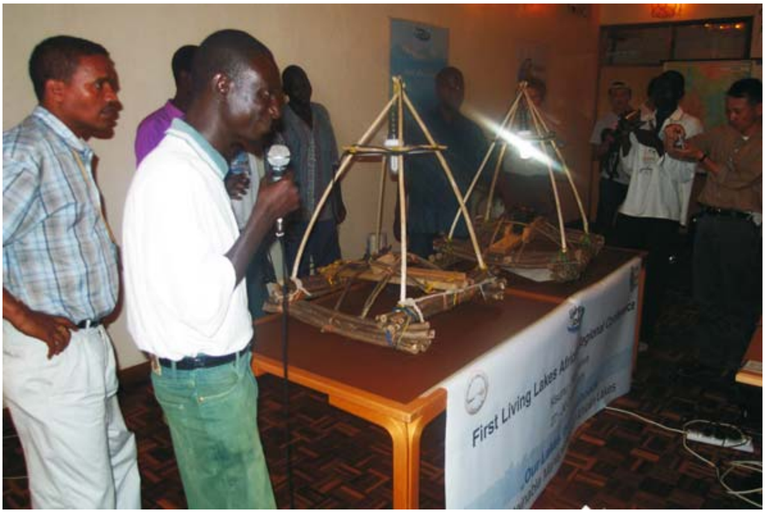

Fig. 7.3. OSIENALA's solar lamp project supported by the Global Nature Fund

involves research, training programmes, setting demonstration sites and campaign for adoption had five components:

1. Solar light for Omena fishing.
2. Establishing Charcoal Cooler Systems at the lake beaches.
3. Setting Solar Water Pumping and Filter System.
4. Establish Fish Smoking Kilns.
5. Hand-operated Sawdust and Biomass Fuel Briquette Machines.

The project target fishers within the riparian countries surrounding Lake Victoria and experts from other lakes that could find it possible to replicate the technology in their lakes. The Objectives of the Project are:

- To reduce the emissions of greenhouse gases into the atmosphere.
- Reduction of the consumption rate of wood fuel and consequently reduce the destruction of tree.
- Reduction of health hazard to mostly women who use wood fuel for smoking fish.

- Improve the standard of living for the rural communities and enhance the fishermen's economic power.

In the *first* phase of the project, OSIENALA received in December 2004, 20,000 EURO from Global Nature Fund (GNF) and the project kicked off by purchasing lake transport in January 2005. Training courses were organized and 33 fishers attended. Solar Hardware bought and research on the correct solar lamps started.

The *second* phase of the project concentrated on the research for appropriate solar lamp to be used by the fisher folks, as this was most technical part of the project. There was also going to be sensitization of the communities to prepare them for the implementation and setting pilot sites and training of the communities. This phase aimed at replacing the currently used Pressure Lamps, and thus:

1. Providing the fisher folk with access to efficient and affordable energy sources and thus reducing poverty through increased incomes. Initially the fisher folk are spending millions of shilling in buying paraffin that are being used on daily basis.
2. Reducing pollution of the lake from Paraffin spillage from the paraffin's pressure lamps.
3. Facilitating access to simple and affordable energy source for the fisher folk.

This project concentrated much on Omena fishing because it was realized that the fish (Omena) is the main source of food for many rural communities around Lake Victoria. It is also used for making animal feeds hence developing rural industries. Studies show that Omena is really a fun of lights. This dictates the time for fishing. During daytime, the fish is scattered everywhere in the lake because of too much light from the sun. At night, the fish is attracted by light that makes it much easier to scoop with nets by the fisher folks. Light also attract several insect that Omena feeds on. The fishers normally uses pressure lamps.

Fishing of Omena is done away from the lake shore. The lamps are left in the water with the floaters. The attracted fish is then surrounded very fast using a net and scooped out of the water. It is the most currently used method. Sometime the lake turns very rough and stormy and most of the pressure lamps are put off by storm. It has been discovered that solar lamps are storm proof; they survive even the heaviest storm.

Field trials were undertaken using solar lamps and a comparison to pressure lamps (which are normally used) done. The following results were obtained:

- The D.C Solar Lamps are much better than the pressure lamps. The Brightness is constant for at least 20Hours working. The Omena fishing is done for 7–9 hours depending on the strength of the darkness or the moonlight. Normally, the fishing of Omena is done as from 6pm - 5am. And during the field trials, the solar lamps and the battery worked perfectly for those hours with constant brightness. The pressure lamps brightness is not constant and it requires that the fishermen must pump the more pressure to keep it brightness.
- The strength of solar light is "cool" and the intensity penetrates deep in the water depth. When compared to pressure lamp, the strength is "Hot" and its intensity is not that deep. The light intensity is a good factor in fishing because the fishermen are trying to fish in deep water and away from the shore. Because of heat generated by pressure lamp allot of insects die. The smoke from the pressure lamp is also dangerous to the fishers.
- Solar lamps have less servicing parts. The bulb can be bought and fixed incase it is faulty. The pressure lamps must be serviced every working day. The cost of servicing the 5 lamps for each boat costs much to the local fishermen.
- The consumable cost is extremely reduced when using the Solar Lamp. Only the cost for charging the battery is incurred by the fisherman. The cost is extremely reduced compared to litres of paraffin burnt per day by the fishermen.

The project was highly welcomed by the fishermen. It is recommended that the project to be done regularly to ascertain the life span of the batteries and solar bulbs.

7.5 Concluding Remarks

The Lake Victoria region is endowed with abundant natural resources and fisheries. It is rich in agricultural soils and forestry resources. Yet the region is characterized by poverty. On the Kenyan side, the region is known as the belt of poverty. Clearly, urgent steps must be taken to rid the region of poverty. This implies that the resources of the region should be utilized for the benefit of the people in the region. A good starting point is to adopt a collective approach by the three riparian states through the East African Community. Presently the government is working on a fish road intended to accelerate the development of the beaches on the Kenyan side of Lake Victoria. The fish road commonly referred to as the ring road should be followed by a power supply to enable the fishermen build cold storages for fish preservation. It is envisioned that these two major developments will be followed by other important investments such as tourism and banking.

Lake Victoria and its environs have enormous development potential and investment opportunities. In recognition of this attribute, the Lake and its environ have attracted local, regional and worldwide attention during the past three or four decades. The Lake itself and its surrounding attract enormous attention. The sheer enormity of the waters of the Lake, the large and expansive nature of the Lake itself, as well as the blending of the surrounding environ with the exuberance of the evergreen vegetation provide aesthetic beauty and awe at the same time. Some possible and potential areas for major investments in the Lake region are agriculture; rice, sugar, cotton and oil crops production. Fish processing industries, Lake transport connecting major ports of Lake Victoria and tourism development amongst many other areas.

At the local scene, Lake Victoria provides benefits to the communities being a source of livelihood for over 30 million people. It is the source of rich proteins from fish; water for domestic and industrial use and for farming and irrigation. The Lake also provides excellent sites not only to the generations to come, but also to present domestic and foreign tourism.

Besides, the environs of the Lake provide yet another set of endowments. The soils surrounding the Lake are fertile for various kinds of agricultural production. Moreover, the climate and the rainfall are usually adequate for crop production, and livestock rearing.

The concerns of the international community have been centered on the Lake itself as a source material for scientific study - its origins, composition, pollution, and fisheries. The additional interest among the international community in the Lake is due to the fact that *it is one of the most important reservoirs of fresh water in the world.* The changes in the Lake are therefore necessarily of interest to scientists of different kinds.

Recently, with the introduction of the Nile Perch into Lake Victoria, there has been a spate of intense competition among foreign fishermen to reap huge benefits from the exports of the Nile Perch. The Perch is in great demand for various uses in the European Union countries, Japan, Canada, the Middle East, and the United States of America.

Finally, there is both local and international community interests in the Lake because of yet another reason. The Lake's health is being threatened by pollution, water hyacinth, environmental degradation and depletion of fisheries resources. Thus, academicians, policy makers and scientists are deeply interested in studying the Lake to find out what could be done not only to restore the health of the Lake but also to ensure its sustainability.

The Lake region is also of intense interest to the international community and to the locals alike because the region offers a paradoxical situation, or a contradiction, whereby there is abject poverty in the midst of extreme natural resource endowment including human beings. This paradox is all the more perplexing given the fact that more than eight billion Kenya Shillings (Kshs 8 billion) are earned annually from the fish exports. Thus, the interest of researchers is to try to solve this apparent contradiction.

8

Rich Wetlands of Lake Victoria

"*We often think of wetlands as being an uneconomic use of land, but IUCN studies in Africa, Asia and Latin America have shown again and again that wetland's goods and services actually have a very high value, and this underlines the need for their conservation and sustainable use*" Ms. Lucy Emerton, Head of the IUCN Asia Regional Environmental Economics Programme.

8.1 Introductory Remarks

Wetlands have been defined as a wide variety of habitats such as *bogs*, *Fens*, *Swamps*, *wet meadows*, *marshes*, *peatlands*, *flood plains*, rivers and Lakes and coastal areas such as *salt marshes*, *mangroves* and *seagrass beds*, *coral reefs* and other marine areas no deeper than six meters at low tide, as well as man-made wetlands such as *wastewater* treatment ponds and reservoirs. A simplified definition of wetland is that it is an area where the land is saturated with water long enough to support and that do support poorly drained soils, plants and animals which have been adopted to such environment, and biological processes suited to wet areas. Of the habitats mentioned above, bogs refer to wetlands which are formed where organic matter have accumulated for a long time and water input is entirely through precipitation. Fens are peat producing wetlands which are influenced by soil nutrients flowing through the system grasses and sledges. Swamps are mostly depicted as water logged areas while marshes are vegetation dominated by sledges and reeds.

The Ramsar International Convention on Wetlands of 1971 advocates for the wise use of wetlands by national action and international co-operation as a means of achieving sustainable development throughout the world. Article 3.1 of the convention states that contracting parties shall formulate and implement their planning so as to promote the conservation of the wetlands and as far as possible the wise use of the wetlands in their territory. In this regard, there exists a Kenyan definition of wetlands.

Indeed, a recent study by [34] demonstrated the high economic value provided by the wetlands of our world. In the study, the Muthurajawela Wetland in Sri Lanka was found to provide benefits at a total value exceeding SFR 10 million, or US$ 7.5 million, per year. This therefore means that wise use of wetlands is their sustainable utilization for the benefit of humankind in a way compatible with the maintenance of the natural properties of the ecosystem.

8.2 Management of the Lake's Wetlands

The wetlands of Lake Victoria comprise about 37% of the total surface area of wetlands in Kenya and about 13% of the same in Uganda. The Lake is fringed by an extensive system of swamps and wetlands, which provide habitat to a host of wildlife species. Many of the rivers and streams are fringed by swamps and often empty into the Lake through vast swamp ecosystems. The Lake is also known to contain unique plants, algae, zooplankton and invertebrates. Wetlands around Lake Victoria are increasingly threatened by agricultural activities and grazing, leading to the loss of biodiversity and reducing the capacity of wetlands to filter and reduce the amounts of pollutants reaching the Lake [15]. Lake Victoria's Wetlands filter nutrients and silt loaded water by incorporating them into the tissues of wetland plants, accumulating them as sediments or by releasing Nitrogen into the atmosphere through denitrification in the root zone of the aquatic plants. The loss of wetlands also influences the hydrology of the catchment area thereby increasing the risk of flooding and erosion.

8.2.1 Economic Values of the Lake's Wetlands

The freshwater wetlands in Lake Victoria basin constitute an important natural resource base upon which the riparian communities depend. They are important in terms of food production, hydrological stability and ecological productivity. While Lake Victoria's wetlands support significant components of biodiversity and are important for socio-economic reasons, they have continued to be under increasing pressure from human activities, such as *conversion for agricultural purposes*, *water pollution* and *destruction of vegetation*. This led the Global Nature Fund to declare it the "*threatened Lake of* 2005" at the world wetlands day on 2nd February 2005. Although research has been undertaken to address gaps in knowledge of wetlands and develop suitable ways of monitoring and managing them in the Lake Victoria basin, a lot more still is unknown.

The wetlands in the Lake basin have found various uses which include:

1. Rainfall formation through evapotranspiration. Water lost through evapotranspiration contributes towards cloud formation and subsequently falls as rain. Wetlands therefore contribute towards balancing of the hydrological circle maintaining both surface and underground water supply.
2. Contributes to weather and climate. Other than contributing to rain formation as stated above, wetlands' contribution to water vapour leads to humidity, increase in greenhouse gases and also in breaking the speed of wind. Their use of CO_2 on the other hand ensures reduction of the greenhouse gases and thus regulating temperature.
3. Being source of goods and services for the riparian communities, i.e., sources of raw materials, handicrafts and fuel. Forested wetlands for example are a source of commercially valuable timber.
4. Supporting fisheries, grazing and agriculture. The Lake's wetlands provide breeding places for mud fish, lung fish and Tilapia. Tilapia fish normally comes in the cool wetlands to bread.
5. Providing outdoor recreation and education for human society, i.e., fishing, hunting, boating, plant identification, scientific study, and wildlife observation etc.
6. Providing habitat for wildlife, especially waterfowl, shorebirds, and other birds which depend on wetlands. This is achieved through the provision of essential water, food, cover, and reproductive areas for wildlife. In areas that are semi-arid, riparian wetlands are crucial to the survival of many wildlife species.
7. Being a source of water and food production during the dry season. Because of their high productivity, wetlands also provide essential food chain support. During dry periods, vegetable and other food

crop can be planted in the wetlands without necessarily destroying them.

8. Through its effective removal of Nitrogen, phosphorus, certain chemicals, and heavy metals from water, wetlands contribute to purification of water which subsequently leads to improved water quality through the filtration process.
9. Some parts of aquatic plants found in the wetlands are edible. These include for example, *Commelina berghalensis* whose leaves and young shoots are edible, rhizomes from *Nymphaea caerula*, leaves from *Ipomea aquatica* and leaves, stem and seeds from *Portulaca oleraceae.*
10. Some plants are of medicinal values. These include, for example, the roots of *Polygonum pulcheria* which are used to treat tropical ulcers, leaves of *Pentas longiflora* which are used to treat fever and *Adenia umicifolia* (whole plant) which is used to treat neurotic illness.
11. Wetlands reduce flood velocities, erosion erosions, and trap water-borne sediments and in so doing control erosion and sedimentation.

8.2.2 Lake Victoria's Wetlands: Overexploitation

Fig. indicate the green wetland along the Lake shore which has not been tempered with. Fig. is a contrast showing a wetland that has been cleared to pave way for sand harvesting and agricultural activities.

Naturally, wetlands will thrive on their own. Their development is however normally hampered by human activities as depicted in Fig. 8.2. These interference by humans normally reduce the sizes and biodiversity as well as the aesthetic value of the wetlands. These activities include:

- Agriculture activities e.g., clearing wetlands for cultivation, application of pesticides and other agro-chemicals and overgrazing. These have the negative impact on the remaining wetland through nutrient loading associated with runoff of fertilizers, pesticides and soil erosion. In addition to nutrient loading on the wetlands, shallower ones have been put under intensive cultivation for crops such as sugar cane and yams leading to the depleting of the remaining few wetlands. Some of the wetlands have become unproductive after two years of drainage for agriculture and are abandoned. Reclamation has been observed to lead to a reduction in the number of permanent springs and a low ground water yield in the wells.

Fig. 8.1. Virgin wetland along Lake Victoria

Fig. 8.2. Destroyed wetland along Lake Victoria. This figure is a pale shadow of Fig. 247

- Urbanization which brings with it constructions, e.g., for roads, dams etc., leads to demand of space causing deforestation to obtain cultivable land, wood fuel and other craft products.
- Planting of exotic plants.
- Harvesting of wetland plants for construction and production of furniture, fuel etc. At Mukona, Mpigi and Amsha districts and Sango

Bay in Rakai district of Uganda, deforestation of wetlands to obtain fuel has been reported.

- Fish farming and smoking activities.
- Sand, gravel and clay harvesting for housing construction and the excavation for brick making. In Chap. 3, Sect. 3.5, we did indicate in Fig. 3.13 in p. 75 how sand harvesting along the Lake devastates the environment. In Fig. 8.3 in p. 249, the wetland has been cleared to pave way for sand harvesting. It can clearly be seen how sand harvesting has completely affected the wetlands and the environment where in Fig. 3.14 of p. 76,the pits left open attract vector borne disease causing mosquitoes and snails. The situation is similar in Kyetinda wetlands in Kampala, Uganda.
- Dumping of waste water and illegal dumping of garbage as seen in places close to Luzira prison, Masese swamp, and Walugogo valley in Iganga town in Uganda.
- During dry seasons, many people do burn the wetlands to pave way for agricultural activities (see, e.g., Fig. 8.4 in p. 249). The consequences of swamp burning are not known but it poses a big threat to biodiversity some of which might not be fire tolerant and also leads to replacement of natural wetland vegetation as depicted in Fig. 8.5 in p. 250.

As already mentioned, in Kenya, the wetlands of Lake Victoria constitute about 37% of the total surface area of wetlands (2,737,790 ha) in the country. The largest in Kenya is the Yala swamp which covers an area approximately 21,765 ha inclusive of water surface of Lake Kanyaboli,Lake Nyamboyo and Lake Sare[1]. Those that are adequately protected are found within the national parks area. Various swamp forests especially outside gazetted areas are unprotected. These particular wetlands are threatened with total destruction due to degradation by the high population. Although Uganda's wetlands are protected, 75% of the wetland area has been significantly affected by human activity and about 13% severely degraded.

The Yala, Nyando and Sondu-Miriu swamps on the Kana plains are being drained for agriculture. It is estimated that at least 14,000 ha of the Yala swamp can be made productive. By 1980, 380 ha had been converted for rice production. On the Kana plains, 900 ha had been converted for rice and sugar cane production. Recent data indicate that 2,300 ha of Yala swamp in Siaya district were reclaimed by Dominion

[1]The standard, 14th December 2005

Fig. 8.3. Wetland cleared along Lake Victoria to pave way for sand harvesting

Fig. 8.4. Burnt wetland along the shores of Lake Victoria

Farm Ltd, an affiliate of Dominion Group of companies based in Olkahoma, USA. This area of reclaimed land were support the cultivation of rice. In a full page paid advert by the Kenya Land Alliance (KLA)

Fig. 8.5. Destroyed ecology following the burning of wetland along the shores of Lake Victoria

however, serious questions are being raised as to weather this wonderful resource is not being pushed to extinction. In part, KLA writes

> In the circumstance, KLA is constrained to conclude that the activities of Dominion Farms (k) Ltd in Yala swamp are environmentally degrading and destructive of Kenya's largest, rich and fragile wetland (ecosystem) in the name of development. We call upon the government to stop immediately the operations of Dominion Farm (K) Ltd pending...

[2]. Wetlands associated with River Nyando are also rapidly shrinking because of human encroachment while the Sondu-Miriu delta is likely to experience severe ecological changes due to damming of the river to generate hydro-electric power through the support of the Japanese government. In Uganda, Munyonyo beach (see, e.g., Fig. 4.1 in p. 91) was built at the expense of wetlands for the purpose of eco-tourism.

A range of plants such as the common reed (*Phragmites australis*) and the reedmace (*Typha latifolia*) has shown the property of breaking

[2]Kenya Land Alliance (KLA): "Poverty reduction or the creation of environmental disaster: Dominion Farms (K) Limited and Yala swamp", The Standard, Wednesday, December 14, 2005

waste water, removing disease causing micro-organisms and pollutants. They have a large biomass both above and below the surface of the soil. The substrate plant tissues grow horizontally and vertically and create an extensive matrix, which binds the soil particles, and create a large surface area for the uptake of plant nutrients [134]. Wetlands act as filters of nutrient and silt loaded water. For example, papyrus swamps have been observed to take up and accumulate considerable amounts of ions in the effluent. Silt is adsorbed with nutrients. They thus play a crucial role in preventing eutrophication in the receiving waters. Other nutrient related roles of the wetlands. Degradation and drainage of wetlands will increase carbon dioxide emissions, burning will add phosphorus to the system, and agriculture usage will results in up to 50% soil organic carbon.

8.2.3 Sustainable Management of Lake Victoria Wetlands

The communities living along the Lake basin combine both fishing and farming activities. Awana beach in Kenya has proved a good example of how management prowess of wetlands can yield good fruits. In dry or wet seasons, the inhabitants of Awana have plenty to take to the market, thanks to the good management of their wetlands. Indeed, the many functions that wetlands provide make *protection*, *restoration*, and *wise management* of wetlands important to the Lake inhabitants. While managing the wetlands, decision makers (e.g., Lake authorities, municipalities, fisheries departments etc.) should ensure that the Lake's wetlands are not converted into upland. The goal in managing wetlands, therefore, is to avoid activities that may convert the wetland to upland and to manage site alterations to retain the benefits provided by the wetland [161]. This therefore calls for incorporating the inhabitants surrounding the wetlands in all wetlands management programmes. Community based organizations can be set up and environmental awareness taught. Regular seminars can also be organized where people meet and exchange ideas.

Due to that fact that wetlands change in a variety of ways, where some changes are inevitable, as landscapes are changing all the time, the key to managing wetlands and woodlands is to plan carefully and thoughtfully, and to be aware of the affects that the planning activities will have on the landscape [161]. It is further noted in [161] that while some changes are natural, this may not be the case for others, or the changes may be accelerated by the activities of people. Some wetland sites may be so sensitive, and so difficult to reforest, that one may consider excluding them from one's harvest plans. As was pointed out at the beginning of this chapter, wetlands are defined by the amount of saturation of the water in the soil. The amount and duration of this water at a location affects soil development which in turn, affects the plant community characteristics. Just as specific water, soil, and vegetation characteristics define a wetland, they are the same characteristics that must be managed with care in order to maintain the functions and values of wetlands [161]. Some potential forest practices disturbances to wetlands have been pointed out by [161] to be:

- Alteration of hydrologic functions.
- Soil disturbance.
- Introduction of invasive plant species.
- Changes in the microclimate due to vegetation removal in and around the wetland.
- Alteration of habitat through the removal of vegetation, snags, and downed wood.
- Reduction of woody species or woody debris that simplify the composition, structure, and stability of wetlands.

For management techniques, [161] list forestry activities which demand careful planning to minimize damage to wetlands as; road and landing constructions, heavy equipment use in and around wetlands, reforestation, and harvesting.

8.2.4 Conservation Measures

Conservation of wetlands is necessary as they have the ability to sequester carbon and also tend to shift to net sources of greenhouse gases when perturbed by land use change such as drainage for agriculture or forestry. In this way they help in preventing *global warming*, consequent *climate change* and its ecological effects on the environment. They have an inherent capacity for storage of carbon. Therefore restoration of wetlands should be considered as a part of the effort to increase carbon sinks in agricultural and forest landscapes. It is thus essential to prevent the conversion of wetlands for other uses. Conservation positive policies and programs are required that recognize the full spectrum of intrinsic values of wetlands. The objectives of conservation and management of wetlands therefore encompass:

- Strengthening institutional and administrative structures for wetland management and conservation.
- Putting in place policy and legislation for wetland conservation and management.
- Enhancing knowledge and understanding of wetlands and associated ecological process, developing and disseminating methodologies for conservation and sustainable use of wetlands. This as already stated can be achieved through the use of community based organizations, seminars, etc.
- Improving awareness and knowledge of and support for wetlands conservation at all levels.
- A multidisciplinary unit to provide technical services to the central government, districts and local communities.
- Outline guidelines for conservation of wetlands.

Inline with the community based wetlands management and conservation, pilot projects can be carried out, e.g., on fish farming, craft making, bee keeping, and eco-tourism ventures to ascertain whether they conform to the recommended standard. There is need to promote production of booklets, posters, calendars, brochures to promote education and awareness of stakeholders and the general public. Use should also be made of radio (e.g., Radio Lake Victoria discussed in Subsect. 7.4.4 in p. 235) and TV to further propagate wetlands conservation measures. Training should be carried out for participants at various levels (e.g., NGOs and local resource users). OSIENALA already has a documentary VCD on wetlands.

Research need to be carried out on the wetlands in general. Efforts have been made in this direction as seen by the Research on Lake Victoria (VicRes)'s 2005 theme which was on wetlands. Through such research, various aspects e.g., level of carbon sink, rates of nitrification/denitrification, net ecosystem of biomass etc., will be unraveled. Long-term monitoring of wetlands is essential to all aspects of their conservation and sustainable use. It is an imperative prerequisite to the understanding, protection and enhancement of wetland ecosystems as carbon sinks.

International organizations have played a major role in research, conservation and socio-economic development. Their primary role has been to implement government policies and obligations to international conventions and agreements in their areas of interest. They are involved in areas of research, conservation, use and management of wetland resources. Studies by LVEMP show that the larger wetland fringes of Lake Victoria have significant buffering capacity against land based pollution. The wetland component of the programme has been carrying out research on wetland biodiversity, resource use patterns and buffering capacity of the riparian wetlands.

The studies on community utilization of papyrus and grass reeds for handicraft in Busia and Nyando districts also demonstrated that small business enterprizes based on the exploitation of wetland products are viable and can help create employment and alleviate poverty [48]. ICRAF has studied the role of Lake Victoria wetlands as sinks of sediment and other pollutants from the Lake's watershed. Preliminary results indicate that the Nyando River catchment has high erosivity and that the river transports large silt load to Nyakach bay. ICRAF has also been promoting agro-forestry and soil erosion control activities in the Lake basin.

The American Zoos and Aquaria Association (AZA) have conducted research on the assessment and conservation of indigenous fisheries. Their findings indicate that wetlands contain a more diverse fauna of indigenous fish species than Lake Victoria. Some of them like the New England Aquarium have conserved some of the haplochomines from Lake Victoria. IUCN instituted studies on the compilation of biodiversity and socio-economic data on fisheries and conducted a series of training workshops. Despite all these studies, there is a wide range of knowledge gaps, which needs further actions. These are[3]:

- The significance of wetlands as an integral and vital part of Lake Victoria ecosystem is not fully appreciated. Little attention has been paid to wetland research. There have been delays in incorporating wetlands in national legislations.
- Existing open access system, lack of official resource use guidelines and the government policies of reclaiming wetlands for agricultural production negate conservation.
- Researchers have paid little attention to assessing and documenting ecosystem values of wetlands such as filtering water and processing pollutants, source of valuable products such as fish, waterfowl and medicine.
- Raw or semi analyzed data, e.g., reports, dissertations, manuscripts and technical reports.
- Limited publication of work in journals.

[3]Getabu, Pers. Comm.

- Fragmented socio-economic studies not linked to ecosystem values of wetlands. Sustainability of human activities not linked to wetland health.
- Findings of biomedical research in wetlands do not filter into the local communities to help them prevent infection.
- Few wetland studies included gender and cultural values.

The following actions are essential for proper management of wetlands.

1. Pilot investments in the sustainable management of wetland products. This will go a long way in alleviating poverty among poor fishermen.
2. Identify and demonstrate practical, self sustaining remedies on wetlands.
3. Establish mechanisms for co-operative management of resources.
4. Maximize the sustainable benefits to riparian communities from using resources within the basin to generate food, employment and income, supply safe water, and sustain a disease free environment.
5. Build capacity for ecosystem management among institutions and riparian communities.
6. Conservation and development of wetlands.
7. Provide the necessary information to improve management of the Lake ecosystem.

8.3 Conservation of Biodiversity

The Lakes shoreline is long and convoluted, enclosing innumerable small, shallow bays and inlets, many of which include swamps and wetlands, which differ a great deal from one another and from the Lake itself.

8.3.1 Birds

The Lake Victoria basin is habitat to 34 endemic waterfowl and migratory species. Conservation activities have included direct protection of bird types and habitat protection. Efforts have involved organizations for example East African Wildlife Society, National Museums of Kenya, Kenya Wildlife Services, World Wildlife Fund, Wildlife Clubs of Kenya, Bird watch groups and Community Based Organizations

(CBOs). Protected habitats include Important Bird Areas (IBAs) such as Lake Nyamboyo and Usenge.

Dunga wetland close to Kisumu City is one of the habitats with richest biodiversity. Out of the 34 endemic bird taxa, 25 are found in it. However, the wetland is currently threatened with destruction due to the expansion of Kisumu City and with its agricultural activities. Its conservation is therefore a matter of great priority.

Fishing birds such as gulls, terns, pelicans, kingfishers and cormorants are abundant in the mouths of rivers Sondu-Miriu, Kuja-Migori, Yala and Nzoia. Rocky beaches with clear sandy waters host plenty of cormorants, little egrets and African fish eagles. This can be attributed to the fact that the visibility allows the birds to capture prey with little effort. Rivers Yala and Sondu-Miriu are home to some of the candidate species for conservation such as the papyrus gonolek (*Luniarus mufumbiri*), the papyrus yellow warbler (*Chloropeta gracilirostris*) and the Madagascar Squaco heron (*Ardea idea*). Plovers, sandpipers and stilts dominate the water edge community on sandy beaches along the Lakeshores. Those dependent on emergent vegetation include herons, storks, cranes and passerines (warblers and weavers).

8.3.2 Other Vertebrates

The Hippopotamus amphibius (see, e.g., Fig. 4.19 in p. 110), Sitatunga and Sykes monkeys, foxes, hares, hyenas, mongooses, wild cats, moles, rats, leopards, warthogs have been recorded. Others include water turtles, aquatic snakes and monitor lizards, crocodiles, rodents and otters. Most of them have been recorded within the Nyanza Gulf.

Conservation of biodiversity should be aimed at the rehabilitation of the Lake ecosystem for the benefit of the people who live in the catchment, the national economies of which they are part and the global economy. There is need to identify the type, nature and extent of the main factors affecting aquatic bio-diversity and propose intervention measures.

The overwhelmingly positive contributions of the current efforts by the governments in East Africa and a number of NGOs will bring environmentally sustainable development of the basin.

8.4 Concluding Remarks

The chapter has outlined important functions played by wetlands and measures that are useful for the protection and sustainable management of the Lake's wetlands. Basic information about wetlands and management techniques that protect the functions and values of these lands are essential for the survival of the few remaining wetlands of Lake Victoria. For interested readers, we refer you to the Wetland research in the Lake Victoria basin: Analysis and synthesis I[4].

[4]Edited by Okedi J, Ogutu ZA and Okeyo Owuor JB, Lake Victoria Research (VicRes) initiative (undated)

9

Management of Lake Victoria

"Rich Fisheries, Poor Fisher folk" International Union for Conservation of Nature (IUCN)

9.1 Introductory Remarks

Probably, the greatest threat to the Lake's management is the lack of unified policies governing the riparian communities surrounding the Lake. The existing policies pertaining to water resources, agriculture, livestock, and forestry within the three riparian countries do not pay particular attention to the issues of lake management or trans-boundary water resources management. Instead, this role is being undertaken by the East African Community (EAC). The EAC is currently spearheading harmonization in policies regulating the fishing sector, thanks to the stringent regulations laid down by the European Union on fish export from Lake Victoria. Besides the fishery sector, other aspects of lake management are national based and uncoordinated. This has hampered uniformity of data upon which managerial decisions could be taken. Policies on industrial pollution of the Lake for instance differs from country to country with reliable data on the same lacking in some cases.

Other than the EAC as the main institution managing issues of Lake Victoria by the three riparian countries, Lake Victoria Fisheries Organization (LVFO) also deals with management issues of the Lake. The main donors for projects within Lake Victoria have been international institutions, e.g., World Bank, SIDA, DANIDA, UNDP, GEF and others, which have led to realization of projects such as LVEMP, Lake Victoria Fisheries Research Project (LVFRP), and Nile Basin Initiative (NBI).

9.2 Management Issues

Within the Lake basin, the management issues revolve around managing the resources within it in a sustainable manner. In Chap. 3, we presented an extensive coverage of the resources. Among the resources, fish appears to be of great concern probably due to its economic value in the region. In this regard, traditional or pre-colonial management system was based on territorial user rights, which coupled with limited fishing pressure ensured effective management of the resource for the good of the entire community [111]. These management system included:

- Clans occupying riparian zones had full authority to oversee and played a central role in the control and management of fisheries resources.
- Some of the beaches were named after the clans, which managed the zones, e.g., Nyamware, Osieko and Kaloka.
- The authority of the clan in regulation of fishing was respected by all persons in the community.
- Only people above 20 years were allowed to fish but not children.
- Punishing of the offenders was done within the community and in most cases the penalties were predetermined for each offence.

Contrary to the traditional management approach, the current management system which is a perfect way of stripping the resource from the local people and marginalizing them – a perfect way of perpetuating poverty from one generation to the next– has the following characteristics [111]:

- Fishery has been heavily commercialized with little or no regard to conservation.
- Currently, many young people who dropped out of school due to lack of school fees are engaged in subsistence fishing.
- Uncultured fishing methods leading to the scenario where poverty is looming in the Lake and its environs.
- Bulk of fish is channeled to the export market through a system which is fully controlled by processors who are outsiders.

- Most of the co-operatives introduced in the 60s and 70s have collapsed or are very weak.
- Women resort to buying fish skeletons for factories to feed families.
- Commercial fishing coupled with written law with gradual erosion of traditional management systems has been introduced.
- Children drop out of school to involve in petty trade in fish.
- Trawling has been a common phenomenon but has now been controlled.
- The modern system closes out fishing communities leading to a situation where there are no spare fish for the family.

As a result, the current management system is fraught with poor organization, inadequate government staff for policing the Lake, hence the use of illegal fishing gears and lack of necessary facilities and infrastructure, e.g., cooling plants and good roads. There is lack of involvement of the communities in formulating rules to regulate and manage the resources hence they observe the rules as strange and of no benefit to them. The government does not provide alternatives during the closed seasons and does not plough back revenue generated from the sector to improve the fishing industry. The pricing of inputs is high while that of outputs is low. The current fisheries cooperatives are weak and not focussed and finally, there is lack of awareness among the communities in the sustainable management of the Lakes resources.

Before the European union imposed a ban on fish exports from Kenya, it used to earn foreign exchange to the tune of Kshs 6 billion. The impact of this income cannot be seen among the local fishermen [111]. To change this scenario and make fishermen benefit effectively from fishing like their counterparts in the agricultural sector, [111] suggest:

1. Credit schemes should be created for fisherfolk. OSIENALA through the introduction of beach bank (i.e., Subsect. 7.4.2) is striving towards this goal.
2. Fishermen still use old technology gear for their operation.
3. Govt should give tax waivers on purchase of fisheries related equipment for fishermen.
4. Government should be less involved in the management of the fisheries sector by creating competent autonomous institutions which will put more effort in the management, e.g., fisheries development authority.

5. Fishermen should be organized into cooperatives which should assist them in lobbying to have a say in prices without undue control from fish processors.

In addition to the suggestions above, the following recommendations would enhance management issues:

- Governments to provide storage facilities and mobilize the communities to contribute towards the procurement of such facilities.
- The governments to reduce tax on inputs to improve the capability of the people to procure them.
- The communities are utilized in policing and management of the resource to ensure effective control of activities over the Lake.
- Strengthening of extension, monitoring and enforcement capabilities.
- Studying and implementing of a fish Levy trust.
- The governments to plough back part of the revenue earned from the industry to improve the facilities and make people appreciate the usefulness of the resource.
- The co-operative movement should be strengthened through creation of awareness on the benefits of movements.
- The fishing industry be organized and an umbrella body to coordinate the activities be formed as has been done for coffee, tea, milk, etc.

The Lake Victoria fishery and its ecosystem more generally are characterized by many features associated with the tragedy of the commons. It is a common access resource at two levels, at the level of states, and the level of fishers and other users. Critical actors in particular, the riparian landowners and communities on who the health of the Lake depend lack incentive to invest in its conservation as they do not derive direct benefits from it [75].

The recovery and sustainability of the fishery can only be achieved through concerted collective action at state and local levels. The pillar of this effort is co-management of the fishery between the government and the fishers, through Beach Management Units (BMUs). The BMU is an organization of fishers who share a common landing beach. It provides a legitimate forum through which the authorities and fishers consult on the administration of effort controls, mediating conflicts when they arise as well as sensitizing and educating fishers on the conservation imperative [75].

In adopting the BMU model, it was not the intention to confer rights to fishers. The model by default acquires some elements of rights based regime. A property right is the legitimate authority to exclude others from deriving the benefits of a valuable thing. BMUs have a right to sanction fishers who violate the rules [75].

The management strategy in place and fisheries regulations are primarily conservation focused. Their compatibility with the economic growth objectives has not been critically evaluated.

Co-management with fishers through BMUs is showing much promise in addressing some of these problems. BMUs have proved to be effective at resolving localized conflicts. The question however is whether the custodial powers that have been delegated to BMUs have conferred an element of rights, in so far as it is not in the interest of existing fishers to admit competition. In Uganda, membership to BMUs is required before one can be given a fishing licence. The principle of co-management entails an implicit contract in so far as fishers have the reasonable expectation of reaping where they have sown. The introduction of BMUs therefore constitutes a tentative step in the direction of a restricted fishery. This warrants an evaluation of the implications for applying the BMU model.

In the BMU model, Beach Management Units are involved in the identification and recommendation of fishers for licensing; maintaining the environment, sanitation and hygiene; community policing to protect life, property and resource; monitoring, control and surveillance and decision making, and revenue identification, collection and utilization and management.

There is the question of reconciling economic growth and securing livelihoods, and the conflict between fishing interests and landowners rights as issues on which management regimes should be evaluated. Since rights can be conferred to people other than existing fishers, a rights regime could provide the means of distributing the benefits and costs between fishing and conservation. All people including those who live far inland, should own quotas, which they can fish themselves or lease out.

A rights based management is not a panacea to conflicts, neither is it a substitute for input management controls. Property rights give rise to different types of disputes. Many of them can be solved informally, but a good number are litigated in courts. Rights are also prone to abuse, for instance by people cheating on catch and poaching, both problems require the states administrative oversight, policing and auditing.

Gender Issues

The government in its efforts to reduce gender inequity, has stepped up the mainstreaming of gender issues and concerns in all sectoral plans and is currently in the process of preparing of a National Policy Document on Gender and Development, spearheaded by the women's bureau. The need therefore for gender dis-aggregated data cannot be gainsaid as these would highlight the disparities in various demographic, social and economic spheres. The results of the 1999 population and housing census show that gender disparities exist for most of the indicators analyzed, but the extent or magnitude of these disparities varies from region to region. The proportion of female-headed households continued to increase from 35% in 1989 to 37% in 1999. Majority of such households were in rural areas. A large proportion of such households did not have access to services and amenities enjoyed by a large proportion of male-headed households. For instance, only 25% of female-headed households had access to piped water compared to 34% of male-headed households, while 75% percent of female-headed households used firewood as main cooking fuel compared to 64% of male headed households [33].

Through community involvement there is need to appropriate for poorer groups a larger share of gains arising from the fishery, and from using water resources in wetlands and other parts of the Lake catchment. The welfare of women should be improved by additional incomes earning opportunities in fishery related and wetland activities, as well as better access to water supply and improved health through the control of aquatic weed infestations. There is therefore need to foster managerial efficiencies in public and private sectors by improving policy analysis, regulatory enforcement, harmonized internal and external systems and procedures and an environmental information base.

Landuse Management

The Lake catchment economy is principally an agricultural one with a number of cash crops. There is a high level of subsistence fishing and agriculture. The quality of the physical environment is considered fundamental in maintaining and increasing living standards of the growing population [83]. The catchment is under intense pressure from rapid population growth and poverty; the pressure to exploit the catchment is intense. In Kenya for instance, the Yala Swamp, an important wetland for the Lake's ecosystem has recently been opened up for irrigation and there are plans to start commercial forestry there [75].

There is need to continue the commitment to conservation, sustainable utilization and management of the environment and natural resources as an integral part of national planning and poverty reduction efforts [33]. The Lake basin is used as a source of food, energy, drinking and irrigation water, shelter, and transport and as a repository for human, agricultural and industrial waste. With the population 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 unstable.

The Lake ecosystem has undergone substantial and to some observers alarming changes, which have accelerated over the last four decades. Massive algal blooms have developed and come increasingly to be dominated by the potentially toxic blue green algae. Waterborne diseases have increased in frequency. Water hyacinth, absent as late as 1989 has begun to choke important waterways, landings and ports. Overfishing and oxygen depletion at lower depths of the Lake threatens artisanal fisheries and biodiversity. Scientists advance two main hypotheses for these extensive changes. First the introduction of the Nile Perch some 40 years ago has altered the food web structure; second; nutrient inputs from adjoining catchments are causing eutrophication [83].

Forests

Efforts should be directed at enhancing sustainable conservation of forest areas. There is need to undertake the strengthening of natural resource management system through initiation of management plans. Objectives are the reduction of widespread logging of indigenous trees and charcoal production. Currently, there is a worrisome trend of degradation and destruction of Kenya's forests in place covering 1,496 ha of indigenous forest, 120,000 ha of plantation area and catchments areas. The aims are planting forest backlogs, enhancing protection against fire, game damage and poaching and maintaining the forest plantations and diversifying participatory approaches with communities and stakeholders for sustainable on farm tree growing and conservation [33]. Therefore; *Afforestation programs should be enhanced through schools and rural communities*, *Agro-forestry programmes to protect riverbanks and Lake Shorelines*, *and Pilot investments in soil conservation and afforestation.*

Environment

There is need to recognize environment as an integral component of all development programmes in poverty reduction strategies as well as enforce legislation for the protection and use of environment and natural resources. Thus it is necessary to increase the use of farmer innovations and new technologies at the community level for food production, combating desertification, and income generation. Cleaner production technologies in small and medium scale enterprize, waste management at the community level should be supported as well as community based biodiversity industry initiatives to generate income and improve livelihoods [33]. Emphasis should be laid on the development of the arid and semi-arid areas as a strategy on poverty reduction. This requires the management of indigenous vegetation for the rehabilitation of degraded rangelands in arid zones aimed at conserving and rehabilitating bio-diversity of the dry land and improve livestock production and marketing [33].

Currently, there is need to create an enabling environment in which government agencies and communities jointly regulate resource use. This is constrained by high populations with attendant human activities, economic systems and policies that fail to put value to the environment and its resources, inequity in the ownership, management and flow of benefits from the use and conservation of biological resources, deficiencies in knowledge and applications and legal and institutional deficiencies [33].

Rising population pressures, migration and rapid urbanization have increased the need for urgent actions to address environmental problems. The more critical problems are related to soil and land degradation, water resource management, biomass and household energy issues and the protection and management of fragile ecosystems including national parks. Rapid urbanization and inadequate physical planning have caused a significant deterioration in the urban environment. Areas of priority action include the development and adoption of a comprehensive environmental policy, the establishment of an effective institutional and legal framework and formalization of a requirement for Environmental Impact Assessment (EIA) for all development projects [83]. Some of the task required for environmental management are:

- Proper management of effluent for organic fertilizer production and water for irrigation.
- Preparation of compost heap manure from water hyacinth.
- Professional inputs into sessional papers before presentation in parliament.
- Pilot investments in industrial and municipal waste management.
- Management of land use in the catchment, including improvement of research and information base for pollution loading from the catchment.
- Assessment of agro-chemicals.
- Priority waste management investments.
- Regular water quality analysis.
- Risk and uncertainty evaluations.
- Preparation of organic fertilizers from droplets of livestock.
- Quantify and locate the environmental problems arising from the very rapid growth of population around the shores of the Lake and in its catchment.

9.3 Conservation and Management

Chap. 3 underscored the fact that fish stocks in Lake Victoria may be dwindling. The fish stocks are affected by many factors including environmental factors. Therefore, there is need to take measures for conservation and effective management of the resources of Lake Victoria and its environ. This is the objective of this chapter.

The greatest development challenges facing Lake Victoria and its basin are the socio-economic and ecological problems. These are mainly related to the linkages between poverty and environmental degradation (see, e.g., [138, p.17]). They are further exacerbated by the lack of capacity among the concerned institutions to manage the human and natural resources of the Lake basin, in a sustainable manner. Similarly, the legal and institutional frameworks that govern the socio-economic activities have so far been inappropriately conceived and have been enforced in an uncoordinated manner.

9.3.1 Sustainable Development of the Region

Sustainable growth is one pre-requisite for poverty alleviation in any country. Considering the fact that population growth in the Lake Victoria basin is in the region of 3% and that 50% of the population live below the poverty line,of US$ per person per day a substantial growth is required in order to alleviate poverty to any significant degree. The growth witnessed in the region over the last few decades has mainly been based on the exploitation of natural resources. Some of it is linked to finite resources, such as mining activities (mainly diamonds and gold) while other parts of it linked to agriculture and fisheries.

Poverty Reduction: A major justification for an intervention in the Lake Victoria region is the inherent widespread poverty. Persistent poverty remains a main cause and consequence of environmental degradation and resource depletion. This, in turn, undermines the possibilities for future economic growth. Greatly expanded and more effective poverty reduction programmes are needed for economic as well as environmental sustainability. Without significant improvements in the lives and livelihoods of the poor majority, environmental policies and programmes have little chance of success.

The current levels of malnutrition, disease and environmental degradation in the Lake Victoria basin are largely driven by poverty. Smallholder farmers in the basin are forced to engage in increasingly desperate and engage in unsustainable land use and land management practices primarily because of lack of alternative livelihood options. These practices include cultivating marginal and fragile areas such as wetlands, and clearing vital forests to open up new arable land or to get access to fuel wood, culminating in intensified soil erosion. The destruction of the basin's wetlands to create space for cultivation and grazing of livestock has resulted in loss of biodiversity and a decreased filtering effect on the water entering the Lake through watercourses.

The development strategy of the East African region should be one that ensures equitable development among the member states thereby uplifting the living standards of the people. Both equity and economic growth are crucial for environmental improvement and sustainable development. Without greater equity in the benefits of development, economic growth cannot be sustained. Rising poverty and population pressure on the resource base accelerates and undermines the possibilities for further economic growth. Without economic growth there will be few or no benefits to share. Poverty-driven environmental degradation will continue to accelerate. In the absence of economic growth, countries cannot generate the resources needed to address environmental degradation.

Urbanization: Urbanization in the Lake Victoria basin, in combination with the widespread poverty, has led to proliferation of informal "squatter" settlements in major towns. Such informal settlements lack garbage collection as well as sanitary facilities, leading to the prevalence of diseases such as diarrhoea, malaria, typhoid and amoebiasis, among others. Existing sewage treatment facilities in all major towns have generally poor coverage and are in very poor shape. Raw sewage is discharged into small rivers or streams or directly into Lake Victoria, contributing significantly to pollution. Industries in the region have very poor waste treatment facilities if any, or are discharging their waste waters to the existing poor municipal waste water systems or directly into the streams and the Lake.

Reversing Environmental Degradation: Given the above considerations, it is clear that the Lake receives an increased load of nutrients, organic material and other pollutants. These contribute to a rapidly increasing eutrophication resulting in strong vegetative growth (algae and plants), and anaerobic conditions in the Lake's deep water. Water quality deteriorates leading to a decrease in both quality and quantity of fish.

A dramatic illustration of how poverty, in combination with lack of enforcement of laws and institutional capacity, aggravates environmental degradation in the basin area is the recent revelations regarding poison fishing, the use of illegal nets and overfishing. A significant increase in fish export, lack of alternative employment opportunities, in particular for women, and decline in food security have served to perpetuate poverty. This has, in turn, enticed local fishermen to use unconventional fishing methods such as poisoning or illegal nets. These adversely affect health and the environment. Furthermore, these practices threaten the future of the fish population and consequently the economy and well being of the communities surrounding the Lake Victoria.

Health and the HIV/AIDs Situation: The general health situation in the Lake Victoria region is alarming. In spite of major improvements in health care in the last three or four decades, water and sanitation related diseases such as malaria, cholera, diarrhoea, tuberculosis and bilharzia are still common in the region. HIV/AIDs aggravate the region's economic problems. A study undertaken by FAO in 1994 reveals that both cash income and labour in farming households are partly diverted to cope with HIV/AIDs. This leaves less labour for agriculture and less income for the purchase of agricultural inputs and for off-farm activities. The disease also leaves many orphaned children. This puts more strain on extended families already under considerable stress.

Although the East African governments have recorded progress in maternal and child care, the mortality rates for infants and children still exceed international standards. Thus health is another area where co-operative efforts may be expected to produce tangible benefits for the East African countries. The first AIDs case was reported among gay men in June 1981. There were only 5 infected people and within the first 20 years, the epidemic, had infected 58 million people and killed 22 million worldwide. When a person is first infected with HIV, the virus begins multiplying in the body and within a few weeks the infected person infects other persons with whom his/her body fluids come into contact.

Kenya has an estimated 2.2 million HIV positive people in mid 2003. Of these, very few know that they are infected or show any outward symptoms of the disease. About 200,000 people of these have AIDs and a similar number develop AIDs each year. The disease has killed over 1.5 million people in Kenya. Children orphaned by AIDs are probably over 900,000 today and will probably increase to 1.5 million by 2005. Nyanza is the leading Province in Kenya with HIV infection in adults between the ages15-49 estimated at almost 0.5 million and a prevalence rate of 22%.

Western Province has a prevalence rate of 12%, (210,000 people). Rift Valley Province has 390,000 infected adults with a prevalence rate of 11%. Infection rates in the districts of West Kenya region are equally high with some of them recording rates as high as 30%. In Kisumu, the HIV infection rate has consistently been very high. The rates in antenatal women which were nearly 20% in the last decade have continued to rise and in 2000 stood at 35.4%. Other districts in the province which have high prevalence rates are bondo, Homa Bay, Kuria, Migori, Nyando, Rachuonyo, Siaya, and Suba at 29.8%, and Kisii Central, North Kisii and Gucha with a rate of 15.8%.

In Kisumu and Busia Districts, bed occupancy rates by HIV/AIDs-related illnesses stands at a high of 70%. It is estimated that in the near future more than half of all hospital beds will be required for

AIDs patients. This leaves an insufficient number of beds for patients with other ailments. Take the case for East Africa's largest hospital, the Kenyatta National Hospital. Over 80% of the patients are HIV/AIDs cases.

Research carried out in pregnant women at urban sentinel surveillance sites in various districts in the region shows Kisumu leading with a prevalence rate of 35% followed by Busia with 22%. Kitale came third with a rate of 17%. Other sites in the region are Kisii with 16%, Kakamega with 12% and Nakuru with 11%. In urban areas this rate was much higher at 17-18%. This means that 470,000 adults in urban areas are HIV positive. The prevalence is increasing in the rural areas at estimated rates of 12% to 13%. This translates to about 1.5 million HIV positive adults in the rural areas.

The study reveals that more young women are HIV positive than young men, but older men have higher infection rates than older women. By June 2000, the adult prevalence had increased to 13.5%. Women in the 20-24 age group have the highest infection levels while for men they are found in the 30-39 age group. The same study found that 18% of women were infected within two years of becoming sexually active.

The high prevalence rates in this region can be attributed to the long distance truck drivers who operate from Mombasa port via these towns as they ferry goods to Kenya's neighbouring land locked countries like Uganda, Rwanda and Burundi, and the Democratic Republic of the Congo. Some of these goods are destined for factories in Western and Kisumu regions. These drivers usually carry a lot of money for contingencies and accommodation in areas where the cost of living is relatively cheaper. This introduces a loose and care free life, which lends a hand to prostitution and thus the spread of AIDs. A notable feature of these towns is the abundance of night spots and roadside inns and motels at regular intervals to act as refreshment points for these truck drivers and other travelers. Some towns have thus developed and with them the increase of the spread of the deadly HIV/AIDs.

The Central Bureau of Statistics estimates that without HIV/AIDs, life expectancy at birth would currently be about 65 years but because of the AIDs pandemic, almost 20 years of this expectancy have already been lost. HIV/AIDs has the potential to create severe economic impacts in Kenya. It causes a reduction in the size of the labour force, increases health care expenditure, raises the cost of labour and reduces savings and investments. Firms have also not been spared. They spend their profits on staff recruitment and training, funeral expenses, medical costs, and increased employee benefits depending on the HIV prevalence among its employees. Even if we prevent new cases of HIV infection in the country, deaths (mortality) caused by HIV will continue to increase because of the number of people already infected with the virus who will develop AIDs.

9.3.2 Environmental Management

The natural resources of the Lake basin are used to obtain food, shelter and energy, water for industrial transport needs, and for irrigation. The Lake receives human, agricultural and industrial waste. In recent decades, with growing population and development, the multiple activities in the Lake basin have increasingly come into conflict and the Lake ecosystem has undergone substantial changes rendering the environment unstable.

The Lake Victoria Environmental Management Project (LVEMP) is a comprehensive programme aimed at rehabilitation of the Lake ecosystems for the benefit of the people in the catchment and the national economies of which they are part. The objectives of the programme are to

1. Maximize the sustainable benefits to riparian communities from using resources within the basin to generate food, employment and income, supply safe water, and sustain a disease-free environment, and
2. Conserve biodiversity and genetic resources

With funding to the tune of US$ 80 million from the Global Environment Facility (GEF) and the world Bank, phase one of the project is a collaborative effort of the three riparian states in matters pertaining to fisheries management, water hyacinth management and control and management of Lake pollution and water quality, management of land use in the catchment, management of wetlands and support for institutions for Lake-wide research and management; and pollution disaster contingency planning. Implementation of the LVEMP was initiated in mid-1997 and the first phase was to last five years.

The most progressive intervention is to bring these diverse cultures together to better manage and utilize the Lake's resources. The communities have, therefore, formed East African Communities Organizations for the Management of Lake Victoria (EcoVic) and Lake Victoria Regional Local Authorities Co-operation (LVRLAC). Both Ecovic and LVRLAC have formalized the operational plan to work together in an effort to improve the environmental situation of the Lake.

9.4 Institutions

The East African Community (EAC)

The East African Community (EAC) is a regional forum that brings together Kenya, Tanzania and Uganda into an economic block. There are also plans to turn EAC into a regional political body. As already mentioned in the introductory remarks, the EAC together with the donors are in the forefront of promoting sustainable development of the Lake Victoria Basin.

Lake Victoria Fisheries Organization (LVFO)

As stated in the introductory remarks, this is one of the projects of the East African Community (EAC) that is specifically responsible for promoting proper management and optimum utilization of the fishery resources of the Lake Victoria. Its establishment was achieved through the funding of the Lake Victoria Environment Management Project (LVEMP) courtesy of the three East African countries, the Food and Agriculture Organization (FAO), the European Union (EU), World Bank and the Global Environment Facility (World Bank/GEF). It has the responsibility of enhancing partnership and collaboration with institutions and stakeholders for the betterment of Lake Victoria's ecosystem for sustainable fisheries resource utilization and socioeconomic development of the riparian communities.

Lake Victoria Environment Management Project (LVEMP)

This is a Global Environmental Facility (GEF) funded project whose second phase is currently underway. The first phase was completed in 2004 with a total funding to the tune of USD 75, 636,000, of which the three East African states contributed 10% [87]. Specific objectives of LVEMP Phase I were to maximize the sustainable benefits to the riparian communities from using resources within the basin to generate food, employment and income; to supply safe water and sustain a disease free environment; to conserve biodiversity and genetic resources for the benefit of the riparian communities; to harmonize national and regional management programs in order to achieve to the maximum extent possible the reversal of environmental degradation; and to promote regional co-operation.

The Lake Victoria Fisheries Research Project (LVFRP)

This was established in 1997 courtesy of the funding from the European Union. The principal aim of the Project was to assist the Lake Victoria Fisheries Organization (LVFO) in establishing a framework for the rational management of Lake Victoria's fisheries. The specific objectives of the project were to carry out stock assessment, to train fisheries researchers, to rehabilitate and construct research vessels, to equip the research institutes and to investigate socio-economic issues related to the Lake and its fisheries.

The Nile Basin Initiative (NBI)

This initiative, funded by donors (e.g., World Bank, Norway and Sweden) comprises ten countries which make up the Nile River Basin, namely, Burundi, Democratic Republic of Congo, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Tanzania and Uganda. Its aim is to promote the exploitation of the development potential of the Nile River in a way that focuses on gaining mutual benefits from developments rather than on defending rights.

9.5 Communities around the Lake

This is mostly prominent in the fisheries sector through the establishment of Beach Management Units (BMUs) discussed in 9.2 in p. 260 and the Non-Governmental Organizations (NGOs). The East African Communities Organization for the Management of Lake Victoria (ECOVIC) and OSIENALA (Friends of Lake Victoria) are some of the most prominent NGOs in the Lake Victoria region. They are primarily focused on poverty and environmental issues. Maseno University is also situated within the Lake basin and through its Department of Environment Studies, research on the Lake is being undertaken.

External and Internal Donors

Recently, the European Union has agreed to finance research and conservation projects in the Lake Victoria region to the tune of 257 million Kenyan shillings[1]. The Swedish support for Lake Victoria basin for the period 2004–2006 is documented in [99]. Other donors are listed in the introductory remarks of this chapter.

9.6 Concluding Remarks

This chapter has addressed some of the most important issues pertaining to conservation and management of Lake Victoria resources. The most important challenge facing the region is the development challenge, especially how to achieve sustainable development of the region, reduce poverty, reverse environmental degradation, improve health status and urbanization. A summary of the institutions that are involved in the management of Lake Victoria have been presented. Detailed discussions of the respective institutions can be found in their web sites on the internet. Further reference for this chapter is [31]

One fact that must be pointed out here is that all management issues will yield no fruit if the decision makers are not introduced to environmental issues at a tender age. Children from pre-primary schools to university students should be introduced to environmental conservation measures and motivated to have a liking for the environment. Such need had been realized by OSIENALA and Maseno University. Fig. 9.1 depicts school children being introduced to Lake issues.

[1]See, e.g., "EU to use 257m on Lake Victoria" in The Standard Newspaper, Thursday, October 13, 2005

Fig. 9.1. School children being motivated in the Lake

10

Challenges Facing Lake Victoria

"Waste in the Lake basin is a two-lane highway: flowing down into the Lake is the waste and pollution generated upstream. In the opposite direction, leaving the basin, flows the region's wealth in different forms: exploitation of fish, and the rich gold mines in Macalder and Kitere". Prof. Oyugi Aseto

10.1 Introductory Remarks

The greatest development challenges facing Lake Victoria and its basin are the socio-economic and ecological problems, which are mainly related to the inter-linkage between poverty and environmental degradation. These are further exacerbated by the lack of capacity among the concerned institutions to manage the resources of the Lake basin, both human and natural, in a sustainable manner. Similarly, the judicial and institutional frameworks that govern the socio-economic activities have so far been inappropriately conceived and enforced, and in an uncoordinated manner.

Sustainable growth is one prerequisite for poverty alleviation in any country. Considering the fact that population growth in the Lake Victoria basin is in the region of 3% and that 50% of the population live under ***poverty line***, a substantial growth is required in order to alleviate poverty to any significant degree. The growth that has been seen in the region over the last few decades has mainly been based on the exploitation of natural resources. Some of it is linked to finite resources, such as mining activities (mainly diamonds and gold), other parts of it linked to agriculture and fisheries.

Critical questions on sustainable growth in the region relates to how the benefits of the exploitation of natural resources are used and to whether the non-finite resources are exploited in a sustainable way. The answers are clear enough. There are indications that a large portion of the proceeds from economic activities in the region is not reinvested in the region. Furthermore, It is evident that most present practices are unsustainable.

With the degradation of natural resources follows rising levels of poverty. Smallholder farmers in the basin are forced to engage in increasingly desperate and unsustainable use of the natural resources. This includes cultivating marginal and fragile areas such as wetlands, and clearing vital forests to open up new arable land or to get access to gathering fuel wood, leading to intensified soil erosion. The destruction of the basin's wetlands to create space for cultivation and grazing of cattle has resulted in loss of biodiversity and a decreased filtering effect on the water entering the Lake via watercourses.

Urbanization in the Lake Victoria basin in combination with widespread poverty has led to proliferation of informal "squatter" settlements in major towns. Such informal settlements lack garbage collection as well as sanitary facilities, leading to the prevalence of diseases such as diarrhea, malaria, typhoid and amoebas, among others. Existing sewage treatment facilities in all major towns have generally poor coverage and are in very poor shape. Raw sewage is discharged into small rivers or streams or directly into Lake Victoria, contributing significantly to pollution. Industries in the region have very poor waste treatment, if any, or are discharging their waste waters to the existing poor municipal waste water systems or directly into the streams and the Lake.

Given the above considerations, it is clear that the Lake receives an increased load of nutrients, organic material and other pollutants which contribute to a rapidly increasing eutrophication resulting in strong vegetative growth (algae and plants), oxygen consumption and anaerobic conditions in the Lake's deep water and a change in the water quality. Water quality deteriorates and quantity and quality of fish decrease.

A dramatic illustration of how poverty, in combination with lack of enforcement of laws and institutional capacity, aggravates environmental degradation in the basin area is the recent revelations regarding poison fishing, the use of illegal nets and overfishing. A dramatic increase in fish export, lack of alternative employment opportunities, in particular for women, and decline in food security have served to perpetuate poverty, which in turn has enticed local fishermen to use unconventional fishing methods such as poisoning or illegal nets, with adverse health and environmental consequences. Furthermore, these practices threaten the future of the fish population and consequently the economy and well being of the communities surrounding the Lake.

The deterioration of Lake Victoria's ecology is demonstrated in the rapid spread of the water hyacinth, which over periods cover bays and vast Lake surface areas along the shores. As already discussed in Chap. 4 water hyacinth blocks access to fish landing sites as well as water intakes for water supply facilities. Areas covered with the weed are perfect breeding places for different kinds of organisms which leads to an increased health hazard from diseases such as malaria and bilharzia. The decreased water quality constitutes a great risk for the part of the population using Lake water directly as drinking water and causes extra costs for the municipalities using Lake water for tap water production.

The general health situation in the Lake Victoria region is alarming. The mortality in diseases such as cholera/diarrhoea, malaria, tuberculosis and HIV/AIDs is very high. The AIDs disease with its impact on society aggravates the region's economic problems. A study in 1994 by FAO reveals that both cash income and labour in farming households are partly diverted to cope with HIV/AIDs. This leaves less labour for agriculture and less income for the purchase of agricultural inputs and for off-farm activities. The disease also leaves many orphaned children, which put more strain on extended families, already under considerable stress.

Problems facing the Lake are compounded by the fact that the relevant municipalities surrounding it, e.g., Kampala in Uganda, Kisumu in Kenya, and Musoma in Tanzania lack the capacity to implement sustainable development policies within a regional context of high urbanization rate and weak national and regional economies [151]. UN–Habitat through its urban management programme initiated the Lake Victoria Region City Development Strategies Programme in early 2002 in a bid to strengthen the capacity of the three centers.

10.2 Management Issues Facing Lake Victoria

Lake Victoria faces several management problems some of which have been mentioned in Chap. 9. These include management issues like reducing conflicts regarding the usage of the shores of the Lake for fish breeding or for papyrus production for domestic usage; the question of allocation of the Lake's fishery benefits between the riparian populations and export to earn foreign exchange; the problem of minimizing overcapacity of fish production and avoiding economic waste; and the issue of reducing threats of existing fish catches from overfishing or activities other than fishing. There is evidence that total fish catches have increased in recent years, but these catches are concentrated on some individual species. That is, whereas some species are decreasing, other species are increasing. This situation causes uncertainty about the future trends in total catch from areas such as the Nyanza Gulf. What kind of decision should there be in this uncertain trend?

Lake Victoria fisheries, especially in the Nyanza Gulf, are being exploited at a very high rate, thanks to the remarkable improvements in the capacities in fisheries such as an increase in the number of boats, improvement of communication network around the Lake, handling shades, provision of cold storage and other preservation methods such as smoking and sun drying of fish. It has been estimated that, on the Kenyan side of the Lake, there are about 21,000 fishermen operating over 5,000 boats. *This is the highest concentration of fishermen in the Lake. However, despite this large numbers, there is no knowledge of the magnitude of fish stocks and the maximum sustainable yields that should be exploited.* In spite of this uncertainty, there are warning signs of a declining fishery in Lake Victoria.

Several factors have been identified as the possible causes of the decline in fishes. These include the cutting of the papyrus swamps for making mats, reclamation for agriculture, dislodge by floating islands and other uses. Pollution is another factor. It emanates from industrial and domestic wastes from large cities like Kisumu in Kenya, Mwanza in Tanzania, and big towns like Jinja in Uganda. In addition, there is a growing threat from increased use of fertilizers and pesticides in the agricultural areas within the Lake basin. These are washed down the rivers by rainfall and eventually find their way into the Lake. Finally, there is the problem posed by the Nile Perch, which has devoured some other fish species in the Lake, thus drastically reducing the number of some species to near extinction. What kinds of management decisions should be taken in these conflicting factors?

The foregoing are some of the issues that management decisions have to encompass. More specifically, the management decisions must include the following considerations:

10.2.1 Management of Lake Victoria Resources

The region needs a lot more than fresh injections of funding. Ultimately, the people of the Lake can only solve the Lake basin's problems themselves. Uganda seems to have taken this sentiment to heart in its campaign to protect and boost the wetland ecologies that fringe the Lake and serve as a crucial natural filter.

Launched in 1989, the key to the Uganda National Wetlands Program's success has been community involvement, and specifically women, because the government recognizes that they are the guardians of water and fire in the community. They know best how to manage those resources.

The program also offers a five-week course in wetland management, trains communities in making a range of products from sustainably harvested wetland plants such as papyrus, rattan cane and hyacinth, and is in the process of quantifying the economic contribution of the wetlands' natural services.

The establishment of colonial rule over the people of the region brought with it resource management structures that removed the power from traditional leaders to the central governments of larger territories of Kenya, Uganda and Tanganyika. This meant that people who had no interest in the Lake could be given the responsibility to manage resources such as fisheries. The ownership of the resources shifted with time.

The population influx and lack of properly planned infra-structural development has brought many problems to these cities. Such problems like sewer system, industrial pollution, shortage of water supply are a serious headache to the citizens. Municipal councils alone cannot address the problems. The citizens have to join them with 'own key' solutions through organized groups such as NGOs and CBOs.

The economic benefits of the Lake's resources has spread to other communities thus increasing pressure on the resources. Farming and industrial activities in the basin and the surrounding highlands has also intensified, resulting into drastic change in land use and increased pollution into the Lake. All these activities put a lot of stress on Lake

Victoria's resources. The number of fish species have drastically decreased to just about 3 of commercial value at present; incidences of water borne diseases have also significantly increased; aquatic weeds began to proliferate at alarming rates. The Lake is gradually dying and could no longer support the millions of people who depended on it. There is therefore dire need to restore the Lake to its original supportive qualities.

The situation cannot be directly reversed to the pre-independence state. The most progressive intervention is to bring these diverse cultures together to better manage and utilize the Lake's resources. The communities have therefore formed East African Communities Organization for the Management of Lake Victoria (EcoVic) and Lake Victoria Regional Local Authorities Cooperation (LVRLAC). The two organization have formalized the operational plan to work together to improve the environmental situation of Lake Victoria.

10.2.2 The Question of Ownership of Lake Victoria: Who Owns the Lake?

If you ask fishermen on the Kenya side of the Lake, 'Who owns the fish?' they will tell you that it belongs to the government. Such attitudes indicate the extent to which many feel that they have lost out or lack a stake in managing their own resources. It doesn't help either, that with the many disasters that have stalked the region in the recent past, armies of aid agencies and NGOs have also come, doing little more than taking the place of *Mama na Baba*, the government.

All of these opportunities, bright spots flickering on the horizon, are fragile, easily extinguished. And they won't amount to much overall if the fundamental problem of the Lake basin is not addressed: resource ownership. It is not for lack of laws - whether old or new - *that fishermen poison fish, that industries flush their untreated waste down rivers, that municipal councils endanger the lives of their citizens by emptying raw sewage directly into the Lake.* These acts of irresponsibility are nurtured in an environment where entire communities have been disenfranchised and the *extraction* and *exportation* of wealth have become the dominant trends. Until these basic issues are addressed, the region's economic potential will be something we'll be talking about forever.

10.2.3 Jurisdiction and the Political Environment

In terms of the surface area, Kenya, Tanzania and Uganda, now partner states in the East African Community (EAC), respectively have control over 6%, 49% and 45% of the total Lake area.

Overwhelmingly, the politics of management and ownership of the Lake fall into the larger context of the establishment of the East African Community [1]. Within the Community, two institutions on Lake Victoria have been established. These are the Lake Victoria Fisheries Organization, which is specific to fisheries, and the Lake Victoria Development Program (covering general development matters of the Basin).

The EAC Partner States recognize three important and convergent issues relating to management of the shared waters. These are; *firstly*, that they share an interest in the well being of the Lake and its living resources and in the rational management and sustainability of these resources. *Secondly*, they recognize the need to develop Lake Victoria region as an Economic Growth Zone. Thirdly, they agree that management decisions relating to any portion of the Lake, within the territorial limits of any one of the Partner States, will affect the others, and hence there is the concomitant necessity that management decisions take such into account.

Fragmentation of the Lake management institutions in Kenya is a big problem. Kenya does not have appropriate institutional mechanisms for integrated management of Lake Victoria and its basin. The management responsibility of the Lake cuts across jurisdictional, administrative and national borders, making it difficult to establish a sound management framework. Moreover, active stakeholder involvement has been lacking in the establishment of many institutions responsible for the management of the Lake and its basin.

Managing the Lake Victoria and its basin should be guided by a common long-term vision. For the Lake to continue to provide benefits into the future, a comprehensive management approach involving all stakeholders and covering all activities affecting the water resources throughout the watershed is required. To work effectively, management plans must be developed at the community level, involve the participation of all groups who benefit directly and indirectly from the Lake, and have clear and transparent procedures for resolving conflicts.

[1] EAC (2000). The Treaty for the Establishment of the East African Community. Arusha, Tanzania.

10.2.4 Development Challenges

After several decades of marginal economic growth, increasing poverty amidst escalating environmental degradation, the East African countries are confronted with a series of critical transitions to attain sustainable socio-economic growth. These transitions include:

- Demographic transition toward an optimal population size, structure and distribution in relation to the environment and natural resources.
- Social transition toward a more equitable sharing of development opportunities and benefits with priority to the poor majority.
- Gender transition toward expanded rights and participation of the vulnerable, particularly women in the development process.
- Economic transition toward equity-led growth with priority to the poor and to protecting the environment and natural resources needed for future development.
- Agricultural transition toward and sustainable land use and land management options to enhance food security, improved livelihoods and conservation of land water and vegetation resources.
- Energy transition toward efficient and less polluting sources of energy. Priority should to development of renewable sources and affordable alternatives to fuel wood for the poor majority.
- Technological transition toward accelerated industrial development with priority to technologies that produce less waste and are more energy and resource efficient.
- Institutional transition toward effective national and regional institutional arrangements with priority to integrating economic, equity and environmental imperatives in planning and decision-making within and among different ministries and countries.
- Governance transition toward greater public accountability and participation with priority to new partnerships among governments, industries and NGOs.
- Capacity building transition toward national and regional self-reliance with priority to accelerated development and use of local know-how, technology and expertise.
- Development budget transition from aid dependence to self-reliance. Peace and security transition toward a new era of regional co-operation and integration with priority to the peaceful settlement of disputes.

10.3 The River Nile Treaties

In the previous chapters, we noted the issues concerning Lake Victoria and its environs. For a complete and comprehensive understanding of the Lake, it is important to address the question of the Nile treaties. These treaties were signed by Egypt and other interested parties to safeguard the interest of Egypt. These treaties controversies have arisen in recent years, with other riparian states demanding the abrogation of the treaties. This chapter presents an overview of the Nile Treaties and their implications for the economic development of the riparian states upstream.

10.3.1 The Origins of River Nile

Most history books credit the "discovery" of the source of the Nile to the 19th century explorer John Speke who captivated the Western world with this news in 1862[2]. This claim, however, no longer holds. In fact, a little-known German explorer, Bruckhart Waldekker, proved Speke wrong[3]. It is now accepted that the Nile originates from two distinct geographical zones - the basin of the "White Nile" and the "Blue Nile". The White Nile originates from the Great Lakes Region and is fed by the Bahr-el -Jebel water system to the North and East of the Nile Congo rivers divides. The Blue Nile originates in the Highlands of Ethiopia and Eritrea, so do the other major tributaries of the Nile, Atbara and the Sobat. Recent research has indicated that the Ethiopian Highlands contribute 85 per cent of the total volume. Lake Victoria, though, is a major source of River Nile. The Lake contributes less than 15 per cent of Nile water. About 84 percent of the water in the Lake comes from the seven rivers in Kenya, even though Kenya owns only 6% of the Lake.

10.3.2 Legal Implications of the Defects of Past Treaties

Most of these consist only of an article in the treaties and agreements about colonial boundaries and economic territories. In chronological order [19]:

1. The Anglo Italian protocol signed on 15th April 1891.

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[2] Britannica Concise

[3] John Mbaria, "Revoke Obsolete River Nile Treaty" in the Daily Nation, Thursday, March 29, 2002

2. The treaty between Britain and Ethiopia of 15th May 1902.
3. The agreement between Britain and the government of the independent state of the Congo signed on 9th of May 1906.
4. The 1901 agreement between Britain and Italy over the use of the River Gash.
5. The Tripartite (Britain-France-Italy) Treaty of December 13, 1906.
6. The 1925 exchange of notes between Britain and Italy concerning Lake Tanner.
7. The agreement between Egypt and Anglo Egyptian Sudan dated 7th May 1929.
8. The 1959 Nile Waters Agreement (between Egypt and Sudan).

Let us closely examine these treaties.

The Anglo-Italian Protocol of April 15, 1891: Only Article III of this treaty refers to the Nile water. The remaining articles define the colonial territorial claims of Great Britain and Italy in East Africa. Article III states that the Italian government engages not to construct on the Atbara River, in view of irrigation, any work, which might sensibly modify its flow into the Nile. This article of the treaty is curious in light of the fact that neither this river flowed in the territory claimed by Italy nor was Italy colonizing a country near the Atbara River, in order to have a claim over the river. However, the reference to the Atbara River on the part of Britain made some sense since the Sudan and Egypt, through which the Atbara flows, were within the British colonial territory. The reason for Italy to sign such an agreement foregoing its irrigation development without receiving any benefit in return is unclear. Moreover, for Great Britain to be interested in including this reference in a treaty with a country at a distance of some thousands of kilometers from the Atbara River makes the essence of the agreement more irrelevant.

It appears that the intent of the treaty was not the use of the Nile water, but to establish a colonial boundary. Given this context, the treaty cannot be seen as an agreement over property rights to the river. Even if, say, the treaty is assumed to define use rights to the river, what it meant by the term "sensibly modify the flow into the Nile". The volume of Atbara water used upstream to be considered, as a sensible modification by downstream users of Britain colonies is undefined. The language used is too vague to provide the parties with clear property rights and guarantees for water use. It is not unreasonable, therefore, for the remaining riparian states to see no reason for this treaty to provide an historical base for binding present and future cooperation on Nile water use.

The Treaty between Great Britain and Ethiopia of May 1902: The aim of this treaty was to establish the border between Ethiopia and the Sudan. One of its articles, Number III, relates to the use of Nile water. The English version, as reviewed by Britain and later by the Sudan, reads as follows: "*His Majesty the Emperor Menilik II, King of Kings of Ethiopia, engages himself towards the Government of His Britannic Majesty not to construct or allow to be constructed any work across the Blue Nile, Lake Tana, or the Sobat, which would arrest the flow of their waters except in agreement with His Britannic Majesty's Government and the Government of Sudan*" The Amharic version, however, gave a different meaning and understanding to Ethiopia and "was never ratified by this country". The treaty was understood by Ethiopia as follows: "... *Securing and maintaining the prior agreement of Britain before construction of any work on the Nile tributaries; not to stop (arrest) the flow of the Nile rivers did not mean not to use; and, that the treaty was made between Britain (colonizer of the Sudan) but not with the Sudan as it was under the colonial power of Britannia. As Britain is no longer ruling the Sudan, this agreement does not hold at present.*"

The 1902 agreement has been the most controversial treaty in the history of Nile agreements as both parties claimed that their own understanding of the treaty was correct. And, not only has the claim remained controversial but it has also been the cause of disputes, which threaten the socio-political and economic dynamics of the basin environment and efforts toward future cooperation. This is because, first, referring to this agreement, Sudan has argued that Ethiopia should not use the Nile water without the permission of the Sudan. Second, the Sudanese claim has been supported by Egypt with the possibility of military retaliation if Ethiopia used the Nile water. Third, there is the possibility that this threat has played some role in Ethiopia's extremely poor record in food production, though poor agricultural policies have no doubt played the major role.

This controversy remained a threat to present and future cooperation over the Nile waters. By forbidding the Nile water from being arrested by Ethiopia, the treaty inadvertently advocated the principle of sustainable development. Whether or not its intent was out of concern over the impact of development of Nile waters on the environment is subject of much debate. Stopping a flow of a river creates an artificial Lake that destroys ecological systems and often results in the relocation of people. However, it is unrealistic to believe that this treaty was predictive enough to anticipate the impact of water impoundment on biophysical and social systems in the basin, looking at its objectives and the time it was constituted.

The Agreement between Britain and the Government of the Independent State of the Congo on 9th May 1906: This was an agreement on the colonial boundary of the Congo between Britain and Belgium. The Congo being called an 'independent state' when the treaty was signed by the Government of Belgium on behalf of this country was hypocritical. Article III of the agreement was about the Nile waters and it stated that: "*The Government of the independent state of the Congo undertakes not to construct, or allow to be constructed, any work over or near the Semliki or Isango River which would diminish the volume of water entering Lake Albert except in agreement with the Sudanese Government*".

Belgium signed this unfair agreement on behalf of the Congo, despite the agreement entirely favoring the downstream users of the Nile waters and restricting the people of the Congo foregoing its Nile water use. The agreement did not require downstream users to consult the upstream countries for anything that they might do to the Nile waters. In this treaty, it is difficult to find any incentive for riparian states that might enhance their future cooperation since it involved neither the principle of equitable water use nor the approach of integrated water development.

The 1901 Agreement between Britain and Italy over the Use of the River Gash: The agreement states that "*The Government of Erythraea, while recognizing all its rights on the waters of the Gash and having regard to the requirements of the Colony, sees no difficulty in declaring that, in so far as the regime of the waters of that river are concerned, it will regulate its conduct in accordance with the principles of good neighbourship*". Evidence is scarce, however, on whether or not this treaty bound the parties to the agreement. Nevertheless, of all the treaties and agreements made during the colonial period, it could be said that this agreement was the most equitable. Because of difficulty in ensuring equitable water use, the agreement was defined and reinforced later by the "the Anglo-Egyptian Exchange of Notes" with subsequent detailed arrangements of 1925.

The exchange of notes included technical provisions suitable for practical implementation as follows: *"Quantified allocation, to each party, of water from the river Gash, Flow regime terms and conditions for water allocation, and the Amount of annual payment by the Sudan to Eritrea as a proportion of Sudanese revenues from irrigated cultivation at Kassala"*. This treaty is held by some of the riparian states as not being binding because the colonial signatory governments are no longer present in the Nile basin. Nevertheless, it can be used as a basis for the effort being undertaken to establish cooperation among the riparian countries.

The Tripartite (Britain-France-Italy) Treaty of December 13, 1906: Article 4 (a) of this treaty dealt with the use of the Nile water in Ethiopia's sub-basin. It states: "To act together to safeguard; the interests of Great Britain and Egypt in the Nile Basin, more especially as regards the *regulation of the waters of that river and its tributaries (due to consideration being paid to local interests) without prejudice to Italian interests*". This treaty denied "**the absolute sovereignty**" of Ethiopia over its water resource. It resulted in Ethiopia immediately notifying its rejection of the agreement by indicating that no country had the right to stop it from using its own water resources. Neither Ethiopia's military power nor its international political and economic influence was strong enough to protect Ethiopia's sovereign rights over its water resource. Ethiopia's rejection of this agreement was a revision, if not retraction, of the May 15, 1902 treaty signed between Ethiopia and Britain.

The 1925 Exchange of Notes between Britain and Italy Concerning Lake Tana: Britain and Italy had signed an agreement in 1919 over Lake Tana, of Ethiopia, which read in part as follows: "In view of the predominating interests of Great Britain in respect of the control of the waters of Lake Tana, Italy offers Great Britain her support, in order that she may obtain from Ethiopia the concession to *carry out works of barrage in the Lake itself ...*".

In 1925 it was expanded to say that:

> "... *Italy recognizes the prior hydraulic rights of Egypt and the Sudan not to construct on the head waters of the Blue Nile and the White Nile (the Sobat) and their tributaries and influence any work which might sensibly modify their flow into the main river*".

Ethiopia opposed this agreement and notified the parties of its objections as follows: To the Italian government, Ethiopia said:

> " *The fact that you have come to an agreement, and the fact that you have thought it necessary to give us a joint notification of that agreement, make it clear that your intention is to exert pressure, and this in our view, at once raises a previous question. This question, which calls for preliminary examination, must therefore be laid before the League of Nations.*"

And, to the Britannia government Ethiopia said:

> "*The British Government has already entered into negotiations with the Ethiopian Government in regard to its proposal, and we had imagined that, whether that proposal was carried into effect or not, the negotiations would have been concluded with us; we would never have suspected that the British Government would come to an agreement with another Government regarding our Lake*".

When an explanation was required from the British and the Italian governments by the League of Nations, they denied challenging Ethiopia's sovereignty over Lake Tana. This notwithstanding, however, there was no explicit mechanism enforcing the agreement. A reliable and self-enforcing mechanism that can protect the property rights of each stakeholder is essential if the principle of economically and ecologically sustainable international water development is to be applied".

The Agreement between Egypt and Anglo-Egyptian Sudan of 7th May 1929:

This agreement included the following terms:

(a) Egypt and Sudan utilize 4 billion cubic meters of the Nile flow per year, respectively;
(b) The flow of the Nile during January 20 to July 15 (dry season) would be reserved for Egypt;
(c) Egypt reserves the right to monitor the Nile flow in the upstream countries;
(e) Egypt assumed the right to undertake Nile river related projects without the consent of upper riparian states.
(f) Egypt assumed the right to veto any construction projects that would affect her interests adversely.

It is important to note that Egypt was still under British influence in 1929 and neither Sudan nor the remaining riparian states, aside from Ethiopia, were independent. The roles of both referee and player were taken, in the process of this agreement, by Britain in the name of its colonial territories in order to favor one, Egypt, by limiting the rights of the Sudan, and by rejecting those of the remaining riparian states. The agreement became the basis for the next agreement, called *The 1959 Nile Water Agreement*, which opened a door for Egypt and the Sudan to acquire rights to Nile water resources and for the full utilization of these waters by developing the Aswan high Dam, with its huge impact on the biophysical and social (disposition of human settlement) environment of the basin.

In May 1929, the Egyptian Prime Minister and the British High Commissioner to Egypt, signed the Nile River Treaty. Although the 1929 agreement was concluded between the British High Commission in Cairo and the Egyptian Government, while the 1959 treaty was between Egypt and the Sudan governments, the pacts bind Uganda, Tanzania, and Kenya to date. They bar the three countries from using Lake Victoria waters without Egypt's permission. The 1929 treaty was signed at a time when Lake Victoria was thought to be the source of river Nile. The treaty was a culmination of previous agreements made in 1889, 1891 and 1902 all which merely satiated British selfish interests against the Italian and (later) the Ethiopian Government. All ended up securing, for the 96 per cent Egyptians crowded along the Nile, the use of 48 billion cubic meters of the water each year while Sudan got 4 billion cubic meters. These agreements were not sensitive to the water needs of the other eight countries in the basin (Tanzania, Uganda, Kenya, Rwanda, Burundi, Ethiopia, and the Democratic Republic of Congo).

The treaty acknowledged Egypt's natural and historical rights to the Nile waters. "Without the consent of the Egyptian Government, no irrigation or hydro-electric works can be established on the tributaries of the Nile or their Lakes, if such works can cause a drop in water level harmful to Egypt", so says a section of the treaty.

The original agreement concluded in 1929 heavily favored Egypt's "historic rights" and allocated it 48 billion cubic meters (bcm) of water a year. The agreement gave Sudan four bcm. The 1929 Treaty gave Egypt and Sudan 100% use and control of the waters from Lake Victoria. Even in the event of floods, other riparian states had no permission to use this water. Thus, in 1949, Owen Falls Treaty prohibited Uganda from using Lake Victoria water for irrigation in Karamoja.

The Nile Treaty of 1959: This was an agreement between the Sudan and Egypt for full utilization of Nile waters. In the 1950s, Egypt was planning the Aswan High Dam project to collect the entire annual flow of the Nile water. The objective of the 1959 Agreement was to gain full control and utilization of the annual Nile flow. One of the financiers of the project, the International Bank for Reconstruction and Development (IBRD) required a secure water allocation for Sudan and compensation for the population to be dislocated due to the project. In 1956 Sudan had become an independent country and wanted previous agreements, which it saw as being unfair, to be changed, so that it could pursue another agreement on the use of Nile water with Egypt. At the beginning of the talks, both Sudan and Egypt claimed large areas of irrigable land and amounts of Nile water: Sudan claimed 44 billion cubic meters of Nile water to irrigate 2.22 million hectares, while Egypt claimed even more water than Sudan that irrigates 7.1 million hectares. The debate over the claims delayed the agreement, but whether or not Sudan agreed, the construction of the Aswan High Dam was seen as a development priority for Egypt. Although neither the Sudan nor Egypt were contributors to the Nile water but only users, the agreement for the full utilization of the Nile Waters was signed in 1959, between Sudan and Egypt. The agreement contained the following main points:

1. The controversy on the quantity of average annual Nile flow was settled and agreed to be about 84 billion cubic meters measured at Aswan High Dam, in Egypt.
2. The agreement allowed the entire average annual flow of the Nile to be shared between the Sudan and Egypt at 18.5 and 55.5 billion cubic meters, respectively.
3. Against this backdrop in the sharing of the waters of the Nile, which disregarded the contribution of the upper riparian states, changing the status quo has been an issue of hairsplitting interpretation. This is why sound water resources management is very crucial.

The general observation from the treaties discussed so far is that, countries have tried to make interpretations in their own words and contexts. It is, however, important for countries to adopt new ways that will help them forge ahead. This will be achieved through respect of the object and the purpose of treaties as established by the International Law. According to the Vienna Law of treaties, a treaty shall be interpreted in good faith in accordance with the ordinary meaning to be given to the terms of the treaty in that context and in the light of its object and purpose.

The object and the purpose of any agreement therefore must serve the interests of all the parties. In conclusion, as discussed above, none of the treaties and agreements dealing with the use of Nile waters signed during the colonial period involved all the riparian countries and they did not deal equitably with the interests of these riparian states. Also they did not take in to account the impact of water development on the basin's social and biophysical environment.

Some Important Terms of the 1959 Nile Treaty:

Egypt and Sudan signed a Treaty in Cairo on November 8, 1959. Its title was "*United Arab Republic and Sudan Agreement (with annexes) for the Full Utilization of the Nile Waters*". The agreement came into force on December 12, 1959. The 1959, agreement set Egypt's share at 55.55 bcm per year and Sudan's 18.5 bcm per year.

Agreement on a Unified View:

1. The Treaty said in part: "If it becomes necessary to hold any allegations with any riparian state, outside the boundaries of the two republics, the governments of the Sudan Republics and the United Arab Republic (Egypt) shall agree on a unified view after the subject is studied by the said technical commission. The said unified view shall be the basis of any negotiations by the commission with the said states".
2. The Sudan–Egypt treaty also notes: "If the negotiations result in an agreement to construct any works on the river, outside the boundaries of the two republics, the joint technical commission shall, after consulting the authorities in the governments of the States concerned, draw all the technical execution details and the working maintenance arrangements".
3. The treaty also gives Egypt and Sudan powers to "supervise the carrying out of technical agreements" by other riparian states.
4. According to the agreement, any other country that wishes to lay claims on the Nile waters, and that includes Lake Victoria, will only get a share, if Egypt and Sudan agree. The treaty reads: "As the riparian states, other than the two republics, claim a share in the Nile Waters, the two republics have agreed that they shall jointly consider and reach one unified view regarding the said claims".[4].

[4]Daily Nation newspaper, March 28, 2002

Deductions in Equal Parts:

1. The Treaty further says: "And if the said consideration results in the acceptance of allotting an amount of Nile water to one or the other of the said states, the acceptance amount shall be deducted from the shares of the two republics in equal parts, as calculated at Aswan. Even then, any water taken out will have to be monitored by a technical commission (which) shall make the necessary arrangement with the states concerned".
2. Little is known about an annex document in which Sudan gave a "water loan" to Egypt. The annex reads: "The Republic of the Sudan agree in principle to give water loan from the Sudan's share [to Egypt] in order to enable the latter to proceed with her planned programs for agricultural expansion".

Sharp focus has been put on the Nile water agreement but it is the 1959 treaty signed by Egypt and the Sudan that has shocking clauses. According to the treaty, none of the Lake Victoria nations can use the Lake's water without supervision by a "technical commission" appointed by Egypt and Sudan. Further, they can only be allocated a certain quota by the two. In one clause, the two nations agree, "if the other riparian states claim a share in the Nile waters, the two republics shall jointly consider and reach one unified view. And... the accepted amount shall be deducted from shares of the two". The treaty authorizes a technical commission to "make the necessary arrangement with the states concerned to ensure that their water consumption shall not exceed the amounts agreed upon".

Consequences of the Nile Treaty: The implementation of the Nile Treaty means the following consequences:

According to the treaty, Egypt's approval must be obtained if any project is to be undertaken on the Nile River. Archival information shows that as early as 1949 when the Owen Dam was constructed, the British Government wrote to the Uganda Electricity Board telling it that the project would only go ahead "*If the Egyptian Government approved it*". To date, there is an Egyptian resident engineer at the dam.

A document titled "Exchange of Notes Constituting An Agreement Between the Government of Great Britain and Northern Ireland and the Government of Egypt regarding the Construction of the Owen Falls Dam, Uganda signed at Cairo on December 5, 1949" is one of the many agreements on the issue. The pack was signed by Britain and Egypt and it binds the former colonies.

Military Coup against Dissenting Foreign Governors: When President Gamal Abdel Nasser begun building the Aswan High Dam, contrary to the agreement, Sudan withdrew from the treaty. Later, there was a military coup in Sudan. The new Sudanese Government renegotiated the treaty resulting in the 1959 agreement, which increased Egypt's share to 55.5 billion cubic meters (or 82 per cent of the annual flow), while Sudan's share was increased to 18.5 billion cubic meters (or 18 per cent). Egypt is today accused of being behind the coup that followed the standoff and saw Mr. Jaffer Numeiri take power in Sudan. Once again, Egypt and Sudan ignored Kenya and all the other basin countries and went ahead to irrigate 6 million acres and 2.75 acres, respectively.

Threat of Usage of Force: To sustain this selfishness, the two countries have used the threat of force to intimidate other countries from utilizing the waters flowing into the Nile. For instance, in May 1978, the then Egyptian Minister of Irrigation and Land Reclamation, Mr. Abd a-Azim Abu al-Ata warned countries in the Horn of Africa that any attempt to control the source of the Nile was "an act of aggression".

Such has been the sensitivity with which Egypt treats any attempt by upstream countries to use the Nile waters for their needs. Even Kenya, which contributes two-thirds of the water flowing into Lake Victoria, is not spared from this threat. "The day that Kenya decides to use water from Lake Victoria, we'll have less water in Egypt. One litre of water used for their irrigation will be reduced from water received in Cairo", a senior official in Egypt was quoted by the Financial Times of London in January 1988. The Egyptian Ambassador to Kenya, Dr Rifaat al-Ansary, has reacted that his country has nothing to do with this and there was no controversy. But as the Ambassador denied any controversy, other countries are not happy with the fact that his country, and Sudan, in 2001 insisted that the treaty could only be renegotiated, if other Nile Basin countries first recognized it as binding.

Nevertheless, the agreement goes against the internationally recognized riparian states' rights of Kenya and the other eight Nile Basin countries. This law states that a riparian state has sovereignty over the stretch of any river within its international boundaries and may use such water as it deems fit so long as it does not infringe upon the rights of other riparian states on the same river. It could be with this law in mind that Tanzania disregarded the treaty in 1962 while Uganda plans to construct a second hydro-electric power generation dam on the Bujagari Falls on the Nile. Kenya seems to have settled for the renegotiation option.

The Near War with Ethiopia over the Use of Nile Water: In June 1980, Egypt nearly went to war with Ethiopia after the latter opposed moves by Egyptian President Anwar Sadat to divert the Nile waters to the Sinai Desert, which is outside the Nile Basin. After making peace with Israel, Mr Sadat had promised Israelis that he would irrigate the desert. On its part, Ethiopia had threatened to obstruct the Blue Nile, a notion that made Egypt prepare for war. Egypt has also placed its hydrologists along the 5,584 kilometer-long course of the Nile ostensibly to monitor its volume.

The eight countries need to disregard the treaty if they are to meet their rising water needs. Today, their combined population stands at 202 million against 98 million Sudanese and Egyptians. Though a substantial section of the eight countries' population may have alternative sources of water, this has not been adequate for the rising population.

The Riparian States and Egyptian Concept on use of River Nile: Meanwhile countries sharing Lake Victoria cannot use its water for development projects. In Uganda, a commissioner for water resource management Mr. Nsubuga Senfuma, explains that "for any project to take place on either Lake Victoria or River Nile, Egypt must be consulted first". Ethiopia too has a right to use Nile Waters without Egypt's permission. Egypt and Sudan must agree that Kenya and indeed the other basin countries have as much right over the use of the waters as they do. While there is merit in the Tanzanian President's statement in 1998 that the Nile resource should be "a formidable unifying factor instead of a source of division and conflict", the eight countries should handle the controversy with more boldness. Collectively, they should disregard the treaty so that Egypt and Sudan can approach the issue in a spirit of give-and-take. The eight Basin countries should not continue honoring a treaty that neglects others' interests.

Demands to Revoke the River Nile Treaty: Sudan was the first country to demand a review of the 1929 treaty. The action brought a brief standoff between Khartoum and Cairo after Sudan got independence from Britain in 1956. In April 2002, there was a heated debate in the Kenyan Parliament about the Nile Treaties signed in 1929 and 1959, respectively. The Members of Parliament questioned the legality of those treaties. Consequently, there was a heated debate as to whether Kenya should or should not honor the treaties. Surprisingly, the debate, just like the treaty, was pegged on the wrong assumption that Lake Victoria is actually the only source of river Nile and the MPs, during their contribution, argued from this point of ignorance.

As East African politicians question the legality of a treaty that gives Egypt and the Sudan absolute rights over river Nile waters, one issue is quickly coming to the fore: How will the two nations react given their enormous economic and agricultural interests? In Kenya, the then Energy Minister Raila Odinga and then minister for roads and public works and Kisumu East Town MP Gor Sungu have questioned the legality of the 1929 and 1959 Nile waters Treaties while the same issue have cropped up at the new East African Legislative Assembly. Recently, Mr. Odinga threw the first salvo in Kenya's parliament, calling upon the government to review the treaty and denouncing it as "*obsolete*", accusing Egypt of planning to "Export" the water to Sinai via a tunnel [4]. The story of the tunnel is little known, although it is part of a huge land reclamation project in Sinai Desert called the North Sinai Agricultural Development project. Since 1987, the project has been diverting Nile water to agricultural developing plots west of Suez Canal, with allegations that the water may end up in Israel.

Debate on a 1929 treaty that bound countries in the upstream of River Nile from "touching" its waters has been simmering for a while now. The treaty gave Egypt and Sudan absolute right to use 100 per cent of the river's water. The debate re-surfaced in April 2002, when a legal consultant with the United Nations Environmental Program, Prof. Charles Okidi, implored the three East African countries to ignore the treaty and go ahead and utilize the waters of Lake Victoria. He asked East African countries to ignore the 1929 treaty[5]. Yet, unlike this treaty, which was binding on British colonies, the 1959 one is between two independent nations Egypt and Sudan without reference to other concerned countries. The then Energy Minister Raila Odinga saying the treaty was "unfair" had earlier made a similar call. By and large, the Kenya government seems reluctant to be drawn into the controversy. An official with the Water Development Department, Mr John Nyaro, termed the treaty as binding, a stand also taken by his boss, the then Water Development Minister Kipng'eny arap Ng'eny. It is not clear

[5]Daily Nation newspaper, March 29, 2002

why Government officials have continued to refer to this flawed water use arrangement as an “Agreement”.

For one, it was made before Kenya was a state, as we know it. “This treaty only benefits Egypt. We cannot sit back while we have water we cannot use to irrigate our land. Why should we preserve our water for Egypt”? Mr. Odinga asked Parliament? Experts predict minimal impact on the Nile if East African countries harvest Lake Victoria water for local use. Parliament was right in demanding a renegotiation of the 1929 Nile Water Agreement between Britain and Egypt over the use of Nile’s waters. A treaty they did not sign in some distant past should not bind Kenyans[6]. In June 2003, members of the East African Legislative Assembly (EALA) called for a renegotiation on the Nile Treaty with a view to selling waters of the Nile to Sudan and Egypt.

Source of Acrimony: With approximately 125 million people depending on the Nile for survival, the river is seen today as possible source of acrimony in East Africa. At the Regional Regulative Assembly, Uganda member Yona Kanyomozi has questioned the importance of the 1949 Owen Fall Dam Agreement and wondered why Egypt was using more water than agreed. He also wonders why Egypt does not participate in conservation of Lake Victoria. He said, “What bothers me is that when Uganda developed a scheme to divert some of the Nile waters to Karamoja for irrigation, the plan was opposed by Egypt, yet for them they can do anything with the Nile waters”[7].

How the treaty binds other riparian countries is doubtful. But since then Egypt the most powerful military power in the region - has been warning that it could go to war over Nile waters. In 1979, Egyptian President Anwar Sadat said: “The only matter that could take Egypt to war again is water”. And in 1988, then Egyptian foreign minister Boutros-Ghali, who latter became UN Secretary-General, went a step further. He said: “The next war in our region will be over waters of the Nile, not politics”.[8]

Such sentiments have for the years caused Nile nations eager to renegotiate the Nile water treaties to tread with caution. They are aware that for Egypt, in particular, Nile waters are a matter of life and death. From as early as 1898, when a French expedition tried to control

[6] Daily Nation newspaper, October 19, 2001

[7] John Mbaria: Revoke obsolete Nile treaty. Daily Nation newspaper, March 29, 2002

[8] John Mbaria: Revoke obsolete Nile treaty. Daily Nation newspaper, March 29, 2002

the headwaters of the of the Nile, Egypt has discussed the Nile with passion. In 1958, it sent a military expedition to a disputed territory with the Sudan, pending negotiations over Nile waters. This eventually led to a coup and installation of a pro-Egyptian government in the country. From 1978 onwards tensions have persisted between Egypt and Ethiopia after Ethiopia proposed to construct dams on headwaters of the Blue Nile. That was when President Sadat warned that Egypt's next war would be over the Nile. But can the region go to war over water? The only recorded incident of an outright war over water was 4,500 years ago in modern southern Iraq between two Mesopotamian city-states over the Tigris-Euphrates. Scholars say that 80 per cent of water's war consists of verbal threats and posturing by state leaders, probably aimed at their own internal constituents.

In the past 50 years, there have been only 37-recorded events in which people actually shot at each other over water along international borders. Of those, 27 were between Israel and Syria over the Jordan and Yarmouk rivers. Is the Nile meandering towards that, or is this just a cold water war?

The New Nile River Treaty: In September 2002, the Coordinator of the Uganda-based inter-state organization, the Nile Basin Initiative, informed a workshop meeting in Kisumu, Kenya, that a new legal framework was to be signed in two months' time by 10 riparian countries, which include Burundi, Democratic Republic of Congo, Egypt, Ethiopia, Eritrea, Kenya, Rwanda, Sudan, Tanzania and Uganda.

The Nile Basin Initiative was launched in 1999 following consultations among the 10 riparian countries. Although Egypt is today backing a new initiative among the Nile Basin riparian states, which might redistribute more equitably the river's water usage rights, it is not clear how far this will go. Note 10.1[9] provides a historic perspective of the basins initiatives.

Note 10.1 (A Brief History of the Nile Basin Initiative (NBI), 1992-2001).

1992: In 1992 the Council of Ministers (Nile-Com) of Water Affairs of the Nile Basin States launched an initiative to promote cooperation and development in the Basin. Six of the riparian countries the Democratic Republic of Congo (D.R.C), Egypt, Rwanda, Sudan, Tanzania, and Uganda; formed the Technical Cooperation Committee for the Promotion of the Development and Environmental Protection of the Nile Basin (TECCONILE). The other four riparian states participated as

[9]Source: The Nile Basin Initiative Secretariat (Nile-SEC)

observers. Within this framework, the Nile River Basin Action Plan (NRBAP) was prepared with support from CIDA. One of the projects (Project 3), whose objective is to develop a co-operative framework for management of the Nile, was endorsed by all countries during the 3rd meeting of the Nile-COM (in Arusha, 9- 11 February, 1995) and is being implemented with UNDP funding.

1995: The World Bank was asked by the COM to play a lead role in co-ordinating the inputs of external agencies to finance and implement the NRBAP.

March 1997: The request from COM to the World Bank was reiterated.

June 1997: The request was accepted by the World Bank. The World Bank proposed that it undertakes the task in partnership with UNDP and CIDA, and that a review and consultation process be launched prior to a Consultative Group-style donor meeting.

November 1997: A review of the Nile River Basin Action Plan was undertaken with the support of an international Advisory Group (IAG). The IAG meeting of international experts was held at Coolfont near Washington, D.C., USA.

January 1998: A Special Review Meeting was held in Cairo with senior officials attending from the riparian countries to discuss the Draft Review Report and move towards the definition of a priority, revised Action Program. Discussions converged on two complementary ideas which provide a structure for the revised Action Program a shared vision, and action on the ground.

March 1998: The 6th COM Meeting, held in Arusha, Tanzania, was attended by eight riparian countries (all except Eritrea and D.R. Congo). It was a major milestone in Nile co-operation. The meeting considered the Revised Action Plan.

July 1998: The 1st meeting of the Nile Technical Advisory Committee (Nile-TAC) was held in Dar es Salaam, Tanzania, under the chairman ship of Mr. Meraji Msuya.

21-22nd Sept 1998: The 2nd meeting of the Nile-TAC, held in Arusha, Tanzania. Meeting agrees on the Terms of Reference of the Nile-TAC, its Rules of Procedure, its Policy Guidelines and a Plan of Action.

23-24Sept 1998: Extra-Ordinary meeting of the Council of Ministers (Nile-COM) was held in Arusha, Tanzania.

22nd Feb 1999: Extra-ordinary meeting of the Nile Basin Council of Ministers, was held in Dar es Salaam, United Republic of Tanzania. Agreed minutes were prepared which formally established the Nile Basin Initiative.

23-24th Feb 1999: 3rd meeting of Nile-TAC in Dar es Salaam, Tanzania.

4-7th May 1999: Nile-TAC held a Strategic Planning and training workshop in Sodere, Ethiopia, which initiated the preparation of projects within the Basin-wide Shared Vision Program.

10-14th May 1999: 4th meeting of the Nile-TAC in Addis Ababa, Ethiopia. The formation of Working Groups to develop Project Concept Documents for the Shared Vision Program.

12-13th May 1999: 7th meeting of the Council of Ministers for Water Affairs in the Nile Basin States (Nile-COM), Addis Ababa.

15th May 1999: First meeting of the Eastern Nile Council of Ministers.

1st June 1999th The Nile Basin Initiative Secretariat started operations in the former TECCONILE building in Entebbe, Uganda, with Mr. Meraj Msuya as Executive Director.

30th August–3rd Sept 1999: 5th meeting of the Nile-TAC in Entebbe and second meeting of the Working Groups to develop Project Concept Documents for the Shared Vision Program in preparation for the ICCON meeting.

3rd Sept. 1999: The official opening of the Nile Basin Secretariat offices in Entebbe, Uganda.

13-18 Dec. 1999: National experts from various sectors meet at the Nile Basin Secretariat in Entebbe to share ideas and work together in initiating project studies under the Shared Vision Program.

24-26th Jan. 2000: 6th Nile-TAC meeting is held at the Nile Basin Secretariat in Entebbe to agree on the work plan for the priority project proposals for the Nile Basin.

18 March 2000: Senior officials from the Nile Basin Initiative present their "Shared Vision" for the time to the international community during the Second World Water World Forum in the Hague, the Netherlands, attended by over 4,000 participants from all over the world.

23rd March 2000: 7th Nile-TAC meeting is held in Deft, the Netherlands to review alternative work plans and meeting schedules towards the first ICCON.

31st July-3rd August 2000: 8th Nile-TAC meeting is held in Khartoum, Sudan, as a precursor to the 8th Nile-COM meeting, to finalize proposals for the priority projects under preparation.

4-5th Aug. 2000: 8th Nile-COM meeting is held in Khartoum. It endorses the priority projects being prepared under the Shared Vision Program and instructs the Nile-TAC to complete preparation of full project documents to be submitted to the Nile-COM in the first week of December 2000. The Council confirms February 2001 and Geneva, Switzerland as the time and venue of the first ICCON

21-25th Aug. 2000: National experts from the Nile Equatorial Lakes region meet in Entebbe to share ideas on a series of possible joint projects for the region, to be prepared under the Nile Equatorial Lakes Subsidiary Action Program (NELSAP).

20-29th January 2001: National experts from the Eastern Nile meet in Addis Ababa to share ideas about joint projects being prepared under the Easter Nile Subsidiary Action Program (ENSAP).

6th September 2002: Mr. Antoine Sendama, Co-ordinator of Nile Basin Initiative, announces that a new legal framework a revision of the Nile Treaty - is to be signed by 10 riparian countries (nations neigbouring water masses). The countries are Burundi, Congo, Egypt, Ethiopia, Eritrea, Kenya, Rwanda, Sudan, Tanzania and Uganda.

10.4 Concluding Remarks

Through its links with Lakes Tana and Victoria and all the rivers that feed them, the great Nile system belongs to the peoples of Rwanda, Burundi, Tanzania, Uganda, Kenya, the Sudan, Ethiopia, and Eritrea. Yet, when the present Nile Treaty was "negotiated" and signed in 1929, these peoples were never consulted. It was a treaty purely between the various British colonial regimes that lorded it over most of these African countries.

That the pact overwhelmingly favoured Egypt is no wonder. Egypt was far more important to Britain than the other colonies. Through the Suez Canal, it was a valid econo-strategic link with the riches of the Middle East, India and the Far East. But more relevant than that, the Egyptian section of the Nile Basin was (and remains) a veritable treasure trove of agricultural products, especially the raw cotton that continues to feed the maws of Lancashire's textile industries. And Egyptian farming - the great irrigation works that have maintained that country ever since Pharaoh Menes-Narmer united it in 3100 BC have depended entirely on extraordinarily fertile alluvium, which the two Niles scoop yearly from Eastern Africa. That was why the treaty banned all the riparian countries south of Egypt from using the Nile water for their own irrigation without Cairo's consent. Even after independence, Cairo has clung tenaciously to this blatant injustice. The benefits have been so great that Egypt has adamantly rejected all calls to democratize the international use of the river's rich resources. But Egypt claims to belong to the comity of African nations and it is good that it has finally seen the sense of sitting down with the other "stake holders" to negotiate the issue afresh.

The need remains, nevertheless, to use the Nile waters with the greatest rationale. Egypt is right to be anxious about wastage. For the fact remains that, for that country, the Nile is the only lifeline. Other interested countries do not depend on it so completely and so desperately. Therefore, they should exploit the river with enough prudence not to harm Egypt's interests. What is to be done? One possible solution, suggested by members of the East African Legislative Assembly, is to sell the Nile waters to Sudan and Egypt, just as Egypt has been selling the Nile waters to Israel.[10]

[10] East African Standard Newspaper, June 17th, 2003

11

Application of Satellites to Lake Victoria

"In December 1999, hurricane Lothar devastated parts of southern Germany and tore huge swathes into forests. In the state of Baden-Wurttenberg alone, about 90% of trees were estimated to have been destroyed and wooden areas left with large bare patches. In order to quickly assess the damage with the aim of taking reforestation measures, forest experts fell back to the faithful helper; the Geographical Information System (GIS)[1]."—Dialog, Vol. 2, 2002, pp.18-21

11.1 Satellite Environmental Monitoring

In 1997, the Kyoto protocol to the United Nation's framework convention on climate change spelt out measures that were to be taken to reduce the greenhouse gas emission that has contributed to *global warming*. Global warming is just but one of the many challenges facing our environment today. The rapid increase in *desertification* on one hand and *flooding* on the other hand are environmental issues that are increasingly becoming of great concern. For instance, Kana and Budalangi within Lake Victoria basin in Kenya are regions that have experienced perennial flooding (see, e.g., Figs. 11.1 and 11.2[2]). These floods have been known to cause havoc destroying properties and displacing people. In some cases, the Kano and Budalangi floods have led to death of people. In USA for example, the torrential rains that caused

[1]Dialog, 2002: Journal of International Advanced Training and Development, Vol 2

[2]source: Associated Press

Fig. 11.1. Flooding in Nyando District of Kenya

Fig. 11.2. Flooding in Budalangi, Kenya

havoc and destroyed properties in 1993 is estimated to have totalled to \$15 billion, 50 people died and thousands of people were evacuated, some for months [80]. Today, the threat from torrential rains and flooding still remains real as was seen in 1997 El'Nino rains that swept roads and bridges in Kenya, the 2000 Mozambique flood disaster, 2002

Germany flood disaster, the Hurricane Isabel in the US coast[3] or the recent Hurricane Katrina in New Orleans in the US. The melting of polar ice thus raising the sea level is creating fear of submerssion of beaches and cities surrounded by oceans and those already below sea level. In-order to be able to predict and model these occurrences so as to minimize damages such as those indicated by [80], atmospheric studies have to be undertaken with the aim of improving on mechanism for providing *reliable*, *accurate* and *timely* data. These data are useful in Numerical Weather Prediction (NWP) models for weather forecasting and climatic models for monitoring climatic changes. Besides, *accurate* and *reliable information* on weather is essential for other applications such as agriculture, flight navigation, etc.

Data for NWP and climatic models are normally collected using balloon filled radiosondes, satellites (polar and geostationary) and other sources, e.g., flight data from aeroplanes. Whereas [92, p. 94] points out that about 9500 surface based stations and 7000 merchant ships exist that send up weather balloons, [158] noted that most of these data cover the northern hemisphere, with the southern hemisphere (mainly Africa and South America) lacking adequate data due to financial constraints. Lack of radiosonde data is also noted in the oceanic areas hence leading to shortage of adequate data for NWP and climatic models. These models require precise and accurate data for estimating initial starting values in-order to give accurate and reliable weather forecast, and to be of use for climate monitoring. The shortage of radiosonde data is complemented with the polar and geostationary satellite data. Polar satellites include for instance the US owned National Ocean and Atmospheric Administration NOAA-14 and NOAA-15, while the geostationary satellites include US based Geostationary Operational Environmental Satellite (GEOS) and Europe owned METEOrological SATellite (METEOSAT).

Polar and geostationary satellites (e.g., NOAA, GOES and METEOSAT) used for temperature and water vapour profile measurements have their own limitations however. In high altitude winter conditions for instance, use of passive Infra Red (IR) is difficult due to *very cold temperatures*, *common near surface thermal inversion*, and *high percentage of ice cloud* that play a role in limiting the IR sounding [98]. In volcanic areas, low flying remote sensing satellites are also affected by the presence of dust and aerosol. Large-scale volcanic eruption nor-

[3]BBC 19th Sept. 2003 online report: http://news.bbc.co.uk/

mally injects large amount of aerosols into the lower stratosphere and thus limiting the IR observation of the stratosphere and lower regions. In-order therefore to enhance global weather and climatic prediction, current systems have to be complemented by a system that will provide global coverage and whose signals will be able to penetrate clouds and dust to remote sense the atmosphere. Such system, already proposed as early as 1965 by Fischbach [40], and which is currently an active area of research, is the new field of ***GPS-Meteorology***. It involves the use of GPS satellites to obtain atmospheric profiles of *temperature*, *pressure* and *water vapour/humidity*.

In Subsect. 11.2.1 in p. 310, it will be shown that the Global Positioning System (GPS) satellites were primarily designed to be used by the US military. Their main task was to obtain the position of any point on Earth from space. The signals emitted by GPS satellites traverse the ionosphere and neutral atmosphere to be received by ground based GPS receivers. One of the major obstacles to positioning or navigating with GPS is the signal delay caused by atmospheric refraction. Over the years, research efforts have been dedicated to modelling atmospheric refraction in-order to improve on positioning accuracy. In the last decade however, [98] suggested that this negative effect of the atmosphere on GPS signals could be inverted to remote sense the atmosphere using space borne techniques and in effect contribute towards monitoring of the environment. Melbourne [98], proposed that Low Earth Orbiting Satellites (LEO) be fitted with GPS receivers and be used to track the signals of rising or setting GPS satellites (occulting satellites). The signal delay could then be measured and used to infer on the atmospheric profiles of temperature, pressure, water vapour and geopotential heights.

This new technology of GPS atmospheric remote sensing, which we consider in details in Sects. 11.2.3 and 11.2.3 in pp. 315–321, has the advantages of;

(a) being *global*,
(b) *stable* owing to the stable GPS oscillators and
(c) having radio frequencies that can *penetrate* clouds and dusts.

The new technology therefore plays a major role in complementing the existing techniques, e.g., radiosondes. Atmospheric profiles from GPS remote sensing have been tested in NWP models and preliminary results so far are promising [59]. Indeed, [77] have already demonstrated using the data of the pilot project GPS/MET that the accuracy of global and regional analysis of weather prediction can significantly be improved. Also motivating are the results of [137] who showed that high accuracy of measurements and vertical resolution around the tropopause would be relevant to monitor climatic changes in the next decades. Accurate temperature measurements of the tropopause will clearly give an indication of global warming. Global warming could be linked to the perennial flooding owing to the high rate of evapotranspiration within the Lake basin.

Several atmospheric sounding missions have been launched, e.g., the CHAllenging Minisatellite Payload Mission (CHAMP) (i.e., Fig. 11.11[4] in p. 323), Gravity Recovery And Climate Experiment (GRACE) (i.e., Fig. 11.15[5] in 330). Constellation Observing System for Meteorology, Ionosphere and Climate (COSMIC) mission that will provide up to 3000 occultation data daily is proposed to be launched by University Corporation of Atmospheric Research UCAR in 2005 [2]. The project was meant to run from 1991–2006. EQUatorial Atmosphere Research Satellite (EQUARS) mission that will provide equatorial coverage was proposed to be launched in 2005 [145]. Probably, when operational, EQUARS mission will be one of the most significant satellites to provide information on weather and climate parameters within Lake Victoria basin. This is due to the fact that it covers equatorial region.

Currently, studies are being undertaken at Jet Propulsion Laboratory (JPL) on possibilities of having future atmospheric sounding missions that will have satellites of the sizes of a laptop with GPS receivers of the sizes of a credit card [163]. Plans are also underway to have the European owned EUropean organization for the exploitation of METeorological SATellites (EUMETSAT) and American NOAA owned National Polar Orbiting Environmental Satellite System (NPOESS) installed with GPS occultation receivers GRAS (GNSS Receiver for Atmospheric Sounding) and GPSOS (GPS Occultation Sensor) [158]. The planned satellite missions together with the proposed GALILEO satellites scheduled to be operational by 2010 [158] and the Russian GLONASS promises a brighter future for environmental monitoring. Indeed, that these atmospheric sounding missions promise to provide daily global coverage of thousands of remotely sensed data which will be vital for weather, climatic and atmospheric sciences studies will be a revolution in the history of environmental studies.

[4]Source: GFZ Potsdam, http://www.gfz-potsdam.de

[5]Source: GRACE homepage

Space borne GPS meteorology which we discuss in detail in Subsect. 11.2.3 in p. 315 is just but one part of this new technique. The other component is the ground based GPS meteorology which will be discussed in detail in Subsect. 11.2.3 in p. 321. Collection of articles on this new technique has been presented for instance in [3, 128]. In ground based GPS meteorology, a dense GPS network is used to measure precisely GPS path delays caused by the ionosphere and the neutral troposphere traversed by the GPS signals. These path delays are then converted into Total Electronic Contents (TEC) and Integrated Precipitate Water Vapour IPWV. Conversion to IPWV requires prior information of surface pressure or estimates along the GPS ray path. These create a continuous, accurate, all weather, real time lower and upper atmospheric data with a variety of opportunities for atmospheric research [155].

Clearly, GPS meteorology promises to be a real boost to atmospheric studies with expected improvements on weather forecasting and climatic change monitoring, which directly impact on our day to day lives. One such area is in the monitoring of flash floods. In [11], the possible use of IPWV for flash flood prediction is proposed, while [13] have outlined the potential of water vapour for meteorological forecasting. Flash floods are the floods that comes instantaneously following heavy rains. Factors that lead to flash flood producing rains are summarized in Fig. 11.3. Let us consider Fig. 11.4, an example of a study

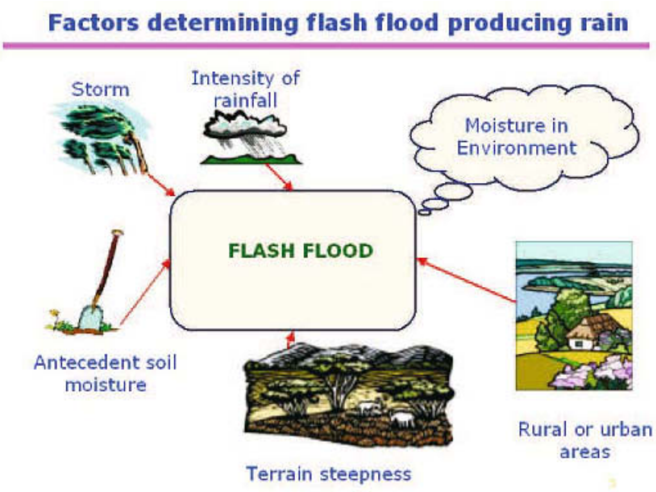

Fig. 11.3. Factors causing flash flood

contacted by Paroscientific Inc.[6] In the figure, the amount of integrated water vapour in the atmosphere is related to the rainfall. Mr. Mustafa Yilmaz of Paroscientific Inc. sought to monitor flash flood in Hawaii (see the left bottom corner of the figure). As it was raining, Integrated Precipitate Water Vapour (IPWV) increased, signifying that more rain will follow. By monitoring the intensity of water vapour therefore, one could be able to predict the occurrence of flash flood. Station PGF1 and others were monitored and an increase noted after day 307. Shortly before day 308, the scientist reported the possibility of flash flood and indeed it occurred. Station PGF1 was thereafter washed away. More on information can be found by visiting http://www.paroscientific.com. In

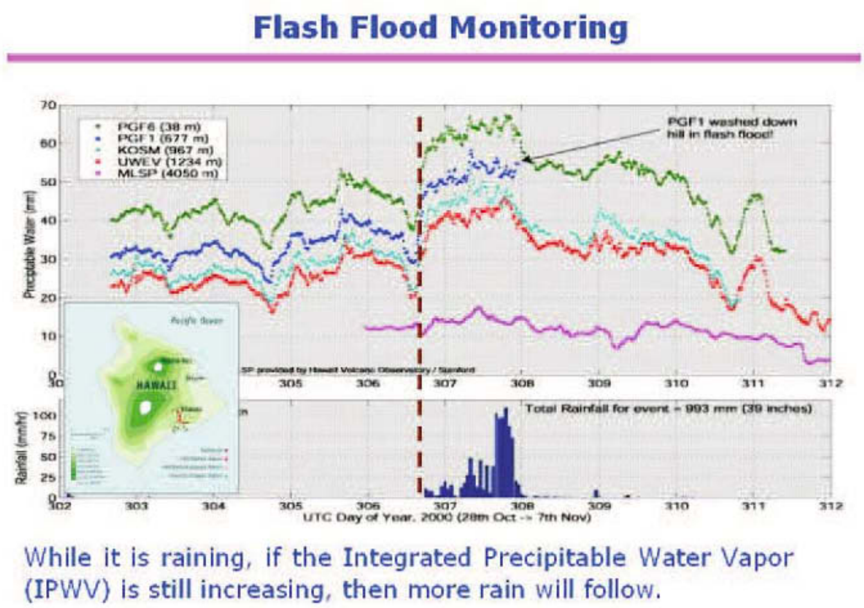

Fig. 11.4. Flash flood Monitoring

the same note, Lake Victoria flood pron areas could be monitored using satellite. Integrated Precipitate Water Vapour of Kana and Budalangi areas, for instance, could be studied using satellite data and an early flash flood warning system established. This could assist in mitigation measures that could lead to saving of life and properties that are nor-

[6]Source: Paroscientific Inc., http://www.paroscientific.com

mally destroyed during flood. Indeed Awange [10] had already pointed out the possibility of using satellites in the monitoring of Lake Victoria.

11.2 GPS Monitoring of Lake Victoria

In Sect. 11.1 we have presented an overview of satellite environmental monitoring in general. In this section, we will focus on the applicability of GPS satellites to the monitoring of Lake Victoria. In-order to achieve this, the reader has to familiarize with GPS satellites. What exactly are GPS satellites which has received prominent mention in the preceding section? How applicable are they to the study of Lake Victoria? The following subsections attempts to provide answers to these questions.

Indeed, that the use of GPS satellites is slowly downing on Lake Victoria can be seen from the work of [58, p. 80], who applies it within the framework of GIS to monitor solid waste deposition which end up polluting the Lake.

11.2.1 Global Positioning System (GPS)

Global Positioning System (GPS) are satellites that were primarily designed for use of US military in the early 60's, with a secondary role of civilian navigation. The oscillators aboard the GPS satellites generate a fundamental frequency f_0 of 10.23 MHz. Two carrier signals in the L band denoted L_1 and L_2 are generated by integer multiplication of the fundamental frequency f_0. These carriers are modulated by codes to provide satellite clock readings measured by GPS receivers. Two types of codes; the coarse acquisition C/A and precise acquisition P/A are emitted. C/A code in the L_1 carrier is less precise and is often reserved for civilian use, while the P/A code is reserved for the use of US military and its allies. It is coded on both L_1 and L_2 [62].

The design comprises three segments namely; the *space segment*, *user segment* and the *control segment*. The space segment was designed such that the constellation consisted of 24 satellites (with a spare of four) orbiting at a height of about 20,200 km. The orbits are inclined at an angle of 55° from the equator with an orbiting period of about 12 hours. The user segment consists of a receiver that tracks signals from at least four satellites in-order to position (see, e.g., Fig. 11.6 in p. 313). The control segment consist of 5 ground stations with the master station located at the Air force base in Colorado. The master station measures satellite signals which are incorporated in the orbital models for each satellite. The models compute ephemerids and satellite clock correction parameters which are transmitted to the satellites. The satellites then transmit the orbital data to the receivers.

The results of the *three-dimensional positioning* using GPS satellites are the three-dimensional geodetic coordinates $\{\lambda, \phi, h\}$ of a receiver station. These coordinates comprise the geodetic longitude λ, geodetic latitude ϕ and geodetic height h. When positioning with GPS, the outcome is the geocentric position for an individual receiver or the relative positions between co-observing receivers.

The *global reference frame* $\mathbb{F}^\bullet$ upon which the GPS observations are based is defined by the base vectors $\mathbb{F}_{1^\bullet}, \mathbb{F}_{2^\bullet}, \mathbb{F}_{3^\bullet}$, with the origin being the center of mass. The fundamental vector is defined by the base vector $\mathbb{F}_{3^\bullet}$ and coincides with the mean axis of rotation of the Earth and points to the direction of the Conventional International Origin (CIO). $\mathbb{F}_{1^\bullet}$ is oriented such that the plane formed by $\mathbb{F}_{1^\bullet}$ and $\mathbb{F}_{3^\bullet}$ points to the direction of Greenwich in England. $\mathbb{F}_{2^\bullet}$ completes the right handed system by being perpendicular to $\mathbb{F}_{1^\bullet}$ and $\mathbb{F}_{3^\bullet}$. The geocentric Cartesian coordinates of a positional vector $\mathbf{X}$ is given by

$$\mathbf{X} = \mathbb{F}_{1^\bullet} X + \mathbb{F}_{2^\bullet} Y + \mathbb{F}_{3^\bullet} Z, \tag{11.1}$$

where $\{X, Y, Z\}$ are the components of the vector $\mathbf{X}$ in the system $\mathbb{F}_{1^\bullet}, \mathbb{F}_{2^\bullet}, \mathbb{F}_{3^\bullet} \,|\mathrm{o}$.

Operational Principles of GPS

Basically, the operations involve distance measurements to GPS satellites. The receiver measures the travel time of the signal transmitted from the satellites. This distance is calculated from the relationship

$$distance = velocity \times time,$$

where velocity is given by the speed of light in vacuum. The distances S_i are then related to the position of the unknown station $\{X_0, Y_0, Z_0\}$ by

$$S_i = \sqrt{(X^i - X_0)^2 + (Y^i - Y_0)^2 + (Z^i - Z_0)^2}, \tag{11.2}$$

where $\{X^i, Y^i, Z^i\}$ are the position of the satellite i. Geometrically, the three unknowns $\{X_0, Y_0, Z_0\}$ are obtained from the intersection of three spherical cones given by the pseudo-ranging equations. Distance

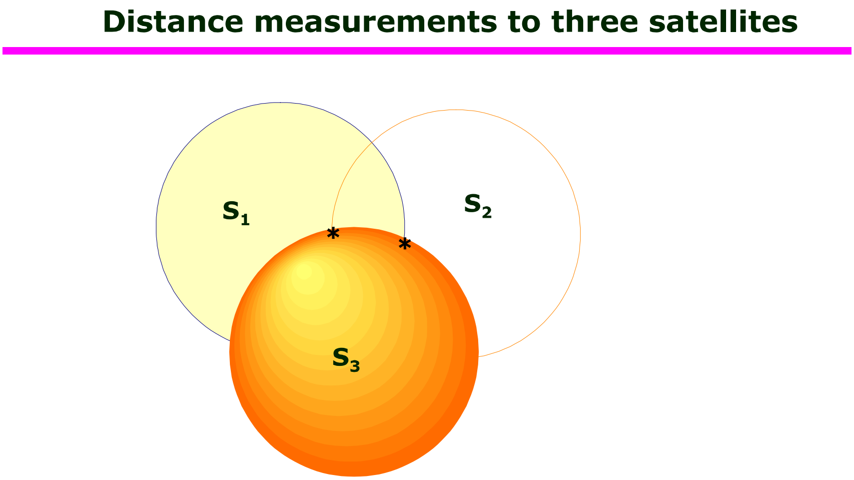

Fig. 11.5. GPS positioning geometry

measurements to only one satellite puts the user's position anywhere within the sphere formed by distance S_1 in Fig. 11.5. Measurements to two satellites narrow the position to the intersection of the two spheres S_1 and S_2 in Fig. 11.5. A third satellite is therefore required to definitely fix the user's position. This is achieved by the intersection of the third sphere S_3 with the other two. If direct distance measurements to the satellites were possible, (11.2) would have sufficed to provide the user's location. Distance measurements to satellites as already stated are however not direct owing to the satellites and receivers' clock biases. Satellites' clock biases can be modelled while the receivers' clock biases have to be determined as an unknowns. For GPS positioning therefore, in addition to position determination from measured distances, the receiver's clock bias has to be added in the observation equations as unknown. Since distances to the satellites in (11.2) are derived from the transmitted signals that are affected by both satellites and receivers' clock uncertainties, they are normally referred to as pseudo-ranges. What one measures therefore are not the actual distances (ranges) but pseudo-ranges.

Pseudo-range measurements lead to GPS pseudo-ranging four-points problem ("pseudo 4P4"), which is the problem of determining the four unknowns. The unknowns comprise the three components of receiver position $\{X_0, Y_0, Z_0\}$ and the stationary receiver *range bias*. Minimum observations required to obtain receiver position and range bias are pseudo-range observations to four satellites as depicted in Fig. 11.6. Besides pseudo-range observations, phase measurements are often used

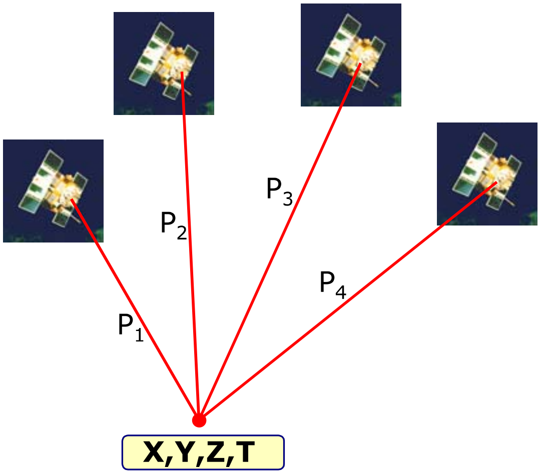

Fig. 11.6. Point positioning using GPS satellites

where accurate results are desired (see, e.g., [62]).

Four pseudo-range equations are formed from (11.2) and expressed algebraically as

$$\begin{bmatrix} (x_1 - a_0)^2 + (x_2 - b_0)^2 + (x_3 - c_0)^2 - (x_4 - d_0)^2 = 0 \\ (x_1 - a_1)^2 + (x_2 - b_1)^2 + (x_3 - c_1)^2 - (x_4 - d_1)^2 = 0 \\ (x_1 - a_2)^2 + (x_2 - b_2)^2 + (x_3 - c_2)^2 - (x_4 - d_2)^2 = 0 \\ (x_1 - a_3)^2 + (x_2 - b_3)^2 + (x_3 - c_3)^2 - (x_4 - d_3)^2 = 0 \\ where \;\; x_1, x_2, x_3, x_4 \in \\ (a_0, b_0, c_0) = (x^0, y^0, z^0) \sim P^0 \\ (a_1, b_1, c_1) = (x^1, y^1, z^1) \sim P^1 \\ (a_2, b_2, c_2) = (x^2, y^2, z^2) \sim P^2 \\ (a_3, b_3, c_3) = (x^3, y^3, z^3) \sim P^3. \end{bmatrix} \quad (11.3)$$

In (11.3), $\{P^0, P^1, P^2, P^3\}$ are the positions of the four GPS satellites whose signals are tracked by the receiver at an unknown station P_0. The satellites' positions are given by the coordinates $\{x^i, y^i, z^i | i = 0, 1, 2, 3\}$, where i indicate a particular satellite number. The measured pseudo-ranges to these satellites from a stationary receiver at P_0 are given by $\{d_0, d_1, d_2, d_3\}$. The parameters $\{a_0, b_0, c_0\}$, $\{a_1, b_1, c_1\}$, $\{a_2, b_2, c_2\}$, $\{a_3, b_3, c_3\}$, $\{d_0, d_1, d_2, d_3\}$ are known elements of the spherical cone that intersect at P_0 to give the unknown coordinates $\{x_1, x_2, x_3\}$ of the receiver and the stationary receiver range bias x_4. Procedures for solving (11.3) have been presented in [8].

11.2.2 Application of GPS to Lake Victoria's Border Conflicts

Consider Fig. 11.7 where we have three boats with fishermen from each of the three East African countries. If the three boats are in the middle of Lake Victoria with no visible land surface in the horizon, the fishermen will be at a dilemma to know who owns that portion of the Lake. In this case, they will not know whether they are in the Kenyan, Ugandan or Tanzanian territory. Fishermen have often found themselves in this situation and the net results has often been conflicts. These have often led to arrests and confiscation of fishing nets and steam boats. In many instances, Kenyan fishermen have been arrested in the Lake and taken to jails in neighbouring countries for fishing in foreign territories. In such cases, a hand held GPS receiver and a map could easily resolve such dilemma. A similar case is illustrated by someone in the middle of the desert who does not know his or her location as illustrated by Fig. 11.7. In this case too, one requires a GPS receiver to be able to locate ones own position. How then does GPS positioning work?

If one has access to a hand held GPS receiver (see, e.g., Fig. 11.7), a mobile phone or a watch fitted with a GPS receiver, one needs only to press the button to know the position of one of the boats. In this case, if one has a map as shown, one will get the position from the hand held GPS receiver in terms of longitude and latitude and locate it on a map. This way, one will be able to know if one is in a foreign territory or not. Availability of hand held GPS receivers which can give positions to about 5m can therefore assist fishermen and tourists navigating Lake Victoria.

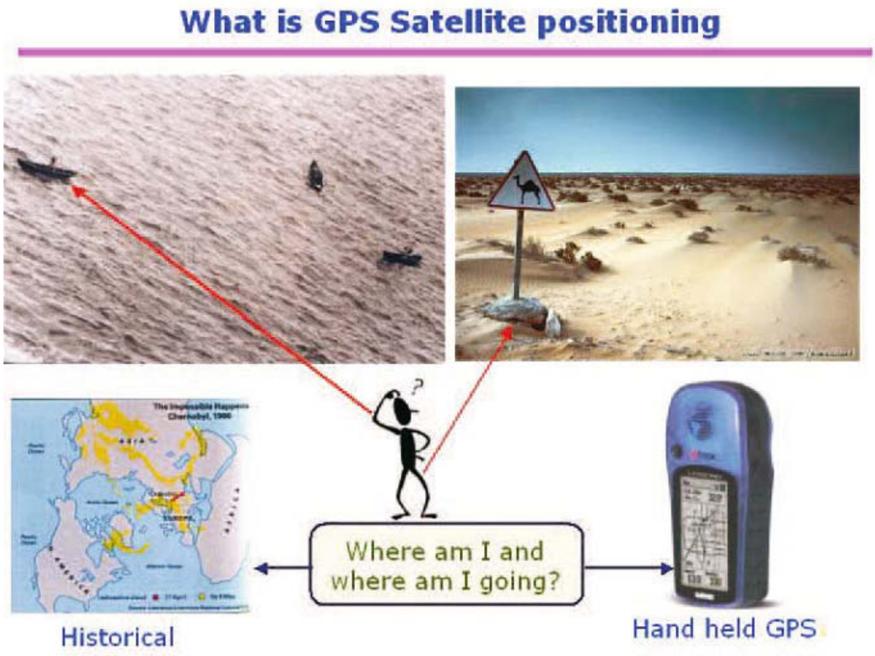

Fig. 11.7. Use of GPS in positioning within Lake Victoria

11.2.3 GPS Applied to the Lake's Meteorology

In Sect. 11.1, we elaborated on the use of satellites for environmental monitoring. We mentioned the new area of GPS meteorology as one of the emerging applications of GPS satellites to monitoring the environment. Indeed, the use of high flying GPS satellites to remote sense the atmosphere has revolutionized the retrieval of atmospheric profiles of *temperature*, *pressure*, *water vapour* and *geopotential* heights relevant for weather and climatic monitoring.

Before the entry of GPS, the profiles have been retrieved by the use of radiosondes (air filled balloons) in weather stations around the world and geo-stationary satellites that are prone to clouds, presence of aerosols and dust in the atmosphere. GPS signals, which operate in the L-band, are not affected by these factors and penetrate the atmosphere and in the process remote sense it. For Lake Victoria region, which lies in the tropical region, the presence of water vapour in the atmosphere is of great importance to control flooding, rise in lake level and El'Nino effects. The GPS-LEO satellites, particularly GPS-EQUARS satellite mission that is expected to be launched in 2005 will provide vast information for monitoring the presence of water vapour.

In the following sections, we will elaborate further on the concept of GPS meteorology and show how it can be applicable to Lake Victoria and its environs.

GPS Remote Sensing: State of the Art

The signals emitted by the GPS satellites often traverse the ionosphere and neutral atmosphere to be received by ground based receivers. One of the major obstacles to positioning or navigating with GPS is always the refraction effect of the atmosphere on the signals. Over the years, scientists have been struggling with coming up with corrective measures to the effect of the atmospheric refraction on positioning using GPS.

In the last decade however, W. G. Melbourne et al. [98] suggested that this negative effect of the atmosphere on the signal could be inverted to remote sense the atmosphere. This suggestion particularly came at a time when the existing remote sensing techniques, particularly, those relying on the geo-stationary satellites and radiosondes (use of air balloons) were succumbing to weather/instrumental and other environmental factors such as aerosols and dusts which affected their performance. In the suggestion of [98], it was proposed that Low Earth Orbiting Satellites (LEO) be fitted with GPS receivers and be used to track the signals of rising or setting GPS satellites (occulting satellites). The signal delay could then be measured and used to infer on the atmospheric profiles of temperature, pressure, water vapour and geo-potential heights.

Currently, there are several missions of the low flying LEO satellites that have been launched. These include the Australian-Jet Propulsion Laboratory (JPL) owned SAC-C and the German-US (NASA/JPL-GFZ) owned CHAMP and GRACE, UCAR/TAIWAN owned COSMIC and Japan/Brazil owned EQUARS. These satellite missions are follow up to the GPS-MET pioneer that is currently non-functional. On daily basis, the LEO satellite is expected to deliver up to 500 occultations, which are global based, all weather and self-calibrating. From these occultations, temperature profiles, pressure profiles, water vapour and geo-potential heights can be inferred. These are used in Numerical Weather Prediction Models (NWPM) to improve on weather predictions. In particular, the geo-potential heights and the tropopause information can be used to predict climatical changes.

The stratospheric temperatures are used to monitor the ozone layer and the natural atmospheric greenhouse gases (carbon dioxide, methane and water vapour) and the man made (chlorofluorocarbons) for the effect of global warming. The burning of organic matter which emit gases to the atmosphere that deplete the ozone layer, increasing the content of the man made green house gases can now be monitored, thanks to the GPS-LEO observation technique. Excellent exposition of Environmental warming is given by [92].

Space Borne GPS Remote Sensing

Radio occultation with GPS takes place when a transmitting GPS satellite, setting or rising behind the Earth's limb, is viewed by a LEO satellite as illustrated in Fig. 11.8[7]. GPS satellites send navigation signals, which passes through successively deeper layer of the Earth's atmosphere and are received by LEO satellites (see, e.g., Fig. 11.11). These signals are bent and retarded causing a delay in the arrival at the LEO satellite (see, e.g., Fig.11.8[7]).

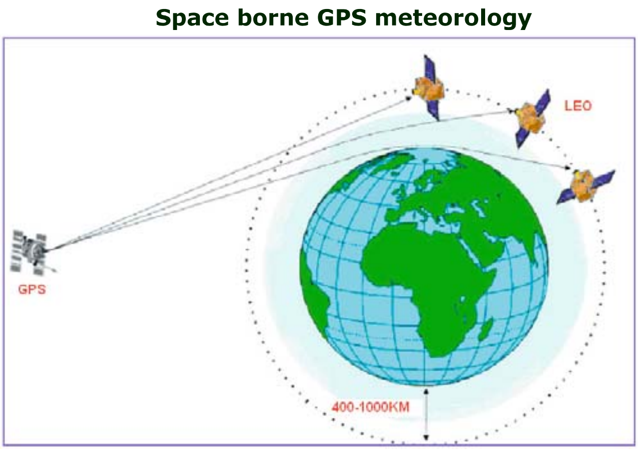

Fig. 11.8. GPS Radio occultation

Figure 11.9 indicates the occultation geometry where the signal is sent from GPS to the LEO satellite passing through dispersive layers of

[7]source: http://geodaf.mt.asi.it/html/GPSAtmo/space.html

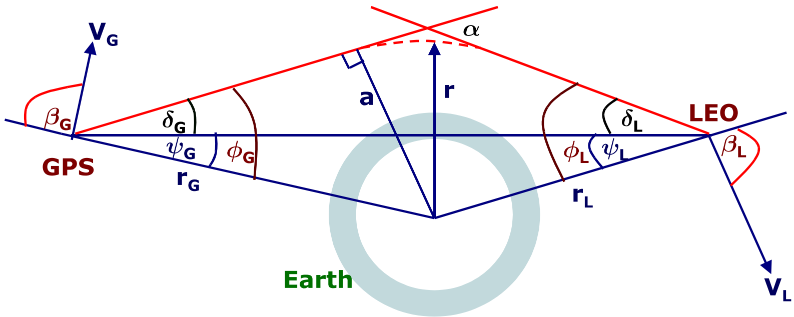

Fig. 11.9. Geometry of space borne GPS meteorology

the ionosphere and atmosphere remote sensing them. As the signal is bent, the total bending angle α, an impact parameter a and a tangent radius r_t define the ray passing through the atmosphere.

Refraction angle is accurately measured and related to atmospheric parameters of temperature, pressure and water vapour via the refractive index. Use is made of radio waves where the LEO receiver measures, at the required sampling rate, the dual band carrier phase, the C/A and P-code group delay and the signal strength made by the flight receiver [98]. The data is then processed to remove errors arising from short time oscillator and instabilities in; satellites and receivers. This is achieved by using at least one ground station and one satellite that is not being occulted. Once the observations have been corrected for possible sources of errors, the resulting *Doppler shift* is used to determine the refraction angle α (see Fig. 11.9).

The variation of α with a during an occultation depends primarily on the vertical profile of atmospheric refractive index, which is determined globally by *Fermat's principle* of least time and locally by *Snell's law*

$$nsin\phi = constant, \tag{11.4}$$

where ϕ denotes the angle between the gradient of refraction and the ray path. Doppler shift is determined by projecting spacecraft velocities onto the ray paths at the transmitter and receiver, so that atmospheric bending contributes to its measured value. Data from several GPS transmitters and post-processing ground stations are used to establish the precise positions and velocities of the GPS transmitters and LEO satellites. These derived positions and velocities are used to calculate the Doppler shift expected in the absence of atmospheric bending (i.e., were the signal to travel in vacuo). By subtracting the *expected* shift from the measured shift, one obtains the excess Doppler shift. Assuming local symmetry and with Snell's law, the excess Doppler shift together with satellites' *positions* and *velocities* are used to compute the values of the bending angles α with respect to the impact parameters a.

Weather Parameters from Refraction Angles

As we have already noted, the measured quantities are normally the excess path delay of the signal obtained by measuring the excess phase of the signal owing to atmospheric refraction during the traveling period. The determination of the refraction angle α from the measured excess phase therefore marks the beginning of the computational process to retrieve the atmospheric profiles of temperature, pressure, water vapour and geopotential heights. The unknown refraction angle α is related to the measured excess phase by a system of two nonlinear trigonometric equations;

1. an equation relating the doppler shift at the Low Earth Orbiting (LEO) satellite (e.g., CHAMP in Fig. 11.11 in p. 323, GRACE in Fig. 11.15 in p. 330, EQUARS etc). expressed as the difference in the projected velocities of the two moving satellites on the ray path tangent on one hand, and the doppler shift expressed as the sum of the atmosphere free propagation term and a term due to atmosphere on the other hand,
2. an equation that makes use of Snell's law in a spherically layered medium [136, p. 59].

The system of nonlinear trigonometric equations for determining the refraction angles formed from (1) and (2) are nonlinear and comprises of two equations given as

$$\left[\begin{array}{l} v_L cos(\beta_L - \phi_L) - v_G cos(\phi_G + \beta_G) = \dfrac{dL_i}{dt} + v_L cos(\beta_L - \psi_L) - v_G cos(\psi_G + \beta_G) \\ r_G sin\phi_G = r_L sin\phi_L, \end{array}\right. \tag{11.5}$$

where v_L, v_G are the projected LEO and GPS satellite velocities in the occultation plane, r_L, r_G the radius of tangent points at LEO and GPS respectively, and $\dfrac{dL_i}{dt}$, the doppler shift. The angles in (11.5) are as shown in Fig. 11.9 in p. 318.

Equation 11.5) has been solved using iterative numerical methods such as Newton's by [54, 78, 136, 153, 158] and algebraically by [8].

Once computed, these bending (refraction) angles are related to the refractive index by

$$\alpha(a) = 2a \int_{r=r_0}^{r=\infty} \frac{1}{\sqrt{n^2 r^2 - a^2}} \frac{\mathrm{d}In(n)}{\mathrm{d}r} \mathrm{d}r, \tag{11.6}$$

which is inverted using Abel's transformation to give the desired refractive index

$$n(r_0) = \exp\left[\frac{1}{\pi} \int_{a=a_0}^{a=\infty} \frac{\alpha(a)}{\sqrt{a^2 - a_0^2}} da\right]. \tag{11.7}$$

Rather than the refractive index in (11.7), refractivity is used as

$$N = (n-1)10^6 = 77.6\frac{P}{T} + 3.73 \times 10^5 \frac{P_w}{T^2} - 40.3 \times 10^6 \frac{n_e}{f^2} + 1.4w. \tag{11.8}$$

In (11.8), P denotes the atmospheric pressure in {mbar}, T the atmospheric temperature in K, P_w the water vapour in {mbar}, n_e the electron number density per cubic meter {number of electron/m^3}, f the transmitter frequency in Hz and w the liquid water content in g/m^3. Three main contributors to refractivity are:

- The *dry neutral atmosphere* (called the dry component, i.e., the first component on the right-hand-side of (11.8)).
- Water vapour (also called the wet or moist components, i.e., the second component on the right-hand-side of (11.8))
- The free electrons in the ionosphere (i.e., the third component on the right-hand-side of (11.8)).

If the atmospheric temperature T and pressure P are provided from external source, e.g., from models and synoptic meteorological data over tropical oceanic regions, then the vertical water vapour density may be recovered from satellite remote sensing data [98]. The refraction effects on the signals in the ionosphere must be corrected using signals at two frequencies at which these effects are substantially different.

Space Borne GPS Remote Sensing of Lake Victoria

For Lake Victoria region, of interest may be the water vapour content in the atmosphere. These tropical regions are highly humid due to the evaporation of the water from the Lake. In order to be able to predict the heavy torrential rains that often lead to flooding often witnessed in Kana and Nyando areas, the GPS-LEO Satellite data could be used to enhance hydrological data and provide early warning signals. Most of the Low Earth Orbiting Satellite missions do not adequately cover the equatorial region. For this reason, the Japanese in conjunction with the Brazilian are currently developing a 5 years mission to be launched in 2005 that will cover the equatorial region called Equatorial Atmosphere Research Satellites (EQUARS) [145].

Global weather parameters computed as illustrated above can be obtained from Jet Propulsion Laboratory (JPL) in the US or Geo-forschungsZentrum potsdam (GFZ) in Germany. These data are given for respective longitudes and latitudes. If one specifies the position of the Lake as given in Table 2.1 in p. 9, one can obtain data that are specific to the Lake. One can therefore make an analysis of the water vapour and be able to infer on the possibility of torrential rains that may lead to flooding (see, e.g., Fig. 11.1 in p. 304). Temperature profiles are plotted e.g., as illustrated in Fig. 11.10. Such profiles can further be used for weather and climate analysis of the Lake Victoria region.

Ground-Based GPS Remote Sensing of the Lake

Whereas GPS receivers are onboard low flying LEO satellites (e.g., CHAMP in Fig. 11.11 in p. 323, GRACE in Fig. 11.15 in p. 330, EQUARS etc) in space borne GPS remote sensing, they are fixed on ground stations in the case of ground-based GPS meteorology. These receivers track the transmitted signals which have traversed the atmosphere as indicated in Fig.11.12[8]. As the signals travel through the atmosphere from the satellites to the ground based receivers, they are delayed by the troposphere. The tropospheric delay comprise the hydrostatic and the wet parts as seen in equation (11.8). The contribution of hydrostatic part which can be modeled and eliminated very accurately using surface pressure data or three-dimensional numerical models is about 90% [23, 26]. The wet delay however is highly variable with little correlation to surface meteorological measurements. Assuming that the wet delay can be accurately derived from GPS data, and that reliable surface temperature data are available, the wet delay can be converted

[8]Source: http://apollo.lsc.vsc.edu/classes/remote/lecture_notes/gps/theory/theoryhtml.htm

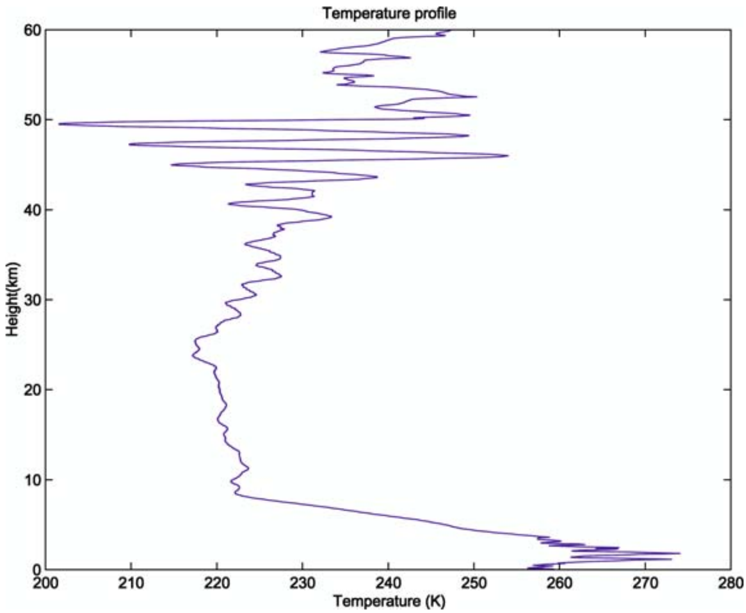

Fig. 11.10. Temperature profile from GPS meteorology

into the estimation of the total atmospheric water vapour P_w present along the GPS ray path as already suggested by [17]. This atmospheric water vapour P_w is termed precipitable water in GPS meteorology.

The precipitable water as opposed to the vertical profile is estimated with a correction made for the fact that the radio beams normally are slanted from the zenith. The phase delay along the zenith direction is called the "zenith delay" and is related to the atmospheric refractivity by

$$zenith\,Delay = 10^6 \int_{antenna}^{\infty} N(z)\mathrm{d}z, \tag{11.9}$$

where the integral is in the zenith direction. Substituting (11.8) in (11.9) leads to the calculation of the zenith wet delay which is related to the total amount of water vapour along the zenith direction. The zenith delay is considered to be constant over a certain time interval. It is the average of the individual slant ray path delays that are projected to the zenith using the mapping functions (e.g., [102]) which are dependent on the receiver to satellite elevation angle, altitude and time of the year.

Fig. 11.11. Champ satellite

The significant application of GPS satellites in ground based GPS meteorology is the determination of the slant water. If one could condense all the water vapour along the ray path of a GPS signal (i.e., from the GPS satellite to the ground receiver), the column of the liquid water after condensation is termed slant water. By converting the GPS derived tropospheric delay during data processing, slant water is obtained. By using several receivers to track several satellites (see, e.g., Fig.11.12[8]), a three-dimensional distribution of water vapour for Lake Victoria basin and its time variation can then be quantified. In Japan for example, there existed (by 2004) more than 1200 GPS receivers within the framework of GPS Earth Observing NETwork (GEONET) with a spatial resolution of 12-25km dedicated to GPS meteorology (see, e.g., [3, 8, 146]). These dense network of GPS receivers are capable of delivering information on water vapour that are useful as already stated in Subsect. 11.1.

In summary therefore, GPS meteorology will further play the following roles in monitoring of the environmental including that of Lake Victoria region:

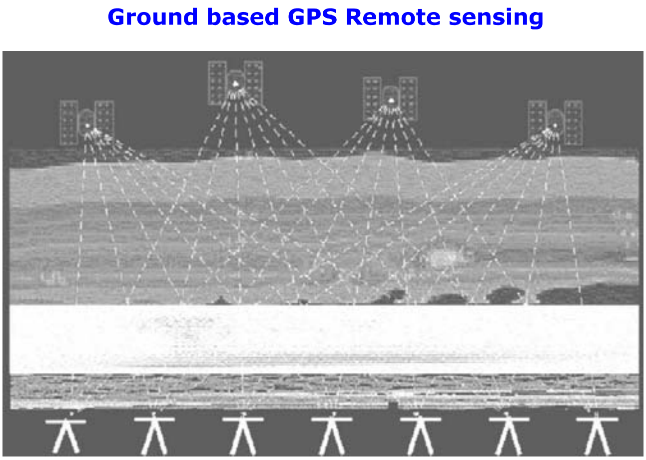

Fig. 11.12. Water vapour from ground based GPS receivers

1. Precisely derive vertical temperature and pressure profiles: These will be useful in the following ways [98]:
   (a) By combining them with other observations of ozone densities and dynamic models, our understanding of conditions which lead to the formation of polar stratosphere clouds will be improved. We will also be able to understand how particles in which heterogeneous chemical reactions lead to ozone loss are believed to occur.
   (b) The precise measured temperature will enable the monitoring of global warming and the effect of greenhouse gases. This is made possible as the change in surface temperatures caused by an increase in the greenhouse gas densities is generally predicted to be the largest and therefore most apparent at high latitudes. Precise temperature can be used to map the structure of the stratosphere, particularly in the polar region where temperature is believed to be an important factor in the minimum levels of ozone observed in spring.
   (c) Accurate high vertical resolution temperature reconstruction in the upper troposphere will increase our understanding on the conditions which cirrus clouds form. The cirrus clouds will generate for instance a positive feed back effect if global warming displaces a given cloud layer to a higher and colder region. The

colder cloud will then emit less radiation forcing the troposphere to warm in-order to compensate for the decrease.

(d) Accurate temperature retrievals from GPS meteorological measurements combined with high horizontal resolution temperatures derived from the nadir-viewing microwave radiometers will provide a powerful data set for climate studies of the Earth's lower atmosphere. This can be achieved by using the derived profiles to monitor trends in the upper troposphere and lower stratosphere where the GPS meteorological techniques yield its most accurate results.

(e) The measured pressure is expected to contribute to the monitoring of global warming. This is because pressure versus geometrical height is potentially an interesting diagnostic of troposphere's climatic change since the height of any pressure surface is a function of the integrated temperature below.

(f) The temperature in the upper troposphere/tropopause influences the amount of energy radiated to space. Accurate measurements of temperature in this region over a long period of time will provide data for global warming and climatologic studies.

2. Derive water vapour: Precise analysis of the water vapour will contribute to the data required by hydrologists to enhance the prediction of local torrential rain that normally cause damage and havoc (see, e.g., [11]). Besides, the knowledge of water vapour density in the lower troposphere will be useful in;
   - providing data that will be directly assimilated into meteorological models to enhance predictability and forecasting of weather,
   - applicable for creation of distribution of water vapour via tomographic techniques (e.g., [41]),
   - applied to correct the wet delay component in both Synthetic Aperture Radar (SAR) and GPS positioning thus benefiting applications requiring precise positioning such as deformation monitoring,
   - beneficial to low altitude aircraft navigation, since limitation in the mitigation of tropospheric delay is a major source of positioning error,
   - global warming monitoring by determining the latent heat suspended in the atmosphere where water vapour comprise one of the greenhouse gases,

- the radiative forcing due to vapour and cloud inferred from humidity,
- improved inputs for weather forecasting, climate and hydrology. Water vapour will be essential for short term (0-24hrs) forecasting of precipitation. Currently, lack of atmospheric water vapour is the major source of error in short term weather forecasting [57].

3. Contribute towards climatic studies: By comparing the observed temperatures against the predicted model values, a method for detecting and characterizing stratospheric climatic variations as well as a means for evaluating the performance of model behaviour at stratospheric altitudes will be developed and the existing ones tested.
4. Enhance geodynamic studies: The study of the gravitation effects of the atmospheric pressure, water vapour and other phenomenons will contribute towards the determination of high-resolution local geoid, which is vital for monitoring crustal deformation. The transient drift that occurs per week in estimate of crustal deformation from GPS measurement will be corrected.
5. Enhance disaster mitigation measures: Its information will contribute to the much-needed information required to improve forecasting of catastrophic weather around the world.
6. With abundance of GPS remote sensing data, accuracy better than 1–2K in temperature given by GPS meteorological missions (e.g., CHAMP, GRACE etc.) will be realized.

In-order to fully realize the potential of the GPS atmospheric remote sensing listed above, estimated profiles have to be of high quality. Already, comparative results with the existing models such as European Centre for Medium Weather Forecast (ECMWF) and National Centre for Environmental Prediction (NCEP) are promising as seen from the works of [129, 158] with respect to GPS/MET and CHAMP missions, respectively.

11.3 Satellite Monitoring of Lake Victoria's Water Level

One area of controversy concerning Lake Victoria is that of fluctuation of its water level. For instance Aseto and Ong'ang'a [4, p. 19] writes

> "...during the period from 1961 to 1964, the Lake water level suddenly increased by about 2.5m to nearly 13.5m. This

> high level has been continued to stay high up to the present time".

A recent newspaper article wrote

> "...the water levels in Lake Victoria are reducing at an alarming rate, which is 0.5m"[9].

The authors therefore believe that this is an important area which has not received adequate scientific attention.

It should be pointed out that the fluctuations above are based on tide gauge data which have their limitations as, pointed out, e.g., by [79, pp. 115–117]. One then is led to asks: Are tide gauge values adequate to uniquely characterize the rises of sea or Lake levels and give a global or local representation? For meaningful deductions over the sea or Lake levels to be made therefore, there must be adequate tide gauges coverage and in addition, one has to account for local and global geophysical processes! In case the Lake level rose by 2.5m as claimed by [4, p. 19], all the areas surrounding the Lake which were 2.5m above the Lake level in height could have been submerged! This could have seen the disappearance of many wetlands and beaches that surround Lake Victoria. The only way to authenticate this fact is by invoking satellite techniques, i.e., GRACE mission and also satellite altimetry.

The fact that the Lake's level is fluctuating is captured by the fact that the Lake's water is now receding at an alarming rate. Consider the foreground of Fig. 11.13. The sand and water hyacinth in the dry land indicate the portion covered by water last year (2004). Deep in the background where there are people and a boat indicate the current position of water. Moving closer to the water, one can actually see almost daily receding as shown in Fig. 11.14. According to Mr. Idi Omari, a local boat maker, the water is going to its original position before the floods of 1963. Could the receding water be triggered by evaporation due to global warming leading to imbalance hydrological cycle? Could this be due to the fast disappearing wetlands resulting in shortage of evapotranspiration needed for the rain formation? Mr. Idi Omari believes this could be due to the expansion of the Owen Falls hydro-electric power in Uganda. Be it as it may, the receding waters or the fluctuating water level are some of the issues that the latest satellite techniques will unravel.

[9] See, e.g., "Lake level dropping alarming" in The Standard Newspaper, Thursday, October 6, 2005

Fig. 11.13. Previous position of water before receding

Fig. 11.14. Receding Lake water

Using satellite altimetry approach, one can determine accurately the fluctuation of the Lake's water level. In satellite altimetry, signals are send from the satellites to the water surface which then reflects them back to the satellites. Knowing the positions of the satellites and with some computations, the variation of water surface as seen from the satellites can be established.

Other than satellite altimetry, advances have been made in the new satellite mission known as Gravity Recovery And Climate Experiment (GRACE) which we present in the next section.

11.3.1 Gravity Recovery And Climate Experiment (GRACE)

GRACE which comprise of twin satellites (see, e.g., Fig. 11.15) was launched in March 2002 with the main task of providing detailed measurements of Earth's gravity field which will lead to more discoveries about gravity and Earth's natural systems. These discoveries are expected to have far-reaching benefits to society and the world's population.

The GRACE mission is expected to accurately map variations in the Earth's gravity field over its 5-year lifetime. It has two identical spacecrafts flying about 220 kilometers apart in a polar orbit 500 kilometers above the Earth as shown in Fig. 11.15) in p. 330. The Earth's gravity field is accurately mapped by making accurate measurements of the distance between the two satellites, using GPS and a microwave ranging system. The mission is expected to provide scientists from all over the world with an efficient and cost-effective way to map the Earth's gravity fields with unprecedented accuracy and in the process yield crucial information about the distribution and flow of mass within the Earth and it's surroundings. The gravity variations that GRACE will study include;

- changes due to surface and deep currents in the ocean;
- runoff and ground water storage on land masses;
- exchanges between ice sheets or glaciers and the oceans;
- and variations of mass within the Earth.

Another goal of the mission is to create a better profile of the Earth's atmosphere through satellite remote sensing (occultation) and thus contribute immensely to global climate change studies as elaborately discussed in [8, Chap. 13]. GRACE mission is a joint partnership between the National Aeronautics and Space Administration (NASA) in the United States and Deutsche Forschungsanstalt fr Luft und Raumfahrt (DLR) in Germany.

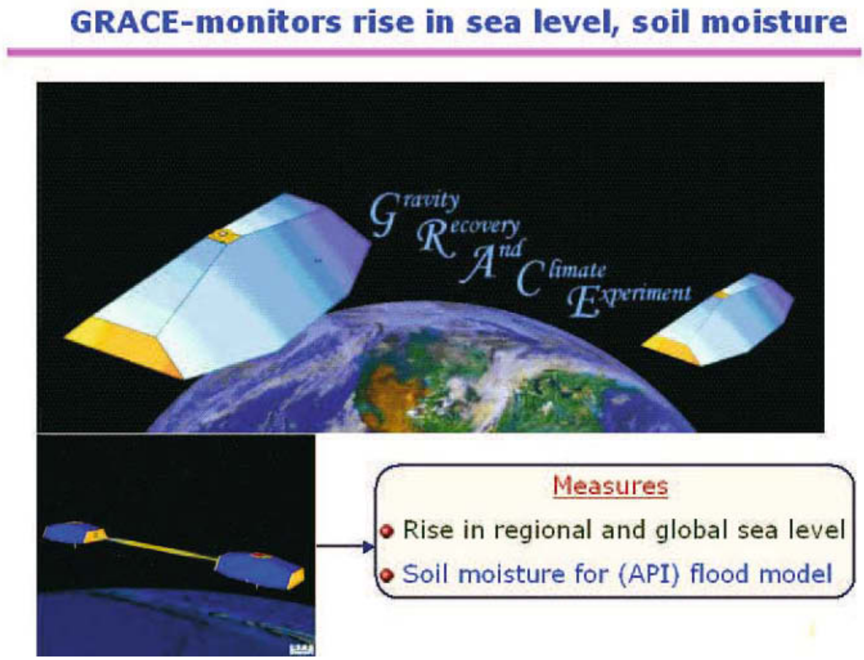

Fig. 11.15. GRACE satellites

Contrary to what one would imagine, i.e., that GRACE satellites directly observe the Earth, they deduce changes in Earth's gravity field by measuring the distance between the two satellites every five seconds. What one measures therefore is the variation in the distance between the two twin satellites believed to be caused by gravitational variation above, below, and beneath Earth's surface which has a pull effect on the satellites. This variation in gravity could be due to rapid or slow changes caused, e.g., by;

- mass of the Earth,
- mass redistribution of water in the oceans,
- movement of water vapor and other components in the atmosphere,
- tidal effect of the attraction between the Sun and the Moon to the Earth, or
- shifting of solid rock in the lithosphere. The data therefore must be pruned to isolate the various effects.

GRACE satellites take almost one month to scan the entire Earth and as such, may not be suitable for detecting fast changing phenomenon (i.e., those changing in less than one month) e.g., ocean tides or weather systems moving across the planet.

11.3.2 Global Rise in Sea/Lake Level

For sea level changes, climate models used to study the effects of atmospheric greenhouse gases predict an overall increase in the global temperature during the current century of 1 to 3.5°C [156]. Such increase in magnitude in temperature will have several effects, notably the global rise in sea level, an undesirable scenario given that a large fraction of the Earth's total population resides close to sea level. The catastrophic impact on agriculture, tourism, industries, etc., of 1m global rise in sea level have already been pointed out by [28]. Dickey et al. [28] further note that low lying regions that slope gently such as Florida and Indonesia with 15% of the world's coastline or regions lying in the flood plains of large rivers such as Rhine, Nile, etc., are all in great risk, should the sea level rise by the predicted amount.

Titus et al. [143] have estimated that in the United States, a global sea level rise by a similar magnitude would suffice to drown 20-85% of the coastal wetlands resulting in an encroachment of up to 7,000 square miles, an area the size of Massachusetts. The foregoing discussion therefore clearly indicates the necessity of monitoring of the rise in sea/Lake level in order to provide early warnings and enable formulation of policies that will provide remedial measures.

Although Warrick et al [156] report that tide gauge data show the sea level to be already rising at a rate between 1.0 and 2.5 mm/yr averaged over the past century, understanding and characterizing the sources of the rise of sea level remains a problem. The two prominent source of rise in sea level are;

1. mass redistribution (from Antarctica, Greenland, and Glaciers and small ice caps), and
2. thermal expansion.

In both sources, global warming contributes to the rise in sea level by melting of the ice and glaciers that find their way into the ocean during of mass redistribution. In the latter case, global warming causes the warming and expansion of the water for thermal expansion. Existing methods for determining secular rise in sea level is based on the tide gauge approach, which as already mentioned has its own limitations. For rise in sea level therefore, it is vital for one to ;

- characterize the sources of global rise in order to clearly distinguish between the thermal and mass redistribution contributions and
- to relate the rise in sea level to global warming.

These can be done using Gravity Recovery And Climate Experiment (GRACE) depicted in Fig. 11.15 which is specifically designed to provide solutions to problems related to Global warming and the rise in sea/Lake level.

11.3.3 GRACE Analysis of Lake Victoria's Stored Water

As already stated, the interest in Lake Victoria basin is the *accurate determination of its fluctuating level* and the *changes in total ground water stored in its basin and catchment.* To achieve these, one must estimate the secular variation in geoid[10], a phenomena that is monitored by satellite observations of time-dependent gravity data. Determination of the variation of geoid from gravity data has been elaborately presented by Wahr [154]. In applying GRACE to the analysis of Lake Victoria, it will not measure exact amounts of water stored in its basin from space, but it will instead give an indication of the changes in storage water with time (i.e., over a month, a season, or a year). Such information will be extremely useful for water resource managers with interest in Lake Victoria.

In order to make maximum use of GRACE for determining changes in total water stored underground, the surface area has to be more than 200,000km^2. This way, GRACE can provide monthly changes in stored water. In Chap. 2, p. 9, we indicated that the Lake's total catchments area to be 193,000 km^2 and its entire drainage basin to have an area of 258,000km^2. This makes it possible to apply GRACE satellite to study the changes in water stored within the Lake's catchment and entire drainage on monthly basis.

To achieve this, changes already mentioned in Subsect. 11.3.1 (mostly related to the atmosphere and ocean) which occur over a timescale shorter than one month, have to be removed using models. Remnant atmospheric and oceanographic effects that last for more than one month can be removed using atmospheric and ocean circulation models before water storage change can be analyzed. The larger effect of gravity variation due to the mass of the Earth, which is always a constant is normally removed by comparing gravity field measurement over two

[10] a surface approximating the figure of the Earth

different time span. The resulting difference, which is called gravity anomaly or geoid variation is usually due to water storage changes. This value can then be related to an equivalent water level change in the Lake's catchment (or drainage) by using a simple conversion that describes how much water it would take to produce the mass change that GRACE observed over the region.

The first steps in the analysis of GRACE data of the Lake would provide an estimate of total water storage change that includes all ground water, soil moisture, snow, ice, and surface waters within the basin. These changes need to be separated in the second step into various components. GRACE analysis of the Lake's water will thus help to reveal ground water depletion since such measurements are not systematically recorded. The GRACE technique will thus offer an objective and unbiased method for monitoring water storage changes within the Lake's basin. In Fig. 11.3, factors contributing to flash flood are shown. In order to predict flash flood, hydrological models require information on the soil moisture (see, e.g., Fig. 11.15). Such information can be provided by GRACE satellite mission as discussed above.

11.4 Lake Victoria Information System–LVIS

Geographical **I**nformation **S**ystem (GIS) is a geo-referenced spatial system of information that may influence decision-making by planners, administrators, politicians etc. This spatially referenced information must be accurate and reliable in order for meaningful decisions to be made. A GIS thus consists of computer system capable of linking information stored in data banks (e.g., climate parameters) with geographically referenced components (see, e.g., [9, 22]). A Geographical Information System is thus a map on a computer that not only depicts what is where but also suggests where certain actions might best be carried out.

Before the advent of computers, geographical information was presented on maps, which referred to various thematic issues. Such information however was difficult to update once new information became available. The remedy was that a totally new map was prepare, an expensive undertaking that was moreover overshadowed by changes in information again. A worse case was when one dealt with larger areas. In such cases, either more sheets of papers were required to be able to represent the required information, or a smaller scale had to be chosen in which case some details had to be omitted.

For a thematic map on soil for example, a map of *soil types* could be prepared. For users requiring information say on the *pH of the soil* for example, it could have been a nightmare to obtain the pH of the soil on a map which was prepared to show only soil types. For users who wanted to know which part of the land was having adequate rainfall sufficient for their crop types, or those who wanted to know the types of drainage existing on their lands, a thematic map showing only soil types was useless. Clearly, *overlaying* of different thematic maps was difficult. It was also difficult for *attributes* of features (e.g., which diseases could be prevented by minimizing the pollution of a river) to be deduced from a thematic maps on rivers.

Another disadvantage was that the mapped information changed even before the completion of the production of paper map. If say a landuse map was to be prepared, before the completion of the map, several structures that never existed during the data capture could have sprung up and updating the paper map was impossible. The paper map was therefore not a reliable and accurate representation of the information on the ground.

With the arrival of Computers and with the switch to automated cartography, digital maps have been prepared that can now address these difficulties which were experienced by the *analogue paper map* version of representing information. Since the digital information can be referenced to a particular coordinate system (geo-referenced) the term Geographical is normally used.

The sources of information for GIS includes satellite remote sensing data, Photogrammetric data, analogue maps and actual field surveying data from, e.g., total stations, GPS etc. Digital data are captured and stored in the computers either in *vector format* (in which case the initial source is digitized as coordinates of points, lines or areas) or as *raster format* in which case the data is captured by scanning, remotely sensed images etc., and stored in pixel format. The stored digital data can easily be retrieved and manipulated. This therefore enables easy update of the data to ensure reliability.

GIS answers most user requirements. Various users who incidentally may require the same information for different purposes have an advantage in using GIS. A GIS system prepared for landuse, for example, may provide an electrician with information on areas frequented by lightning on one hand and a roads engineer with information on swampy areas for construction purposes on the other hand.

A GIS system could be applied in various aspects of Lake Victoria and its surrounding. Such system could be called Lake Victoria Information System (LVIS). The general applications of LVIS which will not only be limited to Lake Victoria include;

(a) Use in environmental studies around the Lake and its environs. For environmental purposes, several issues may be of interest to several users. In this respect,LVIS can be used to satisfy these user requirements. Some of the application of LVIS for environmental purposes include the provision of information to the Forestry department on the extend to which the forest has been damaged by forest fires in which case quick measures can be taken. An environmental LVIS could comprise an information system that can give information on environmental issues such as pollution of water bodies (e.g., rivers and Lakes), rate of spread of desert due to forest lands giving way to human settlements, increase in temperature due to green house effects etc. This is just to name but a few areas where LVIS could be of use for Environment.
(b) Use of LVIS and GPS for agricultural studies. In this regard, farmers around the Lake region could correlate their farms, amount of fertilizers and yields for example. Using LVIS will thus optimize yield with respect to the expensive costs of fertilizers.
(c) LVIS could be applied to mineralogy studies around the Lake.
(d) Geological studies within the Lake basin could be done by LVIS. These could also include the study of soil types and erosion etc.
(e) Natural hazards prevalent in the region such as flooding could be analyzed using LVIS.
(f) Of interest would be to monitor the spread of dominant diseases e.g., malaria, HIV/AIDs. This could perfectly be done using a LVIS.
(g) Limnology studies, watersheds, wetlands and other water related studies could easily be done by the system.
(h) Engineering sector, particularly transport planning in the Lake basin region could benefit from such a system.
(i) The LVIS could be used to manage the regions resources.
(j) Cadastral survey, dealing with the land system in the region could benefit from such a system.

In summary therefore, a LVIS system for the Lake will be relevant in answering queries on what is where. It also gives hidden attributes that would otherwise be difficult to obtain from the conventional analogue map. One great advantage in using a GIS system is that it is also capable of giving suggestions on what should be done at which place and thus lead to the most cost effective measures to be taken. Users within Lake Victoria region are therefore invited to embrace LVIS for meaningful management of the resources at their disposal. They will be at a position to make decision based on accurate, reliable and up to date data.

11.5 Concluding Remarks

This Chapter has presented elaborate satellite techniques that would propel research on the Lake. Such techniques are not only desirable but a MUST if meaningful and realistic understanding of the Lake is to be achieved. The realization of these methods however will require initial capital investment by the stakeholders. They will be valuable treasures to invest in.

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