UNITED REPUBLIC OF TANZANIA

Ministry of Water

Applied **R**esearch **P**rogramme **for** **L**ake **V**ictoria **B**asin

MTB/VPO/2004/2005/03

FINAL REPORT

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ABBREVIATIONS AND SYMBOLS

ADRI	Animal Diseases Research Institute
AIDS	Acquired Immune Deficiency Syndrome
AMD	Acid Mine Drainage
AR	Applied Research
ARDI	Agricultural Research and Development Institutes
ARI	Agricultural Research Institute
BAT	Best Available Technologies
BATNEEC	Best Available Technology not Entailing Excessive Costs
BEP	best environmental practices
BICO	Bureau for Industrial Cooperation
BMUs	Beach Management Units
BOD	Biochemical Oxygen Demand
BPEO	Best Practical Environmental Option
CBD	Convention on Biological Diversity
CBOs	Community Based Organisations
CBP	Contagious Bovine Pleuropneumonia
CBSV	Cassava Brown Streak Virus
CEO	Chief Executive Officer
CESR	Corporate Environmental and Social Responsibility
CGM	Cassava Green Mite
CH_4	Methane
CMD	Cassava mosaic disease
CO_2	Carbon Dioxide
COD	Chemical Oxygen Demand
COET	College of Engineering and Technology
CP	Community Participation
CPCT	Cleaner Production Centre of Tanzania
CW	Constructed Wetlands
DAP	Draft Animal Power
DDT	Dichloro-Diphenyl-Trichloroethane
EAC	East African Community
EAH	East African Highland
ECF	East Coast Fever
EIA	Environmental Impact Assessment
ESD	Ecologically Sustainable Development
EU	European Union
E-W	East - West
FADECO	Family Alliance for Development and Cooperation
FAO	Food and Agriculture Organisation
FAST	Faculty of Aquatic Sciences and Technology
FC	Faecal Coliform
FMD	Foot and Mouth Disease
GATT	General Agreement on Tariffs and Trade
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GEMS	Global Environment Management System
GHG	Green House Gases
GIS	Geographical Information Systems
GLOW	Great Lakes of the World
H_2O	Water

HEST	Haplochromine Ecology Survey Team
HIV	Human Immune Deficiency Virus
IAPS	Integrated Algal Ponding System
ICT	Information Communication Technology
IFMP	Implementation of Fisheries Management Plan
IMS	Institute of Marine Sciences
IPM	Integrated Pest Management
IRA	Institute of Resource Assessment
ISWC	Integrated Soil and Water Conservation
IT	Information Technology
ITNs	Insecticide Treated Nets
IUCN	International Union for Conservation of Nature
IWRM	Integrated Water Resources Management
IWRM	Integrated Water Resources Management
KARADEA	Karagwe Development Association
KEMFRI	Kenya Marine and Fisheries Research Institute
LFA	Log Frame Analysis
LITI	Livestock Training Institute
LV	Lake Victoria
LVB	Lake Victoria Basin
LVBMA(T)	Lake Victoria Basis Management Authority for Tanzania
LVEMP I & 2	Lake Victoria Environmental Management Project, Phase I and Phase II, respectively
LVFO	Lake Victoria Fisheries Organisation
LVFRP	Lake Victoria Fisheries Research Project
M & C	Monitoring and Communication
M&C	Monitoring and Communication
M&E	Monitoring and Evaluation
MAC	Maximum Admissible Concentration
MARI	Maruku Agricultural Research Institute
MEM	Ministry of Energy and Minerals
MET	Meterological
MKUKUTA	A Kiswahili acronym for National Strategy for Growth and Reduction of Poverty
MNRT	Ministry of Natural Resources and Tourism
MoAF&C	Ministry of Agriculture Food Security and Cooperatives
MoW	Ministry of Water
MSW	Municipal Solid Waste
N	Nitrogen
NACP	National AIDS Control Program
NAFTA	North American Free Trade Agreement
NBCC	National Biological Control Centre
NELSAP	Nile Equatorial Lakes Subsidiary Action Program
NEMC	National Environment Management Council
NGOs	Non Governmental Organisations
NIMR	National Institute for Medical Research
NO_X	Nitrogen Oxides
NSGRP	National Strategy for Growth and Reduction of Poverty
O & M	Organisation and Management
O_3	Ozone
ODS	Ozone Depleting Substance
OECD	Organisation for Economic Co-operation and Development
P	Phosphorus

PhD	Doctor of Philosophy
POPs	Persistent Organic Pollutants
Pov-env	Poverty-environment
PRA	Participatory Rural Appraisal
R&D	Research and Development
RAC	Research Advisory Committee
REPOA	Research on Poverty Alleviation
RWRI	Rwegarulila Water Resources Institute
SA	South Africa
SAP	Strategic Action Plan
SEA	Strategic Environmental Assessment
SIA	Social Impact Assessment
SOIT	Solar Innovations of Tanzania
SOx	Sulfur Oxides
SRP	Soluble Reactive Phosphorus
STDs	Sexually Transmitted Diseases
SUA	Sokoine University of Agriculture
SWC	Soil and Water Conservation
TACAIDS	Tanzania Commission for AIDS
TAFIRI	Tanzania Fisheries Research Institute
TAFORI	Tanzania Forest Research Institute
TANESA	Tanzania Essential Strategies Against AIDS
TaTEDO	Tanzania Traditional Energy and Environment Development Organisation
TB	Tuberculosis
TBSi	Total Biogenic Silica
TDA	Transboundary Diagnostic Analysis
TDTC	Technology Development and Transfer Centre of the College of Engineering
TDTC	Transfer Centre of the College of Engineering
TFBB	Three Phase Fluidised Bed Bio Reactor
TFBB	Three Phase Fluidised Bed Bio reactor
TGNP	Tanzania Gender Networking Programme
TIRDO	Tanzania Industrial Research Organization
TL	Total length
TMA	Tanzania Meteorological Agency
TN	Total Nitrogen
ToR	Terms of Reference
TP	Total Phosphorus
TPC	Total Particulate Carbon
TPN	Total Particulate Nitrogen
TPP	Total Particulate Phosphorus
TPRI	Tanzania Pesticide Research Institute
TSS	Total Suspended Solids
UASB	Anaerobic Sludge Bioreactor
UCLAS	University College of Lands and Architectural Studies
UDSM	University of Dar es Salaam
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
URT	United Republic of Tanzania
USA	United States of America
UV	Ultraviolet Radiation
UWSAs	Urban Water Supply and Sanitation Authorities
VIC	Veterinary Investigation Centre

VIcRes	Lake Victoria Research Initiative
VIP	Ventilated Improved Pit
VPO	Vice President's Office
WC	Water Closet
WHO	World Health Organisation
WSP	Waste Stabilization Ponds

CHAPTER 1: INTRODUCTION

1.1 Background

The Lake Victoria basin is a very strategic zone for the socio-economic development of East Africa. Heavy degradation of the environment, pollution of water resources and loss of biodiversity both in terrestrial and aquatic ecosystems are increasingly threatening this strategic resource. The underlying causes of these problems are many and varied and they include poverty, poor know-how and expanding human activities. The LVEMP was therefore conceived to address the major threats facing the basin.

The main development objective of the LVEMP is to contribute to poverty reduction and sustainable socio-economic development of the riparian states. The project purpose is to lay the foundation for:

- Maximizing the sustainable benefits to riparian communities from using resources within the basin to generate food, employment and income, supply of safe water, and sustain a disease-free environment;
- Conservation of bio-diversity and genetic resources for the benefit of the riparian and global community;
- Harmonization of global and regional programmes in order to enhance efforts directed at reversing environmental degradation;
- Promotion of regional cooperation amongst the East African countries.

The Lake Victoria Environment Management (LVEMP) was prepared and started to be implemented in 1994. The implementation of the LVEMP-1 resulted in improved ability of the riparian States to embark on a long-term programme of resource management and environmental improvements. As a result of the establishment of the East African Community and subsequent materialization of the East African Development Strategy (2001 -2005) designated the Lake Victoria Basin (LVB) as a regional economic growth zone. The identification of the Lake Victoria Environment Management phase two (LVEMP-2) was done through a process involving review of performance of the Lake Victoria Environment Management phase one (LVEMP-1) and development of a Vision and Strategy Framework for management and development of Lake Victoria Basin.

A Regional Stakeholders Concept Workshop identified the priority areas of focus for LVEMP-2 as Socio-Economic Development, Management and Research. Therefore, the next step is to develop intervention that use the information and capacity developed to promote environmentally and socially sustainable economic development. The Research Programme will strengthen the capacity for research and contribute research data that can be used to inform decisions for enhancing sustainable utilization of natural resources of the Lake Victoria Basin.

1.2 Applied Research Programme

Applied Research is designed for the purpose of producing results that may be applied to real world situations. Applied Research may fall in at least one of three types. First is *Innovative Research*, which is designed to apply theories and principles to finding new solutions for identified problems. Second is *Technological Transfer*, in which case the technology developed in one place is transferred and applied to solve problems in another situation. Third is *Adaptive research*, where the technology is transferred from one place but has to be modified to address new problems, or be applied in a different setup[1].

[1] KEMFRI, (2006), Applied Research Programme for the Lake Victoria Basin, Mid-Term Report

1.3 Terms of Reference for the Applied Research Programme Assignment

The objective of this study was to identify key themes for the Applied Research Programme in natural resources, environment, socio-economic sectors and transboundary issues.

The Applied Research Programme has focused on the following:

Economic growth and private sector and environmentally friendly market driven development

Some areas of focus include:

- Sustainable and environmentally appropriate technologies
- Development of appropriate boost and post harvest technologies for adoption by farmers
- Developing cost effective water harvesting for livestock use and crop irrigation
- Building the capacities of rural communities to mobilize savings and build microfinance institutions
- Impacts of introducing low cost technologies for treatment of both municipal and industrial effluent

Transboundary Natural Resources Regional Management

This has involved the assessment of transboundary issues within the lake basin including Rwanda and Burundi to be addressed under the applied Research Programme. Among them were:

- Fisheries
- Water hyacinth
- Pollution
- Effects of mercury, oil spills, agrochemicals and other chemicals on food web structure, system productivity and lake environment
- Biochemical oxygen demand
- Land use and sedimentation
- Water quality and quantity
- Conflict in resource use
- Pests and diseases

Natural Sciences including

- fisheries research
- water research
- atmospheric deposition of phosphorus and meteorology and
- aquatic weeds research including water hyacinth

The following tasks were expected to be undertaken during the consultancy:

(i) Review research information available from previous interventions including LVEMP, Kagera River Basin Integrated Water Resources Management Project, Mara River Basin integrated Water Resources Management Project and other sources to establish nature of problems, extent and geographic location of key issues

(ii) Review past and ongoing research and identify gaps which need to be filled in research issues, problems, their causes, impacts, socio-economic consequences

and the perceived solution

(iii) Propose a prioritised applied research programme agenda to generate relevant environment, social and economic related findings and outcomes for application by private/public sector with emphasis on environmentally friendly market driven development

(iv) Assess and propose targeted research capacity building with view to developing predictive scientific capacity that will require greater application of models and databases management

(v) Review existing research outputs on atmospheric deposition with emphasis on phosphorus with a view to proposing further research

(vi) Review information available from Transboundary Diagnostic Analysis (TDA) and Strategic Action Plan (SAP) reports with a view to developing a proposal for implementation by the applied research programme

(vii) Collaborate closely with the National Secretariat and liaise with consultants from other partner states to consolidate the National Reports into a Regional Report lead by Uganda as lead Consultant. The lead Consultant from Uganda would present the draft Report to the Regional Stakeholders' workshop coordinated by EAC Secretariat.

(viii) To collate information from national consultancies and present the Applied Research Report to National Workshops. The consultant should participate in the Regional stakeholders' workshop coordinated by EAC Secretariat to create consensus on the applied research agenda at the regional level.

(ix) To prepare a final and a prioritised research programme which should include a clear logical framework and a detailed budget.

1.4 Goals, Objectives and Rationale

1.4.1 Goals

The **goal** of LVB Applied Research programme is to enable the LVBMA (T) and its partners to achieve a sustainable development, growth and poverty reduction of the LVB through scientific research.

1.4.2 Objectives

The objectives of the Applied Research Programme are to:

- Facilitate informed decisions and plans based on availability of sound research data for sustainable development, growth and poverty reduction in the LVB;
- Develop research agenda relevant to the current situation of the LVB;
- Develop a prioritized and costed applied research programme to be implemented at local, national and regional level.

1.4.3 Rationale

The need to promote sustainable development of LVB is underscored by the LVB Vision and Strategy. In order to implement the strategy, it is increasingly becoming apparent that good quality research, which addresses the priority needs of the basin, is needed in order to inform policy analysis and development. This Research Agenda/Programme is intended as a technical guide for planning targeted research programmes, projects and activities in the basin. The Research Agenda/Programme is expected to facilitate research institutions and other stakeholders to promote and undertake research that is in line with the Agenda.

1.5 Approach Used Develop the Applied Research Programme

The assignment was carried out in two stages: Inception stage and main stage. During the inception stage, the consultant (a) carried out a preliminary assessment of available data (b) conducted field visits to key stakeholders, projects and programmes relevant to the assignment (c) and produce a draft inception report which was presented a National Inception Workshop.

During the main stage, the following major activities will be carried out:

Establishing the baseline information: This level sought to establish the nature of problems, extent and geographic location of key research issues by reviewing available research information from previous interventions. The idea was to identify existing themes where basic information was available. This step also identified research gaps that needed to be filled in applied research issues, problems, their causes, impacts, socio-economic consequences and perceived solutions.

Action areas: an overview of the specific actions proposed for each identified issue: Working on the basis of the issues identified previously, this step:

a. established the cause-effect relationships underlying identified problems/issues;
b. identified long-term measures to address the problems;
c. assessed and proposed targeted research capacity building activities; and
d. Proposed a prioritized applied research programme/agenda.

Marketing the Applied Research Programme for Lake Victoria Basin: This step entailed a national workshop aimed at getting the key stakeholders who are important for effective and efficient adoption and implementation of the Applied Research Programme to understand it and buy-in. These stakeholders are government institutions, research institutions, universities, politicians, financial institutions, private sector, NGOs and development partners.

1.6 Prioritization of Research Issues

Table 1.1: Criteria for Prioritization of Research Issues

	Category A (Prioritization of Themes)	**Score**		
1	Contribution to Human Health	High=40	Medium=20	Low =10
2	Contribution to Ecosystem Health	High=40	Medium=20	Low =10
3	Contribution to socio-economic development	High=40	Medium=20	Low =10
4	Contribution to Value addition and market chain development	High=40	Medium=20	Low =10
	Category B (Prioritization of Research Issues)			
1	Affordability of carrying out the research	High=20	Medium=10	Low=5
2	Availability of local research institution/personnel	High=20	Medium=10	Low=5
3	Time to receive applicable research results*	Short=20	Medium=10	Long=5
4	Availability of basic equipment	High=20	Medium=10	Low =5
5	Replicability	High=20	Medium=10	Low =5
6	Applicability of the Research Information	High=20	Medium=10	Low =5

***Key to research time**

Short	t≤3 years
Medium	3<t≤5 years
Long	>5 years

1.7 Layout of the Document

Considering the ToRs, the following organization of the document was found appropriate:

- Chapter 1: Introduction
- Chapter 2: Status of Research Activities in the LVB
- Chapter 3: Applied Research Agenda for LVB
- Chapter 4: Applied Research Programme Implementation Action Plan
- Chapter 5: Link of the AR Agenda with sustainable economic growth in the LV basin
- Chapter 6: Implementation (Institutional) Framework
- Chapter 7: Monitoring and Evaluation Framework
- Chapter 8: Communication and Dissemination Plan

CHAPTER 2: STATUS OF RESEARCH ACTIVITIES IN THE LAKE VICTORIA BASIN

2.1 Introduction

The approach used to review the achievements and gaps/needs of LVB targeted research initiatives aimed to produce a comprehensive and integrated strategic assessment embracing both environmental and related socio-economic issues.

There review identified and focused on the following key research focus areas:

1. Fisheries Research and Management
2. Water Resource Management
3. Atmospheric Deposition of Phosphorus and Meteorology
4. Aquatic Weeds including Water Hyacinth
5. Forests, Wetlands and Watershed Management, Soil and Water Conservation
6. Pests and Diseases
7. Waste Management
8. Economic Growth, Private Sector and Sustainable Market Driven Development
9. Cross- cutting Issues

In each research focus area, the review sought the following:

- Identification of key research institutions active in the respective area
- Identification of major research activities (in the past and at present)
- Delineation of major research findings/lessons from the past and present research efforts
- Analysis of the major research needs/gaps and potential strategies for addressing the gaps
- Analysis of research capacity building needs/areas and potential strategies for addressing the gaps

2.2 Fisheries Research and Management

2.2.1 Background

During the seven years of LVEMP (1997-2005), extensive biotic field surveys were conducted and all the data were analysed to provide the required fish biology, fisheries and biodiversity data and baseline information. In addition, policy recommendations have been formulated and appropriate technologies have been packaged to address fisheries management issues. This is contributing towards improved ecological efficiency, greater biodiversity and ecological balance in the lake system. The fisheries data and information that were generated were synthesized and in the process, a number of gaps were revealed and several recommendations made (Mgaya, 2005). It became obvious that a lot still remained to be addressed through a concerted research effort if the fishery resources of Lake Victoria are to be harvested rationally for the benefits of the present and future generations. Subsequent sections highlight research gaps and activities that need to be implemented in a multidisciplinary approach so as to safeguard the fishery resources in Lake Victoria.

2.2.2 Key Fisheries Research Institutions

Institutions involved in fisheries research include the following:
- Tanzania Fisheries Research Institute through its mandate as the research wing of the Fisheries Division.
- University of Dar es Salaam for fisheries and aquaculture research.
- Sokoine University of Agriculture for aquaculture research.

Fisheries Division is responsible for fisheries management in the Tanzanian side of Lake Victoria.

2.2.3 Major Research Activities

Information on fisheries research and management in Lake Victoria has been generated through implementation of a number of projects/programmes which include:

- Haplochromine Ecology Survey Team (HEST) which addressed taxonomic and ecological aspects of the cichlid haplochromines in Lake Victoria from 1984 – 1990.
- Lake Victoria Research Team addressed limnological aspects and its impact on species diversity including nutrient loading from 1985 – 1991.
- FAO funded project on Improved Utilization of Nile perch from 1986 – 1990.
- Lake Victoria Species Rescue Project that carried out extensive surveys on the haplochromines and initiated a captive breeding programme for the threatened Lake Victoria fish species from 1990 – 1995.
- FAO funded Inland Fisheries Project Planning that covered Lake Tanganyika and Lake Victoria in terms of fisheries research, planning and development.
- IUCN funded Nile Perch Project Phase I that collected socio-economic information and disseminated it through a series of Technical Documents.
- IUCN funded Nile Perch Project Phase II that was concerned with information dissemination and developing network between scientists, media, managers and policy makers.
- Lake Victoria Fisheries Research Project (LVFRP) Phase II that carried out lake wide trawl and hydroacoustic surveys from 1994 to 2003.
- Implementation of Fisheries Management Plan (IFMP) (2003-2008) that has been operating in Lake Victoria from 2004.
- The Lake Victoria Environmental Management Project (1997-2004; bridging phase 2005-2007) financed by the World Bank.

2.2.4 Major Findings and Lessons

The researches show that fisheries productivity of the Lake Victoria system has increased and the standing stock has expanded for the last 30 years. Total fish biomass estimates during the period 1997-2001 were 2.17×10^6 metric tons as compared to the values of 1969-1971 at 0.402×10^3 metric tons. Fish standing crop is estimated to be approximately four times as high in inshore waters and also high around the islands compared to the open offshore areas.

However, the fish species diversity in the Lake Victoria has tremendously declined from multi-species, to a stock dominated by a few foreign species. Lake Victoria fish stock is now mainly comprised of fish species that were introduced into the Lake in the 1950s – 1960s with Nile perch *Lates niloticus* making, on average, about 85% of fish stock and the main commercial species followed by *Rastrineobola argentea* –

"dagaa" and Nile tilapia *Oreochromis niloticus* which amount to 40% at certain sites. The endemic species including haplochromines, the endemic *Oreochromis (O. esculentus*, *O. variabilis)* and non-cichlid genera including *Protopterus (P. aethiopicus), Labeo (L. victorianus), Schilbe (S. intermedius), Brycinus (B. sadleri, B. jaacksonii)* are now recorded in low percentages by weight and numbers in the main lake. Recent research found the family Protopteridae (represented by a single species of the African lungfish *Protopterus aethiopicus)* contributed only 1.1% of fish stock at Mwanza Gulf which is close to the urban area. Haplochromines were recorded at 5.7% in 2000. Other species found in low levels include *Bagrus docmac, Barbus* spp., *Oreochromis leucostictus, Clarias gariepinus, Tilapia zillii, Tilapia rendalli, Synodontis afrofischeri,* and *Marcusenius victoriae.*

Several fish species that are currently known to be rare, missing or in very low levels in the main lake including endangered and threatened species such as lungfish (*Protopterus aethiopicus*), the Ningu (*Labeo victorianus*), *O. variabilis*, *O. esculentus,* and *Clarias gariepinus* are represented in isolated groups of small water bodies (satellite lakes, rivers, ponds, dams and floodplains) in the Lake basin acting as refugia.

Increased fishing pressure in the lake impacted the quality and quantity of the fisheries resources e.g. the modal size for Nile perch has been progressively decreasing and size at first maturity for both females and males has been decreasing from 110 cm and 60 cm TL respectively recorded in 1990 to 54 cm for males and 77 cm for females observed in 2002. The changes in Lake Victoria environment (water quality) are partly responsible for the observed trophic dynamics and species composition.

The research activities under LVEMP-I did not focus on the activities which are of transboundary nature that contribute to the loss of biodiversity, cause threat to biodiversity which includes endangered species and vulnerable species. Transboundary activities could also contribute to over fishing of key commercial species. The TDA consultancy identified root causes and immediate causes for these environmental issues.

Root Causes

- Historical unsustainable development
- Systemic socio-economic crisis
- Prevailing attitudes which undervalue the environment

Immediate Causes

- Over-exploitation (Increased effort, gear and mechanization, decreased level of recruitment, decreased habitat/nursery grounds, shift in population distribution.
- Destructive fishing practices (changes within the sector e.g. practice, overall pressure); illegal fishing practices (poison fishing, use of undersize nets); poverty.
- Pollution and diseases (changes in the aquaculture sector e.g. overstocking, inappropriate choice of stocks, etc.; issues related to pollution, eutrophication, BOD etc.).
- Change in biological and genetic diversity (intentionally released non-native species (e.g. introduction of Nile perch; escaped non-native species; issues related to loss/modification of habitat; modification of stream flow (damming))).

LVEMP-I research activities were to a large extent confined within territorial boundaries of the three riparian countries. While it is true that the results could have implication to the entire lake, there were no efforts to establish this link. Linking the research results could assist in the development of holistic intervention strategies.

Table 2.1 provides a summary of key research findings in the Lake Victoria Basin. Some of the important research findings for the Lake Victoria fisheries can be found from various studies listed below:

1. Barel, C.D.N., Ligtvoet, W., Goldschmit, T., Witte, F. and Goudswaard, P.C. (1991) The hapolchromine cichlids of Lake Victoria: An assessment of biological and fisheries interest. In: *Cichlid Fishes, Behaviour, Ecology and Evolution* (Ed. M.H.A. Keenleyside). Chapman and Hall, London, pp. 258-279.
2. Bwathondi, P.O.J. and Mahika, G.C. (1997) *Aquaculture Potential of Mwanza Region with the View to the Establishment of Pilot Aquaculture Activities*. Lake Victoria Environment Management Project (LVEMP), Dar es Salaam. 32 pp.
3. Bwathondi, P.O.J., Shoko, A.P.A., and Kyojo, A. (1998) *Aquaculture Potential of Kagera Region.* Report to the Lake Victoria Environment Management Project (LVEMP). 31 pp.
4. Cowx, I. (Ed.) (2005) *Review of the Exploitation Pressures on the Fisheries Resources of Lake Victoria.* Unpublished LVEMP Report. 125 pp.
5. Graham, M. (1929) *The Victoria Nyanza and its Fisheries - A Report on the Fishing Surveys of Lake Victoria (1927-1928).* Crown Agents Colonies, London. 256 pp + Appendices.
6. Greenwood P.H. (1974) The cichlid fishes of Lake Victoria, East Africa: the biology and evolution of a species flock. *Bulletin of British Museum of Natural History (Zoology) Supplement **6***, 1-134.
7. Katunzi, E.F.B. (2003) Satellite lakes, rivers and dams as refugia for the endangered species of Lake Victoria. In: *Proceedings of the LVEMP – Tanzania 2001 Scientific Conference*, 6-10 August 2001, Mwanza, Tanzania (Ed. S.G.M. Ndaro and M. Kishimba). Lake Victoria Environmental Management Project, Dar es Salaam, pp. 44-53.
8. Katunzi, E.F.B. and Kishe, M.A. (2004) Changes in population structures of the major species in selected satellite lakes around Lake Victoria following changes in fishing effort. *Tanzania Journal of Science* **30**, 53-64.
9. Kling H.J, Mugidde R. and Heck R.E. (2001). Recent changes in the phytoplankton Limnol 25: 39-48.
10. Kudhogania, A.W. and Cordone, A.J. (1974) Batho-spatial distribution patterns and biomass estimation of the major demersal fishes in Lake Victoria. *African Journal of Tropical Hydrobiology and Fisheries* **3,** 15-31.
11. Mahatane, A., Mgaya, Y.D., Hoza, R.B. and Onyango, P. (2005) Co-management in Lake Victoria. In: *National Synthesis Report on Fisheries Research and Management* (Ed. Mgaya, Y.D.). LVEMP Secretariat, Dar es Salaam, pp. 179-200.
12. Mgaya, Y.D. (2005) *National Synthesis Report on Fisheries Research and Management*. LVEMP Secretariat, Dar es Salaam. 250 pp.
13. Mkumbo, O.C. and Ligtvoet, W. (1992) Changes in the diet of Nile perch, *Lates niloticus* (L.) in Mwanza Gulf, Lake Victoria. *Hydrobiologia* **232**, 79-83.
14. Mkumbo, O.C. (2002) *Assessment and Management of Nile Perch* (Lates niloticus L.) *Stocks in the Tanzanian Waters of Lake Victoria.* PhD Thesis, University of Hull, UK. 275 pp.
15. Ogutu-Ohwayo, R. (1990) The decline of the native fishes of lakes Victoria and Kyoga (East Africa) and the impact of introduced species, especially the

Nile perch, *Lates niloticus* and the Nile tilapia, *Oreochromis niloticus*. *Environmental Biology of Fishes* **27**, 81-96.
16. Seehausen, O., van Alphen, J.J.M. and Witte, F. (1997) Cichlid fish diversity threatened by eutrophication that curbs sexual selection. *Science* **277**, 1808-1811.
17. Witte, F., Goldschmidt, T., Goundswaard, P.C., Ligtvoet W., Oijen, M.J.P. van and Wanink, J.H. (1992) Species extinction and concomitant ecological changes in Lake Victoria. *Netherlands Journal of Zoology* **42**, 214-232.

LVEMP played a key role in the introduction of co-management through formation of Beach Management Units (BMUs) in the lake zone (Mahatane et al., 2005). Fisheries co-management as an alternative to centralized command and control fisheries management is being advocated as a solution to the problems of resource use conflicts and overexploitation. Since the introduction of the co-management programme, BMUs have continued to work in collaboration with Fisheries staff to curb illegal fishing practices, participate in data collection for Catch Assessment Surveys and Frame Surveys, beach hygiene and sanitation, environmental conservation amongst others.

The involvement of fishing communities in the management of fishery resources through the establishment of BMUs has created a forum for exchange of ideas, knowledge and experience on the lake fishery resources. This strategy has made the communities understand the importance of self compliance and effective management measures on Lake Victoria fishery resources. Awareness on the importance of sustainable fishery resources management and environmental protection is more evident now among the fishing communities than before LVEMP. The Government is expected to facilitate all BMUs to establish BMUs Association from beach level to regional level. This action will help to establish an effective Lake Victoria wide networking of all BMUs and Government**.**

2.2.5 Major Research Needs/Gaps

2.2.5.1 Sustainability of Target Species

Previous research has provided a good basis for management of Lake Victoria's fisheries. There have been considerable improvements to our understanding of the biology and dynamics of the key species (Nile perch, Nile tilapia and Dagaa). While there is a substantial body of information on the target species, there are still some key gaps. There is much less biological information about the less abundant species.

Significant advances in quantitative stock assessment using hydroacoustics have been made for some species. The coverage of previous surveys was restricted to the deeper parts of the lake. Therefore, channels, bays and generally shallow areas where density of fish is thought to be high were not sufficiently covered. In addition, there is need to develop methods and new approaches that may be less data reliant hence cost-effective. **Table 2.2** shows the summary of gaps and needs.

2.2.5.2 Sustainability of Fish Habitats and the Ecosystem

Management of fisheries also requires knowledge of key habitats and anthropogenic (including fishing) impacts upon them. The shift in emphasis to fishery impacts on ecosystems is supported by a number of studies carried out elsewhere which show clearly the negative impacts of fishing on biodiversity.

Although some knowledge exists, there is still a lack of understanding in the interactions between fish, habitats and fisheries, particularly in Lake Victoria and satellite lakes. There are two issues here. First, knowledge of the functional relationships between harvested species (at all life history stages) and the habitats that support them is needed for informed decision making on human modification such as proposed developments. Second, knowledge of the impact of fishing on aquatic environments more generally is needed so that mitigation measures such as changed fishing practices can be implemented.

The recent shift in focus toward managing fisheries with a more ecosystem-based approach highlights the need for a better understanding of ecosystem function and the role of harvested species. It requires assessing and monitoring the ecosystem impacts of fishing and inclusion of a wider range of expertise in fisheries assessment. Thus new data sets may be required and new modeling approaches developed to provide management advice. Ecosystem indicators, reference points and performance measures, must also be developed.

2.2.5.3 Impacts of Habitat Modification

There are many human activities that impact directly on fish habitats and aquatic resources. These are most evident in the lake basin systems. The integrity of aquatic resources is under threat from, for example, land management in catchments that alter flow regimes and increase sedimentation, and lakeshore developments that may modify/destroy fish habitats.

2.2.5.4 Impacts of Climate Variation

Many species demonstrate considerable variation in recruitment and availability that appears to be independent of fishing. Research has shown that year-class strength is often correlated with certain environmental conditions but reasons for these relationships, in most cases, have yet to be determined. For fisheries assessments it is important to be able to distinguish between natural variation in fish stocks and changes caused by harvest. Major events such as drought and bushfires, and the way we manage them, also significantly impact on fishery resources. In addition to natural variability, “greenhouse-induced” changes to climate have the potential to significantly affect fisheries and aquatic resources.

2.2.5.5 Economic and Social Assessment of Fisheries and Aquaculture

Assessment of economic performance is important to ensure that community-owned resources are efficiently utilised and that information is available to facilitate resource and business management decisions. Some economic surveys and economic impact assessments have been undertaken on important species like the Nile perch but generally these have not been undertaken within a systematic framework and results have often been controversial or not widely accepted. There have been no studies on the economic performance of aquaculture.

Social assessments are a key component of Ecologically Sustainable Development but there have been few studies that focus on the social attributes of fisheries and aquaculture. Social values may be difficult to measure but they are important considerations in resource management. Public perception of fisheries is poor and there is also increasing concern regarding marginalization of artisanal fishers.

2.2.5.6 Aquaculture

It is expected that research agenda will be shifted to studies that focus on economic viability (e.g., reduce production costs and increase effectiveness/value), environmental impacts (e.g., monitoring water quality parameters), regulation (e.g., unblocking the regulatory blockages) and social issues. The focus should primarily be on improving efficiencies, maximizing returns and industry productivity through creation of new technologies, knowledge and information systems designed to facilitate investment as well as sustainable resource management. Research should also aim to assess the actual environmental impacts and the risks associated with aquaculture operations. Furthermore, research should aim to assist the preparation of best practice environmental management frameworks that ensure public confidence and environmental sustainability.

2.2.5.7 Transboundary Issues

Generally there are no research activities that have focussed on activities that have transboundary impacts. Applied research efforts should be directed towards solving root causes namely historical unsustainable development practices, systemic socio-economic crisis and prevailing attitudes which undervalue the environment.

Over fishing affects fish stocks in the entire lake. Introduction of exotic species (Nile perch and other species) has affected the biodiversity in the lake. Illegal fishing (e.g. using pesticides) affects the entire lake regardless to where illegal fishing is practiced. Release of chemicals changes the water quality and biodiversity regardless where chemicals are released.

LVEMP-I research activities were to a large extent confined within territorial boundaries of the three riparian countries. While it is true that the results could have implication to the entire lake, there were no efforts to establish this link. Linking the research results could assist in the development of holistic intervention strategies.

Important research questions of transboundary relevance include the following:

- Which are regional development practices that significantly contribute to over-fishing?
- What is the extent of illegal fishing within the region and factors driving the same?
- How does social economic developments and needs influence the fisheries industry in the riparian countries?
- How does the understanding and attitudes of riparian communities affect the fish industry?
- What is the carrying capacity of the lake in terms of fish processing plants, fish stocks, habitat/nursery grounds?
- What is the regional trend on use of destructive fishing practices and their impacts (to include illegal fishing practices (poison fishing, use of undersize nets);
- How does poverty influence the fishing industry?
- What is the regional pollution trends and fish-diseases burden
- What is the potential for introduction of non-native species in the lake?
- What is the impact of modified river flows on the fish industry?

2.2.6 Major Research Capacity Building Needs

Capacity building needs/areas and strategies will have to be put place with a view to developing predictive scientific capacity that will require greater application of models and databases management. Research capacity exists within institutions of higher learning and public research institutions, e.g. TAFIRI. However, these institutions are in dire need of research infrastructure and facilities for carrying out the envisaged research work.

For staff in the line ministry, there is need to build capacity of staff in research methodology and data analysis. Capacity building should also be extended to fisheries data collection and frame surveys. Capacity building in database design, implementation and management should be considered for those who are working in Fisheries Division in the Statistics Unit. As the SAMAKI database is already in place, there is a need for the Division to train all those working in fisheries statistics on how to use it. In addition, computers and accessories should also be in place at the district level so that they can be used in data entry.

Table 2.1: LVB Fisheries Management - Research Conducted

Type of Research Conducted	When Conducted	Research Institutions (involved in the research)	Key Research Findings/Lessons
Biodiversity	1984 to 1990 (HEST) 1997 to 2005 (LVEMP)	TAFIRI • HEST programme • LVEMP	• Lake Victoria fish diversity has declined following drastic reduction in haplochromines, with evident ecosystem changes. • A multispecies fishery with over 350 species has been reduced to a fishery dominated by three species (Nile perch, Nile tilapia and Dagaa). • Small water bodies (satellite lakes, rivers, ponds, dams and floodplains) in the catchment have been singled out as important faunal reservoirs for Lake Victoria endangered species.
Fish biology / ecology	1997 to 2005	TAFIRI Leiden (The Netherlands)	• Cichlid sexual selection has been disrupted by increased eutrophication and sedimentation over the years that have affected light penetration (important for visual cues in courtship). • Nile perch disrupted the Lake Victoria ecosystem by simplifying the food web through elimination of haplochromines from many interactions and shortening of food chain.
Aquaculture	1998 to 2000	TAFIRI • LVEMP	• Lake Victoria basin has great potential for aquaculture with *Bagrus docmac, Oreochromis niloticus* and *Clarias gariepinus* being the most acceptable species.
Fish stocks	1994 to 2003	TAFIRI • LVFRP	• The total estimated catch of Nile perch has declined in recent years from the picks in the 1990s. This is coupled with a shift in contribution of catches from higher trophic level species (Nile perch) to lower trophic level (*dagaa*) species. • Nile perch catch per unit effort has declined from about 80 to around 45 kg per boat per day. Other biological indicators (size at first maturity, growth, longevity and maximum size) of fish populations under stress also point towards heavy overexploitation. • The size at first capture and mean size of the catch has reduced markedly since the mid-1990s, partly as a result of the reduction in mesh sizes of gears in operation and the use of illegal gears. • There has been a progressive decline in modal length of fish caught by experimental trawling over the years. In 1988 the modal length was 70-80 cm

Type of Research Conducted	When Conducted	Research Institutions (involved in the research)	Key Research Findings/Lessons
			TL, while it decreased to 50-60 cm TL in 1992 and even further to 40-50 cm TL in 1994, but has remained around the same level to the end of the 1990s. Much of this decline in size at first capture has been linked to a reduction in mesh size of nets used in the commercial fishery, which now seems to have stabilized around 12.5 cm (5"). • The biological characteristics of Nile perch population have changed since the 1980s, with a reduction of size at first maturity and reduction in the maximum size that fish can attain. • The biomass index for the small pelagics (Dagaa and all the *Haplochromis* spp. combined) increased substantially during the 1999-2001 hydroacoustic survey.
Socio-economics	1999-2002	TAFIRI • LVEMP	• Lake Victoria fisheries are a great source of income, employment and food for the riparian communities. • The fisheries are currently operating under a new socio-cultural environment from that of the historical fishing communities.

Table 2.2: LVB Fisheries Research and Management Needs

Sub-Research Area/Theme			Research Needs/Gaps		Research Capacity Gaps			Remarks
No	**Area**	**Priority**	**No**	**Need/Gap**	**No**		**Priority**	
1.	Sustainability of target species	High	1	Development of recruitment indices for key species	1	Inadequate trained staff in research institutions	High	

Sub-Research Area/Theme			Research Needs/Gaps		Research Capacity Gaps			Remarks
No	**Area**	**Priority**	**No**	**Need/Gap**	**No**		**Priority**	
			2	Improved understanding of the basic biology of less abundant species such as *Bagrus docmak, Schilbe intermedius, Synodontis* spp., *Labeo victorianus* and *Barbus* spp.	2	Inadequate trained staff in research institutions	Medium	
			3	Understanding of the ways in which exploited stocks (e.g. Nile tilapia, Dagaa) may respond as they are fished down	3	Inadequate trained staff in research institutions	High	
			4	Identification of under-utilised fish resources	4	Inadequate trained staff in research institutions	Medium	
			5	Understanding of behavioural (e.g. Ningu migration), reproductive (e.g. haplochromine mating success) and limnological influences (e.g. Nile perch) on recruitment.	5	Inadequate trained staff in research institutions Field equipment	High	
			6	Determination of movement rates and patterns of major fish species, within and between the lake and rivers.	6	Fish tracking equipment Inadequate trained staff in research institutions	High	

Sub-Research Area/Theme			Research Needs/Gaps		Research Capacity Gaps			Remarks
No	**Area**	**Priority**	**No**	**Need/Gap**	**No**		**Priority**	
			7	Investigation of the potential of restocking to rehabilitate depleted fish stocks (e.g. *Oreochromis variabilis, O. esculentus* and Ningu).	7	Inadequate trained staff in research institutions	Medium	
			8	Continued refinement of existing stock assessment methods, particularly developing models that include finer spatial resolution.	8	Inadequate trained staff in research institutions	High	
			9	Evaluation of current and alternative methods to assess the stock structure and migratory dynamics of key species, as appropriate	9	Inadequate trained staff in research institutions	High	
2.	Sustainability of fish habitats and the ecosystem	High	1	Application of GIS-based habitat mapping methods for monitoring of important habitats	1	Relevant equipment Inadequate trained staff in research institutions	High	

Sub-Research Area/Theme			Research Needs/Gaps		Research Capacity Gaps			Remarks
No	**Area**	**Priority**	**No**	**Need/Gap**	**No**		**Priority**	
			2	Introduction and development of innovative technologies such as stable isotope analysis, otolith microchemistry and real-time data acquisition of environmental parameters to help identify relationships between fish and their supporting ecosystems	2	Lack of laboratory equipment and inadequate scientific and skilled technical staff	High	
			3	Characterization of benthic communities in fished and unfished areas	3	Inadequate technical staff, laboratory and field equipment	Medium	
			4	Development of fishing gear and practices that minimize impacts on biodiversity and habitats	4	Lack of resources to develop the gears	Medium	
			5	Identification of key ecosystem indicators and development of cost-effective monitoring protocols	5	Inadequate trained staff	High	
			6	Determination of the trophic relationships within key commercial and artisanal fisheries.	6	Inadequate trained staff	High	

Sub-Research Area/Theme			Research Needs/Gaps		Research Capacity Gaps			Remarks
No	**Area**	**Priority**	**No**	**Need/Gap**	**No**		**Priority**	
			7	Development of ecological modeling capabilities and approaches that have predictive capacity	7	Inadequate trained staff	High	
			8	Development of meaningful and practicable ecosystem indicators, reference points and performance measures for key species and fisheries.	8	Inadequate trained staff	High	
3.	Impacts of habitat modification	Medium	1	Assessment of the critical linkages between riverine and lake systems for sustainable fishery resources and the impacts of changes to flow regimes	1	Inadequate trained staff and lack of field equipment	Medium	
			2	Development of science-based guidelines for water management to maintain fishery resources	2	Inadequate trained staff	Medium	
			3	Assessment of the effectiveness of restoration and rehabilitation of fish habitats	3	Lack of field equipment and inadequate trained staff	Medium	
			4	Assessment of the responses of fish populations to human-induced disturbances, e.g. urban development.	4	Lack of field and laboratory equipment and inadequate trained staff	Medium	

Sub-Research Area/Theme			Research Needs/Gaps		Research Capacity Gaps			Remarks
No	**Area**	**Priority**	**No**	**Need/Gap**	**No**		**Priority**	
			5	Investigation of the relationship between sedimentation, turbidity and wetland macrophyte dieback	5	Inadequate trained staff	Medium	
4.	Impacts of climate variation	Medium	1	Development of cost-effective monitoring protocols for collecting long-term environmental and biological data sets for key species	1	Inadequate trained staff in research institutions	Medium	
			2	Determination of the relationships between environmental factors and reproductive success, recruitment and availability of key species and assessment of the mechanisms that drive them	2	Inadequate field equipment and trained staff	Medium	
			3	Development of methods to enable “natural” versus anthropogenic changes to be distinguished	3	Inadequate trained staff	Medium	
			4	Development of modeling approaches that explicitly account for natural variability in fish stocks	4	Inadequate trained staff	Medium	

Sub-Research Area/Theme			Research Needs/Gaps		Research Capacity Gaps			Remarks
No	**Area**	**Priority**	**No**	**Need/Gap**	**No**		**Priority**	
			5	Development of drought management strategies for fishery resources	5	Inadequate trained staff	Medium	
			6	Risk assessment on the impact of climate change on Lake Victoria's aquatic resources to identify high-risk species/areas and future research requirements	6	Inadequate trained staff	Medium	
5.	Market development	Medium	1	Development of marketing and promotion strategies to maximize the value of fisheries and aquaculture products	1	Inadequate trained staff	Medium	
			2	Development of methods for more innovative marketing to creating niche products	2	Inadequate trained staff	Medium	
			3	Investigation of methods to promote cultural changes to take market from being price driven to quality driven	3	Inadequate trained staff	Medium	

Sub-Research Area/Theme			Research Needs/Gaps		Research Capacity Gaps			Remarks
No	**Area**	**Priority**	**No**	**Need/Gap**	**No**		**Priority**	
			4	Conduct of a study to establish the size, extent and capabilities of the post harvest sector and its economic and social contribution to the Lake Victoria fish industry	4	Inadequate trained staff	Medium	
6.	Economic and social assessments of fisheries and aquaculture	Medium	1	Periodic assessment of the economic performance of major fishery and aquaculture sectors	1	Inadequate trained staff	Medium	
			2	Economic evaluation of prospective aquaculture species and integrated aquaculture systems	2	Inadequate trained staff	Medium	
			3	Assessment of the social benefits of fisheries and aquaculture and the social costs of management decisions	3	Inadequate trained staff	Medium	
			4	Investigation of public perceptions of fisheries and aquaculture, and their origins, and development of methods to influence and improve perceptions	4	Inadequate trained staff	Medium	

Sub-Research Area/Theme			Research Needs/Gaps		Research Capacity Gaps			Remarks
No	**Area**	**Priority**	**No**	**Need/Gap**	**No**		**Priority**	
7.	Aquaculture	High	1	Development of more efficient and economical feeds and feeding strategies	1	Inadequate trained staff and lack of laboratory equipment	High	
			2	Development of programmes to ensure maintenance of the genetic diversity of broodstock	2	Inadequate trained staff	High	
			3	Initiation of cost-effective selective breeding programmes for growth, disease resistance and other preferred traits to produce high performance strains	3	Inadequate trained staff	Medium	
			4	Development of closed life cycles for high-value species	4	Inadequate trained staff	High	
			5	Development of more efficient grow-out and husbandry methods	5	Inadequate trained staff, equipment and facilities	High	
			6	Development of systems to enhance agri-aquaculture production	6	Inadequate trained staff	High	
			7	Development of environmental indicators, reference points and performance measures for aquaculture operations	7	Inadequate trained staff	High	

Sub-Research Area/Theme			Research Needs/Gaps		Research Capacity Gaps			Remarks
No	**Area**	**Priority**	**No**	**Need/Gap**	**No**		**Priority**	
			8	Development of guidelines and protocols for assessing potential aquaculture sites	8	Inadequate trained staff	High	
			9	Determination of methods to minimize nutrient discharges	9	Inadequate trained staff	Medium	
			10	Assessment of the carrying capacity of terrestrial and aquatic systems in relation to the impact of aquaculture activities	10	Inadequate trained staff and equipment	High	

2.3 Water Resources Management

2.3.1 Background

Lake Victoria ecosystem has increasingly degenerated since early 1960s both in water quality and its fishery (Evans, 1961; Talling1965; 1966; Ogutu-Ohwayo, 1990; Hecky, 1993; Mugidde, 1993; Kling *et al*., 2001). These changes were driven by high population increase and their associated activities and economic development. The activities resulted in increased flows of pollutants and nutrients to the lake and its tributaries leading to pollution, sedimentation and eutrophication of the lake and public health problems. Recent initiatives by LVEMP to gather information on the environmental state of the lake have proved success. During the LVEMP I period (1997 to 2005), it was observed that some of the rivers and streams feeding the lake and the near -shore areas were particularly polluted by raw and partially treated municipal and industrial effluents, contaminated urban surface runoff, and the unsanitary conditions of the shoreline settlements. These pollutants introduced into the lake increased faecal coliforms, oxygen demanding organic wastes, heavy metals such as chromium, lead and mercury as well as pesticides. Also some inflow of residues from the use of chemical herbicides and pesticides in some areas in the Lake catchment and gold mining, were viewed as potential sources of chemical pollution. Essentially, the lake water quality problems to a greater extent arose in the watershed. Water quality monitoring was made and continues to be an integral part of the management of Lake Victoria ecosystem. LVEMP has put in place a monitoring programme in the Lake Victoria basin.

Table 2.3 provides a summary of the current of status of research on water resources management in the Lake Victoria Basin. Additional pertinent elaborations are provided in the following sub-sections.

2.3.2 Key Water Resources Management Institutions

Institutions dealing with Water Resources Management:	Area of expertise
• Ministry of Water	• Policy issues • Monitoring of water quality
• Tanzania Fisheries Research Institute	Fisheries research
• Faculty of Aquatic Sciences and Technology, UDSM • College of Engineering and Technology, UDSM • UCLAS	Water resources research

2.3.3 Research Activities (Past and Present)

Major projects directly involved in collection of data on water resources in the Lake:

- Hydromet Survey of Lake Victoria, Kyoga, and Mobutu Seseseko, 1968 – 1990.
- Global Environment Management System – Water (GEMS – Water) 1983-1996.
- LVEMP 1997 – to date

Research initiatives which indirectly provided water resources data:

- Haplochromine Ecology Survey Team (HEST) which addressed taxonomic and ecological aspects of the cichlid haplochromines in Lake Victoria from 1984 – 1990.
- Lake Victoria Research Team to address limnological aspects and its impact on species diversity including nutrient loading from 1985 – 1991.

2.3.4 Key Research Findings/Lessons

2.3.4.1 Watershed management

Human activities in the catchment that are associated with pollution of the lake are unsustainable agriculture and livestock keeping, deforestation, burning of grasslands and mining. On the other hand, urbanization in the lake basin is among the prominent sources of pollution of the lake. Apart from urban and rural settlements, it is estimated that Lake Victoria basin has about 600 shoreline settlements. Sanitary conditions in the shoreline settlements are very poor and the Lake water along the settlements show high faecal coliforms counts. Cachments of major rivers are poorly managed, leading to discharge of excessive loads of suspended sediments and pollutants into the lake (Scheren et al, 2000; Mnyanza et al., 2006). Mercury is released in large quantities into the environment in Lake Victoria basin from gold mining operations (Nriagu, 1992; van

Straaten 2000a; 2000b). However, studies show that mining activities have led to accumulation of metals in the environment immediate to the mines and in wetland soils receiving discharges from mining (DHV consultants 1998; van Straaten, 2000a; 2000b; Campbell *et al*., 2003; Ikingura and Akagi, 2002; Machiwa, 2003).

2.3.4.2 Water Quality Model

The Lake Victoria Water Quality Model framework was developed by Delft Hydraulics and Delft IHE-UNESCO of The Netherlands and HYRO-QUAL of USA. The model is still not yet operationalized pending on gathering of reliable, adequate data for validating it.

2.3.4.3 Nutrients input and enrichment in the lake

Non-point nutrient loading

The greater inputs of N and P are by atmospheric deposition (LVEMP, 2002, Tamatamah, 2002, Tamatamah, 2005). Another significant input is riverine sources basically due to municipal discharges, agricultural and other land denuding activities in the catchment. These two sources when combined account for 99 and 98% of the total N and P inputs to Lake Victoria (Mnyanga and Pazi, 2001; Myanza, *et.al*, 2006).

Point sources of excessive nutrients

Industrial and municipal effluents are primary contributors to point source discharges into Lake Victoria. Factories so far include fish processing, coffee processing, cane sugar making, textile mills, abattoirs, gold mines, soft drinks industries, breweries, vegetable oil industries etc. Almost all industries are located in Mwanza City, Musoma and Bukoba Municipalities (Mnyanga et al. 2006).

2.3.4.4 Nitrogen fixation

A general pattern of increasing dominance of N-fixing cyanobacteria (*Anabaena* and *Cylindrospermopsis*) in inshore waters has been observed (Machiwa et al, 2003; Rutagemwa *et a*l. 2006) confirming earlier findings by Kling *et al*. (2001). Currently, biological fixation of nitrogen is the largest single source of N and account for over 80% of total N loading to Lake Victoria, exceeding dry atmospheric and rivers inputs (Mugidde *et al*., 2003).

2.3.4.5 Eutrophication

In Lake Victoria, eutrophication has been the result of increased inflow of nutrients particularly nitrogen and phosphorus. During LVEMP I it was observed that the concentration of phosphorus rose markedly in the deeper lake waters and nitrogen in the near shore areas. Stimulated by these nutrients, algal growth increased five fold and its composition shifted towards domination by heterocystous blue-green cynobacteria (Hecky 1993; LVEMP, 2002) leading to decline of transparency (Mugidde 1993). The extreme dominance of blue green algae, large blooms of scum forming algae and water hyacinth are symptomatic of eutrophication caused by excessive nutrients from the catchments. Near shore areas are highly affected by eutrophication, especially Mwanza Gulf and Mara and Rubafu bays (Rutagemwa et al 2006). The lake's pelagic environment has relatively low TN: TP ratio indicating potential nitrogen limitation and the littoral zones are either potentially nitrogen or phosphorus limited or both (Guilford and Hecky, 2000).

2.3.4.6 Hydraulic conditions

The global wind pattern shows that from March to May and October to December the winds approach the lake from South East moving at very high altitude and as they cross the lake, they turn towards the north. This wind meets another stream of wind from Congo approaching the lake from southwest. These two wind streams meet in a convergence zone along the western side of the lake creating very strong surface waves on the western part of the lake. From January to February and June to September the main global winds flow from east to west. By the time these winds reach the western part of the lake, they have long fetch. These winds are capable of creating very high waves on the western part of the lake. This accounts for the mixing of the water column on the western part of the lake for most period of the year.

It has been noted that in southern part of Lake Victoria, thermal stratification begins in January to May. The thermocline in this part of the lake may develop at depths of 50 to 60m in pelagic stations, the surface temperatures reach maximum in March. Earlier report by LVEMP (2002) predicted that thermal stratification seems to exist in most of the time in Mwanza gulf, but the current information (Myanza, et. al., 2006) indicates that mixing in the gulf seems to occur most of the time except from late March to late May. However, the stratification seems to be shallow and weak. Cooling and almost complete mixing of the water column is observed between June and August coinciding with the global winds blowing from E-W. Thermal stratification seems to influence fish migration from the southern part of Lake Victoria which suffers from low oxygen concentration to other areas.

Large scale circulation in the lake has not been observed in previous studies. The lack of large scale circulations entails that spreading of pollutants from the near-shore areas to the centre of the lake during most of the year is mainly caused by dispersion and not by advection.

2.3.4.7 Plankton

It has been established that there is high algal (both blue-green and diatoms) biomass in near-shore areas and low offshore. The phytoplankton are as diverse in inshore as offshore, cynobacteria dominate (>50% of total wet biomass). The potentially toxic cynobacteria of the genus *Microcystis* and *Anabaena,* and nitrogen fixers dominate the algal blooms frequently observed (Rutagemwa *et a*l. 2006). Green algae show the greatest species diversity, principal species observed are *Ankistrodesmus falcutas, Chordatella subsalsa, Cosmarium* spp*, Crucigenia pulchra, Pediastrum simplex, Scenedesmus* spp, *Kirchneriella obesa* and *Oocystis species*. Diatoms are second most diverse group with identified 58 species. The common species are *Nitzschia acicuralis, Navicula, Cyclotella, Synedra ulna.* Zooplankton community is composed of rotifers and crustaceans comprising cyclopoid and calanoid (diaptomid) copepods and clodocerans (water fleas). Other members of the zooplankton community are larvae stages of insects especially chaoboridae. A total number of 39 species were observed in the littoral zone. Generally, rotifera contributed the highest number of species in the littoral and pelagic zones, 23 and 15 species respectively. Zooplankton can provide a lot of information with respect to measure of the health of the environment because of their sensitivity to

changes in characteristics of the aquatic ecosystems. Certain species of zooplankton especially amongst the cladocerans and rotifers may be used as indicators of organic and chemical pollution in the water (Mavuti and Litterick 1991), either through direct analysis of the food they take, or by monitoring the changes in species richness or abundances.

2.3.4.8 Algal toxins

Phytoplankton of the group Cyanobacteria produce a variety of toxins (cyanotoxins), which have been detected in the lake. Sakadende *et al.* (2005) detected algal toxins of the type microcystin-RR at concentration of 992 mg MC-LR equivalent/L in Mwanza gulf on 2ndJuly, 2002.

2.3.4.9 Sedimentation

The suspended sediment load from the catchments to the lake is currently estimated at 4,905.2 ktons/year, with Simiyu River carrying the largest suspended sediment load estimated at about 42.3% (179.2 ktons/km^2/y) of the total load to the lake, possibly due to its relatively large size and widespread agricultural activities (Machiwa, 2001; Rwetabula, 2004). The sedimentation rate in Magu bay has been estimated at 0.7mm/year (Machiwa et al., 2003; Rutagemwa et al., 2006). Kagera River is rated the second contributing to about 26.1%. Data on sedimentation rate and settling velocities of TPP, TPN, TPC and TBSi show that sedimentation rates are highest at the littoral stations compared to pelagic stations. The stoichiometric composition of the settling material indicates nitrogen limitation and a non-dominance of diatoms. The differences in settling velocities indicate that the settling material consist of dead and living particulate matter including diatoms (Rutagemwa et al., 2006).

2.3.4.10 Water Quantity

There exists little information related to water quantity in Lake Victoria. The data gathered so far include estimates of the total water balance of Lake Victoria which include estimates of daily input and output of water. There is no monitoring of consumptive uses of Lake Victoria waters; it is desirable that management of multi-purpose Owen falls and similar projects be guided by an ecosystem approach to lake management to ensure optimum results for the beneficial uses of the lake.

2.3.4.11 Ground water

Groundwater plays an important role in the water cycle. Surface water and groundwater are intimately linked to each other within the hydrologic cycle. Groundwater is very important as it supplies springs, and much of the water found in ponds, marshland, swamps, streams, rivers and bays. Although it is “out of sight,” it is critical that we learn about groundwater, how it is part of the water cycle, and the importance of protecting and maintaining the quality and quantity of this water resource. Unfortunately groundwater resource has not been given due attention in Lake Victoria basin.

2.3.4.12 Metal and Pesticides pollution

Since the activities associated with metals and pesticides contamination of the environment are increasingly carried out in the Lake Victoria basin, LVEMP has since 2000 continued to identify sources and levels of heavy metals in water, biota, sediments, and the atmosphere. The studies have concluded that generally, at present the mining activity in the Lake basin has had no significant impact on levels of heavy metals in the Lake ecosystem. Also to a great extent, it is now apparent that neither fish nor humans are at risk from increased levels of heavy metals particularly mercury in the lake basin (Akagi and Ikingura, 1996; Machiwa, 2004). Mercury concentrations in common fish species are generally lower than the WHO maximum allowable concentration of 500 ng/g ww in edible fish parts. Indeed, Nile perch that weigh less than 10 kg have less than 200 ng total Hg g^{-1} ww and are safe for regular consumption by the at risk groups such as children and pregnant women (WHO, 1990). Machiwa *et al.* (2003) showed that mercury concentration in fish from areas suspected to be affected by mining activity and areas that are remote from mining activity was not significantly different. However, artisanal gold mining utilizing mercury in extracting gold from its ore remains a potential source of mercury pollution to Lake Victoria. Total mercury concentration in soil and river sediments in mining areas is generally low except in specific locations where mercury was being used by artisanal miners. The effective buffering capacity of wetlands in the lake basin has been emphasized in the case of heavy metals.

The use of pesticides in the lake basin and contamination of waterways have a long history (Musabila, 2000; Machiwa *et al*. 2006), organo- chlorine compounds such as DDT have been extensively used for cotton production and malaria control. Cotton and coffee are major cash crops that require usage of pesticides as well as protection of livestock against ticks. From 1990 to 1996, more than 15 formulations of pesticides were introduced in Mwanza region.

Pertinent references for major findings include:

Campbell, LM 2001 Mercury in Lake Victoria (East Africa): Another emerging issue for a beleaguered Lake? PhD Thesis. University of Waterloo, Canada. 145pp

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2.3.5 Key Research Needs and Gaps

Most of the issues in water resources management are addressed under environmental monitoring programmes, few gaps are highlighted. **Table 2.4** provides the summary of research needs and gaps.

2.3.5.1 Nutrients budget in the Lake

Accurate partition the sources of nutrients to the lake is still a gap. There is need to establish linkages between nutrient levels and the potential sources in areas where aquatic weeds, especially the water hyacinth proliferate and propose appropriate management strategy. Equally important is to accurately determine the nutrients budgets for the lake and verify the significance of nitrogen fixation in the nitrogen budget.

2.3.5.2 Eutrophication

Studies are needed to locate areas of severe anaerobiosis in the lake bottom as well as the timing for these incidents and their influence on fisheries. Data on levels of dissolved oxygen on the lake bottom and the importance of autochthonous particulate carbon in bottom deposits is needed.

2.3.5.3 Hydraulic conditions

Studies on the lake hydrodynamics which is the major driving force for pollutants dispersal and fish migration are needed.

2.3.5.4 Pollution Bio-indicators

Studies have shown that some zooplankton species can be used either by a single species abundance or relative abundance as pollution indicators. Although such a scenario complicates the whole issue of a simple readily available bio-indicator of pollution, nevertheless, the idea is sound. Therefore, there is a great need so far to conduct a study that will search for a suitable pollution bio-indicator.

2.3.5.5 Algal toxins

It is important that environmental factors associated with the triggering of toxic cyanobacteria be investigated. Lake areas that have a potential for growth of toxic microalgae should be identified and appropriate management measures taken.

2.3.5.6 Sedimentation, palaeoclimatology and pollution history

Generally, there is paucity of information as regards to rates of sedimentation in different parts of the lake. A large part of the lake has not been covered mainly because of logistics. There is a need to carry out studies to estimate sedimentation rates especially adjacent to all mouths of rivers and in other prominent depositional areas of the lake.

Palaeoclimate in the lake basin has not been adequately studied; there is a need to retrieve long sediment cores from depositional areas in the open lake for climatology and pollution studies. Stable isotope data should be invoked to delineate sources, pathways and fate of pollutants in the lake. Such information will lead to implement appropriate and relevant management options for the concerned areas.

2.3.5.7 Water quantity

There is little work done on establishment or confirming the bathymetry of Lake Victoria in order to verify the water balance as well as to accurately estimate the discharge from

major rivers. The lake level is said to decline at an alarming rate, it is appropriate that studies on global and micro climate change be conducted to determine their possible role in the declining lake levels.

2.3.5.8 Heavy Metals and Pesticides

Pathways, receptors, controls and fate of mercury released into the environment by Lake Victoria Gold Fields mining activities are still not well construed. Studies on biogeochemistry of mercury in Lake Victoria are needed. Also it is important to investigate the adsorption and buffering capacities of various soil minerals and organic matter in the lake basin so as to know the retention time and capacity of these soils to retain the metals.

Studies on the fate of organochlorine pesticides in the lake basin environment are lacking.

2.3.5.9 Groundwater Resource Evaluation

There is a need for evaluation of groundwater quantity, quality, recharge capacity and groundwater dynamics.

2.3.6 Research capacity building needs

- Basic research infrastructure (laboratories, instruments and personnel) exists in different research institutions; there is a need for collaborative research and sharing of equipment.
- There is a need to upgrade or service/maintenance some of the equipment.
- Undertake training needs assessment in order to establish current needs for water resources management.
- Training of technicians in new laboratory techniques (instrumentation and safety procedures)
- Sensitization of various stakeholders especially local communities on caring of field equipment and the role of research in water resources management
- Equip laboratories with state-of-the-art equipment for scientific analyses
- Training of scientists on information packaging and strategies for dissemination to target groups.

Table 2.3: LVB Water Resources Management - Research Conducted

Type of Research Conducted	When Conducted	Research Institutions (involved in the research)	Key Research Findings/Lessons
Eutrophication studies	1999 - 2005	LVEMP	Concentration of phosphorus rose markedly in the deeper lake waters and nitrogen in the near shore areas. Algal growth increased five fold and its composition shifted towards domination by heterocystous blue-green cynobacteria. Decline of transparency from 5 meters in the early 1930s to one meter or less for most of the year.
Plankton and Lake productivity	1999 - 2005	LVEMP, UDSM	Phytoplankton are as diverse in inshore as offshore and cynobacteria dominate contributing >50% of total wet biomass. An increasing dominance of N-fixing types (*Anabaena* and *Cylindrospermopsis*) in inshore waters of Lake Victoria was observed. At one incidence algal toxins were detected in Mwanza gulf. Zooplankton community dominated by rotifers,crustaceans (cyclopoid and calanoid copepods) and clodocerans.
Point sources of pollution to Lake Victoria	1999 - 2005	LVEMP	Industrial and municipal effluents are primary contributors to point source discharges into the Lake. Increased nutrient loads into the Lake seem to have spurred water hyacinth infestations, particularly in bays receiving municipal sewage, urban run-off, and wastewater from industries, agricultural activities and shoreline settlements.
Non-point sources of nutrients to Lake Victoria	1999 - 2005	LVEMP	Pollution of the lake is closely connected with unsustainable agriculture and livestock keeping, deforestation and burning of grasslands in the lake basin
Mercury pollution from LV Gold fields in Lake Victoria basin	1996 - 2004	UDSM, LVEMP, DHV Consultants BV, Private researchers	Mercury concentrations in most fish species are generally lower than the WHO maximum allowable concentration of 500 ng/g ww in edible fish parts. Indeed, Nile perch that weigh less than 10 kg have less than 200 ng total Hg g^{-1} ww. Total mercury concentration in soil and river sediments in mining areas is generally low except in specific locations where mercury was being used by artisanal miners.
Pesticides pollution in LV basin	2000 - 2005	LVEMP, UDSM	High pesticide loads are associated with increased Simiyu river discharge to the Speke gulf.
Hydraulic condition	2002 - 2005	LVEMP	Cooling and almost complete mixing of the Lake water column occurs between June and August coinciding with the global winds blowing from E-W. For most of the year, there is no recognizable, large-scale horizontal

Type of Research Conducted	When Conducted	Research Institutions (involved in the research)	Key Research Findings/Lessons
			circulation pattern in Lake Victoria.
Sedimentation	2000 - 2005	LVEMP, UDSM	The sedimentation rate in Magu bay is estimated at 0.7 mm/year. Sedimentation rates are highest at the littoral stations compared to pelagic stations. The stoichiometric composition of the settling material indicates nitrogen limitation and a non-dominance of diatoms.

Themes/sub-themes

Nutrient input to the lake and Eutrophication

- Partitioning of sources of nutrients in the catchments (deforestation, agriculture, fires, grazing, etc).
- Linkages between nutrient levels and the potential sources of aquatic weeds.
- Benthic regeneration of nutrients in littoral and open lake areas.
- Location analysis of areas of severe anaerobiosis in the lake bottom as well as the timing for these incidents and influence on fish behaviour.
- The significance of nitrogen fixation in nutrient budget of Lake Victoria.
- The significance of atmospheric deposition on the nutrient budget of the lake

Lake productivity and Phytoplankton blooms

- Strategies for enhancing Lake productivity.
- Assessment of new and regenerated production in the lake
- Determination of the most limiting nutrient in primary productivity of littoral and pelagic zones of the lake.
- Environmental factors associated with the triggering of toxic cyanobacteria.
- Mapping of lake areas that have a potential for growth of toxic microalgae
- Management measures for algae toxins.

Bio-indicators of pollution in the lake

- Search for suitable pollution bio-indicators and how to manage them.

Hydraulic condition in the lake

- Lake Hydrodynamics in relation to pollutants dispersal and fish migration.
- Influence of thermal stratification on fish behaviour

Water quantity and Lake Levels

- Verification of bbathymetry of Lake Victoria
- Establishment of water balance based on accurate data on precipitation, evaporation, discharge, abstraction etc. (covered in monitoring programme)
- Global and micro climate change as factors in the declining lake levels.

Sedimentation, palaeoclimatology and pollution history

- Estimation of sedimentation rates at prominent depositional areas of the lake.
- Tracing pollution history of the lake
- Establishment of palaeoclimate of the lake

Persistent pollutants

- Regional/global atmospheric transport as a possible route for mercury deposition to Lake Victoria.
- Establishment of the biogeochemistry of mercury in the Lake.
- The fate of organochlorine pesticides in the lake basin environment.
- Assessment of pollutant retention ability of various soil types in the lake basin.

Groundwater resource evaluation

- Assessment of groundwater quantity and quality.

- Determination of recharge capacity of major aquifers.
- Establishment of groundwater dynamics in the lake basin.

Table 2.4: LVB Water Resources Management - Research Needs

Sub-Research Area/Theme			Research Needs/Gaps			Remarks
No	**Area**	**Priority**	**No**	**Need/Gap**	**Priority**	
1.	Nutrient input to the lake	High	1	Partitioning sources of nutrients from the catchment	High	Equipment and expertise locally available; Feasible
			2	Benthic regeneration of nutrients	High	Equipment and expertise locally available; Feasible
			3	Significance of atmospheric deposition of nutrients	High	Equipment and expertise locally available; Feasible
			4	Nutrient levels and potential sources of aquatic weeds	High	Equipment and expertise locally available; Feasible
2.	Eutrophication	High	1	Influence of anaerobiosis on fish behaviour	High	Equipment and expertise locally available; Feasible
			2	The role of nitrogen fixation in nutrient budget	High	Equipment and expertise locally available; Feasible
3.	Lake productivity and Phytoplankton blooms	High	1	Studies on new and regenerated production	Medium	Need to procure the equipment and training
			2	Strategies for enhancing Lake productivity.	High	Equipment and expertise locally available; Feasible
			3	Studies on algal toxins	High	Need to procure the equipment and training
4.	Bio-indicators of pollution	Medium	1	Search for Bio-indicators		Expertise locally available; Feasible
5.	Hydraulic condition	Medium	1	Influence of thermal stratification on fish behaviour	Medium	Expertise locally available; Feasible
6.	Sedimentation, palaeoclimatology and pollution history	Medium	1	Estimation of sedimentation rates	High	Expertise locally available; Feasible
			2	Tracing pollution history of the lake	Medium	Expertise locally available; Feasible
			3	Establishment of palaeoclimate	Medium	Expertise locally available; Feasible

Sub-Research Area/Theme			Research Needs/Gaps			Remarks
No	**Area**	**Priority**	**No**	**Need/Gap**	**Priority**	
7.	Persistent pollutants	High	1	Biogeochemistry of mercury in the Lake.	High	Equipment to be procured; Feasible
			2	Assessment of pollution retention ability of soil types	High	Equipment and expertise locally available; Feasible
			3	Fate of organochlorine pesticides in the lake basin	High	Equipment and expertise locally available; Feasible
8.	Groundwater resource evaluation	High	1	Assessment of groundwater quantity and quality	High	Expertise locally available; Feasible
			2	Determination of recharge capacity of major aquifers	High	Expertise locally available; Feasible
			3	Establishment of groundwater dynamics in the lake basin	High	Expertise locally available; Feasible

2.4 Atmospheric Deposition and Meteorology

2.4.1 Introduction

2.4.1.1 Atmospheric deposition

Lake Victoria is greatly affected by nutrient inputs, particularly nitrogen and phosphorous, from point source and non- point sources. The point sources include municipal and industrial wastewater discharges while non point sources refer to land runoff from agricultural areas and atmospheric deposition. The available research findings indicate that atmospheric deposition is the predominant source of nutrient loading to Lake Victoria. This section focuses on atmospheric deposition.

2.4.1.2 Meteorology

Hydrological and meteorological characteristics of the LVB have influence on the quality water quality. To identify the reasons for the changes in water quality knowledge of the changes in the pollution loadings to the lake, which, in turn, depends on the discharges to the lake from the catchment and the atmosphere and lake outlet to River Nile i.e. hydrology and meteorological characteristics. Using these inputs the water balance of the lake is computed also this allows the calculation of loads of specific water quality variables during the estimation of non-point pollution loadings, atmospheric deposition of nutrients. Meteorological study was done under water quality component of the LVEMP-1.

2.4.2 Key Research Institutions

2.4.2.1 Atmospheric Deposition

Although atmospheric deposition is considered to be a major driving force as far as eutrophication of the Lake Victoria is concerned limited research activities have been devoted to understand the sources and trends of atmospheric deposition. The literature review has identified that few research institutions have done studies in this area. These are:

a) Lake Victoria Environmental Management Programme – 1, Water Quality Component
b) Department of Chemical and Process Engineering at the University of Dar es Salaam in collaboration with Eindhoven Technical University, The Netherlands.
b) The then Department of Zoology and Marine Biology, at the University of Dar es Salaam in collaboration with University of Waterloo in Canada.

2.4.2.2 Metereology

Apart from the continuous metrological measurements made by the Airport authorities around the lake, only Lake Victoria Environmental Management Programme – 1, has made some studies on meteorology.

2.4.3 Major Research Activities

2.4.3.1 Atmospheric Deposition

Samples for dry and wet atmospheric deposition have been collected from four (4) land based stations and two islands near the towns of Mwanza and Bukoba (figure 3 below). The atmospheric deposition was divided into wet deposition, washed down by rain, and dry deposition which is the amount of nutrients deposited onto the water surface from the air during dry weather periods. For wet deposition, rainwater was sampled and analyzed for various parameters including total-nitrogen, and total phosphorus. Due to lack of special sampling equipment for dry deposition, a simple method of analysing the increase of nutrients in distilled water exposed in a bucket with surface area of $0.07m^2$ for a certain period of time normally 24hrs. The total atmospheric deposition load was then calculated by summing up the wet and dry season loads. The nutrients (N and P) were analysed using standard methods for water and wastewater analysis (AWWA, APHA, WEF 1998), using Hitachi Spectrophotometer Model U-2001.

2.4.3.2 Meteorology

Historical hydrometeorological data that was collected collated, analysed, quality controlled and was used with other similar data from other two countries of whom Tanzania share the lake waters to produce COWI report in 2000 for LVEMP, which acted as a baseline water quality status at the start of the project. Three national “index” stations Mwanza, Bukoba and Musoma were chosen for period of record including LVEMP period. The mean, maximum and minimum values of three climatic parameters; rainfall, evaporation and temperature were examined and analysed by looking at the following:
The meteorological trend of the historical data
Mean data of LVEMP period is compared to the relative long term means (1950-2000)
Discussion of global and regional climate change

Estimates of rainfall over Lake surface and lake evaporation for Tanzanian portion were reviewed with new information on rainfall data. The summary of research activities for atmospheric deposition and metereology is shown in **Table 2.6**

2.4.4 Major Findings and Lessons

2.4.4.1 Atmospheric Deposition

Research findings from the studies identified by the literature review could be found in the following publications:

- Scheren, P.A.G.M, Zanting, H.A., Lemmens, A.M.C. (2000). Estimation of Water Pollution Sources in Lake Victoria, East Africa: Application and Elaboration of the Rapid Assessment Methodology. Journal of Environmental Management. Pp 235-248
- Tamatamah R.E. (2002). Non-point Source Loading of Phosphorus to Lake Victoria from the Atmosphere and Rural Catchments in Tanzania, East Africa. PhD Thesis, Waterloo, Ontario, Canada.
- Myanza, O.I.; Rutagemwa, D.K.; Mwanuzi, F. (2005). Non Point Pollution Loading In Tanzania Chapter
- Mirambo, V.; Katima, J.H.Y. and Lemmens, A.C.M. (2000): Biomass Burning and Its Potential Towards Increasing Atmospheric Nutrients' deposition in Lake Victoria. Proc. of the Regional Seminar on Engineering for Sustainable Development. 6th – 8th December 2000, Arusha, Tanzania, pp 170 – 186.
- Mirambo, V. (2002). Assessment of Atmospheric Deposition in Lake Victoria. M.Sc. Dissertation, University of Dar es Salaam, Tanzania.
- Tamatamah R.A., Hecky R.E., Duthie H.C. (2005). The Atmospheric Deposition of Phosphorus in Lake Victoria (East Africa) Biogeochemistry (2005) 73: pp 325-344.
- LVEMP, 2005. Tanzania National Water Quality Synthesis Report. Vice President's Office

The study by the lake Victoria Project reported that nutrient loading to Lake Victoria is atmospheric deposition which contributes 84 and 75% of N and P, respectively, whereas that by Scheren *et al,.* reported that atmospheric deposition contribution is 72% for Nitrogen and 36% of Phosphorous.

Mercury is another pollutant that has been suspected to be transported via atmospheric deposition (Machiwa *et al.* 2003). This was based on the fact that mercury concentration in fish from areas suspected to be affected by mining activity and areas that are remote from mining activity was not significantly different. However, there has never been a specific research to confirm this fact.

The Transboundary Diagnostic Analysis (BICO, 2006) identified that atmospheric deposition has a transboundary characteristic, in which case pollutants produced in other countries may be deposited in Tanzanian border and vice versa.

2.4.4.2 Meteorology

Research findings from the studies identified by the literature review could be found in the following publications:

- R.J. Mngodo, O.I Myanza, and F. Mwanuzi (2005). Meteorology/Hydrology – Water Quality Synthesis Report
- Lehman J.T. (1998). Role of climate in the modern condition of Lake Victoria. *Theoretical and Applied Climatology. 61(1-2)*: 29-37.

- Rwegoshora G., Mabula W., and Nahozya E. (2004) Sustainable Development and Equitable Utilization of the Common Nile Basin Resources. *Regional Training Course on Data Evaluation and Interpretation Report on Project RAF/8/037*. International Atomic Energy Agency Vienna, Austria.

Only rainfall and evaporation are reported. **Table 2.5** shows rainfall trend in the LVB.

Table 2.5: Mean Annual Rainfall

Box No.	Name	Weight	Mean Ann. Rainfall for Box (mm)	Mean Ann. Rainfall for station (mm)	Mean Ann. Rainfall (1950-2004) (mm)
1	Musoma	0.135	1300	839	901
2	Ukerewe	0.258	1600	1502	1515
3	Mkula	0.040	886	886	886
4	Mwanza	0.094	1000	958	966
5	Bukerebe	0.190	2400	2609	2609
6	Kahunda	0.173	1450	1163	1165
7	Izigo	0.048	1950	1731	1731
8	Bukoba	0.017	2400	2060	2020
9	Rubafu	0.046	2300	1710	1710

During the LVEMP period of 2001-2004, the average annual evaporation for Musoma MET station increase slightly by 1% and this value was further smoothened in the combine long-term period of 1950-2004 to a mere 0.1%. As for Mwanza Airport evaporation decreased by 8.3% for the LVEMP period but overall the increment was reduced to 0.6% for the period 1950-2004. Although there was an increase of 13.3% in evaporation for Bukoba Airport, the long-term period of 1950-2004 show a decrease in evaporation by only 1% due to smoothening effect. Lehman (1998) concluded that climatic changes appear to be part of a global change in climate conditions of the high elevation tropics.

2.4.5 Major Research Needs/Gaps

2.4.5.1 Atmospheric Deposition

Research efforts towards understanding the atmospheric deposition in LVB are limited. The research results reported are not consistent as such they can be used to make a generalized conclusion of the nutrient loading from atmospheric depositions. Besides the information gathered on wet and dry deposition has been on very limited sample area. For reliability purposes data collection should be both offshore, on shore, on islands and onboard ships. As mentioned earlier, there was no proper sampling equipment, especially for the dry deposition. Furthermore, while the research activities were focussing on quantifying atmospheric deposition, understanding of the sources of atmospheric depositions had not been identified.

2.4.5.2 Meteorology

Understanding meteorology behaviour of the area is very important for explaining the processes taking place in the lake basin. For example meteorology has influence to the water level in the lake, water quality etc. Studies on the impact of climate change on the

meteorology of the lake basin have not been done. Other important parameters that are influenced by the meteorology but have not been studied include ground water resources, physical and Socio-economic impacts of climate change, vulnerability, resilience and adaptation to climate change impacts etc. **Table 2.7** provides the summary of research needs and gaps.

2.4.6 Major Research Capacity Building Needs

2.4.6.1 Atmospheric Deposition

In order to understand, monitor and manage lake eutrophication, monitoring of all sources of nutrients should not be a one off exercise. There is a need to have continuous monitoring stations of nutrient loading, in particular atmospheric deposition. This requires capacity building in terms of acquiring suitable sampling equipment for wet and dry depositions, training of technicians to do the sampling and analysis, interpretation data.

2.4.6.2 Meteorology

Capacity to carry out continuous monitoring of metrological parameters need to be built. Mass balance of Lake Victoria should be constantly updated using national and regional data from the riparian countries, and this information need to be related to meteorological data of the area. Since meteorology has a bearing on river flows, river gauging stations for the un-gauged catchments that were recommended in the first phase of LVEMP should be established. Staff training is essential to ensure that the data collected is accurate and consistent.

Table 2.6 provides a summary of the current status of research on meteorology and atmospheric deposition in the Lake Victoria Basin and Table 2.7 summarises research needs.

Table 2.6: Status of Atmospheric Deposition and Meterology Research

Type of Research Conducted	When Conducted	Research Institutions (involved in the research)	Key Research Findings/Lessons
Modelling of Nutrients Loading into Lake Victoria	1999 - 2000	Chemical and Process Engineering, University of Dar es Salaam	74% of N loading is from dry deposition 70% of P loading is from dry deposition 70.4% of N deposition is from biomass burning 100% of P deposition is from biomass burning
Estimation of Water Pollution Sources in Lake Victoria	1999 - 2000	Eindhoven Technical University and Department of Chemical and Process University of dare s salaam	72% of N loading is from atmospheric deposition 36% of P loading is from atmospheric deposition
Non-point Source Loading of Phosphorus to Lake Victoria from the Atmosphere and Rural Catchments in Tanzania	1996 - 2000	Department of Zoology and Marine Biology and Waterloo University	84% of N loading is from atmospheric deposition 75% of P loading is from atmospheric deposition
Meteorology and hydrology	2001 - 2004	LVEMP-1	- A slight increase in evaporation (0.1% -

Type of Research Conducted	When Conducted	Research Institutions (involved in the research)	Key Research Findings/Lessons
			0.6%) - A slight increase in rainfall during rain season - A slight decrease in rainfall during dry season

Table 2.7: Atmospheric Deposition and Meteorology Research Needs

Sub-Research Theme			Research Needs/Gaps			Research Capacity Gaps			Remarks
No	**Theme**	**Priority**	**No**	**Need/Gap**	**Priority**	**No**		**Priority**	
1.	Wet deposition of N and P	High	1	Extent of the problem	High	1	Lack of sampling equipment	High	
			2	Source	High	2	Inadequate laboratory facilities	High	
			3	Transport/transformation	High	3	Inadequate trained staff for making proper sampling	High	
2.	Dry deposition of N and P	High	1	Extent of the problem	High	1	Lack of sampling equipment	High	
			2	Source	High	2	Inadequate laboratory facilities	High	
			3	Transport/transformation	High	3	Inadequate trained staff for making proper sampling	High	
3.	Atmospheric deposition of other pollutants e.g. heavy metals	Low	1	Extent of the problem	High	1	Lack of sampling equipment	High	
			2	Source	High	2	Inadequate laboratory facilities	High	
			3	Transport/transformation	High	3	Inadequate trained staff for making proper sampling	High	
3.	Meteorology	Medium	1	Impact of climate change	High	1	Inadequate research interest in carrying out climate related research	Medium	

Sub-Research Theme			Research Needs/Gaps			Research Capacity Gaps			Remarks
No	Theme	Priority	No	Need/Gap	Priority	No		Priority	
			2	Impact of climate change to ground water	High	2	Inadequate laboratory facilities	Medium	
			3	Vulnerability and adaptation	High	3	Inadequate trained staff to carry out climate related research including vulnerability and adaptation		

Wet deposition
- The effects of nitrogen fixation by blue-green algae;
- Assessment of magnitude of nutrient loading from wet atmospheric depositions

Dry deposition
- Effect of land use changes (population pressure, deforestation etc.)
- Assessment of magnitude of nutrient loading from dry atmospheric deposition

Meteorology
- Impact of climate change on LVB ecosystem
- Continuous monitoring of metrological parameters
- LV mass balance updating

2.5 Aquatic Weeds including Water Hyacinth

2.5.1 Introduction

Aquatic weeds continue to be an environmental problem in Lake Victoria and its catchment. These are mainly invasive aquatic macrophytes, which have invaded the lake and have had significant socio-economic and environmental impacts, which remain largely unquantified. Water hyacinth has been the most serious aquatic weed, which has continued to infest the lake, rivers, gulfs and satellite lakes/ponds in the basin, despite the control efforts undertaken during LVEMP I. River Kagera is considered to be the main source of water hyacinth into the lake.

In addition to water hyacinth, other aquatic weeds have also emerged in recent years. Ecological succession is evident in water hyacinth managed sites whereby pure water hyacinth is invaded by other macrophytes mainly the water lettuce *Typhae sp., Vossia sp., Papyrus sp.,* water chestnut *Trapa natans*, *and Azolla spp.* These are also a potential threat to the Lake Victoria ecosystem.

Table 2.8 provides a summary of the current status of research on aquatic weeds in the Lake Victoria Basin. Additional pertinent elaborations are provided in the following sub-sections.

2.5.2 Key Aquatic Weeds Research Institutions

Extensive research has been done on aquatic weeds, especially water hyacinth in the LVB. Literature review, however, shows that only very few institutions have been involved. These are:

a) Lake Victoria Environmental Management Programme – 1, Water Hyacinth Component

b) Plant Protection Division (Mwanza and DSm) - Ministry of Agriculture, Food Security and Cooperatives
c) United States Geological Survey/EROS Data Centre
d) BICO - University of Dar es Salaam
e) Clean Lakes, Inc.

2.5.3 Major Research Activities

Researches that have been done have largely focused on water hyacinth to document its status both at national and regional levels, impacts and control. These include a Transboundary Diagnostic Assessment that was recently done to assess transboundary issues related to the existence of water hyacinth "hot spots" and effects of resurgence of water hyacinth in the lake. Very little work, however, has been done to document and explain the status of other aquatic weeds. A list of major researches that have been done so far in relation to aquatic weeds is as follows:

(i) Ecological factors affecting performance of *Neochetina* weevils in the river systems. The study, which is being carried out in river systems (Kagera and Mara in the Lake Victoria Basin and Pangani and Sigi in North-eastern Tanzania, where weevils have controlled the water hyacinth) aims at establishing factors attributing to the failure of establishment of *Neochatina* weevils in the river systems and propose the alternative control methods.

(ii) Impact of weevils (*Neochatina eichhorniae* and *N. bruchi*) on control of water Hyacinth;

(iii) Impact of water hyacinth infestation in Lake Victoria on socio-economic characteristics of Riparian communities. The aim was to estimate the economic losses/gains attributed to water hyacinth at local level, determine community perception of gains/losses of water hyacinth control methods and assess the social impact of water hyacinth at household level to family life;

(iv) Study to identify water hyacinth hot spots and probable factors contributing to water hyacinth persistence;

(v) Water hyacinth infestation in ponds and satellite lakes in the Lake Victoria basin on Tanzania: status and efforts to tame it. The study was undertaken to ascertain the presence of water hyacinth and assess its status and effects to the communities and the environment and take appropriate control measures;

(vi) Impact of agricultural activities on proliferation of water hyacinth on Kagera River;

(vii) A rapid survey to assess the infestation of aquatic weeds;

(viii) (viii Assessment of water hyacinth status and weevil release in River Mara. This survey was undertaken to assess the impact of released *Neochetina* weevils and to establish the status of water hyacinth in the river;

(ix) Assessment of water hyacinth infestation, weevils' impact and agricultural activities in River Kagera;

(x) The abundance and Distribution of water hyacinth in Lake Victoria and the Kagera River Basin, 1989-2001. The survey used remotely sensed imagery and fieldwork to document the abundance and distribution of water hyacinth from its establishment to 2001;

(xi) Transboundary Diagnostic Assessment that looked on transboundary issues in relation to effects of resurgence of water hyacinth in the Lake; Effects of existence of water hyacinth "hot spots" related to socio-economic activities in the Lake Basin; Effects of blue green algae occurrence as a result of nutrient loading discharge from both point and non-point source

2.5.4 Major Findings and Lessons

Research findings on aquatic weeds can be found in the following reports and publications:

- Albright, T., Moorhouse, T., and McNabb, T. 2001. The Abundance and Distribution of Water Hyacinth in Lake Victoria and the Kagera River Basin, 1989-2001. USGS/EROS Data Center and Clean Lakes, Inc. U.S.A. 42 pp.

- Bureau for Industrial Cooperation (2006) Transboundary Diagnostic Analysis for the Lake Victoria Basin. Final Report prepared for the Ministry of Water, Dar es Salaam, Tanzania

- Bwathondi, P., and Mahika, G., 1994, A report of the infestation of water hyacinth (*Eichhornia crassipes*) along the Tanzanian side of Lake Victoria: National Environment Management Council.

- Katagira, F., Mjema, P., Rajabu, C.A., and Mnyanza, O. 2002. Report on Rapid Field Verification of Water hyacinth "Hot Spots" Areas in Lake Victoria, Tanzania Side. LVEMP.

- LVEMP, 2003. Regional Water Hyacinth "Hot Spots" Mapping Workshop Report, 24th-27th November 2003, Entebbe, Uganda. Water Hyacinth Control Mjema, P. 2003. Impact of water hyacinth infestation in Lake Victoria on socio-economic characteristics of riparian communities – Tanzania. Nyanza Review Control Components (Kenya, Uganda and Tanzania).

- LVEMP. 2005. Water Hyacinth control component Annual Report July 2004-June 2005. LVEMP, Mwanza.

- LVEMP, 2005. A Brief Report on Water Hyacinth Control Activities to MPs Kenya. LVEMP-Tanzania, Water Hyacinth Control Component, Mwanza.

- Mallya, G.A., 1999, Water hyacinth control in Tanzania, *in* First IOBC Global Working Group Meeting for the Biological Control and Integrated Control of Water Hyacinth, p. 25-29.

- Mallya, G., Mjema,P. and Ndunguru,J. 2001. Water hyacinth control through integrated weed management strategies in Tanzania. In Julien, M.H., M.P. Hill, T. D. Center and Ding Jianqing. Ed. ACIAR Proceedings 102. pp. 120-122

- Mjema, P. 2003. Impact of water hyacinth infestation in Lake Victoria on socio-economic characteristics of riparian communities – Tanzania. Nyanza Review 6:9

- Ndunguru, J., Mjema, P., rajabu, C.A. and Katagira, F. 2001. Water Hyacinth infestation in Ponds and satellite lakes in the lake Victoria basin on Tanzania: status and efforts to tame it. LVEMP.

- Ndunguru,J., Rajabu, C.A., Mjema,P., Mallya,G., Katagira, F., Luyagira, R. and Dohoyi, R. 2001 Demonstration of the effects of water hyacinth weevils (*Neochetina eichhorniae* & *N. bruchi*) in the management of water hyacinth in Tanzania. LVEMP

- Sibuga, K.P. 2005. Lessons Learnt: Water Hyacinth Control Component. National Report, LVEMP.

The major findings of the various research initiatives indicate that the Lake Victoria basin, including the lake, its bays and gulfs, rivers Kagera, Mara and satellite lakes/ponds was seriously infested by Water hyacinth (*Eichhornia crassipes*) especially in the 1990s. The total water hyacinth cover in the lake in 1998 was estimated at 2,000 hectares. Albright et al. (2001), however, observed that between 1996 and 1997, the levels of infestation ranged between 825 ha and 2004, followed by a peak of 4081 ha in March 1998 and a decline thereafter. These levels were much lower than those observed in Kenya and Uganda. Approximately 20,000 ha were present on the entire lake by end of 1998. Out of the 12 ponds and 2 satellite lakes surveyed between 2000 and 2001, water hyacinth was found in 11 (78%) of them, the highest infestation being recorded at Ngulyati pond in Bariadi, with 31.5 ha. Ground and aerial surveys conducted in the basin in 2000 and in 2004, however, revealed reduction in the weed coverage by 70% to 80% respectively, mainly through the introduction of insect bio-control agents.

Water hyacinth had posed serious environmental and socio-economic problems in the use and management of water resources. The immediate effect of the infestation in the ponds, for example included difficulty in accessing water for domestic use and loss of water through evapo-transpiration. The weed was also making fishing almost impossible. The extensive proliferation of the weed in the lake also interfered with water transport, displaced natural biodiversity of the lake, clogged fish landing sites bringing to a halt fishing activities in the affected areas, reduced water quality and supply and harboured increased populations of vectors of diseases, such as malaria and bilharzias and other dangerous animals, including hippos, snakes and crocodiles (Sibuga, 2005). According to Mjema (2003), fishermen changed from fishing to other activities such as farming and petty trading. Income of fishing communities decreased by 50% before implementation of water hyacinth control programme, but there was an increase of 30% following water hyacinth control.

Recent studies have shown that there has been 80% reduction of water hyacinth infestation through integrated pest management, which has helped restore use of the lake water resources for fishing, domestic, recreation and travel. Fish catches are also reported to have increased (Mjema, 2003). Today, the water hyacinth community around the Tanzanian shore of Lake Victoria is characterized by intermittent small stands of water hyacinth, damaged by weevils, with tall grasses overgrowing the back of the fringe, and confined to sheltered bays. However there are exceptions, regarding continued survival of water hyacinth in hotspot areas, which must be addressed. For reasons yet to be established, biological control measures have proved not effective in rivers as establishment of the released weevils on the weed was poor with low weevil feed marks (mean 0.8 per plant). The weevils have failed to establish completely in Kagera River, where the velocity of water is high and siltation is also high. As a result of poor weevil establishment, especially on rivers Kagera and Mara, fresh inputs of water hyacinth from the rivers into the lake have been recorded.

Water hyacinth re-growth (resurgence) has, however, been observed along lake shoreline and 17 water hyacinth hot spots believed to coincide with spatial distribution of nutrient-enriched water conditions in the Lake, Kagera, Mara (8 kilometres from the river mouth on Tanzanian side), Kanoni and Kahororo rivers and ponds are still infested with water

hyacinth. In seasonal ponds the weed flourishes in the rain season. Identified probable causes for the persistence of water hyacinth in hot spot areas are:

a) nutrients enrichment especially Nitrogen and Phosphorus;
b) shoreline geomorphology in the form of sheltered bays and gulfs (e.g. Mwanza and Emin Pasha gulfs and Rubafu and Mara bays);
c) germination from huge seed bank available in the lake and rivers;
d) input of fresh water hyacinth from river Kagera (daily input of water hyacinth into lake Victoria through the river estimated at 0.2 to 2 ha during the rain season and 0.8 to 1.8 ha during the dry season; and
e) withdrawal of stranded water hyacinth from Mara, Kanoni and Kahororo rivers and ponds.

A rapid assessment that was conducted in the lake Victoria to assess the infestation of aquatic weeds revealed that ecological succession was evident in water hyacinth managed sites whereby pure water hyacinth had been invaded by other macrophytes, mainly the water lettuce *Typhae sp., Vossia sp., Papyrus sp.,* water chestnut *Trapa natans*, *and Azolla spp.* (LVEMp, 2005). Research has also shown that *Azolla* and *Trapa natans* are becoming a menace and threat in the lake and ponds, particularly in areas where water hyacinth has been removed or reduced by the IPM strategies and that some of the waters are already chocking with such weeds. *Trapa natans* was identified as the most serious threat to the fishing communities. The survey also showed that Biharamulo was the most highly infested district, and for the first time the weed was reported to occur in this area in the basin in 2001. The highly infested sites surveyed included Karumo (16 ha), Kasala (14.3 ha), Kwenyejosho (5.6 ha) in Biharamulo District and Ilalambogo (5.2 ha) in Missungwi District). In 2004, the weed covered a total area of about 52.3 hectares. *Azolla* sp. is mainly found in Magu and Mara River and in most of the bays.

Water hyacinth and other aquatic weed are symptoms of eutrophication, which is a state of nutrient rich water body. Eutrophication leads to excessive growth of algae or macrophytes e.g. water hyacinth, affecting seriously the water quality (e.g. low oxygen content, high turbidity, release of toxic gases from the sediments such as hydrogen sulphide).

2.5.5 Major Research Needs/Gaps

Despite the several researches that have been undertaken on water hyacinth, there are still many areas that need to be researched on in order to provide explanations on observed phenomena and facilitate control of the weeds through integrated pest management. The key research areas that need to be addressed are:

(i) Persistence of water hyacinth in hot spots
(ii) Socio-economic and environmental impacts of water hyacinth
(iii) Dynamics and Performance of Weevils in the lake and rivers
(iv) Resurgence of water hyacinth and control options
(v) Occurrence and control of other aquatic weeds

2.5.5.1 Persistence of water hyacinth in hot spots:

Although research activities on water hyacinth have, to a great extent, contributed to the understanding of the weeds' biology and ecology and facilitated its control, information is, however, lacking as to why there is persistence of the weed in the hot spot areas despite the more or less successful control measures. There is therefore need for ongoing and new control and research activities in these areas. Continuous monitoring of the weed is also necessary to provide up-to-date information on its status in the basin in general.

2.5.5.2 Socio-economic and environmental impacts of water hyacinth:

Information on the extent to which reduction of water hyacinth has impacted on the socio-economic conditions of the people in the basin is lacking. It is, for example not known how the livelihoods of the fishing communities changed as a result of water hyacinth infestation and what the situation is likely to be now given that the weed has been tremendously reduced. Are more people engaged in fishing now than before the weed control? What are their levels of income compared to the past? Has water supply and quality improved compared to the past, and to what extent? These and many other questions can only be answered through research. More detailed studies should be conducted on the status and implications in terms of socio-economic and environmental impacts of the weed to guide selection of control options.

2.5.5.3 Dynamics and Performance of Weevils in the lake and rivers:

Although biological control methods are sustainable over the long term and have proved effective in controlling the water hyacinth, they are slow acting and/or with a long incubation period. Given the fact that water hyacinth is a fast growing plant compared to the slow-acting nature of the two weevil species currently used, there is need to intensify search for more efficient, fast acting bio-agents that would complement the weevils in use. In addition, because the weevils have failed to effectively establish in rivers, research is needed to determine the factors that hinder establishment of biological control weevils in rivers and on water hyacinth established on muddy shores and solutions including the potential use of other bio-control agents such as the mite (Orthogalumna terebrantis) be examined for application against the weed in such sites.

2.5.5.4 Resurgence of water hyacinth and control options

The research findings above have shown that despite the 80% reduction in water hyacinth coverage, there has been resurgence of the weed along the lake shores and hot spot areas. These colonies pose a continual threat of re-infestation or further infestation of the lake. Further research is needed on the dynamics of the weed and other techniques that could be integrated into already demonstrated methods to ensure better and more sustainable control of water hyacinth and other aquatic weeds that threaten the lake's ecosystem and livelihood of the riparian community. In particular, it will be necessary to examine the causes and dynamics of resurgence and proliferation of water hyacinth in the Lake Victoria basin. Studies are also necessary to understand the roles of the communities and factors that will motivate them in favour of recommended IPM for the weed.

2.5.5.5 Occurrence and control of other aquatic weeds

This is clear evidence of succession of water hyacinth; yet very little is known about it. Research is, therefore, needed to determine the likely changes in weed species composition and ecosystem balance when subjected to certain interventions and the control measures that should be taken. There could be other aquatic species that may become the aquatic weeds of the next generation after water hyacinth as it is already evidenced by *Azolla,* and *Trapa natans*, which may not necessarily respond to the *Neochetina* weevils.

2.5.5.6 Eutrophication

Water hyacinth and other aquatic weeds are symptoms of eutrophication, which leads to excessive growth of algae or macrophytes e.g. water hyacinth, affecting seriously the water quality (e.g. low oxygen content, high turbidity, release of toxic gases from the sediments such as hydrogen sulphide). There is input of significant amount of organic and nutrient substances into the LVB bodies in the territories of the riparian countries of the basin (wet and dry precipitation. discharge of untreated domestic waste in the Lake affect entire lake).

Application of fertiliser in farms also increases nutrient burden in the lake, and because of mixing and water currents nutrients are not localised. The key research needs are related to the following:

(i) Which development practices (within all riparian countries) significantly contribute to eutrophication?
(ii) What are the driving factors for nutrient loading into water bodies?
(iii) Influence of social economic developments and needs on release of nutrients into water bodies?
(iv) Understanding of attitudes of riparian communities on relationship of their activities and eutrophication of the water bodies.

The research gaps that need to be filled are:

(i) Regional sources of nutrients, especially Nitrogen and Phosphorus;
(ii) Size and magnitude of water hyacinth seed bank within the region;
(iii) Extent of cross border recharge of fresh water hyacinth into the lake;
(iv) Regional efforts on control measurers.

2.5.6 Major Research Capacity Building Needs

There is limited capacity in terms of staff who can undertake research particularly in the area of plant protection. Expertise is also lacking in modeling and use of remote sensing and Geographical Information Systems (GIS) for mapping the extent of coverage of water hyacinth and changes over time. Short-term training is, therefore, needed in information technology (IT) related to aquatic weeds, management of aquatic weeds, research methodology, statistical techniques and modeling.

At community level, 68 BMUs have been involved in the monitoring of the incidence of water hyacinth in their areas and participated in its removal. These need to be empowered to effectively engage in the monitoring process. In particular, they need to be trained in the following areas:

(i) Weevil production, harvesting and release;
(ii) Record keeping and reporting during monitoring;
(iii) Weevil management or rearing;
(iv) Knowledge of aquatic weeds in terms of their types, threats, control and monitoring (awareness raising),

More BMUs also need to be established to strengthen the local capacity to undertake monitoring. At the institutional level, institutional and other mechanisms for facilitating implementation and collaboration of researchers and research institutions are required. Such mechanisms will help to address the problem of shortage of qualified staff in LVEMP to undertake research on aquatic weeds. **Table 2.9** shows the summary of research needs and gaps.

Table 2.8: LVB Aquatic Weeds - Research Conducted

Type of Research Conducted	When Conducted	Research Institutions (involved in the research)	Key Research Findings/Lessons
Ecological factors affecting performance of *Neochetina* weevils in the river systems	2003-2006	Ministry of Agriculture- Plant Protection Division (LVEMP Water Hyacinth component)	• Findings not available as research was still in progress
Impact of weevils (*Neochetina eichhorniae* and *N. bruchi*) on control of water Hyacinth;	1999-2000	Ministry of Agriculture- Plant protection Division (LVEMP Water Hyacinth component)	• Neochetina eichhorniae and N. bruchi caused significant damage to water hyacinth • Ability of weevils to control water hyacinth demonstrated and mainly relied on their ability to reduce plant roots and population • Progressive replacement of water hyacinth by other aquatic weeds, particularly Cyperus sp.
Impact of water hyacinth infestation in Lake Victoria on socio-economic characteristics of Riparian communities.	2001	Ministry of Agriculture- Plant protection Division (LVEMP Water Hyacinth component)	• Interference with water transport, • displaced natural biodiversity of the lake, • clogged fish landing sites bringing to a halt fishing activities in the affected areas, • reduced water quality and supply and • harbouring of increased populations of vectors of diseases, such as malaria and bilharzias and other dangerous animals, including hippos, snakes and crocodiles • Difficulty in accessing water for domestic use and loss of water through evapo-transpiration. • Change of economic activities from fishing to farming and petty trading. • Decrease of Income of fishing communities by 50% before implementation of water hyacinth control programme, but an increase of 30% following water hyacinth control.
Study to identify water hyacinth hot spots and probable factors contributing to water hyacinth persistence	2003	Ministry of Agriculture, Plant Protection Division (LVEMP Water Hyacinth component)	• Water hyacinth re-growth (resurgence) observed along lake shoreline • 17 water hyacinth hot spots believed to coincide with spatial distribution of nutrient-enriched water conditions in the Lake, Kagera, Mara, Kanoni and Kahororo rivers and ponds still infested with water hyacinth. • River Kagera identified as the major water hyacinth hot spot and major source of water hyacinth into Lake Victoria • Probable causes for the persistence of

Type of Research Conducted	When Conducted	Research Institutions (involved in the research)	Key Research Findings/Lessons
			water hyacinth in hot spot areas are: nutrients enrichment especially Nitrogen and Phosphorous; shoreline geomorphology in the form of sheltered bays and gulfs; germination from huge seed bank available in the lake and rivers; input of fresh water hyacinth from river Kagera; and) withdrawal of stranded water hyacinth from Mara, Kanoni and Kahororo rivers and ponds.
Water hyacinth infestation in ponds and satellite lakes in the lake Victoria Basin on Tanzania: status and efforts to tame it.	2000-2001	Ministry of Agriculture-Plant Protection Division (LVEMP Water Hyacinth component)	• Flourishing of the weed in seasonal ponds in the rain season. • Out of the 12 ponds and 2 satellite lakes surveyed between 2000 and 2001, water hyacinth was found in 11 (78%) of them, the highest infestation being recorded at Ngulyati pond in Bariadi, with 31.5 ha
A rapid survey to assess the infestation of aquatic weeds;	2004-2005	Ministry of Agriculture- Plant Protection Division LVEMP Water Hyacinth component	• Ecological succession in water hyacinth managed sites with pure water hyacinth being invaded by Typhae sp., Vossia sp., Papyrus sp., water chestnut (Trapa natans), and Azolla spp. • Azolla and Trapa natans becoming a menace and threat in the lake and ponds • Sites highly infested with Trapa natans included Karumo (16 ha), Kasala (14.3 ha), Kwenyejosho (5.6 ha) in Biharamulo District and Ilalambogo (5.2 ha) in Missungwi District) • ITrapa natans covered a total area of about 52.3 hectares in 2004
The abundance and Distribution of water hyacinth in Lake Victoria and the Kagera River Basin, 1989-2001 (Regional survey)	2001	United States Geological Survey (USGS0/EROS Data Centre and Clean Lakes, Inc.	• between 1996 and 1997, the levels of infestation on Tanzanian side of lake ranged between 825 ha and 2004, followed by a peak of 4081 ha in March 1998 and a decline thereafter • maximum lake-wide coverage of approx. 20,000 ha attained in late 1998 with severe infestations in the northern portion of the lake (Kenyan and Ugandan portions) • Presence of water hyacinth infestation in all of the flood plains, lagoons and lakes which have linkage to Kagera River
Assessment of water hyacinth status and weevil release in River Mara.	2001	Ministry of Agriculture- Plant Protection Division LVEMP Water Hyacinth component	• Failure of the weevils to establish
Assessment of	2001	Ministry of	• Establishment of the released weevils

Type of Research Conducted	When Conducted	Research Institutions (involved in the research)	Key Research Findings/Lessons
water hyacinth infestation, weevils' impact and agricultural activities in River Kagera		Agriculture- Plant Protection Division LVEMP Water Hyacinth component	on the weed was poor with low weevil feed marks (mean 0.8 per plant). • The weevils have failed to establish completely in Kagera River, where the velocity of water is high and siltation is also high • Intensive crop cultivation in the river basin led to soil degradation and nutrient loading hence contributed to continued proliferation of the weed
Monitoring and impact assessment of water hyacinth;	2004	Ministry of Agriculture- Plant Protection Division LVEMP Water Hyacinth component	• Reduction in the weed coverage by over 82% • A total of 17 hot spots identified • Persistence of water hyacinth in hot spot areas

Table 2.9: LVB Aquatic Weeds – Research Needs/Gaps

Sub-Research Area/Theme			Research Needs/Gaps			Research Capacity Gaps	
No	**Area**	**Priority**	**No**	**Need/Gap**	**Priority**		**Priority**
1.	Water hyacinth	High	1.	Reasons for persistence of the weed in the hot spot areas	High	Inadequate staff with skills to work in the area of aquatic weeds	high
			2	causes and dynamics of resurgence and proliferation	High	Inadequate staff with skills to work in the area of aquatic weeds	High
			3	Status and succession of water hyacinth	High	Lack of expertise in modeling and use of remote sensing and GIS techniques	High
			4.	Extent of water hyacinth seed bank in the region	High	Inadequate trained staff with appropriate research methods for trans-boundary assessments	high
			5.	Status and extent of socio-economic and environmental impacts	High	Inadequate staff to undertake impact assessment	Medium
			6.	Control options to better manage the weed	High	Inadequate local capacity to manage the weed	Medium
2.	Weevils	High	1.	Poor performance of weevils in rivers e.g. Kagera	High	Inadequate staff with skills to work in the area of aquatic weeds	High
			2.	Dynamics of weevils	Medium	Inadequate staff with skills to work in the area of aquatic weeds	High
3.	Bio-control agents	High	1.	Alternative bio-control measures including more efficient, fast acting bio-agents	High	Inadequate staff with skills to work in the area of aquatic weeds	High

Sub-Research Area/Theme			Research Needs/Gaps			Research Capacity Gaps	
No	**Area**	**Priority**	**No**	**Need/Gap**	**Priority**		**Priority**
4.	Other aquatic weeds	High	1.	Extent of other aquatic weeds	High	Inadequate staff with skills to work in the area of aquatic weeds	High
			2.	Appropriate control methods	High		High
5.	Eutrophication	High	1.	Regional sources of nutrients	High	Inadequate trained staff with appropriate research methods for trans-boundary assessments	High
			2.	Extent and volume of nutrients	High	Lack of appropriate equipment for research on transboundary issues	high
			3.	Transboundary driving factors	High	Inadequate trained staff with appropriate research methods for trans-boundary assessments	High

2.6 Forests, Wetlands and Watershed Management, Soil and Water Conservation

2.6.1 Background

The lake basin is endowed with rich natural resources and provides water for domestic, agricultural and industrial use. Both natural and planted forests offer the best land protection mechanism in watershed areas (EAC, 1996). High forests interception rate, the spongy conditions, high water retention time and soil binding mechanism all constitute important processes for preventing floods and soil erosion. Forests also increase dry season water flow in streams and rivers.

Utilization of lake basin natural resources such as water gives employment opportunities and sources of income, provides hydropower generation and networks of transport and communication (EAC, 2005). Furthermore, the basin has vast potential for economic development, and the East African Community has declared the area as a Regional Economic Growth Zone. Strategies are developed to foster economic growth in the basin (EAC Development Strategy 2001-2005).

More than 80% of the populations in the lake basin are engaged in agricultural production, the major part as small-scale farmers or livestock keepers producing maize and cash crops such as sugar, tea, coffee, cotton and meat (EAC Secretariat 2005). However, such human activities on the land have contributed to environmental problems in the basin. Land degradation is of major concern, not only for the healthy of the lake, but also for food and livelihood security of its rapidly expanding population (Liwenga, 2005). Soil erosion is evident in many parts of the lake basin exacerbated by poor land and water management. However, slope is among the factors contributing to land vulnerability to soil erosion. Steep areas are potentially more vulnerable to soil erosion than flat areas (Yanda et al., 2001a). Land use/cover is among the factors normally considered in assessing potential soil erosion hazards. Different land use/cover types have different effects in protecting the soil from erosion.

Resource pressure and lack of employments in the rural areas give rise to extensive migration to the urban areas of the basin (EAC, 2005). The rapidly increasing population also contributes to the existence of “hot spots” of population and environmental degradation caused by human waste, urban run-off, effluent discharge from industrial activities and processing of fish and agricultural produce. The multiple livelihood activities undertaken by respective communities in the lake basin have increasingly come into conflict (Nyirabu, 2001). These multiple activities, coupled with weak regulatory mechanisms have led to unsustainable use of the land, water resources and the vegetation cover. This unsustainable use has consequently resulted into serious environmental impacts leading to degradation of the land, water quality in the lake and rivers, deforestation, soil erosion and sedimentation of the lake, and loss of biodiversity (Nyirabu, 2001; Yanda et al., 2001a; Kangalawe et al., 2005, Liwenga et al., 2005).

Ecological threats materialize as continued contamination and eutrophication of the lake caused by inflow of residues from use of chemical herbicides and pesticides in agriculture, and, increasingly, also from heavy metals from gold mining operation. Nutrients inflows have given rise to increase in algae growth since 1960s causing de-oxygenation of the water thus threatened the survival of deep water-fish species (EAC Secretarial, 2005).

Table 2.11 provides a summary of the current of status of research on Forests, Wetlands and Watershed Management and Soil and Water Conservation in the Lake Victoria Basin. Additional pertinent elaborations are provided in the following sub-sections.

2.6.2 Key Research Institutions

2.6.2.1 Forests

Very few institutions have been involved in forestry research. Many of the researches undertaken during LVEMP I were done by the LVEMP– Catchment Afforestation Component. Other key research institutions that have been involved are:

- SUA
- University of Dar es Salaam (BICO, IRA, Botany)
- Ministry of Natural Resources and Tourism (Forestry and Beekeeping division)

2.6.2.2 Wetlands and Watershed Management

The key research institutions in Wetland research include LVEMP I - Wetlands Component, SUA, University of Dar es Salaam, NEMC.

2.6.2.3 Soil and Water Conservation

Research on soil and water conservation has mainly been undertaken by LVEMP I integrated Soil and Water Conservation Component. Other key institutions include:

- Institute of Resource Assessment UDSM

- Lake Zone Agricultural Research and Development institute (ARDI), Ukiriguru
- Ministry of Agriculture and Cooperatives
- SUA
- MARUKU

2.6.2.4 Landuse and Sedimentation

The key Research Institutions that have been involved in research related to land use and sedimentation include the following:

- University of Dar es Salaam (IRA, Geology Department, CoET)

2.6.3 Research Activities (Past and Present)

2.6.3.1 Forests

Very few studies have been undertaken to assess forests in the Lake Victoria Basin. These include:

- Yanda et al. 2001. Survey and mapping of land use/cover and erosion hazard in Lake Victoria Basin. Final Report to LVEMP
- BICO, 2006. Trans-boundary Diagnostic Analysis for the Lake Victoria Basin. Final Report to LVEMP
- Chamshama, S. 2005. Lessons Learnt on Catchment Afforestation Component of the Lake Victoria Environmental Management Project. Final Report to LVEMP
- Zahabu, E. 2001. Inventory on Permanent Sample Plots Established for Kibangabitare Village Forest in Tarime, Musoma, Tanzania. Report to LVEMP
- Status of Forest reserves in Mwanza and Mara. LVEMP - Catchment Afforestation Component

2.6.3.2 Wetlands and Watershed Management

Several research activities have been undertaken with respect to wetlands and watershed management; these include:

- Impact of gold mining in Lake Victoria basin on mercury levels in the environment
- Buffering Capacity of Wetlands study
- Nutrient removal by natural wetland (Kagondo- Bukoba)
- Soil appraisals on selected fringing wetlands of lake Victoria
- Simulation of pollution buffering capacity of wetlands fringing in Lake Victoria using wetland model.
- Inventory surveys on utilization and management of wetlands products in Mwanza Gulf of lake Victoria.on strategy.
- The impact of immigrant pastoral herds on the fringing wetland areas of Lake Victoria Basin and proposed livestock production strategy.
- Vegetation surveys at Nyashishi, Ngono and Geita wetlands in lake Victoria Basin based on satellite Imagery analysis.
- Trans-boundary Diagnostic Analysis for the Lake Victoria Basin
- Rapid Assessment of Lake Victoria Fringing Wetlands.
- Land Use Conflicts in Wetlands: A case study of Nyashishi River, Mwanza,
- Status of Utilization and Conservation of Doom Palm (*Phenix reclinata*)
- A study of Macrophytes with Medicinal Potential in Lake Victoria and Its Surrounding Wetlands, Preliminary Study
- Indigenous knowledge of fishers on utilization and conservation status of wetlands biodiversity at Simiyu Wetland of Lake Victoria

2.6.3.3 Soil and Water Conservation

Different studies have been undertaken on soil and water conservation Such research projects and programs are outlined below:

- Liwenga, E.T. 2005. Integrated Soil and Water Conservation (ISWC): Final Report on Lessons Learnt.
- Benefits of soil and water conservation measures: A case of pilot areas in Magu and Tarime Districts
- Mang'ombe, et al. 2004. Benefits of Soil and Water Conservation Measures: A case of Pilot Areas in Magu and Tarime Districts
- Ngazi, H.S., Peter, D. and Mang'ombe, E.R. 2004. Effects of Soil and Water Conservation Measures on crop production: A Case Study of Kalemela and Mwitore catchments in Magu and Tarime Districts, Tanzania
- Kaboni, et al. 2004.Soil Information for Nyangwi Proposed Drip Irrigation Project, Nyamagana District, Mwanza City. Lake Zone ARDI, Ukiriguru
- Kaboni, E.L and A.O. Kataballo 2002. soil conditions of mwabagole farm and their suitability for irrigated Agriculture. Lake zone ARDI, Ukiriguru
- Kaboni et al. 2002. Soils and Land Suitability for Irrigated Agriculture at Kilungalunga Farm – Lamadi Village, Magu District, Tanzania.
- Peter, et al. 2000. Field implementation of integrated soil and water conservation activities in Simiyu Catchment: Approaches, success and constraints. Lake Victoria Environmental Management Project. Vice President's Office, United Republic of Tanzania.
- Mahuha, F.E. 1998. Baseline information for implementation of integrated soil and water conservation component in Simiyu watershed. LVEMP & Soil Conservation and Land use Planning Section (SCLUPS), Ministry of Agriculture and Cooperatives, Dar es Salaam

2.6.3.4 Landuse and Sedimentation

Several studies have been undertaken in relation to land use and sedimentation. Conflict on resource use was, however, not covered under LVEMP-I. Details of the various studies can be found in the following reports/publications.

- Yanda, et al. 2001.Survey and mapping of land use/cover and erosion hazard in Lake Victoria Basin.
- An inventory of agro-chemicals in the Lake Victoria Basin.
- Study of agro chemicals use and handling by farmers and their potential risk to human health and environmental pollution (a study carried out in Magu district).
- BICO 2006. Trans-boundary Diagnostic Analysis for the Lake Victoria Basin. Final Report prepared for the Ministry of Water, Dar es Salaam, Tanzania.
- Anthropogenic threats, Impacts and Conservation Strategies in the African Great lakes
- The Limnology, Climatology and Paleoclimatology of the East African lakes.
- Integrated Water Quality Limnology Study for Lake Victoria.
- UNEP, 2006.Trans boundary Agro-ecosystem management programme for the Kagera River Basin
- Identification of information and knowledge Gaps for the Mara River Basin project.
- Yanda, P.Z. and Majule, A.E. 2004. Baseline studies on socio economic and cultural aspects on the Mara River Basin. Final report submitted to WWF (TPO).
- Baseline Study on the Hydrology of Mara River Basin – the Tanzania Section.
- Liwenga, et al. 2005. Livelihood Diversification and Changing Land Use Patterns in the Lake Victoria Basin: An Assessment of Causes and Implications to Local Communities. Interim Research Report to VicRes.
- Kangalawe, R.Y.M, Liwenga, E.T. Majule, A.E and Madulu, N.F. (2005) Dyamics of Farming systems, Food Security and Poverty Alleviation strategies in the changing environment of the semi arid Areas of Sukumaland, Tanzania. Research Report submitted to REPOA, Dar es Salaam.

- Machiwa J.F. Kishe, M.A., Mbilinyi, H.G. Mdamo, A. and Mnyanga, O. (2003). Impact of Gold Mining in Lake Victoria Basin on Mercury Levels in the Environment. LVEMP – Vice President's Office.
- Machiwa, J.F. 2003. Metal concentrations in sediment and fish of Lake Victoria near and away from catchments with gold mining activities. Tanzania Journal of Science 29 (No.2): 43-54
- Machiwa, J.F., Muzuka, A.N.N., Dubi, A.M., Ndaro, S.G.M and Lugomela, C. (2003). Sedimentation studies at the Simiyu River mouth (Magu Bay, Speke Gulf), Lake Victoria, Tanzania. Report submitted to Lake Victoria Environmental Management Project. 97pp
- Rwetabula, J., F. De Smedt, M. Rebhun and F. Mwanuzi, 2005. Transport of micropollutants and phosphates in the Simiyu river (tributary of Lake Victoria), Tanzania. The 1st International Conference on Environmental Science and Technology, New Orleans, Louisiana, USA January 23-26th, 2005
- Tamatamah R.E. 2002. Non-point Source Loading of Phosphorus to Lake Victoria from the Atmosphere and Rural Catchments in Tanzania, East Africa. PhD Thesis, Waterloo, Ontario, Canada, 2002

2.6.4 Major Findings and Lessons

2.6.4.1 Forests

Findings from studies outlined above indicate that ecosystems in the basin have been altered through human-induced activities. For example, the overall forestry situation in the area has deteriorated during the past few years (WSP, 2003). However, deforestation has been in existence since the early 1860s, involving large-scale tree felling for the control of tsetse flies (Kikula et al., 1999). The demand for fuelwood and wood for building purposes far exceeds the potential supply resulting into over-harvesting. Increased wild fire during the dry season and overgrazing contribute much to the loss of natural vegetation. Natural vegetation cover is rapidly being degraded from the "cultivation steppe" of Mwanza and Shinyanga Regions westwards threatening protected areas in districts like Geita, Kahama, Biharamulo, Ngara and Karagwe (Yanda et al., 2001). As a result human induced vegetation types appear to dominate in these areas. In the eastern parts of the basin there is evidence of ongoing deforestation in Bunda, Serengeti and Tarime districts. In the highly deforested districts like Kwimba, Magu, Misungwi, Musoma Rural and part of Sengerema District land lacks vegetation cover which protects it from water and wind erosion (Yanda, et al., 2001). Petty trading is another potential cause of deforestation whereas it involves activities such charcoal making and firewood collection as energy sources for sale, brick and pot making, and local brewing. Other factors are faulty agricultural practices, agriculture expansion, wild fires, overgrazing, and mining activities (EAC, 1996). Carpentry work and other furniture making activities use tremendous amount of wood as well (Yanda et al., 2001). Artisanal mining for gold has caused huge loss of natural forests in Geita district where more than 50,000 ha have been destroyed (EAC, 1996). The indiscriminate cutting of trees by miners for timber, supports in the underground mines, building shelters and firewood have largely been responsible for the deforestation. High population growth (2.9%) and general poverty common in the area are also major factors pushing these environmental problems.

Moberg (1973) cited in Tamatamah (2000) identify the Southwestern part of the Lake Victoria region (i.e. Simiyu and Kagera areas) to have virgin vegetation with mixture of forest and woodland on hilly and swampy areas in flood and river plains that are poorly drained. These habitats have not readily attracted agricultural activities. However, the forest and woodland ecosystems have been converted into bush grassland due to fire regime. In Kagera, the nature reserves in the region have been experiencing changes resulting from encroachment. These changes are due to adherence to the traditional inheritance system of

land subdivision, which often creates disputes within families. Most families have too small plots to ensure food security and; thus, are forced to encroach on protected areas.

Kikula *et al.* (1991) study on causes of land degradation in parts of Sukumaland indicates depletion of natural vegetation through cultivation, grazing and procurement of forest products. This had resulted into poor land cover condition that exposes the land to agents of erosion, mainly, by rain and wind, and large numbers of livestock (See also Brandstorm, 1985).

There have been a number of initiatives to restore vegetation cover in degraded areas. Forestry and Beekeeping Division in the Ministry of Natural Resources and Tourism leads the implementation of most of the afforestation programs aiming at protecting vital parts of the lake catchments. Such programs involved trees planting, increase awareness among communities on catchments protection and tree farming, develop local seed sources and conserve forest biodiversity in collaboration with local communities (Yanda et al., 2000).

2.6.4.2 Wetlands and Watershed Management

Lake Victoria and its basin is endowed with a variety of wetlands, ranging from fringing swamps, draw downs, flood plains, groundwater forests, and riverine systems. Wetlands of Lake Victoria play many important roles to the lake ecosystem (Chisara et al., 1999). Wetlands in the basin are of the four types, namely permanent swamps, seasonal floodplains, tree swamps and open water. Tentatively the total area of all four wetland types within the Tanzanian side of LV basin has been estimated at 422,000 hectares, which is almost five percent of the Lake Victoria basin in Tanzania (84,920 km^2). By far the most abundant wetland type is the seasonal swamp (73%), followed by permanent swamps (14%), tree swamps (8%) and open water (5%) (ARCADIS Euro Consult, 2001) (Table 1).

Table 2.10: Types of wetlands and their extent of coverage in the Lake Victoria Basin

Wetland type	Area covered (ha)	Percentages
Permanent Swamps, mainly reed/papyrus	58,000	14
Seasonal swamps/flood plain	308,000	73
Tree swamps	33,000	8
Open water, mainly inland lakes	23,000	5
Total	422,000	100

Source: ARCADIS Euro Consult, 2001

Lake Victoria wetlands support high biodiversity i.e. species of flora and fauna, many of which are exploited as wetland products. Moreover, wetlands buffer the lake from various pollutants (Chisara et al., 1999, Njau, 2005). Conservation of wetlands with high biodiversity values such as fish breeding sites is necessary (Njau, 2005). Wetlands play important role of buffering nutrients and heavy metals from entering into the Lake Victoria. The studies on buffering capacity have clearly indicated that fringing and non-fringing wetlands buffer nutrients and heavy metals that would have entered the lake (Njau, 2005). Buffering capacity of wetlands is ability to trap, store, and release pollutants into the neighboring water body thereby restoring its ecological and hydrological equilibrium. According to Roggeri (1995) the wetland performs buffering services i.e. nutrient retention, sediment retention and toxicant removal (Katondo, 2001).

The good and fertile soil makes wetlands suitable for agricultural activities. Wetlands encroachment for food crop cultivation and animal grazing is as serious threat to their existence. Such wetlands are intensively cultivated and overgrazed in regions like Shinyanga, Mwanza and Mara (Yanda et al., 2001, Njau, 2005). As a result, such wetlands have been degraded and thus can no longer perform their ecological and hydrological functions such as trapping of sediments and biodiversity conservation (Yanda et al, 2001).

Instead, these wetlands are now contributing to sediment load into the lake (Yanda et al, 2001). Sustainable wetland utilization methodologies have to be put in place to prevent further encroachment and degradation. Developing and implementation of wetlands management strategies can guide better wetlands utilization and conservation (Njau, 2005)

Studies in the basin have established distribution of heavy metals in different portions of environment down stream of mining areas. The buffering capacity of wetlands study has indicated high levels of heavy metals in vegetation and in waters of Mtakuja and Mabubi wetlands. Also Mtakuja and Mabubi wetlands have suffered massive encroachment for agricultural activities. The main crop grown in the area is rice and it has been shown that rice plants grown in this area contain heavy metals.

Heavy metals are present in soils as natural components or as a result of human activities. Metal-rich mine tailings, metal smelting, energy and fuel production, downwash from power lines and sludge dumping are among the most important human activities that contaminate soils and aqueous streams with large quantities of toxic metals. The application of plants in environmental cleanup is the technology that is coming up (phytoremediation) because of lower costs involved and minimum environmental disturbance. There is wide range of aquatic and terrestrial plants including trees, some of them being hyper accumulators that have been identified to accumulate heavy metals. Geita is one of the areas with intensive large and small-scale gold mining activities that bring heavy metals into the environment.

In view of the ongoing wetland degradation processes, there is a need to develop wetland management plan as a way towards development of sustainable wetland management (Njau, 2005). According to Ramsar Convention Bureau (1997), an umbrella plan for the management of wetland resource use and the maintenance of biodiversity should be established in collaboration with all users and interested parties. Within this overall plan, zoning may be appropriate to regulate actions in different parts of the area, and each area may have its own subsidiary plan. Management plan should cover habitat management, species management, wise usage, education, and research. Strategies for the wise use of papyrus involve control of harvesting systems. There should be awareness raising programs on environmental conservation. Also, stakeholders training on wise use of natural resources (including wetland resources) and wetland restoration are of significant importance.

2.6.4.3 Soil and Water Conservation

Environmental degradation in the Lake Victoria Basin has been identified in various studies as a common problem (e.g. Yanda, et al., 2001). Degradation of natural resources such as land, forests, rivers and lakes in the basin has resulted due to improper land use and mismanagement (Mang'ombe et al., 2004). Soil erosion has been one of the major environmental problems facing the basin and it has also been the major cause of the declining productivity of soil and non-point pollution (Mahuha, 2000).

The Integrated Soil and Water Conservation Component has been implementing two sub-programmes namely, soil and water conservation and agro-chemicals management. The pilot areas for ISWC are located in Simiyu River Catchments in Magu District (Liwenga, 2005). Various practices of soil and water conservation were executed in the pilot areas. Such practices includes contour farming, ridges, gullies control, conservation tillage, rain water harvesting techniques, agro-forestry technology, in-situ conservation, agronomic practices, use of combinations of practices and promotion of making of energy saving stoves. Some test crops used include maize, cotton, rice, cassava, sorghum and sweet potatoes (Mang'ombe, 2004).

The ISWC component has made substantial achievements during the project time in relation to the objectives set (Liwenga, 2005). The number of farmers adopting various soil and

water conservation measures has been increasing since 1999 (Liwenga, 2005). Sustainable soil and water conservation in the pilot areas showed greater advantages on increased food security, environmental management, economic growth and poverty alleviation (Mang'ombe et al., 2004). Agricultural production of some major crops such as maize, rice, cassava and cotton were drastically increased (Ngazi et al., 2004) while at the same time reducing soil erosion problem that has big contribution to land degradation. Although the ISWC component has realized several successes in the pilot areas, several challenges remain to be addressed. Land degradation is still a serious threat to larger parts of the Lake Victoria basin and therefore land conservation measures need to be enhanced to cover other parts (Liwenga, 2005). Inadequate extension services contribute to poor support in promotion of soil and water conservation.

A review of approaches and methods used by ISWC component show that the catchment approach was more effective as compared to the individual approach which was tedious and time consuming (Liwenga, 2005). The catchments approach appears to be sustainable taking into consideration of inadequate manpower to undertake soil and water conservation (SWC) activities together with farmers. Furthermore, Participatory Rural Appraisal (PRA), which implies involvement of stakeholders in planning, implementation and evaluation of land use management activities, played a big role in ensuring sense of ownership as well as sustainability of conservation activities (Liwenga, 2005). Integrated catchment approach was attempted but was not very successful except for collaboration with the catchment afforestation component in Mwitore Catchment (Liwenga, 2005). The use of conservative tillage was more pronounced in Kalemela sub-catchments possibly due to more prevalence of hard plans (Liwenga, 2005). However, findings further show that very few farmers practice agro-forestry (Liwenga, 2005). Results from the SWC intervention indicated that good performance was achieved from combining different conservation practices e.g. contours bund farming, tie ridging and farmyard manure. Overall, farmers involved in the soil and water conservation interventions have realized the benefits of these measures at various levels.

The implementations of soil and water conservation interventions have resulted into various benefits. Regarding the impact to the environment, there has been a realization of benefits such as reduced soil erosion, increase in vegetation cover, reclamation of gullies and improvement in aquifer recharge e.g. in Kwibuse village (Liwenga, 2005). With regard to livelihood of local communities, farmers involved in SWC have realized various benefits such as increase in crop yield, improvement in food security and improved incomes (Liwenga, 2005). Despite these benefits, factors such as labour shortages, land shortage, lack of capital, limited knowledge and skills, and land tenure appear to hinder participation of farmers in SWC practice (Liwenga, 2005). The technology of energy saving stoves is new, thus the adoption rate is low. Raw materials like proper clay soil could not be available at abundance and sometimes would require traveling at distant places to find them (Mang'ombe, 2004).

Areas for expansion of ISWC component activities should be ones where soil erosion is evident and where erosion hazard is foreseen and expansion should cover other catchments areas within the lake basin. These areas include Bunda district in Mara region and Karagwe and Ngara in Kagera region and Sengerema in Mwanza region (Liwenga, 2005). Other areas to be considered for expansion are districts where rivers draining water into Lake Victoria start e.g. in Meatu, Bariadi and Maswa (Liwenga, 2005).

2.6.4.4 Landuse and Sedimentation

Studies have shown that environmental degradation characterized by degradation of natural resources such as land, forests, rivers and lakes due to improper land use and mismanagement has been a common problem in the Lake Victoria Basin (Yanda, et al.,

2001, Mang'ombe et al., 2004). Deforestation and soil erosion have been some of the major environmental problems facing the basin and have also been the major cause of the declining productivity of soil and non-point pollution (Mahuha, 2000).

Historically, the land resource of the LVB Basin has been intensively used for a number of different purposes including agriculture, which is the major economic undertaking of the population in the basin, forestry, mining, livestock keeping and settlements. Dense settlements are largely found on good agricultural land as demonstrated in Muleba, Bukoba, Biharamulo, Geita, Tarime and Sengerema Districts where the highlands and the lake shore are densely populated. Large forest reserves and mining activities prevail in the western part of the basin, which attract a large number of immigrants in search for arable land, pasture, and other income generating opportunities, such as charcoal making, lumbering, hunting, beekeeping and mining. Mining activities have increased, especially in Geita, Kahama, Kwimba, Tarime and Biharamulo Districts.

As a result of the above activities, deforestation has become widespread in the basin, and this coupled with overgrazing, have had serious negative consequences on land productivity arising from serious soil erosion and farmland degradation. All cultivated areas in the basin especially in Kwimba, Magu, Misungwi and Musoma Rural districts and part of Sengerema districts, which lack vegetation cover, have been exposed to different levels of erosion risks. Poor agronomic practices, including extensive and shifting cultivation still persist in the basin, thereby influencing soil erosion processes. A high risk of soil erosion is in cultivation and grazing areas where soil and water conservation measures are not practised. As a result of soil erosion, there has been an increased sedimentation of the lake. Sediments enter the Lake Victoria water bodies with discharges from point and non-point pollution sources, exacerbated by land drainage/irrigation activities (BICO, 2006). The suspended sediment load to the lake was estimated at 4,905.2ktons/year, with Simiyu River carrying the largest suspended sediment load estimated at about 42.3% of the total load to the lake (Mwanuzi, 2005). This is approximately 0.7mm/year. Sediment in the Mara River was probably the major source of pollution in the Mara River Basin (Mbuya, 2004). The rivers in the basin indicate high concentration of turbidity and colour in the rainy season and the situation changes in the dry season.

Soil erosion and consequently sedimentation into the lake has had social economic and environmental impacts such as loss of agricultural uses, reduced availability of food, loss of clean water supplies, loss of tourism and/ recreational values, loss of water quality and costs of controlling invasive species. Environmental impacts include modification of habitats, changes in biological community composition, increased sediment deposition and siltation in the lake, thus leading to blanketing of benthic communities, fish kills, loss of wetlands, increased nutrient inputs into the lake and loss of natural barriers.

Although there was no research component in LVEMP –I which dealt with conflict resource use, the TDA identified some potential areas of conflict and contributing factors. The main causes of conflict identified include limited water resources, environmental degradation, poor governance, conflicting policies and institutional interests, inadequate natural resource base including water, and increased human and livestock population and poverty, among others.

The East African Community (2005) has also revealed that territorial conflicts are manifest as unresolved disputes over international borders in parts of the Lake Basin and claims to sovereignty and ownership over certain parts of the lake. It is claimed that the distribution of fishermen gear and catches does not tally with each country's share of the lake (EAC, 2005). Conflicts are still occurring after the harmonization of fishing laws and the existence of mechanisms within EAC for dispute resolution. Mechanisms and institutions for allocation of resources may be a source of conflict as observed in the issue of local natural resources

management where local communities want management and control of natural resources to be entrusted in institutions at local level (EAC, 2005).

Despite the good institutional framework in place for conflict resolutions, implementation is still a problem due to lack of resources (committed personnel, money, and political will) and inadequate public awareness about the existing legal framework. LVB is a transboundary natural resource shared among three countries (Tanzania, Uganda and Kenya. Any socio-economic development including agriculture in other basin countries could be enhanced with a more adequate distribution of water resources.

2.6.5 Major Research Needs and Gaps

2.6.5.1 Forests

- Assessment of temporal land cover/use changes to determine magnitudes of change over time so as to identify hotspot areas for intervention.
- For areas that require vegetation restoration through afforestation, there is a need for a study on the appropriate tree species to be planted.
- A study should be conducted on the rate of natural vegetation regeneration in the region for various tree species. Information to be generated will be an input to the management of the vegetation
- Research on livelihood issues such as alternative energy sources that are environmentally friendly, changes in livelihood patterns etc.
- Applicable ITK in forest cover improvement

2.6.5.2 Wetlands and Watershed Management

Despite the several studies on wetlands that have been undertaken, there are still many areas that need to be researched on. These include:

- Monitoring biomass and productivity of papyrus and other macrophytes
- Research on the biodiversity of wetlands in different localities in the basin
- Assessment of impact of human activities on wetland biodiversity (i.e., grazing, bush fire, shifting cultivation)
- Determining buffering capacity of major wetlands
- Wetland hydrology studies
- Mapping wetland coverage in different years in order to detect changes,
- Biodiversity search on the restoration of wetland plants of socio-economic importance
- Effects of soil erosion on wetlands biodiversity
- Guidelines and preliminary investment proposals for wetland rehabilitation and artificial wetland construction
- Guidelines for wetland monitoring
- Economic valuation of lake Victoria wetlands
- Growth Characteristics of *Cyperus papyrus* in Selected Major Wetlands of Lake Victoria.
- Changes of vegetation communities in selected major wetlands of Lake Victoria for the past 20 years
- Indigenous knowledge and its application on wetlands conservation
- Carrying capacity of major lake Victoria wetlands
- Application of remote sensing and GIS for land use/cover studies in major wetlands
- Viability of alternative projects/interventions that will reduce dependency to wetlands
- Market research of wetlands products
- Socio-economic and cultural aspects of wetlands communities and their impact on wetlands utilization
- Predictive model to determine response of wetlands to various pressures/threats

- Modeling of spatial and temporal degradation of lake Victoria fringing wetlands

2.6.5.3 Soil and Water Conservation

During the implementation of ISWC activities several lessons of experience have been learnt, some need to be adopted for future expansion of component's activities and some need to be improved in order to enhance sustainability. The following are gaps that need to be addressed.

(i) The overall objective of the component was to improve land use management of the lake catchment. The objective has been realized in the pilot areas. Land degradation is still a serious threat to larger parts of the Lake Victoria basin and therefore land conservation measures need to be enhanced and expanded to cover other parts. The measures adopted in the pilot areas need to be scaled up.

(ii) Provision of adequate extension services to promote soil and water conservation.

(iii) A review of approaches and methods used by the ISWC component show that the catchment approach was more effective as compared to the individual approach. The catchment approach appears to be more suitable taking into consideration of limitation of adequate and appropriate manpower to undertake soil and water conservation (SWC) activities together with farmers. Furthermore, Participatory Rural Appraisal (PRA), which implies involvement of stakeholders in planning, implementation and evaluation of land use management activities, played a big role in ensuring sense of ownership as well as sustainability of conservation activities. Integrated catchment approach was attempted but was not very successful except for collaboration with the Catchment Afforestation component in Mwitore Catchment. More efforts are needed to enhance integration among LVEMP components for effective land management and for realization of greater impact. Catchment approach should also be practiced for wetlands management, catchment afforestation etc.

(iv) The use of conservative tillage was more pronounced in Kalemela sub-catchment possibly due to more prevalence of hardpans. However, findings further show that very few farmers practice agroforestry. Results from the SWC interventions indicated that good performance was achieved from combining different conservation practices e.g. contours bund farming, tie-ridging and farmyard manure. Effectiveness of soil and water conservation can therefore be achieved by using a combination of practices.

(v) Other areas that need research include issues related to water harvesting/irrigation, agroforestry/cover crops, use of agricultural inputs, assessment of soil and water resources, assessment of farming systems and research on livelihood issues such as alternative energy sources that are environmentally friendly, changes in livelihood patterns

2.6.5.4 Landuse and Sedimentation

The following are the research need and gaps that have been identified.

- Temporal land cover/use changes would determine magnitudes of change over time so as to identify hotspot areas for intervention.
- Development practices (within all riparian countries) that influence land use change
- Influence of social economic developments and needs on release of land use change
- Regional approach on the understanding of attitudes of riparian communities on relationship of their activities, land use change and their impact to environment.
- Regional trends on land cover change.
- Regional demographic dynamics and its impact to land use change.
- Unsustainable agricultural practices within the region.
- Regional carrying capacity of grazing land.
- Link between LVEMP activities and poverty eradication with a focus on relative contribution of different natural resources to community livelihood in the basin.

- Further studies on impacts of gold mining (especially in artisan mining areas) on the environment and socio-economic conditions of the surrounding communities
- Research on livelihood issues such as alternative energy sources that are environmentally friendly, changes in livelihood patterns etc River pollution from different sources is reported by various studies, thus threatening the integrity of aquatic ecosystem. Studies on pollution levels associated with various human activities (e.g. mining, illegal fishing by using chemicals) ought to be conducted.
- Research on different types of conflicts and conflict resolution measures, which exists in the Lake Victoria basin, where new inputs to negotiation can be realized or will give room for improvement of existing methods.
- Evaluation and documentation of indigenous knowledge and its application on natural resources management (e.g. forests, wetlands). Such information will form a basis for enhancing ecosystems management in the basin.
- Research should be directed in establishing the distribution of heavy metals in the different portion of the environment and in particular establish level of contamination of drinking water sources (wells) and food crops grown in the area and other mining areas.
- Land tenure systems in the basin need to be investigated further so as to get an understanding on implications of the tenure systems on natural resources management and how these systems could be enhanced.

2.6.6 Major Research Capacity Needs

2.6.6.1 Forests

- Equipment such as transport (lorry), still camera, video camera and audio-visual aids.

2.6.6.2 Wetlands and Watershed Management

- Too few modeling experts
- Regular training of scientific staff

2.6.6.3 Soil and Water Conservation

- Facilities/equipment such as GIS unit
- Elaborate land use plans that promote conservation of the lake environment and livelihood of local communities. Development activities need to be guided by land use plans such that suitable arable lands with high agricultural potential.

2.6.6.4 Landuse and Sedimentation

There has been massive capacity building during Phase I of LVEMP and during the vision and strategy development process. For example, more than 120,000 people participated in the vision and strategy development workshops, and approximately one hundred have contributed to the process as members of Natural or Regional Task Forces or consultant teams. This unique capacity and knowledge base should be utilized for the follow up work that should be carried out.

Various agencies including Forestry and Beekeeping Division have been actively involved in building the capacity of institutions and communities to manage forest resources. Capacity building has been through training of communities and awareness creation on management of natural vegetation, production of seedlings, and tree planting.

Despite capacity building efforts outlined above, it was evident during this study that most of the research institutions have limited research capacity. For example, they have limited number of experts with appropriate education to undertake research in the identified priority

research areas. For specialized research that requires laboratory work, most of the laboratories are under-equipped, thus making undertaking of some research difficult or expensive because of the use of commercial laboratories. The most crucial part of the research capacity is funding, and most of the research institutions are under-funded as the government allocates inadequate funds for research. As a result, most of research activities being undertaken are donor funded.

In order to ensure effective research in the basin, there is need for more research capacity building including in the following areas;

(a) Undertake training needs assessment in order to establish needs for the different fields
(b) Training of research scientists at different levels
(c) Training of technicians in data collection and analyses techniques (laboratory and data)
(d) Sensitization of various stakeholders including local communities on the role of research in environmental management
(e) Equip laboratories with appropriate equipment for scientific analyses
(f) Training of scientists on scientific information packaging and dissemination strategies

The summary of research needs and gaps is provided in **Table 2.12**

Table 2.11: Forests, Wetlands and Watershed Management, Soil and Water Conservation - Research Conducted

Type of Research Conducted	When Conducted	Research Institutions (involved in the research)	Key Research Findings/Lessons
Forests			
Forests cover in LVB, causes of loss of natural vegetation cover and environmental impacts.	1999 - 2005	UDSM (IRA) WSP LVEMP EAC	• Terrestrial ecosystems in the basin have been altered through human-induced activities. For example, the overall forestry situation in LVB has deteriorated during the past few years despite the existence of deforestation since the early 1860s, involving large-scale tree felling for the control of tsetse flies. • The demand for fuelwood and wood for building purposes far exceeds the potential supply resulting into over-harvesting. Petty trading encourages deforestation. It involves activities such charcoal making and firewood collection as energy sources for sale, brick and pot making, and local brewing. • Increased wild fire during the dry season and overgrazing contribute much to the loss of natural vegetation. • Other factors are faulty agricultural practices, agriculture expansion, herds of cattle, mining activities, and carpentry work. • Artisanal mining for gold has caused huge loss of natural forests in Geita district where more than 50,000 ha have been destroyed. The indiscriminate cutting of trees by miners for timber, supports in the underground mines, building shelters and firewood have largely been responsible for the deforestation. • High population growth (2.9%) and general poverty common in the LVB area are also major factors pushing degradation of land cover resources leading to environmental problems. • Natural vegetation cover is rapidly being degraded from the “cultivation steppe” of Mwanza and Shinyanga Regions westwards threatening protected areas in districts like Geita, Kahama, Biharamulo, Ngara and Karagwe. As a result human induced vegetation types appear to dominate in these areas. • In Kagera, the nature reserves have been experiencing changes resulting from encroachment. These changes are due to adherence to the traditional inheritance system of land subdivision, which often creates disputes within families. • In the eastern parts of LVB there is evidence of ongoing deforestation in Bunda, Serengeti and Tarime districts. • In the highly deforested districts like Kwimba, Magu, Misungwi, Musoma Rural and part of Sengerema District land lacks vegetation cover which protects it from water and wind erosion.

Type of Research Conducted	When Conducted	Research Institutions (involved in the research)	Key Research Findings/Lessons
Afforestation of degraded areas.	1997 - 2005	Ministry of Natural Resources and Tourism IRA LVEMP	• There have been a number of initiatives to restore vegetation cover in degraded areas. • Forestry and Beekeeping Division in the Ministry of Natural Resources and Tourism leads the implementation of most of the afforestation programs aiming at protecting vital parts of the lake catchments. Such programs involved trees planting, increase awareness among communities on catchments protection and tree farming, develop local seed sources and conserve forest biodiversity in collaboration with local communities.
Appropriate farming techniques in LVB for soil and water conservation.	2000 - 2005	LVEMP	• Pilot areas for ISWC located in Simiyu River Catchment in Magu District have used various practices of soil and water conservation. Such practices includes contour farming, ridges, gullies control, conservation tillage, rain water harvesting techniques, agro-forestry technology, *in-situ* conservation, agronomic practices, use of combinations of practices and promotion of making of energy saving stoves. • Sustainable soil and water conservation in the pilot areas showed greater advantages on increased food security, environmental management, economic growth and poverty alleviation. • Some test crops used include maize, cotton, rice, cassava, sorghum and sweet potatoes. • Agricultural production of some major crops such as maize, rice, cassava and cotton were drastically increased while at the same time reducing soil erosion problem that has big contribution to land degradation.
Land use in LVB	2000 - 2005	LVEMP UDSM (IRA)	• Historically, the land resource of the LV Basin has been intensively used for agriculture, which is the major economic undertaking of the population in the basin, forestry, mining, livestock keeping and settlements. • Dense settlements are largely found on good agricultural land e.g. Muleba, Bukoba, Biharamulo, Geita, Tarime and Sengerema Districts where the highlands and the lake shore are densely populated. • Large forest reserves and mining activities prevail in the western part of the basin, which attract a large number of immigrants in search for arable land, pasture, and other income generating opportunities, such as charcoal making, lumbering, hunting, beekeeping and mining. • Mining activities have increased, especially in Geita, Kahama, Kwimba, Tarime and Biharamulo Districts.

Type of Research Conducted	When Conducted	Research Institutions (involved in the research)	Key Research Findings/Lessons
Sedimentation, its causes and impacts in LVB		LVEMP UDSM (IRA)	• Soil erosion has resulted into increased sedimentation of the lake. • Sediments enter the Lake Victoria with discharges from point and non-point pollution sources, exacerbated by land drainage/irrigation activities. • The suspended sediment load to the lake is estimated at 4,905.2 ktons/year, with Simiyu River carrying the largest suspended sediment load estimated at about 42.3% of the total load to the lake. This is approximately 0.7mm/year. • The rivers in the basin indicate high concentration of turbidity and colour in the rainy season and the situation changes in the dry season. • Soil erosion and consequently sedimentation into the lake has had social economic and environmental impacts such as loss of agricultural uses, reduced availability of food, loss of clean water supplies, loss of tourism and/ recreational values, loss of water quality and costs of controlling invasive species. • Environmental impacts include modification of habitats, changes in biological community composition, increased sediment deposition and siltation in the lake, thus leading to blanketing of benthic communities, fish kills, loss of wetlands, increased nutrient inputs into the lake and loss of natural barriers.
Wetlands and Watershed Management			
Soil Fertility Appraisal and Agricultural Production Potential for selected rain fed crops in five pilot villages in Mara and Mwanza Regions.	2000	LVEMP - Wetlands Management Component	• The upland soils are very deep, well-drained sandy to sandy-loam while the wetland soils are loamy and clayey, are imperfectly drained and differ largely from those of uplands. These soils have very low to moderate fertility, nitrogen and phosphorus being the major limiting nutrients. • Upland soils are best suited to drought resistant crops such as cassava and sorghum. In years with sufficient rainfall upland soils can support an early maturing maize crop, but the unreliable onset date of rainfall and high risk of dry spells during critical stages of crop growth lead to crop failures and yield reductions, even when other factors such as management, crop husbandry and fertilizer application are optimal. Wetland soils have a good potential for lowland rice cultivation under the current circumstances. But with improved drainage and water control crops such as maize could perform well especially in seasonal flood plains.
Buffering Capacity of Wetlands	2001	LVEMP - Wetlands Management Component,	• Four types of wetlands identified in the LVB. A total of 422 hectares of wetlands were found to occur in 28 more or less distinct sub-basins of the Tanzanian part of the Lake Victoria basin, i.e. 57,000 hectares of permanent swamp (14%)

Type of Research Conducted	When Conducted	Research Institutions (involved in the research)	Key Research Findings/Lessons
		CoET-UDSM	308,000 hectares of seasonal swamps (73%), 33,000 hectares of tree swamps (8%) and 42,000 hectares of open water (4%). • Threats to LVB wetlands include over-utilization, improper techniques, pollution, changes in hydrology and sedimentation, Change of wetland habitats, Introduction of exotic species and Natural disasters • Ranking of wetlands in terms of the provision of buffering services to Lake Victoria was carried out for Nyashishi, Geita, and Ngono wetlands. Nyashishi wetland is ranked higher followed by Ngono in terms of buffering services. Nyashishi showed retention rate of 50-80% of Suspended Solids (SS), 50-80% of Total Phosphorus (TP), and 55-90% of Total Nitrogen (TN) while Ngono showed 50-80% of both SS and TP and 40-60% of TN. • The key buffering processes (i) Nitrification, De-nitrification and mineralization for nitrogen (ii) Sorption processes for phosphorus and heavy metals (iii) Sedimentation
Inventory survey of Lake Victoria fringing wetlands	1999	LVEMP - Wetlands Management Component	• Wetlands have high ecological values to the lake in terms of supporting high biodiversity. Local communities exploit various species of flora and fauna, and the fertile wetlands are suitable for agricultural activities. Most wetlands, especially in Mara and Mwanza regions are threatened mainly by agricultural encroachment, over-exploitation of resources and wild fires.
A study of Macrophytes with Medicinal Potential in Lake Victoria and Its Surrounding Wetlands	2001	LVEMP - Wetlands Management Component, FoS-UDSM	• 31 plant species that are used as medicine or used for various domestic purposes by the local population
Status of utilization and conservation of doom palm (phenix reclinata) at Minziro cross boarder wetland – Kagera region-Tanzania	2001		• Doom palms leaves are extensively used for mat weaving locally known as mikeka of different sizes ranging between 14 sq ft (2x7ft) to 24 sq. ft (3x8ft). • Mats contribute over 61% of the annual income for mat weavers, followed by crop cultivation that scored 33%. Other activities contribute between 0.5 and 2% of the income. • Decline of doom palms has been observed. Strategies for sustainable utilization and management of doom palms included prevention of bush fires, wise harvesting programme, restoration of depleted palms, training on propagation of palms, prevention of agricultural encroachment.
• **Soil and Water Conservation**			

Type of Research Conducted	When Conducted	Research Institutions (involved in the research)	Key Research Findings/Lessons
Survey and mapping of land use/land cover and erosion hazards in lake Victoria Basin.	2001	Institute of Resource Assessment	• The lake basin is characterized by three types of landscapes; the lowland ranging between 1,100 and 1,200 metres above sea level, the midland zone lying between 1,300 and 1,500 metres above sea level, and the highlands situated at an altitude of 1,500 to 1,800 metres above sea level. • The different landscapes have different slope characteristics. Slope is among the factors contributing to land vulnerability to soil erosion. Steep areas are potentially more vulnerable to soil erosion than flat areas • Soil erosion has been one of the major environmental problems facing the basin and it has also been the major cause of the declining productivity of soil and non-point pollution. • There is high risk of soil erosion in the cultivation and the grazing areas where SWC measures are not practised. • Degradation of natural resources such as land, forests, rivers and lakes in the basin has resulted due to improper land use and mismanagement.
Soil and Water Conservation Activities on Pilot Areas	2000-2004	LVEMP-SWC component	• Catchment approach was more effective as compared to the individual approach which was tedious and time consuming. The catchments approach is sustainable taking into consideration of inadequate manpower to undertake soil and water conservation (SWC) activities together with farmers. • Participatory Rural Appraisal (PRA), involving stakeholders in planning, implementation and evaluation of land use management activities, played a big role in ensuring sense of ownership as well as sustainability of conservation activities. • Results from the SWC interventions indicated that good performance was achieved from combining different conservation practices e.g. contours bund farming, tie-ridging and farmyard manure. Effectiveness of soil and water conservation can therefore be achieved by using a combination of practices.

Table 2.12: Forests, Wetlands and Watershed Management, Soil and Water Conservation - Research Needs/Gaps

Sub-Research Area/Theme			Research Needs/Gaps			Research Capacity Gaps			Remarks
No	Area	Priority	No	Need/Gap	Priority	No		Priority	
1	Forestry Management	High	1	Impact of Globalization	High		• Undertake training needs assessment • Train of research scientists at different levels • Train technicians in data collection and analyses techniques (laboratory and data) • Sensitize various stakeholders including local communities on the role of research in environmental management • Equip existing (strategic) laboratories in the country with appropriate equipment for research in forests, wetlands and watershed Management, soil and water Conservation ▪ Equipment such as		
			2	Wood energy	High				
			3	Tree species site matching	High				
			4	Appropriate Agroforestry systems in subcatchments	High				
			5	Forest Inventory/ Forest stock assesment	High				
			6	Surface runoff	High				
			7	Social impacts/ livelihoods of communities	High				
2.	Land Use and Sedimentation	High	1	Trends in temporal land cover/use changes so as to identify hotspot areas for intervention	High				
			2	Land tenure systems and natural resources management	High				
			3	Management of micro-catchments in the river basins	High				
			4	Effect of micro-catchments on river hydrology	High				
3.	Wetlands and Watershed management	High	1	Wetlands Biodiversity	High				
			2	Economic valuation of lake Victoria wetlands	High				
			3	Buffering capacity of major LVB wetlands	High				

Sub-Research Area/Theme			Research Needs/Gaps			Research Capacity Gaps			Remarks
No	Area	Priority	No	Need/Gap	Priority	No		Priority	
			4	Remote sensing and GIS for land use/cover studies in major wetlands	High		transport (lorry), still camera, video camera and audio-visual aids. ▪ Too few modeling experts ▪ Regular training of scientific staff ▪ Facilities/equipment such as GIS unit ▪ Elaborate land use plans that promote conservation of the lake environment and livelihood of local communities. •		
			5	Alternative projects/interventions that will reduce dependency to wetlands	High				
			6	Socio-economic and cultural aspects of wetlands communities and their impact on wetlands utilization	High				
			7	Predictive model to determine response of wetlands to various pressures/threats	Moderate				
			8	Modeling of spatial and temporal degradation of lake Victoria fringing wetlands	High				
			9	Guidelines and preliminary investment proposals for wetland rehabilitation and artificial wetland construction	High				
			10	Indegineous Technical Konowlegde	High				
			11	Conflict Resolution	High				

Sub-Research Area/Theme			Research Needs/Gaps			Research Capacity Gaps			Remarks
No	Area	Priority	No	Need/Gap	Priority	No		Priority	
4.			10	Land degradation is still a serious threat to LVB. Land conservation measures need to be enhanced and expanded to cover other parts. The measures adopted in the pilot areas need to be scaled up.	High				
			2	Effectiveness of soil and water conservation can be achieved by using a combination of practices e.g. contours bund farming, tie-ridging and farmyard manure.	High				
			4	water harvesting for irrigation	High				
			5	Agro-forestry/cover crops					
			6	Management of agricultural inputs					
			7	Assessment of soil and water resources					
			8	Assessment of farming systems					
			10	research on livelihood issues such as alternative energy sources that are environmentally friendly, changes in livelihood patterns					

2.7 Pests and Diseases

2.7.1 Introduction

Pests and diseases are major problems that affect the health and livelihoods of communities in the Lake Victoria Basin. Most of the health problems in Tanzania and the LVB, in particular, can be attributed to communicable diseases. Major diseases, which contribute to deaths, include malaria, tuberculosis (TB), pneumonia, maternal health problems and HIV/AIDS related diseases. Water-borne and water related diseases, mainly bilharzia (*Schistosomiasis*), cholera, typhoid, dysentery, diarrhoea, intestinal worms, amoebiasis, malaria and skin infections are also very common in the basin. The country has embarked on health sector reform with the intention of revisiting strategies to improve quality of health services and increase accessibility and utilization of these services by people on equitable basis.

Agricultural production in the LVB is also constrained by pests and diseases. The major crop pests include African armyworm (*Spodoptera exempta*), red-billed Quelea bird (*Quelea quelea)*, Banana weevils and Nematodes, and cassava mealy bug (*Phenacoccus manihot*). The major crop diseases are mainly coffee wilt, Banana Bacteria wilt (*Xanthomonas campestrise)*, Banana Fusarium wilt and Sigatoka, sweet potato mosaic and virus, cassava mosaic disease (CMD) and cassava brown streak virus (CBSV).

In livestock development, inadequate grazing pasture, diseases and inadequate or unaffordable veterinary services, are among the limiting factors. The most common livestock diseases are East Coast Fever (ECF), Foot and Mouth Disease (FMD), Black quarter, and Contagious Bovine Pleuropneumonia (CBPP), while pests include a plant weed *Lantana camara* which has become widespread and it kills grass, thereby degrading the pasturelands.

Table 2.13 provides a summary of the current status of research on pests and diseases management in the Lake Victoria Basin. Additional pertinent elaborations are provided in the following sub-sections.

2.7.2 Key Research Institutions

2.7.2.1 Human health

Currently there is one national research institute, NIMR that undertakes Malaria research in the basin. NIMR has also being involved in AIDS and Schistosomiasis research. There are, however, other research institutes like TAFIRI whose scientists have collaborated with NIMR staff to study health and health care in the Lake Victoria rural riparian communities, focusing on Malaria and other water related diseases. Tanzania Essential Strategies Against AIDS (TANESA) has also been undertaking social studies related to HIV/AIDS particularly among riparian and fishing communities. Research on water borne and water related diseases has, mainly been done by the LVEMP I Water Quality component.

2.7.2.2 Crop Pests and Diseases

Research on crop pests and diseases has mainly been done by the Agricultural Research and Development Institutes and research centres in the basin. These include:

- Maruku Research Centre in Kagera Region.
- Agricultural Research and Development Institute at Ukiriguru
- Sokoine University of Agriculture
- Horti-tengeru

- National Biological Control Centre (NBCC), Kibaha

Plant Protection Services Zonal Centre at Shinyanga

2.7.2.3 Livestock Diseases and pests

Researches on and diagnosis of animal diseases in the Lake zone have mainly been done by the Veterinary Investigation Centre (VIC) in Mwanza and, to a certain extent, VIC Tabora. Other institutions that have been involved in livestock research, including research on pasture management are the zonal Agricultural Research Institute (ARI) at Ukiriguru with its substation, the Livestock Research Centre at Mabuki both located in Misungwi District.

2.7.3 Major Research Activities

2.7.3.1 Human health

During LVEMP I, an attempt was made by Laugerud (2004) to establish the water quality-health relationship in the Lake Victoria basin through water quality assessment, and collection of data and information on waterborne contamination and water vectored diseases. NIMR- Mwanza and TAFIRI also conducted a study[2] on health and health care in Lake Victoria rural riparian communities, in Tanzania. This study was aimed at providing baseline information on malaria, anaemia, human intestinal parasites, schistosomiasis, malnutrition, access to sanitation and safe water, quality of health services and perceptions, attitudes and practices of the people with regard to preventable and communicable diseases. Transboundary Diagnostic Assessment (TDA) covered impacts of HIV/AIDS. It should, however, be noted that there was no component dealing with human diseases during LVEMP I.

2.7.3.2 Crop Pests and Diseases

Crop pests and diseases were not covered under LVEMP-I except for one PhD research that focused on “Modeling of pest sites in Simiyu Catchment” (Senzota, 2005). Nevertheless, various research initiatives have been undertaken in the basin. These include:

- ARI Maruku, 2004. Research Proposals for Agricultural Season 2004/2005. ARI-Maruku, Bukoba.
- Bosch, C.H., Loorkers, A., Ndile, M.R. and Sentozi, E., 1996. Diagnostic survey: Constraints to banana productivity in Bukoba and Muleba District, Kagera Region, Tanzania. Working Paper no. 8. ARI Maruku, Royal Tropical Institute, Amsterdam.
- Ministry of Agriculture, Food Security and Cooperatives, n.d. Proposal for Strengthening National capability in Early Warning and Control of Armyworm Outbreaks in Tanzania. Dar es Salaam
- Ministry of Agriculture, Food Security and Food Security 2005 Quelea Birds Invasion in Lake Victoria Basin 2004/2005
- Ndunguru, J., Jeremiah, S., Kapinga, R. and Sseruwagi, P., 2004. White flies as Vectors of Plant Viruses in Cassava and Sweet potato in Africa. Paper Series 8. International Institute of Tropical Agriculture.

There are also various research programmes that have been implemented in the lake zone. These include:

- The National Coffee Research Programme coordinated by the Maruku Research Centre in Kagera Region.
- Cotton Research programme by ARDI Ukiriguru, whose objective is to produce high yielding varieties as well as improved production technologies for the varying environmental conditions prevailing in the growing areas.

[2] Health and Health Care in Lake Victoria Rural Riparian Communities in Tanzania, A.I.S. Muro *et al* (June 2005)

- Banana Research Programme coordinated by ARDI Maruku, with trials conducted by Maruku itself, Sokoine University of Agriculture and Horti-Tengeru. The programme puts emphasis on disease and pest control, breeding and soil fertility activities.
- Root and Tuber Crops research focusing on cassava and sweet potatoes by ARI Ukiriguru, sometimes in collaboration with the National Biological Control Centre – kibaha. Researches undertaken include screening of cassava varieties for tolerance and resistance to cassava mosaic disease (CMD) and cassava brown streak virus and trials to assess the impact of an exotic predatory mite *Typhlodromallus aripo* as a natural enemy against Cassava Green Mite (CGM)

The Plant Protection Services Zonal Centre at Shinyanga has mostly been involved in the monitoring of outbreak pests, mainly the grain eating birds (*Quelea quelea*) and armyworms and developing integrated pest management (IPM) techniques. The major focus has been on the management of the outbreak pests through integrated pest management and biological control.

2.7.3.3 Livestock Diseases and pests

Not much research was done by LVEMP I in relation to livestock diseases in the basin. The only study done focused on the impact of immigrant pastoral herds on the fringing wetland areas of Lake Victoria Basin (Kisoza *et al.,* 2000).The Livestock research Institute at Ukiriguru has pastures and forage agronomy and management, animal production, breeding and genetics and livestock management on range.mainly been doing research on The Veterinary Investigation Centre has conducted studies related to *Brucellosis* in cattle and humans in the lake Victoria zone and on ticks and tick-borne diseases.

2.7.4 Major Findings and Lessons

2.7.4.1 Human health

A study conducted by NIMR- Mwanza and TAFIRI (Muro et al., 2005) confirmed that malaria is endemic in the Lake Victoria basin. It was the most prevalent disease in Kagera Region. Also self medication was a common practice in the basin. Self medication can lead to under-dose or overdose. Use of Insecticide Treated Nets (ITNs) was found to be very suitable and practical for control of malaria transmission. However, ITNs are not available in some villages. It has been proposed that the communities need to be sensitized, mobilized and empowered to practice integrated control of malaria using ITN.

The study also revealed that intestinal parasites are a public health problem in the LV rural riparian communities. Overall prevalence of common parasites are: *Schistosoma mansoni* (43.7%); hookworms (28.4%); *Entamoeba histolytica* (21%); *Giardia lamblia* (4.8%); *Trichuris trichura* (12.7%); *Ascaris. lumbricoides* (14.6%); *Strongyloides stercoralis* (4.2%). Prevalence of these parasites has much to do with the hygiene and sanitary conditions in the LVB. It was also noted that lack of access to safe water, low sanitary and hygiene education among the people, improper disposal of human excreta and poverty are the contributing factors to the poor health situation in the riparian communities. These diseases, together with HIV/AIDS were debilitating leading to reduced social economic performance of the communities and hence the associated poverty to the riparian communities.

The study looked on the nutritional status of the Basin. It was revealed that malnutrition represented by prevalence of stunting and underweight among under-fives is a public health problem. Kagera was found to have the highest prevalence of malnutrition.

People's awareness on sexually transmitted diseases including HIV/AIDS was also studied. Results indicated high level of awareness on STDs (94.4%) and HIV/AIDS (98.9%). Radio, relatives/friends and community meetings were reported as the main sources of information about STDs/HIV/AIDS. HIV/AIDS is a big problem in the Lake Zone. Data from the National AIDS Control Program Report Number 18 shows the prevalence rates to be 8.7%, 7.8%, and 20.7% for Mwanza, Mara and Kagera in 2003, respectively (URT, 2004).

Detailed information on diseases can be found in the following publications or research reports:

- URT. 2004. "HIV/AIDS/STI Surveillance Report Number 18." Dar es Salaam: National AIDS Control Program (NACP).
- Kessy, F. 2005. Lessons learnt on Community Participation. Final Report
- Laugerud, T. 2004. Study on Water Quality and Human Health, Tanzania. LVEMP
- Muro, et al., 2005. Health and Health care in the Lake Victoria Rural Riaprian Communities, Tanzania. Final report. LVEMP, Dar es salaam
- P. Semili, V. Mnyanga, D. Rutagemwa and F. Mwanuzi, 2004. Water Quality and Health Conditions in Lake Victoria Region (Tanzania)

2.7.4.2 Crop Pests and Diseases

Research on banana reveals that banana bacteria wilt, caused by bacteria *Xanthomonas campestrise* is a transboundary disease, first reported in Uganda (in 2004) but now spread over Kagera region (reported in the districts of Muleba, Bukoba and Karagwe). The disease is affecting all cultivars of bananas and is transmitted mainly by the pollinators (bees, wasps); planting of diseased materials, working tools e.g. knifes and pangas. Banana Fusarium wilt and Sigatoka are also trans-boundary diseases, found allover East Africa. These two diseases are widely spread allover the areas of Kagera and Mara regions causing extinction of some banana cultivars. Banana fusarium wilt, locally known as Panama diseases, is caused by a fungus Fusarium exysporum f. cubebse, which affects all banana cultivars except the East African Highland type (EAH-bananas). Sigatoka disease, which exists in both yellow and black, is caused by fungi of the genus Mycospharella.

Research done on evaluation of banana cultivars for resistance and integrated pest management of banana weevils and nematodes has revealed that potential enemies of the weevils and nematodes are found in the group of fungi, helminthes as well as ants but they are found in limited numbers in East Africa environment. Furthermore, although broad spectrum chemicals like Furadan are effective in controlling these pests, their uses are limited by their prices and availability.

Screening of cassava varieties for tolerance and resistance to cassava pests and diseases, including cassava mealy bug (*Phenacoccus manihot*), cassava green mites (*Mononychellus tanajoa*), the variegated grasshopper (*Zonocerus variegates* L) and cassava scale (*Aondomytilus albus*), cassava mosaic disease (CMD) and cassava brown streak virus (CBSV) has indicated that all landraces are resistant to cassava pests but all succumb to CMD. Practices such as selection of clean planting materials indicated to be useful in some areas with low disease pressure but difficult to implement in the areas with high disease pressure. Introduction and screening of CMD resistant varieties has been done and the results show that few promising varieties are available in small quantities at research stations. However, most of the resistant varieties do not have qualities desired by farmers hence they are less preferred.

The outbreak of armyworm in the LVB is not as severe as it has been in other parts of the country. Available data indicate an outbreak in Magu District in the 1998/1999 season,

during which 183.5 ha of crops were destroyed (District Agricultural Office statistics). A total of 257.1 ha of crops are reported to have been destroyed between 1995/96 and 2005/2006. The chemical that has been used to spray the infested areas is KARATE 50.EC.

Quelea quelea is a big and yearly problem in the basin, particularly in the semi-arid areas. The birds cause a lot of damage during ripening period of the small grain cereals, especially millet, sorghum, rice, and the damage is often locally devastating for smallholder farmers. In 2004/2005, Quelea birds' invasion occurred in Shinyanga, Mwanza and Mara regions where a total number of 595 ha were affected.

Other important pests are the banana weevils (*Cosmopolites sordidus*), banana Nematodes (*Radophorus similis*, *Helicotylenchus multicinctus* and *Pratylenchus goodeyi*), cassava mealy bug (*Phenacoccus manihot*), cassava green mites (*Mononychellus tanajoa*), the variegated grasshopper (*Zonocerus variegates* L) and cassava scale (*Aondomytilus albus*).

Crop diseases of transboundary nature include Bacteria wilt (*Xanthomonas campestrise)*, Banana Fusarium wilt and Sigatoka, sweet potato mosaic and virus, which occur in Kagera Region, but are believed to have originated from Uganda. Viral diseases are the most important cassava diseases threatening cassava production in the world. In Tanzania, especially in Kagera Region, cassava mosaic disease (CMD) and cassava brown streak virus (CBSV) are two most important viral diseases affecting cassava in the fields (Ndunguru et.al., 2004). The region is also affected by Coffee wilt disease.

2.7.4.3 Livestock Diseases and pests

The study by Kisoza et al. (2000) revealed that high disease incidences ranked highly among the livestock constraints mentioned by pastoralists. Other constraints were shortage of water, shortage of pastures, lack of veterinary drugs and lack of animal health knowledge. The highest disease incidences were East Coast Fever (ECF), heart water, *Babesiosis*, and *Anaplasmosis*. These diseases could be controlled through routine dipping using appropriate acaricides. Many people, however, were unable to do that because of high prices and erratic supply of acaricides, as well as the breakdown of common dips. Veterinary drugs were also not easily available. Other reported important diseases were Foot and Mouth Diseases, Contagious Bovine Preural Pneumonia (CBP), Trypanosomiasis, *Haemmorrhagic septiceamia*, *Brucellosis* and Lumpy skin disease. The study by Mkonyi et al. (2004) revealed that *Brucellosis* was very widespread on domestic cattle and humans who attended the cattle and that the disease was zoonotic. Tick borne disease was also widespread and there was very little control of the disease. Details of the research findings can be obtained from the following reports:

- Mkonyi, et al. 2004. Surveillance for *Brucellosis* in cattle and humans in Lake Victoria Zone. Proceedings of the Tanzania Veterinary Association Scientific Conference.
- Mkonyi et al. 2005. Revival of dipping in the lake zone. Proceedings of the Tanzania Veterinary Association Scientific Conference.
- Kisoza, L.J. et al. 2000. The impact of immigrant pastoral herds on the fringing wetland areas of lake Victoria Basin and a proposed livestock production strategy (Tanzania Experience)

2.7.5 Major Research Needs/Gaps

2.7.5.1 Human Diseases

A study conducted by NIMR- Mwanza and TAFIRI confirmed that malaria is endemic in the Lake Victoria basin. Also self medication is a common practice. Self medication can lead to under-dose or overdose. A research question is how should self medication be practiced in

order to address the potential problems associated with it? (Best approach to self medication). Does long exposure to ITNs have any health impacts?

Prevalence of intestinal parasites in the LV rural riparian communities has much to do with the hygiene and sanitary conditions in these areas. Provision of safe water to communities should save as a preventive measure. Development of simple and affordable human excreta disposal facilities (VIP latrines), guidelines on location of wells in relation to latrines, public education and provision of public health extension services are steps that would assist in improving the health standards of the communities. It is important to establish nutrition research to identify causes of the observed malnutrition and provide intervention measures.

Although knowledge on HIV/AIDS seems high translation of the knowledge into behavior change was yet to take place. It is important to come up with modalities to translate this knowledge into actions on the ground. Fishing communities are particularly susceptible to HIV/AIDS infection and its impacts. Yet there are not many HIV/AIDS support services that have focused on fishing communities. It is therefore important to understand the dynamics of fishing communities first so as to come up with strategies to address the epidemic.

2.7.5.2 Crop Pests and Diseases

Extent of Crop pests and diseases and their impacts

Data on crop pests and diseases as well as the extent of their impacts are limited. For, example, despite the existence of crop diseases, such as Bacteria wilt (*Xanthomonas campestrise)*, Banana Fusarium wilt and Sigatoka, sweet potato mosaic and virus, cassava mosaic disease (CMD) and cassava brown streak virus (CBSV), there are no data to show even the extent of the problem and their impact on crop yields and food security. This is therefore an important area for research that LVEMP II needs to concentrate on.

There are also some plant pests that are not well known in terms of dynamics and impacts. Mexican coffee, for example, requires special attention in research because of its extent of spread in farms, which poses a threat to crop production. Also in Musoma, witch weed "*striga hermothica*" is reported to thrive well. This weed is known to strive well in areas of low fertility and affects cereals especially sorghum. Currently there are no efforts to deal with it.

Alternative control measures for pests and diseases

Migratory pest such as armyworms and *Quelea* quelea birds necessitate use of large quantities of pesticides, which are toxic. These chemicals are normally sprayed from the air to the affected areas, and are likely to contaminate the environment and kill unintended organisms. Because of high costs, unavailability and impacts of broad spectrum chemicals, which can be used against crop pests and diseases, alternative control measures against them are necessary to address the problem. Research is, therefore, needed on alternative control measures, such as NPV virus for armyworms, locally produced plant preparation for quelea birds and promotion of predators.

New Approaches to managing pests

Research is also needed on new approaches that would empower farmers to take more of the pest control actions themselves. This might reduce dependence on chemicals that are detrimental to the environment.

Research on transboundary impacts

Generally there are no research activities that have focussed on activities that have transboundary impacts. LVEMP-I research activities were to a large extent confined within territorial boundaries of the three riparian countries. While it is true that the results could have implication to the entire lake, there were no efforts to establish this link. Linking the

research results could assist in the development of holistic intervention strategies. Applied research efforts should be directed towards solving root causes namely historical unsustainable development practices, systemic socio-economic crisis and prevailing attitudes which undervalue the environment.

2.7.5.3 Livestock Diseases and pests

There is information gap on the extent and impact of diseases on livestock production and livelihoods of communities. In addition, given the fact that many people are unable to treat their animals because of the high prices and erratic supply of acaricides, as well as the breakdown of common dips, alternative or other back-up disease control mechanisms/measures need to be sought to address the problems. Further investigation of zoonotic diseases is also needed to establish their extent and impacts. There is also public outcry on *Lantana camara*, a plant pest that has become widespread in the basin and is affecting pastures. Yet no studies have been done to assess its extent of coverage and the extent of degradation of the pastures. Studies need to be undertaken to understand not only the extent of coverage of the pest, but also the plant's dynamics and control measures.

2.7.6 Major Research Capacity Building Needs

2.7.6.1 Human Diseases

The National Institute for Medical Research (NIMR) has the capacity to undertake research on human diseases, including malaria and bilharzia in the basin. They, however, may need to be expanded and improved to enable the researchers undertake research on other diseases, including HIV/AIDS.

2.7.6.2 Crop Pests and Diseases

Although there is some manpower and infrastructure for undertaking research, particularly on crop pests and diseases in the basin, such is heavily handicapped by lack of finances that would facilitate work, travel, acquisition of tools and equipment and rehabilitation of infrastructure. Funding strategies need to be put in place to support research in the basin.

So far, only one person was trained under LVEMP I at PhD level on modeling of pest sites and two attended 2-8 weeks training on pest control. More training at higher levels is required, particularly in the area of biotechnology to build the capacity of the researchers and extension staff. Farmers also need improved knowledge on crop and livestock disease symptoms, means of spread and means control measures.

There are two Agricultural Research Institutes, Maruku Research Centre and Ukiriguru in the Basin that have the capacity to undertake research in their respective areas. Their laboratory facilities are, however, need to be expanded and improved to enable the researchers undertake applied research. Acquisition of biotechnology facilities is particularly important.

2.7.6.3 Livestock Diseases and pests

The Veterinary Investigation Centre in Mwanza has laboratories for diagnosis of diseases. The facilities, including equipment, however need to be updated and upgraded, including installation of modern diagnostic equipment appropriate for research in pests and diseases. Training of staff in research methodology, modern pests and diseases, data collection and data analysis appropriate for pests and diseases issues is necessary. The training can range from short-term courses for scientists and technicians to formal training at diploma and degree levels.

Table 2.14 Provides the summary of research needs and gaps

Table 2.13: Pests and Diseases - Research Conducted

Type of Research Conducted	When Conducted	Research Institutions (involved in the research)	Key Research Findings/Lessons
Water quality-health relationship	2004	LVEMP I Water Quality Component, University of Dare s Salaam	• Water borne and water related diseases, were very common and are associated with poor water quality and poor sanitary conditions, particularly of the shoreline settlements. These included Bilharzia (*Schistosomiasis*), cholera, typhoid, dysentery, diarrhoea, intestinal worms, amoebiasis, malaria and skin infections; • Malaria was most prevalent in Kagera Region although intestinal worms were on the increase, particularly in Bukoba Urban District and Bukoba Town; • These diseases together with HIV/AIDS were debilitating leading to reduced social economic performance of the communities and hence the associated poverty to the riparian communities.
Health and health care in Lake Victoria rural riparian communities	2003	NIMR, TAFIRI,	• Malaria is endemic in the Lake Victoria basin • Self medication was a common practice and could lead to under-dose or overdose. • Intestinal parasites were a public health problem in the LV rural riparian communities. • Overall prevalence of common parasites was: *Schistosoma mansoni* (43.7%); hookworms (28.4%); *Entamoeba histolytica* (21%); *Giardia lamblia* (4.8%); *Trichuris trichura* (12.7%); *Ascaris. lumbricoides* (14.6%); *Strongyloides stercoralis* (4.2%). • Lack of access to safe water, low sanitary and hygiene education among the people, improper disposal of human excreta and poverty are the contributing factors to the poor health situation in the riparian communities. • Malnutrition represented by prevalence of stunting and underweight among under fives was a public health problem, with Kagera having the highest prevalence of malnutrition. • high level of awareness on STDs (94.4%) and HIV/AIDS (98.9%)
Screening of cassava varieties for tolerance and resistance to cassava mosaic disease (CMD) and cassava brown streak virus.	2004	ARI Ukiriguru	• All landraces of cassava are resistant to cassava pests but they all succumb to CMD • Practices such as selection of clean planting materials indicated to be useful in some areas with low disease pressure but difficult to implement in the

Type of Research Conducted	When Conducted	Research Institutions (involved in the research)	Key Research Findings/Lessons
			areas with high disease pressure. • Few promising CMD resistant varieties were available in small quantities at research stations. • Most of the resistant varieties did not have qualities desired by farmers hence they were less preferred.
Evaluation of banana cultivars for resistance and integrated pest management of banana weevils and nematodes	Since 1996, routenly	Maruku Research Centre, SUA, ARI Ukiriguru, HORTI-Tengeru,	• Potential enemies of the weevils and nematodes are found in the group of fungi, helminthes and ants though are limited in numbers in East Africa environment • Although broad spectrum chemicals like Furadan are effective in controlling these pests, their uses are limited by their prices and availability.
Transboundary Diagnostic Analysis	2006	BICO	• Banana bacteria wilt was a transboundary disease first reported in Uganda in 2004 and was affecting all cultivars of bananas • Banana Fusarium wilt and Sigatoka, widely spread allover the areas of Kagera and Mara regions were causing extinction of some banana cultivars • Armyworm and Quelea quelea birds were transboundary pests because of their migratory nature • Other diseases included sweet potato mosaic and virus and Coffee wilt disease
Diagnostic survey on constraints to banana productiviry in Bukoba and Muleba District, Kagera Region	1996	Maruku Research Centre, Royal Tropical Institute Amsterdam	• Banana weevils (*Cosmopolites sordidus*) regarded as the biggest constraint to banana production • Burrowing nematodes (species *Radophorus similis*, *Helicotylenchus multicinctus* and *Pratylenchus goodeyi*) are also important pests of bananas.
Monitoring of outbreak pests, mainly *Quelea quelea* and armyworms and developing integrated pest management (IPM) techniques	Continuous	Plant Protection Services Zonal Centre at Shinyanga, District Agricultural and Livestock Offices	• *Quelea quelea* is a big and yearly problem in the basin, particularly in the semi-arid areas. • A total of 595 ha affected by Quelea birds' invasion in Shinyanga, Mwanza and Mara regions in 2004/2005 • The outbreak of armyworm in the LVB is not as severe as in other parts of the country • A total of 257.1 ha of crops are reported to have been destroyed between 1995/96 and 2005/2006 in Magu District. • KARATE 50.EC used to spray the infested areas.
The impacts of	1999	LVEMP Wetland	• High disease incidences ranked highly

Type of Research Conducted	When Conducted	Research Institutions (involved in the research)	Key Research Findings/Lessons
immigrant pastoral herds on the fringing wetland areas of Lake Victoria Basin		Component, TPRI, LITI	among the livestock constraints • The highest disease incidences were East Coast Fever (ECF), heart water, Babesiosis, and Anaplasmosis. • Many people were unable to routinely dip animals using appropriate acaricides because of high prices and erratic supply, as well as the breakdown of common dips. • Veterinary drugs were not easily available. • Other important diseases were Foot and Mouth Diseases, Contagious Bovine Preural Pneumonia (CBP), Trypanosomiasis, Haemmorrhagic septiceamia, Brucellosis and Lumpy skin disease • Need to empower the rural communities for common action and motivate the pastoral and agriculture communities to adopt sustainable land management practices.
Surveillance for *Brucellosis* in cattle and humans	2004	Veterinary Investigation Centre, Mwanza (VIC)	• Brucellosis is widespread on domestic cattle • The disease was also found in humans who tended the cattle
Ticks and tick borne diseases in the lake Zone	2005	VIC Mwanza	• Despite the fact that the disease was widespread there was little control of it as no cattle dipping was taking place

Table 2.14: Pests and Diseases - Research Needs

Sub-Research Area/Theme			Research Needs/Gaps			Research Capacity Gaps			Remarks
No	**Area**	**Priority**	**No**	**Need/Gap**	**Priority**	**No**		**Priority**	
1.	Human Health	High	1.	Best approach to self	High	1.	Update and upgrade facilities appropriate for research in pests and diseases	Medium	
			2.	medication).	High				
			3.	Health Impacts of long exposure to ITNs	High				
			4.	Preventive measure for improving the health standards of the communities	High				
			5.	Nutrition research to identify causes of the observed malnutrition and provide intervention measures	High				
				Modalities to translate HIV/AIDS knowledge into actions on the ground.					
						2.	Train staff in research methodology, modern pests and diseases data collection and data analysis appropriate for pests and diseases issues	High	

Sub-Research Area/Theme			Research Needs/Gaps			Research Capacity Gaps			Remarks
No	**Area**	**Priority**	**No**	**Need/Gap**	**Priority**	**No**		**Priority**	
2.	Crop Pests and Diseases	High	1.	Extent of Crop pests and diseases and their impacts	High	1.	Update and upgrade facilities appropriate for research in pests and diseases	High	
			2.	Alternative control measures	High				
			3.	New approaches to managing pests through farmer involvement	Medium				
						2.	Train staff in research methodology, modern pests and diseases data collection and data analysis appropriate for pests and diseases issues	High	
						3.	Equip existing (strategic) laboratories in the country with appropriate equipment for research in trans-boundary issues	High	
						4.	Empower farmers to undertake pest control actions	Medium	
3.	Livestock Diseases	High	1.	Extent and impacts of zoonotic diseases, as well as plant pests	High	1.	Update and upgrade facilities appropriate for research in pests and diseases	High	
			2.	Back-up disease (ticks) control mechanisms	High	2.	Install modern diagnostic equipment	High	

Sub-Research Area/Theme			Research Needs/Gaps			Research Capacity Gaps			Remarks
No	**Area**	**Priority**	**No**	**Need/Gap**	**Priority**	**No**		**Priority**	
						3.	Train staff in research methodology, modern pests and diseases data collection and data analysis appropriate for pests and diseases issues	High	
4.	Transboundary pests, diseases and impacts	High	1.	Development practices which significantly contribute to transboundary disease burden	High	1.	Undertake training needs assessment in trans-boundary research issues	High	
			2.	Regional patterns of pests	High	2.	Train of research scientists and technicians in research methods appropriate of trans-boundary issues	High	
			3.	The driving factors for transboundary diseases transmission within the region	High	3	Sensitize various stakeholders including local communities on the role of research in trans-boundary environmental management	Medium	
			4.	Influence of social economic developments and needs on disease transmission	High	4	Equip existing (strategic) laboratories in the country with appropriate equipment for research in trans-boundary issues	High	
			5.	Extent of resistance of target vector in the region	High				

Sub-Research Area/Theme			Research Needs/Gaps			Research Capacity Gaps			Remarks
No	Area	Priority	No	Need/Gap	Priority	No		Priority	
			6	The climate change impact on regional pest trends	High				

2.8 Waste Management

2.8.1 Introduction

Industries and urban centres (towns) contribute to pollution of the LVB environment. Wastes emanating from processes and activities need to be well managed in order to reduce their ultimate stress on the environment. During LVEMP I much emphasis was put on industrial and municipal liquid waste but very little attention was put on solid waste management. Yet solid waste can introduce toxic substances through leachate emanating from waste dumping sites. Improper disposal of solid waste can also cause health hazard. **Table 2.17** provides a summary of the current status of research on waste management in the Lake Victoria Basin. Additional pertinent elaborations are provided in the following sub-sections.

2.8.2 Key Waste Management Research Institutions

- University of Dare Salaam (UDSM)
    - WSP & Constructed Wetlands Research Project
    - Chemical and Process Engineering Department
    - Microbiology and Bio Technology Department
    - Water Resources Engineering Department
- University College of Lands and Architectural Studies (UCLAS)
    - Department of Environmental Engineering
- Cleaner Production Centre of Tanzania (CPCT)
-

2.8.3 Major Research Activities (past and present)

- From 2000-2005 samples from 19 large urban centres and 31 Industries were collected and analyzed for selected water quality variables namely BOD_5, TP, TN, TSS and FC following standard methods.
- The Waste Stabilization Ponds and Constructed Wetlands research project of the University of Dar es Salaam researched on Constructed Wetlands Technology and has successfully introduced it as a sustainable wastewater treatment technique in Tanzania based on research knowledge accumulated over a period of more than ten years. Practical systems have been successfully constructed in Iringa (2), Shinyanga (4), Moshi (1), Kibaha (1), Dar es Salaam (2 household wetlands).

CW have been proved to have the following advantage

- provide effective and reliable wastewater treatment
- easy to maintain.
- relatively tolerant to fluctuating hydrologic and contaminant loading rates; and
- may provide indirect benefits such as green space, wildlife habitats and recreational and educational areas.

2.8.4 Key Research Findings/Lessons

- The total resulting municipal pollution load (Kg/day) from the urban centres of 996,108 inhabitants into Lake Victoria was found to be: BOD_5 9,998; TN 1,778; TP 711, TSS 6,664, and FC 6.3 x 10^{14} No. /day while the resulting industrial load was found to be: BOD_5 5,201; TN 653; TP 185; TSS 4,934 and FC 1.1 x 10^{14} No. /day.
- Urban centers contribute more pollution loading to the Lake compared to industries. They contribute 66% BOD_5; 73% TN; 79% TP; 57% TSS and 85% FC.

- There is generally low enthusiasm among the medium and small scale companies to deal with environmental issues as a result of: lack of sufficiently strong pollution disincentives (i.e. fines are low enough to be considered a cost of production much like electricity); weak enforcement of existing laws; lack of economic instruments for environmental management; financial limitations.

- Low cost options for industrial wastewater has been proposed as[3]:
    - Cleaner production measures
    - Waste stabilization pond
    - Constructed Wetlands

- The following institutions were identified as regional research centrers for industrial wastewater[4]
    - Constructed Wetland and WSP Research Project of the University of Dar es Salaam
    - Centre for Industrial Ecology of the University of Nairobi, Kenya
    - Centre for Environmental Studies of Makerere University, Uganda
    - Cleaner Production Centre of Tanzania (CPCT) for cleaner production issues

2.8.5 Key Research Needs and Gaps

2.8.5.1 Solid Waste

- Intergrated Solid waste management is not practiced in any of the LVB towns and municipalities
- Not much efforts have been put in place to make/recover useful products from solid waste e.g. energy
- Processing of solid waste from major industries i.e fisheries into by products is practically inexistent

2.8.5.2 Municipal/Domestic Wastewater

Selecting and adopting appropriate technology for wastewater treatment depends upon wastewater characteristics and on the treatment objectives as translated into desired effluent quality. The latter depends on the expected use of the receiving waters. Effluent quality control is typically aimed at public health protection (for recreation, irrigation, water supply), preservation of the oxygen content in the water, prevention of eutrophication, prevention of sedimentation, preventing toxic compounds from entering the water and food chains, and promotion of water reuse. These water uses are translated into emission standards.

[3] Private Sector Development in the Lake Victoria Basin and Its Possible Role in a Regional Management Strategy

[4] Private Sector Development in the Lake Victoria Basin and Its Possible Role in a Regional Management Strategy

In general, the number of available treatment technologies, and their combinations, is nearly unlimited. However, considerations for wastewater treatment facility options include:

- Costs both capital and operation and maintenance (including energy)
- availability of space
- degree of treatment required by national emission standards
- municipal or municipal plus industrial
- flow rate
- distance from residential properties especially with regard to odors, flies, other nuisances
- agricultural usage or land application options
- presence of pathogens
- experience of design engineers

Table 2.15 present some of the available technologies that may be considered for wastewater treatment.

Table 2.15: Classification of common wastewater treatment processes

Primary	Secondary	Tertiary	Advanced
Bar or bow screen	Activated sludge	Nitrification	Chemical treatment
Grit removal	Extended aeration	Denitrification	Reverse osmosis
Primary sedimentation	Aerated lagoon	Chemical precipitation	Electro dialysis
Comminution	Trickling filter	Disinfection	Carbon adsorption
Oil/fat removal	Rotating bio-discs	(Direct) filtration	Selective ion exchange
Flow equalisation	Anaerobic treatment/UASB	Chemical oxidation	Hyperfiltration
pH neutralisation	Anaerobic filter	Biological P removal	Oxidation
Imhoff tank	Stabilisation ponds	Constructed wetlands	Detoxification
	Constructed wetlands	Aquaculture	
	Aquaculture		

Some of the secondary treatment technologies are shown in Table 2.16. The most common technology used for secondary treatment of wastewater relies on (micro) biological conversion of oxygen consuming substances such as organic matter, represented as BOD or COD, and Kjeldahl-N. The technologies can be classified mainly as aerobic or anaerobic depending on whether oxygen is required for their performance, or as mechanised or non-mechanised depending on the intensity of the mechanised input required.

Table 2.16: Classification of secondary treatment technologies

Conversion method	Mechanised technology	Non-mechanised technology
Aerobic	Activated sludge	Facultative stabilisation ponds
	Trickling filter	Maturation ponds
	Rotating bio-contactor	Aquaculture (e.g. algal, duck weed or fish ponds)
		Constructed wetlands

Anaerobic	Upflow anaerobic sludge bed (UASB)	Anaerobic ponds
	Anaerobic (upflow) filter	

The choice between mechanised or non-mechanised technologies centres on the locally or nationally available technology infrastructure which may ensure a regular supply of skilled labour, local manufacturing, operational and repair potential for used equipment, and the reliability of supplies (e.g. power, chemicals, spare parts).

The use of mechanised technologies in wastewater treatment in Tanzania should only be applied to cases where there are limitations to use non mechanised technologies. This is because of higher running costs associated with such technologies and availability of limited technology infrastructure to support it. Of the non mechanised technologies facultative, anaerobic and maturation ponds are well known where waste stabilization ponds have been used such as in Mwanza.

The Constructed Wetlands (CW) are artificial or engineered systems that imitate natural wetlands as far as processes are concerned. Sub-mergent and emergent plants with associated microorganisms, and wetland soils are responsible for the majority of the treatment effected by CW. They may be surface or subsurface flow CW. Because of health exposure of almost stagnant water provides breading ground of disease vectors such as mosquito, subsurface CW is preferred over surface flow CW. Figure 2.1 shows a schematic representation of a subsurface flow CW.

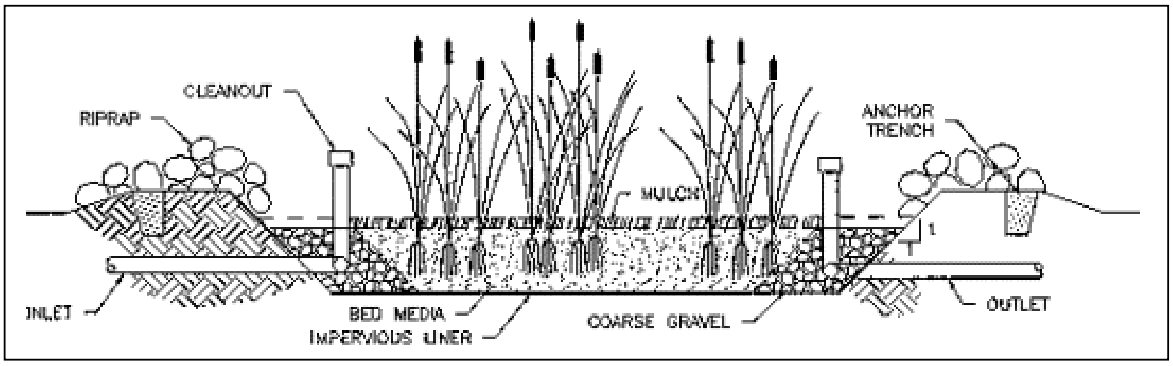

Figure 2.1: Subsurface flow Constructed Wetland

Selection of the Best Technology

The technology selection process results from a multi-criteria optimisation considering technological, logistic, environmental, financial and institutional factors within a planning horizon of 10-20 years. Key factors to be considered include:

- The characteristics of the wastewater;
- The sources of industrial wastewater (domestic, process);
- The future opportunities to minimise pollution at source;
- The required discharge standards for treated effluents;
- The availability of local skills for design, construction and O&M.
- Environmental conditions such as land availability, geography and climate.

Best available technology

In taking precautionary or preventive end-of-pipe treatment measures, it may be logical to adopt best available technology (BAT), the best available technology not entailing excessive costs (BATNEEC), the best environmental practices (BEP) and the best practical environmental option (BPEO).

The best available technology is generally accessible technology, which is the most effective in preventing or minimising pollution emissions. It can also refer to the most recent treatment technology available. Assessing whether a certain technology is the best available requires comparative technical assessment of the different treatment processes, their facilities and their methods of operation, which have been recently and successfully applied for a prolonged period of time, at full scale.

The BATNEEC adds an explicit cost/benefit analysis to the notion of best available technology. "Not entailing excessive cost" implies that the financial cost should not be excessive in relation to the financial capability of the industrial sector concerned, and to the discharge reductions or environmental protection envisaged.

The best environmental practices and the best practicable environmental options have a wider scope. The BPEO requires identification of the least environmentally damaging method for the discharge of pollutants, whereas a requirement for the use of treatment processes must be based upon BATNEEC. Best practical environmental option policies also require that the treatment measures avoid transferring pollution or pollutants, from one medium to another (from water into sludge for example). Thus BPEO takes into account the cross-media impacts of the technology selected to control pollution.

Selection criteria

The general criteria for technology selection comprise:

Average, or typical, efficiency and performance of the technology. This is usually the criterion considered to be best in comparative studies. The possibility that the technology might remove other contaminants than those, which were the prime target, should also be considered an advantage. Similarly, the pathways and fate of the removed pollutants after treatment should be analysed, especially with regard to the disposal options for the sludge in which the micro-pollutants tend to concentrate.

Reliability of the technology. The process should, preferably, be stable and resilient against shock loading, i.e. it should be able to continue operation and to produce an acceptable effluent under unusual conditions. Therefore, the system must accommodate the normal inflow variations, as well as infrequent, yet expected more extreme conditions. This pertains to the wastewater characteristics (e.g. occasional illegal discharges, variations in flow and concentrations, high or low temperatures) as well as to the operational conditions (e.g. power failure, pump failure, poor maintenance). During the design phase, "what if scenarios should be considered. Once disturbed, the process should be fairly easy to repair and to restart.

Institutional manageability. In developing countries few governmental agencies are adequately equipped for wastewater management. In order to plan, design, construct, operate and maintain treatment plants, appropriate technical and managerial expertise must be present.

Financial sustainability. The lower the financial costs, the more attractive the technology. However, even a low cost option may not be financially sustainable, because this is determined by the true availability of funds provided by the polluter. The ultimate goal should be full cost recovery.

Application in reuse schemes. Resource recovery contributes to environmental as well as to financial sustainability. It can include agricultural irrigation, aqua- and pisciculture, industrial cooling and process water re-use, or low-quality applications such as toilet flushing.

Regulatory determinants. Increasingly, regulations with respect to the desired water quality of the receiving water are determined by what is considered to be technically and financially feasible.

Ultimately, for each, pollution problem one strategy and technology are more appropriate in terms of technical acceptability, economic affordability and social attractiveness. In developing countries, where capital is scarce and poorly skilled workers are abundant, solutions to wastewater treatment should preferably be low technology orientated. This means that the technology chosen is less mechanized and has a lower degree of automatic process control, and that construction, operation and maintenance aim to involve locally available personnel rather than imported mechanized components

Technologies for Domestic and Municipal Waste Water
Urban centers in the Lake Victoria basin with the exception of Mwanza City are all not sewered. The urban population use onsite sanitation including pit latrines, septic tanks coupled with soak-way pits, VIPs and open defecation. Mwanza, the only city in the basin is 3% sewered (only the central part) serving 4% of its population. The collected sewage is treated through ten Waste Stabilization Ponds System (one anaerobic, one facultative and eight maturation ponds all in series) at Butuja and disposed into the Iloganzala Stream before entering Lake Victoria about 300m away through an encroached natural wetland. However, some areas of the city being hilly and rocky, part of its squatter population is forced to construct shallow pit latrines with spillways, which are opened during rainy season and take advantage of surface run-off to flush contents to the Lake.

Applied Research should work to introduce decentralized waste treatment options and using common technologies or combination of various technologies.

- Constructed Wetlands may be used for decentralized treatment in combination with Communal Septic Tanks or Stabilization Ponds.
- Applied Research should also adopt and adapt Integrated Algal Ponding System (IAPS) as a viable technology for LV basin. A short description of the system is described below:

Integrated Algal Ponding System (IAPS) technology for the polishing and beneficiation of effluent from municipal sewage treatment facilities.

The Integrated Algal Ponding System (IAPS) as developed by Rhodes University, SA is composed of three unit operations namely the Primary Facultative Pond with an anaerobic fermentation pit, the high rate algal pond which is a shallow, paddle-wheel mixed raceway, generating profuse algal growth and the algal settling pond designed to be quiescent, allowing the algae to settle and the treated effluent to overflow. As the algal sludge is rich in nutrients and plant hormones, there is potential for its use as a fertilizer or animal feed.

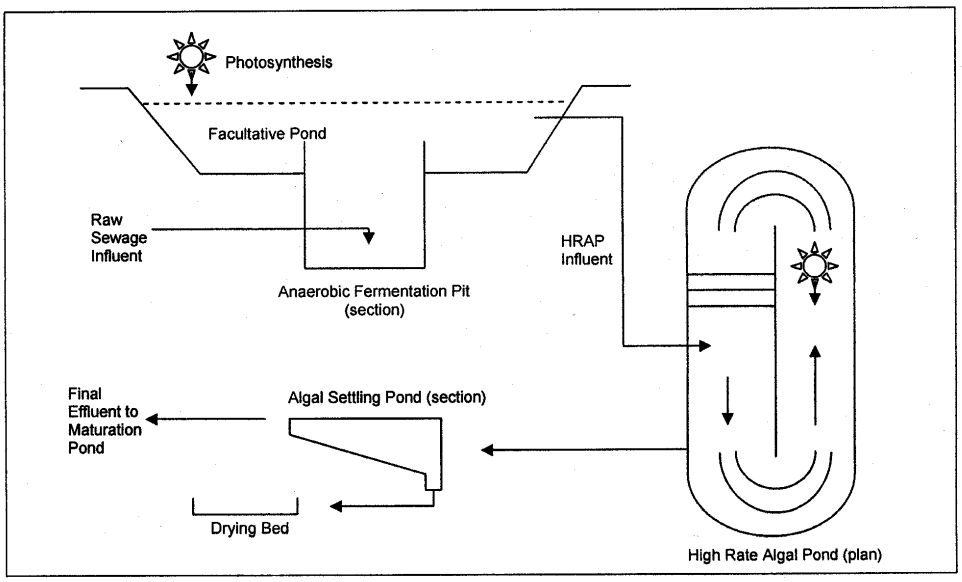

Figure 2.2: Schematic diagram of the principal unit operations associated with the IAPS

Source: Rhodes University Environmental Biotechnology Experimental Field Station, Grahamstown Disposal Works, SA[5].

2.8.5.3 Industrial Wastewater

Technologies for Industrial Wastewater

Most industries in the LV basin do not have adequate waste water treatment system to meet the national standards for effluent discharge. Some of the existing systems are either overloaded, inadequately designed to handle the type of wastewater subjected to. A good example are the fish processing plants which treatment systems for treating their wastewater loaded with both fat and organic matter. These are definitely not working as can be evidenced from typical analyses which indicate that they are discharging effluent with BOD above the limits.

Most of the industries within Mwanza, which discharge their effluent directly into Lake Victoria, are located in south Mwanza. The remaining ones are mostly located in the Nyakato area where their discharges are drained by Nyashishi River to Lake Victoria. Waste minimisation options such as cleaner production have been introduced to industries in the Mwanza Municipality.

Research is needed to:

- Develop soft and appropriate technologies to deal with industrial wastewater from fish processing, textile manufacturing, beverage industries etc. Research should aim at technologies used alone or in combination. Examples are the development of Three Phase Fluidised Bed Bio reactor (TFBB) and upward flow Anaerobic Sludge Bioreactor (UASB) for the treatment of fish processing wastewater. Basic research in these areas has been done at UCLAS and Chemical and Process Engineering Department of the Univeristy of Dar es Salaam.

[5] C. D. Wells (2005) "Tertiary Treatment in Integrated Algal Ponding Systems" MSc Thesis, Rhodes University, Grahamstown SA.

2.8.5.4 Sanitation in unplanned and rural areas

Low cost sewerage for the urban poor

Rural areas, some of the peri-urban and urban areas rely heavily on pit latrine for human waste disposal. However, the coverage is low, in most parts of the Lake Basin no more than 40% coverage is recorded. Planning for sanitation for these areas poses a challenge because of lack of the necessary infrastructure. In other parts of the world where similar problems exist innovative low cost technologies have been introduced. Example of such a system is the condominial sewer system.

The Condominial sewer systems

The simplified sewerage also known as condominial sewer collects all household wastewaters (WC wastes and sullage) in small-diameter pipes laid at fairly flat gradients—for example, a 100 mm diameter sewer laid at a gradient of 1 in 200 (0.5 percent) will serve around 200 households of 5 people with a wastewater flow of 80 litres per person per day. The sewers are often laid inside the housing block, or in the front garden or under the pavement (sidewalk), rather than in the centre of the road as with conventional sewerage. It is suitable for existing unplanned low-income areas and new housing estates with a more regular layout. Simplified sewerage schemes have been successfully been implemented in Brazil since 1991. To date there are over 1200 km of 1,200 km of condominial sewers in operation.

Applied Research should aim at adopting this system for the LV basin towns and adapt it to suit the local situation

Technologies for Sanitation in Rural Areas

Most rural areas and some parts of urban areas in the LV basin depend on pit latrines for domestic sanitation. There have been attempts to introduce modified latrines in order to improve the sanitation status of the areas. The Ventilated Improved Pit (VIP) latrine is the most viable option.

The VIP Latrines

The VIP latrine is similar to a conventional pit latrine, but has an offset pit that permits the installation of a vertical ventilation pipe (or structure) beside the latrine superstructure. The design of the VIP latrine causes air to flow down into the latrine pit through the latrine squat hole and up out of the ventilation pipe, thus removing odours from the latrine. Flies are always attracted by the smell from latrines, but in a VIP latrine they are attracted to the top of the vent-pipe rather than to the latrine squat hole. There they are prevented from entering the vent-pipe by a fly screen fixed across the top of it. Some flies inevitably find their way into the latrine pit by other routes, and may breed in there. However, flies are attracted to light, and the VIP design makes use of this fact to get rid of them. The interior of a VIP latrine is always kept semi-dark, so that the flies inside the pit are drawn towards the light at the top of the vent pipe, where the screen traps them and they fall back into the pit or die. VIP latrines have been successfully introduced in Zimbabwe. It has also been introduced in Tanzania but has not become widely used.

Applied research should aim at designing and promoting affordable VIP latrines for use in the LV basin.

Guidelines for placement of water wells in relation to pit latrines

During the inception meeting, participants expressed concerns that currently there are no guidelines to direct the placement of latrines in relation to water wells. This can result into contamination of water wells by the seeping wastewater.

The Applied Research program should assist in developing standards to that effect.

2.8.5.5 Management of Used Oils

Used oil can be the single largest non-watery liquid waste stream LVB. During use, oil becomes contaminated with a number of substances that are hazardous to human health and the environment. There is no management structure to ensure that all used oil is used, stored or disposed of in such a way that it does not cause environmental damage or harm to human health. One could make a general conclusion that “all used oil in LVB ends up into the environment”. There are no facilities for dealing with waste oils in the LVB. Most of the oils used in the LVB end up into the environment

2.8.6 Major Research Capacity Building Needs

- Laboratory accreditation
- Training of laboratory personell in advanced analytical skills
- Replacement of old/obsolete analytical equiepment

Table 2.18 shows the summary of research needs and gaps.

Table 2.17: LVB Waste Management –Research conducted

Type of Research Conducted	When Conducted	Research Institutions (involved in the research)	Key Research Findings/Lessons
Establishment of water quality status in 19 large urban centres and 31 Industries.	1997-2005	Water Quality and Ecosystem Management component	▪ The total resulting municipal pollution load (Kg/day) from the urban centres of 996,108 inhabitants into Lake Victoria was found to be: BOD_5 9,998; TN 1,778; TP 711, TSS 6,664, and FC 6.3 x 10^{14} No. /day while the resulting industrial load was found to be: BOD_5 5,201; TN 653; TP 185; TSS 4,934 and FC 1.1 x 10^{14} No. /day. ▪ Urban centers contribute more pollution loading to the Lake compared to industries. They contribute 66% BOD_5; 73% TN; 79% TP; 57% TSS and 85% FC. ▪ There is generally low enthusiasm among the medium and small scale companies to deal with environmental issues as a result of: lack of sufficiently strong pollution disincentives (i.e. fines are low enough to be considered a cost of production much like electricity); weak enforcement of existing laws; lack of economic instruments for environmental management; financial limitations. ▪ Constructed Wetlands provides low cost technology for treatment of domestic wastewater ▪ Low cost options for industrial wastewater has been proposed as[6]: o Cleaner production measures o Waste stabilization pond o Constructed Wetlands
Constructed Wetlands and Waste stabilization ponds	1995-todate	WSP & Constructed Wetlands Research Project -UDSM ▪ University College of Lands and Architectural Studies (UCLAS) o Department of Environmental Engineering	
Cleaner Production	1995-2002	▪ Cleaner Production Centre of Tanzania (CPCT)	

[6] Private Sector Development in the Lake Victoria Basin and Its Possible Role in a Regional Management Strategy

Table 2.18: LVB Waste Management Research Themes and Gaps

Research Theme			Research Needs/Gaps			Research Capacity Gaps
No	**Theme**	**Priority**	**No**	**Need/Gap**	**Priority**	
1.	Solid Waste Managemen t in Urban	High	**1**	Introduction of Intergrated Solid waste management practices in the LVB towns and municipalities	High	▪ Training of laboratory personell in advanced analytical skills ▪ Replacement of old/obsolete analytical equipment
			2	Recovery of useful products from solid waste e.g. energy	Medium	
			3	Processing of solid waste from major industries i.g fisheries into by products is practically inexistent	High	
2	Decentralise d systems for domestic and industrial wastewater treatment	High	**1**	Constructed Wetlands should be used for decentralized treatment in combination with Communal Septic Tanks or Stabilization Ponds. Adopt and adapt Integrated Algal Ponding System (IAPS) for LV basin.	High	
			2	Develop soft and appropriate technologies to deal with industrial wastewater from fish processing, textile manufacturing, beverage industries etc. Research should aim at technologies used alone or in combination. Examples are the development of Three Phase Fluidised Bed Bio reactor (TFBB) and upward flow Anaerobic Sludge Bioreactor (UASB) for the treatment of fish processing wastewater in combination with Constructed Wetland.	High	
3	Sanitation for the Unpllaned Urban and Rural Areas	High	**1**	The Condominial sewer system for unplanned urban areas of LVB	High	
			2	Promoting affordable VIP latrines for use in the LV basin.	High	
			3	Developing standards for placement of latrines in relation to water wells	High	

Research Theme			Research Needs/Gaps			Research Capacity Gaps
No	**Theme**	**Priority**	**No**	**Need/Gap**	**Priority**	
4	Waste oil management	High	**1**	Waste oils handling, treatment and reuse in the LVB.	High	
5	Cleaner Production	High	**1**	Cleaner production measures not widely adopted by LVB industries	High	

2.9 Economic Growth, Private Sector and Sustainable Market Driven Development

2.9.1 Background

Increased economic growth and decreasing food and income poverty through increased investment in the production sectors is a priority challenge affecting the living conditions and quality of life for LVB populations. Some of the strategies to address the challenge include

- Creating, promoting and strengthening credit provision in both rural and urban areas
- Promoting agro-processing industries in the rural areas and encouraging increased investment in small-holder irrigation systems and improving marketing services for agricultural and livestock products
- Improving productivity, profitability and commercialization of agriculture and livestock

The establishment of the East African Community and the subsequent materialisation of an East African Development Strategy 2001-2005 have designated the Lake Victoria Basin as a regional economic growth zone. Economic growth of the LVB must be able to meet the basic needs of the people without harming ecosystem health and depleting natural resources. This implies that economic growth must be pro-poor and pro-environment.

Education and research is instrumental in generating economic growth apart from having intrinsic values and benefits in itself. Institutions of higher education are potential vehicles in providing necessary data and knowledge needed to formulate and operationalise sustainable development strategies for utilization of Lake Basin resources.
Table 2.19 provides a summary of the current status of research on economic growth, private sector and sustainable market driven development in the Lake Victoria Basin. Additional pertinent elaborations are provided in the following sub-sections.

2.9.2 Status of Technologies applied in production

2.9.2.1 Agriculture sector

Agriculture is the most important economic activity in the Lake Victoria Basin providing food for the rapidly growing population, raw materials for the agro-industries, employment as well as foreign exchange. Still, agriculture is the most important complementary activity even among the fish traders and fishermen. The majority of the farmers in the Lake Victoria Basin are engaged in subsistence agriculture, which is characterized by small land under cultivation and poor farming technologies like hand hoe, shifting cultivation and limited use of inputs. The main crops grown include coffee, cotton, bananas, beans, paddy, millet, cotton, sugar and tea. In addition to land pressure, farmers use inferior agricultural technologies, they are faced with pests problem and inadequate irrigation facilities, soil exhaustion, soil degradation and inadequate extension services. Furthermore, technical advice and innovations on soil fertility are either rudimentary or non-existent. On the other hand the sector is highly vulnerable to drought and erratic rainfall, and floods.

Agriculture has strong linkages with non-farm sector through agro-processing, urban markets and export trade. Trends in income generation and poverty reduction are highly dependent on the growth of agriculture and related rural non-agricultural activities. There are several farming systems in the Lake Victoria Basin influenced by agro-ecological zones determined by rainfall, temperature, geology, landscape and population density.

All over the basin the area under cultivation is increasing at the expense of forest cover, wetlands and riverbanks, purposely to meet the increasing demand for food and cash. Cash crops are expanding at the expense of traditional food crops, creating disparities between different socio-economic groups. In various lowland areas, off-season production cannot be undertaken due to inadequate irrigation facilities. Loss of traditional seed banking techniques affect farmers who cannot afford certified seeds. Women lack access to emerging technological innovations, yet they are most active in farming.

Draft Animal Power (DAP) is an important ingredient for improvement of agricultural productivity in rural Tanzania[7]. Most of the farmers still use the hand hoe but draft power could reverse the trend by increasing the size of the farms and providing a leeway towards timely farm operations. Draft animals also play a major role in transport of farm produce and assisting women for domestic chores like fetching water where the key role actors are women. Draft animals play a major role in a number of activities such as ploughing, harrowing, hauling water and fetching firewood. The main animals used for draft power are the donkeys and oxen. It is a clear fact that increased and sustainable agricultural development can only be achieved through introduction and proper utilization of appropriate technologies to boost agricultural productivity of the majority of farmers.

2.9.2.2 Livestock

In Tanzania, the Lake Victoria Basin area is estimated to have a total of 4 million livestock (about 61 livestock per square kilometer), which include cattle, goats, sheep, chicken and donkeys. Indigenous breeds characterize livestock production in the Basin whereby only about 28 thousands of cattle are improved or exotic breeds. However, development of the livestock sector is constrained by inadequate grazing pastures and water shortages, inadequate skills to improve domestic livestock breeds, especially for dairy production, and inadequate veterinary services. Technological innovations such as zero grazing are limited and farmers are reluctant to adopt improved breeds for fear of losses.

2.9.2.3 Mineral sector (small and medium scale mining)

Mineral resources in Lake Victoria Basin include apatite, graphite, ilmenite, carbonatite, copper, gold, diamond, radio actives, rare earths, iron, limestone, silver, soapstone, tin, nickel, and dimension stones. Phosphate rock also exists in the area. Since early 1990s up to now, mining of these minerals has attracted foreign investors, which include both large and small-scale mining operations.

Small-scale mining operators and artisanal workers engage largely in mining of building materials namely sand, stones and clay. This sector requires secure water resources and prevention of potential pollution from mineral processing. There is also small scale mining of precious metals such as gold by artisanal miners. The scale of operation varies considerably and the technologies in use are generally basic, relatively inefficient and have wide-ranging effects on the environment. Small-scale mining of gold in various locations has reported severe environmental impacts. Severe deforestation is reported in areas where small-scale mining is practiced. Mining of sand and clay has been reported to be a threat to the environment particularly due to lack of legal and regulatory framework to enforce sustainable exploitation of these resources. In some cases huge mining pits are left unfilled leading to expansion of sites for mosquitoes breeding. A detailed examination of how artisanal miners currently extract and process the ore is needed, to be used as a basis to assess the levels of

[7] The improvement of draft animals management for appropriate mechanization in Arumeru District in Northern Tanzania, M. Kingamkono and H. Mruttu, March 2002

appropriate technology and training required in this sector. Appropriate technologies to assist artisanal miners in exploration, mining and processing should be developed and introduced.

2.9.2.4 Environmental Sector

Surface and underground water sources are the main sources of water in the Lake Victoria Basin. Unfortunately, most of the surface water sources are heavily polluted. Water schemes for the provision of safe and clean water for consumption are limited to urban areas. Protected point sources, i.e. boreholes, spring are easily contaminated and some dry up during the dry season. A treatment system of sewers and sewage is generally bad. Rural areas, some of the peri-urban and urban areas rely heavily on pit latrine for human waste disposal. However, the coverage is low; in most parts of the Lake Basin no more than 40% coverage is recorded.

Water pollution in the Lake basin has also been linked to industrial discharges. Wastewater treatment plants are either not installed or generally malfunctioning. Laws and regulations intended to control pollution are regularly outdated, their enforcement is weak and the penalties too small to act as an incentive for installing effective treatments systems. There are also few incentives to use environment friendly technologies.

2.9.2.5 Fisheries sector[8]

Fish production in Lake Victoria comprises about 50 percent of Tanzania's total production volume. The economic and social significance of the fisheries sector to the LVB communities lies in the fisheries related activities including fish processing, marketing, distribution, net making, boat building, marine engine repair, and production of other accessories used in the fishery. There has been rapid buildup of fish processing factories around Lake Victoria in response to international demand for Nile perch. The fishing in Lake Victoria is by artisanal fisher folk. No industrial fishing is practiced. The fishing activity is characterized by gillnets, also hook and lines are used. Transportation and the fishing are usually done using small boats of up to five meters. The fish catch is handled in iceboxes to preserve. Some boats are fitted with onboard iceboxes for fish preservation. The main type of commercial fish includes Nile perch, Nile tilapia and *'dagaa'* (sardines*).*

Prior to the establishment of Nile perch processing plants in Lake Victoria, in 1990s, the major processing methods were artisanal fish smoking, salting and sun-drying. However, the quality of the final product was poor due to the lack of ice for lowering temperature soon after harvesting. The commercial or industrial processing methods were started early 1990s for producing mainly Nile perch fillets for export to international markets (Europe, Japan, Middle East and Australia). Apart from fillets there are by-products which are in use, such as, fish frames/carcass, off-cuts, belly flaps and fish maws. These are either sun-dried or salted for export to Rwanda, Burundi and Democratic Republic of Congo. Currently, there are eleven fish processing plants along the Tanzanian side of Lake Victoria.

The fish processing industry in Tanzania ranges from sophisticated state of the art facilities (commercial) to small artisanal operations producing traditional fish and fishery products for the domestic markets. Artisanal processing involves smoking, dry salting and sun drying. A chorkor type kiln is used. Alternatively, dry salting is used for similar raw materials (poor quality tilapia and Nile perch). *Dagaa* is sun dried on shore sands, on flat rock or hard and dry soils, the process is not always hygienic because the *dagaa* is not salted before drying

[8] The Vision and Strategy Framework for Management and Development of Lake Victoria Basin Annex III: Tanzania Country Report

so as to kill micro-organisms. Tilapia are gutted and washed for freezing. The frozen Tilapia finds markets in Arusha, Dar es Salaam and Dodoma.

All the fish processing factories are located close to the lake and do not adequately treat their wastewater. They therefore discharge untreated water into the Lake Victoria.

In other parts of Tanzania (Lake Nyasa) the fish to be dried is first boiled to remove oil and then sun dried. This can be applied particularly to *"dagaa".*

Post-harvest losses for Tanzania Fisheries are estimated at 25–40% of the total production whereby 10–15% is of Nile perch (Nanyaro and Makene, (1998)) due to poor fish handling and processing and poor infrastructure in the fishing industry in terms of fishing boats, landing sites, fish transportation, storage, pre- and post-processing handling and market conditions.

2.9.2.6 Forestry

Natural forests in the lake basin are threatened by the expansion of settlements, forest fires, mining activities, over-grazing, illegal harvesting and demand for agricultural land. Activities, such as charcoal burning, firewood collection and brick making, consume massive quantities of wood. Carpentry and forest inputs for building and construction materials are visibly causing forest degradation in the Basin. The influx of refugees in the basin has also aggravated the situation particularly in areas around the camps.

There are five categories of forests in the LV basin namely

(i) National Forest Reserve
(ii) Village Forest Reserve
(iii) Private Forest Reserve
(iv) Community Forest Reserve
(v) Forest in General Land

Some of the technologies used that have direct impact on the forestry sector include the maintenance of *'ngitiri'*, a traditional woodlot kept for supply of firewood. Also introduction of improved cooking stove (*jiko bora/jiko sanifu*) contributes to the conservation of forests.

2.9.2.7 Energy

A large proportion of the rural population depends on forest resources to meet the firewood needs. In addition to other forest products, the sustainability of forest resources has increasingly become questionable. The introduction of efficient charcoal stove (*jiko bora or jiko sanifu*) and fuel wood stove is aimed reducing the consumption of charcoal and firewood and thus contributing to the conservation of forests. Such technologies have been adopted in Magu District; however, the improved cooking stoves are not widely used in the LV basin. There is therefore a need to identify bottlenecks to the wide use of improved charcoal and fuel wood stoves and propose modalities to overcome them.

Wood is also used in the burning of bricks used for construction. Efforts should be directed into using agricultural waste instead on wood for this purpose.

During drought times forests resources are used as the main source of some income. At this times people harvest fuel wood and prepare charcoal for some incomes. It is important to research on alternative income generation activities so that people should not turn to forest reserves during hard times.

Consequences of changes in fishing policies and land use need to be a continued research issue in order to provide sound evidence of which policies are working and which ones are not. For those policies which are working, strategies for scaling up consistent practices should then be developed and promoted. Those which are not working should be dropped or adjusted as necessary.

2.9.3 Technologies that empower women to conserve and manage natural resources

Women in the rural areas interact with the environment and natural resources on a daily basis. They are fully engaged in such activities as searching for firewood and water, farming and other field operations as well as taking care of household chores. Those along the shores of the lake engage themselves in fish processing, particularly fish smoking as an economic activity. In the pursuit of these activities, many of them still rely on conventional technologies such as the traditional three-stone open fires for cooking, and fish smoking which consume a lot of firewood and lead to degradation of forests, particularly where there is commercialisation of firewood. In the urban areas, many of them use the traditional charcoal stoves that are less fuel efficient.

Given the high deforestation rates being experienced in the basin, the sustainability of firewood and charcoal supply has become questionable. Local scarcity of these products is being experienced in various places in the basin. To address this problem, women need to be exposed to technologies of low fuelwood (both firewood and charcoal) consumption stoves, particularly where there is no alternative source of energy. This will finally improve the vegetation cover and subsequently reduce run-off and reduce pollution loading into the lake. Already, some women groups, such as “Mwanzo Mgumu” at Chamugasa and Mayega villages in Kalemera ward, Magu District have adopted these technologies. The group produces low fuelwood consumption stoves and sells them to buyers from neighboring villages where the demand is very high.

There is need for investing in R&D, focusing in enterprises where the basin has a comparative advantage. Research is needed in order to clearly pin-point the areas of comparative advantage and the specific needs as far as R&D is concerned.

Research is also needed to provide guidance on how to promote sustainable, demand driven research-extension system, where private sector is encouraged to take a leading role. This research should inform policies and strategies aimed at developing a market for research – extension services.

2.9.4 Key Research Institutions

2.9.4.1 Agricultural Sector

- Ukiriguru Agricultural Research Institute
- Agricultural Research and Development Institute, Maruku
- Sokoine University of Agriculture

2.9.4.2 Livestock

Animal Diseases Research Institute (ARDI)

2.9.4.3 Mineral sector (small and medium scale mining)

2.9.4.4 Fisheries sector

- Lake Victoria Fisheries Organisation (LVFO)
- Tanzania Fisheries Research Institute (TAFIRI)
- Faculty of Aquatic Sciences and Technology (FAST) of the University of Dar es Salaam

2.9.4.5 Forestry

- Tanzania Forest Research Institute (TAFORI)
- Sokoine University of Agriculture (SUA)
- Botany Department of the University of Dar es Salaam

2.9.4.6 Energy

- Department of Mechanical Engineering (Energy) of the UDSM
- Physics Department of the UDSM
- Center for Energy and Environmental Studies of Tanzania (CEEST)
- Tanzania Industrial Research Development Organisation
- Chemical and Process Engineering Department of UDSM

2.9.5 Key Research Needs and Gaps

2.9.5.1 Agricultural Sector

Agricultural inputs

- Use of improved seeds adapted to the semiarid and other agro-ecological conditions of the lake basin
- Proper management of agrochemical, including fertilizers, herbicides and pesticides.

Soil and water resources

- Prevention of soil erosion and different farming systems, and soil load in the water systems.
- Improvement of soil fertility
- Assessment of aquifer recharge as influenced by SWC interventions
- Soil and Water conservation measures over a large pilot area (river basin)

Farming systems

- Research on best ways to integrate crop farming, livestock keeping and soil conservation.
- Research to assess the suitability/performance of different crops under different soil and water conservation measure.
- Upgrading of the farming technologies
- Gender access to emerging technological innovations

Research on farming systems could be undertaken in close collaboration with the Ukiriguru Agricultural Research Institute.

Indigenous knowledge

- Identification and documentation of indigenous knowledge related to soil and water conservation in the Lake Victoria basin.

Livelihood issues

- Research on implications of livelihood patterns of local communities as influenced by SWC intervention e.g. shifts from fishing to agriculture.

- Rural-urban migration and influence on adoption of SWC interventions in the lake zone

Water Harvesting for Livestock and Crop Irrigation

Water harvesting is the collection and concentration of water run-off for the production of crops, fodder, pasture or trees for livestock. It can also be used for supply of domestic water or other productive purposes. During LVEMP 1 water harvesting was introduced in Kalemela and Itumbili sub-catchments. This included deviation of run-off from road sides or natural waterways to fields or farms for crop production; and harvesting water from the hills and tapping into micro basins or bunded rice fields commonly known as *majaruba* through a technology known as micro-catchment water harvesting). Under NELSAP there was also a project entitled "Enhancement Agricultural Productivity through Rain water harvesting.

Technology adoption has occurred and spill over effects in SWC activities plus construction of rain water harvesting units (ferro-cement tanks) and shallow water wells. Increased production per unit area has contributed to food security and resulted in higher incomes.[9]

Other projects working in the lake basin, e.g. Mara-FIP introduced a macro-catchment water harvesting technology that can be used for irrigation by small-scale farmers in Buswahili and Chirorwe villages in Musoma Rural District. There is however a need to assess the impacts of such irrigation, for example, in terms of health and environmental aspects. Experience from Buswahili village indicate that as result of water harvesting structures there are plenty of mosquitoes that find breeding grounds in the impounded water. Also people complained of rampant bilharzias as a result of spending much time in the irrigation water. Further to ensure that the water retaining structures do not silt up, there is need to also conserve the catchment areas where the harvested water comes from.

Research is needed in the following:

- Enhancement of agricultural production under smallholder irrigation and SWC interventions
- Sustainable rainwater harvesting techniques that ensure ecosystem balance and minimises water use conflicts (e.g. to facilitate irrigation schemes, large and small scale).

Sustainable Agriculture Projects

During LVEMP 1 small irrigation pilot projects were introduced by the wetlands component. These irrigation projects were drawing water from Lake Victoria for irrigation. The pilot projects had very positive impacts on the small holder farmers involved. In a number of cases water abstraction from the lake was achieved by cutting a channel through wetlands to get the Lake Victoria water in to the upper edge of the wetlands and thereafter was distributed by small pumps.

Research is needed in the following areas:

(i) Appropriate technologies for drawing and distributing water for irrigation (windmill vs mechanical pumps, proper design of delivery channels etc)

(ii) Water abstraction techniques and their socio- economic and environmental impact

Appropriate Boost and Post Harvest Technologies for Farmers

[9] A Report on Stock-taking of Lake Victoria Environmental Management Project Phase I Activities July 1997 – March 2003

Post harvest technology is a multidisciplinary field that includes various treatments and operations on the harvested crops for the purpose of preservation or enhancement of quality for marketing and consumption. The major operations are threshing, drying, storage, processing packaging, transport etc.

In many areas of the LVB cassava is a staple food crop (Musoma). However there are no storage structures for Cassava. Harvesting is done piecemeal. Loses are high for various reasons. Applied research should come up with improved storage facility for cassava. Also sweet potatoes are grown in large quantities but no preservation is done. Research to diversify use of potatoes should be carried out. The sweet potatoes can be dried.

Solar energy is free, non polluting and inexhaustible. Solar heating systems to dry food and other crops can improve the quality of the product, while reducing wasted produce. Solar food dryers are an appropriate food preservation technology for sustainable world. Drying preserves foods by removing enough moisture from food to prevent decay and spoilage. Water content of properly dried foods varies from 5-25%. Lake Victoria Basin has the right climate for solar drying.

Preservation of food by solar energy is common in Tanzania. The most common method used to preserve food products is sun-drying. Although it is cheap, it results in a poor quality of dried product. There is no control over the drying process; it is possible to contaminate the product by dirt, rodents, animals[10] etc. There have been some projects which introduced solar driers in Tanzania. Different designs have been adopted such as trays and mats, swing solar drier, box solar drier etc. However, Most of the installed systems are small and process maximum of 25 kg of raw materials per batch using between 3-5 days depending on the climatic condition. There are at least 40 companies/NGOs dealing with solar energy of which more than 50% are found in Dar es Salaam and others are located in main cities like Arusha and Mwanza. TaTEDO, KARADEA, SOIT training facility and Ultimate Energy have conducted training; and the supporters are Umeme Jua and UNDP.
Initiative on the use of solar energy for thermal purposes i.e. drying and cooking has been carried out by TaTEDO, SOIT, AMKA, FADECO and Karadea.

The department of Chemical and Process Engineering of the University of Dar es Salaam has been carrying out research aimed at improving the efficiency and the capacity of the commonly used dryer (Cabinet type). It has been realised that the capacities so far available are too small to support any commercial exploitation. Similarly the Technology Development and Transfer Centre (TDTC) of the College of Engineering and Technology (CoET), UDSM has worked with groups in the Coast Region to use simple solar tunnel dryers for drying cassava. A commercial solar dryer is currently being developed by the Chemical and Process Engineering Department through generous financial support from the Rockefeller Foundation. The Tanzania Industrial Research and Development Organisation (TIRDO) in collaboration with CoET is also developing solar dryers for fish, fruits and vegetables as a poverty reduction strategy.

The following crops available in the LVB can be dried in a solar dryer: Cassava, fruits and vegetables, bananas, coffee, maize, sorghum, sweet potatoes, vanilla, fish, meat etc

[10] Makwaia B.N., " Sun-drying of fruits, vegetables, spices, tubers and other perishable products in Tanzania", Proceedings of the Expert Consultation on Planning the Development of Sundrying Techniques in Africa, FAO, 1985

Figure 2.3: Modified cabinet solar dryer fitted with solar driven circulation fans
Source: (*Chemical and Process Engineering Department*)

Research is needed in the following:

- Appropriate harvesting, storage and preservation methods for common food crops i.e cassava, sweet potatoes.

Diversification of food products from common food crops (banana, cassava, sweet potatoes) to add value. Solar drying of agricultural products

2.9.5.2 Livestock

- Development water harvesting technologies for livestock
- Development and promotion of zero grazing technology in LVB
- Improvement of domestic livestock breeds.
- Develop cross-breeding of available diary animals (cows and goats) to improve local animals
- Create appropriate management practices for animals(feeding and health).
- Improvement of agro-processing of milk products (cheese and margarine) and milk collection infrastructure (collection points and cold mobile)

2.9.5.3 Mineral sector (small and medium scale mining)

- Development of appropriate technologies to assist artisanal miners in exploration, mining and processing
- Development of legal and regulatory framework to enforce sustainable exploitation of mineral resources

- Development of appropriate technologies for environmental management in small scale mining operations (e.g. use of retort where mercury is used for extraction of gold etc.)

2.9.5.4 Fisheries sector

- Introduction of soft technologies for adequate treatment of wastewater from fish processing factories
- Development of appropriate fish preservation technologies for artisanal fisheries
- Introduction of economic and efficient solar dryers for drying fish particularly the Sardines *('dagaa')*.
- Processing of fish heads "mapanki" for human consumption
- Processing diversification for local consumption
- Utilization of Nile Perch waste to produce useful products (swim bladders, fish skin, fish sillage, fish oils)
- Fish marketing systems to eliminate unnecessary middlemen and reducing cheating of the fisherfolk
- Harmonisation of fishing laws within the East African Countries
- Capacity building among the fisher folk to reduce post harvest losses

2.9.5.5 Forestry

Agroforestry/cover crops

- Development of appropriate agro-forestry techniques in catchments with rivers draining water into the Lake Victoria.
- Evaluation of the relevance of already approved technologies such as improved fallows, rotational woodlot system and mixed intercropping. This aspect should include determination of appropriate tree species (multipurpose) that can be used in agroforestry and other related soil conservation measures.
- Assessment of the effect of different tree species, leguminous plants, and cover crops in improving the improving soil fertility, through nitrogen fixation and/or organic matter deposition. Studies should also be undertaken to determine the level of organic matter under different soil and water conservation interventions.
- Management and Promotion of traditional woodlot *'ngitiri'*

2.9.5.6 Energy

- Research on alternative sources of energy so as to reduce dependence on wood fuel and manure
- Energy conservation technologies (Jiko Bora)
- Renewable energy technologies (solar)
- Use of Biogas
- biofuels (bio-dieasel, gasohol, co-generation)

2.9.5.7 Tourism

- Suitability for ecotourism in socio-economic development and its impact
- Development of pilot historical sites under private public partnership arrangement
- Comanagement of touristic sites

2.9.5.8 Technologies that empower women to conserve and manage natural resources

- Energy saving (conservation) technologies
- Fish processing technologies (e.g. solar dryers)

2.9.6 Research Capacity (Human + Infrastructure)

- Train communities, especially women (individuals and groups) in construction of low firewood and charcoal consumption stoves.

Table 2.20 shows the summary of research needs and gaps

2.9.7 Innovative Clusters for Lake Victoria Basin

2.9.7.1 Introduction

The fundamental factors necessary for the development of innovations include skills, the exchange of knowledge and opportunities for mutual learning as part of the interaction between businesses, research institutions and political bodies. Innovation can be defined as the capacity of a nation to adapt to worldwide changes in nature, technology and economics but also its capacity to influence these. To a firm innovation can be defined as the process by which firms master and turn into practice product design and manufacturing processes that are new to them, whether or not they are new to the universe. Clustering is a process of firms and actors co-locating within a concentrated geographical area, cooperating around a certain functional niche and establishing close linkages and working alliances to improve their collective competetetiveness. Joint strategies and actions motivated by the anticipation of mutual benefits are greatly important in clustering[11]. Innovative Clusters innovates in the broadest sense of definition, where innovation can emanate from improvements in the way actors organize themselves, products are developed, produced, commercialized, distributed etc.

A number of activities in the LVB could form clusters. These include fisheries, horticulture, livestock keepers, diary product processing, agroprocessing, etc.

2.9.7.2 Key Innovative Clusters Research Institutions

- The College of Engineering and Technology (CoET) of the University of Dar es Salaam has established an Innovation System and Clusters Programme under Sida-SAREC funding.

Depending on the activities of a Cluster and the problem area, a number of research institutions would be involved.

2.9.7.3 Major LVB Innovation Clusters Needs/Gaps

- Identification and mobilization of potential clusters in LVB
- Develoment of Clusters Initiatives with potential government support and strong research needs

2.9.7.4 Major Capacity Building Needs

- Training on Development of Innovative Clusters
- Training on specific aspects of cluster initiatives

[11] Prof BLM Mwamila, " Towards an Innovation Systems and Clusters Programme for Eastern Africa(ISCP-EA) Proceedings of the second Regional Conference on Innovation Systems and Innovative Clusters in Africa, March 2005, Jinja- Uganda.

Table 2.19: Economic Growth, Private Sector and Sustainable Market Driven Development - Research conducted

Type of Research Conducted	When Conducted	Research Institutions (involved in the research)	Key Research Findings/Lessons
Soil and water conservation	1997-2005	Soil and Water Conservation Component	Improved land productivity after application of soil and water conservation measures
Solar Dryers	2005 todate	Chemical and Process Engineering Department	Performance of the dryers can be improved by introducing forced circulation of air in the dryer Current sizes of solar dryers are not economic and can not support commercial scale production
	2005 todate	Technology Development and Transfer Centre (TDTC)	Solar tunnel dryers can provide a cheap and hygienic drying technology for rural areas
	2005 todate	Tanzania Industrial Research Development Organisation	Fish drying in Kigoma and Mwanza has been very successful. For fruits and vegetables trial runs and SME training is underway.
Sustainable Utilization of Wetland Products	1997-2005	Wetlands Component of LVEMP	Wetland encroachment for farming and grazing purposes is a serious threat to LVB wetland *Cyperus papyrus* is a macrophyte with commercial and non- commercial uses among the LVB communities. Mats weaving activity has been found to be of great economic importance to the weavers around the Lake Basin contributing about 61% of their annual income.
Innovation Systems and Clusters in East Africa has been Initiated	2003 todate	College of Engineering and Technology (CoET)	Eight pilot Clusters Initiatives were established in Feb 2006

Table 2.20: Economic Growth, Private Sector and Sustainable Market Driven Development Research Needs and Gaps

Research Theme			Research Needs/Gaps			Research Capacity Gaps
No	**Theme**	**Priority**	**No**	**Need/Gap**	**Priority**	
1.	Improvement of Land Productivity and Farming systems	High	**1**	Use of improved seeds adapted to the semiarid and other agro-ecological conditions of the lake basin	High	
			2	Proper management of agrochemical, including fertilizers, herbicides and pesticides	High	

Research Theme			Research Needs/Gaps			Research Capacity Gaps
No	**Theme**	**Priority**	**No**	**Need/Gap**	**Priority**	
			3	Prevention of soil erosion and different farming systems, and soil load in the water systems.	High	
			4	Improvement of soil fertility	High	
			5	Assessment of aquifer recharge as influenced by SWC interventions	Low	
			6	Soil and Water conservation measures over a large pilot area (river basin)	High	
			7	Research on best ways to integrate crop farming, livestock keeping and soil conservation.	low	
			8	Research to assess the suitability/performance of different crops under different soil and water conservation measure.	High	
			9	Upgrading of the farming technologies	High	
			10	Gender access to emerging technological innovations	Medium	
2	LVB Indigenous knowledge for economic growth	Medium	**1**	Identification and documentation of indigenous knowledge related to soil and water conservation in the Lake Victoria basin.	High	
			2	Management and Promotion of traditional woodlot *'ngitiri'*	High	
			3	*Livelihood issues* Research on implications of livelihood patterns of local communities as influenced by SWC intervention e.g. shifts from fishing to agriculture.	low	
			4	Rural-urban migration and influence on adoption of SWC interventions in the lake zone	High	

Research Theme			Research Needs/Gaps			Research Capacity Gaps
No	**Theme**	**Priority**	**No**	**Need/Gap**	**Priority**	
			5	Enhancement of agricultural production under smallholder irrigation and SWC interventions	High	
3	Water Harvesting and Water Abstarction	High	**1**	Sustainable rainwater harvesting techniques that ensure ecosystem balance and minimises water use conflicts (e.g. to facilitate irrigation schemes, large and small scale).	High	
			2	Development water harvesting technologies for livestock	High	
			3	Appropriate technologies for drawing and distributing water for irrigation (windmill vs mechanical pumps, proper design of delivery channels etc)	High	
			4	Water abstraction techniques and their socio- economic and environmental impact	High	
4	Post harvest handling, processing and Value addition	High	**1**	Appropriate harvesting, storage and preservation methods for common food crops i.e cassava, sweet potatoes.	High	
			2	Diversification of food products from common food crops (banana, cassava, sweet potatoes) to add value.	High	
			3	Solar dryers for agricultural products	High	
			4	Introduction of economic and efficient solar dryers for drying fish particularly the Sardines *('dagaa')*.	High	
			5	Improvement of agro-processing of milk products (cheese and margarine) and milk collection infrastructure (collection points and cold mobile)	High	

Research Theme			Research Needs/Gaps			Research Capacity Gaps
No	**Theme**	**Priority**	**No**	**Need/Gap**	**Priority**	
			6	Development of appropriate fish preservation technologies for artisanal fisheries	High	
			7	Fish Processing diversification for local consumption	High	
			8	Capacity building among the fisher folk to reduce post harvest losses	High	
			9	Fish marketing systems to eliminate unnecessary middlemen and reducing cheating of the fisherfolk	medium	
			11	Harmonisation of fishing laws within the East African Countries	High	
5	Improvement of livestock productivity	High	**1**	Development and promotion of zero grazing technology in LVB	low	
			2	Improvement of domestic livestock breeds.	medium	
			3	Develop cross-breeding of available diary animals (cows and goats) to improve local animals	High	
			4	Create appropriate management practices for animals(feeding and health).	High	
6	Improvement Small Scale Mining	High	**1**	Development of appropriate technologies to assist artisanal miners in exploration, mining and processing	High	
			2	Development of legal and regulatory framework to enforce sustainable exploitation of mineral resources	High	
			3	Development of appropriate technologies for environmental management in small scale mining operations (e.g. use of retort where mercury is used for extraction of gold etc.)	High	

Research Theme			Research Needs/Gaps			Research Capacity Gaps
No	**Theme**	**Priority**	**No**	**Need/Gap**	**Priority**	
7	Waste Management and Reuse	High	**1**	Introduction of soft technologies for adequate treatment of wastewater from fish processing factories	High	
			2	Processing of fish heads "mapanki" for human consumption	High	
			3	Utilization of Nile Perch waste to produce useful products (swim bladders, fish skin, fish sillage, fish oils)	High	
8	Improvement of Forestry Production	Low	**1**	Development of appropriate agro-forestry techniques in catchments with rivers draining water into the Lake Victoria.	High	
			2	Evaluation of the relevance of already approved technologies such as improved fallows, rotational woodlot system and mixed intercropping. This aspect should include determination of appropriate tree species (multipurpose) that can be used in agroforestry and other related soil conservation measures.	medium	
			3	Assessment of the effect of different tree species, leguminous plants, and cover crops in improving the improving soil fertility, through nitrogen fixation and/or organic matter deposition. Studies should also be undertaken to determine the level of organic matter under different soil and water conservation interventions.	High	
9	Development and Improvement of Energy Systems and Sources for LVB	Medium	**1**	Research on alternative sources of energy so as to reduce dependence on wood fuel and manure	High	Train communities, especially women (individuals and groups) in construction of low firewood and charcoal consumption stoves
			2	Energy conservation technologies (Jiko Bora)	High	

Research Theme			Research Needs/Gaps			Research Capacity Gaps
No	**Theme**	**Priority**	**No**	**Need/Gap**	**Priority**	
			3	Renewable energy technologies (solar, wind)	High	
			4	Use of Biogas	Medium	
			5	Biofuels (bio-dieasel, gasohol, co-generation)	Medium	
10	Tourism	Low	**1**	Suitability for ecotourism in socio-economic development and its impact	Medium	
			2	Development of pilot historical sites under private public partnership arrangement	Medium	
			3	Comanagement of touristic sites	High	
11	Innovative Clusters for the major production sectors of LVB	High	**1**	Establishment of baseline data for the existing clusters	High	Training on development of Innovative Clusters Cluster specific training (eg. Management skills, production techniques, business plan etc
			2	Assessement of strengths and weaknesses of anticipated cluster initiative	High	
			3	Awareness creation on the concept of Clusters (change of mindset)	High	
			4	Introduction of Innovative Clusters Concept for the Fishing Sector	High	
			5	Introduction of Innovative Cluster Concept for the Artisanal Fish Processing Sector	High	
			6	Introduction of Innovative Cluster Concept for the Horticulture growers in LVB	High	
			7	Introduction of Innovative Cluster Concept for the Handcraft makers in LVB	High	
			8	Introduction of Innovative Concept Cluster for the Dairy Processing Sector	High	
			9	Introduction of Innovative Concept Cluster for the Agro Processing Sector	High	

Research Theme			Research Needs/Gaps			Research Capacity Gaps
No	**Theme**	**Priority**	**No**	**Need/Gap**	**Priority**	
			10	Introduction of Innovative Concept Cluster for the Bio energy Sector	High	

2.10 Cross Cutting Issues

2.10.1 Introduction

Table 2.21 provides a summary of the current of status of research on cross-cutting issues in the Lake Victoria Basin. Additional pertinent elaboration are provided in the following sub-sections. The issue of HIV/AIDS has been covered under the Section 2.7 on Pests and Diseases.

2.10.2 Key Research Institutions: Cross-Cutting Issues

The main research institutions as regards cross-cutting issues related to LVB include the institutions of higher educations especially the University of Dar es Salaam, REPOA, the LVEMP and VicRes.

2.10.3 Major Research Activities

In general, very few research activities in LVB focused directly on the key cross-cutting issues such as the following have been carried-out.

- Poverty and Environment
- Environmental Economics and sustainable Production and Consumption
- Social and cultural aspects in Environmental Management
- Trans-boundary environmental issues
- Environmental Governance including environmental Planning and Monitoring Systems
- Environmental Information Management
- Gender issues

Notable research activities include:

- The lessons learnt reports and other studies commissioned by LVEMP.

2.10.4 Major Findings and Lessons

Research findings from the studies identified by the literature review could be found in the following publications:

1. Kessy, Flora (2005); Lessons Learns on Community Participation. LVEMP Research Report
2. LVEMP. (2002). “Field Report on Participatory Dialogue for Preparing River Mara Watershed Management Plan. Mwanza: LVEMP.
3. LVEMP. (2003a).“Micro Projects as an Alternative Strategy for Creating Local Community Assets.” *Nyanza Review*. Special Issue, February 2003, pages 6-7.
4. LVEMP. (2004). “Lake Victoria Basin Development: Community Participation Strategy.” Final Draft. Dar es Salaam: LVEMP.
5. LVEMP. (2005): Implementation Completion Report for LVEMP
6. LVEMP. (2005): Lessons Learnt on Westlands Management
7. LVEMP. (2006); TDA Report
8. Msambichaka, D. A. (1998). “Report of the Workshop for Preparing Community Participation Guidelines for LVEMP. Mwanza: LVEMP.
9. Msongwe, Y. (2005). “Report of a Training Workshop: Community Participation, Gender Analysis, and Stakeholders’ Participation.” Mwanza: LVEMP.
10. Musoke, I. K and M. Nyirabu. (2004). “Mass Media/Audience Research Report.” Dar es Salaam: LVEMP.

11. Nanai, N.A.K. (2000). "Draft Report on the Status of Communities' Participation in Implementing Lake Victoria Environmental Management Project: The case of Tanzania." Mwanza: LVEMP.
12. Nanai, N. A and M. Nyirabu (2001). "Community Particiaption and Sustainability of LVEMP Activities." In S. G. M. Ndaro and M. Kishimba (Eds), *Proceedings of the LVEMP-Tanzania 2001 Scientific Conference*, 6-10 August, 2001, Bank of Tanzania Training Institute, Mwanza, Tanzania.
13. NEMC(2005): Draft Agenda for Environmental Research in Tanzania.
14. Ng'weshemi, J. Z. (2001). "Mobilization of Communities and Government Machinery for HIV/AIDS Response." In S. G. M. Ndaro and M. Kishimba (Eds), *Proceedings of the LVEMP-Tanzania 2001 Scientific Conference*, 6-10 August, 2001, Bank of Tanzania Training Institute, Mwanza, Tanzania.
15. SUDA, C. A. (2000).Gender, Culture and Environmental Conservation in Western Kenya: Contextualizing Community Participation and the Choice of Techniques Nordic Journal of African Studies 9(1): 31-48 (2000)
16. URT. (2005b). "The National Strategy for Growth and Reduction of Poverty (NSGRP)—MKUKUTA." Dar es Salaam: Vice President's OfficeMajor Research Needs/Gaps

Understanding cross-cutting issues – especially community participation, gender issues, policy/governance issues - is very important for explaining the processes taking place in the lake basin and enhancing sustainable and effective environmental responses. Although there are few studies which focussed on these issues in the Basin, in general, there is need for more systematic, comprehensive and integrated research studies on the relevant cross-cutting issues:

- Poverty and Environment
- Environmental Economics and sustainable Production and Consumption
- Social and cultural aspects in Environmental Management
- Environmental Governance including environmental Planning and Monitoring Systems
- Environmental Information Management
- Gender issues (e.g. gender roles in and influences on environmental management)

Livelihoods of people and economic development at large depend either directly or indirectly on environmental resources, hence a healthy environment is vital for sustainable development. In the government efforts to eradicate poverty, environmental issues need to be addressed and incorporated in development plans. This calls for a need to undertake research to get a clear understanding of poverty-environment linkages, and how sustainable development can be achieved with good environmental management.

Environmental economics is concerned with the impact of the economy on the environment, the significance of the environment to the economy, and the appropriate way of regulating economic activity so that balance is achieved between environmental sustainability and other social goals. The essence of the environmental problem is the economy – producer behaviour and consumer desires. Without the economy, most environmental issues are simply research questions of concern to chemists or biologists with no policy significance. Hence there is a need to have detailed studies on these in order to carry out informed policy decisions.

Trans-boundary environmental research issues have been discussed in detailed in the other sections.

There is need to research for effective environmental governance mechanisms appropriate for the LVB- that is, policy legal and institutional framework for sustainable management of LV environment, principles for management, impact and risk assessment, prevention and control of pollution, waste management, environment quality standards, public participation, compliance and enforcement. For example research is needed to design Lake Victoria wetlands policy (LVEMP, 2005b).

2.10.5 Major Research Capacity Building Needs

Capacity to carry out research on community participation, community mobilisation, gender analysis, environmental governance relevant to the Lake Basin need to be built. This capacity building is in terms of new methodologies, research skills, creation of databases of research information which are regularly updated and widely and flexibly accessible.

Table 2.22 Provides a summary of cross cutting issues research needs.

Table 2.21: Crosscutting Issues - Research Conducted

Type of Research Conducted	When Conducted	Research Institutions (involved in the research)	Key Research Findings/Lessons
Community Participation	1996 - 2005	LVEMP; SUDA, CA (2000)	• Community participation is extremely important in ensuring sustainable environmental management • More research needed to assess impacts of community participation and to design effective community participation approaches and mechanisms
Gender aspects	2000-2005	LVEMP; SUDA, CA (2000)	• Gender issues are increasingly through research in Tanzania. However, research studies focused on the LVB are rather few. • Existing findings have underscored the important contribution of taking a gender perspective to LVB environment management • There is need for a thorough Gender Roles research since available information is too scanty to provide any insight on gender roles and responsibilities in the community and in implementing LVEMP activities.
Social cultural issues	2000- 2006	LVEMP (TDA Report); SUDA, CA (2000); NEMC	• Certain social and cultural aspects are key to sustainable development of the LVB. For example the influx of refugees from neighbouring war-affected countries has significant negative impacts on the environment and upset the existing social framework in the communities12. There are also a number of social and cultural norms and values that govern sustainable utilisation of natural resources in some communities in the LVB. These must therefore be studied and documented for future use in the planning process.
Governance issues	2006	LVEMP (TDA	• There is very limited research on governance issues related to LVB although such issues are

[12] Centre for Study of Forced Migration, UDSM. 2003. The Impact of the Presence of Refugees in Northwestern Tanzania. Commissioned by Africare, Concern, Oxfam GB and Tanzania Christian Refugees Services, Tanzania.

		Report)	seen as being quite critical for sustained efforts to ensure sustainable and integrated development of the basin.
Poverty and Environment	1996- 2006	LVEMP REPOA	• There is need to undertake research to get a clear understanding of poverty-environment linkages, and how sustainable development can be achieved with good environmental management in the LVB. This is in line with the National Strategy for Growth and Reduction of Poverty (MKUKUTA)
Environmental Economics	1996-2006	LVEMP	• The LVB is rapidly facing intense economic activities and research is needed to inform their impact on the environment. But without socially bearable amount of resource extraction, sustainability[13] of environmentally economic growth will be impossible.

Table 2.22: LVB Cross-Cutting Aspects - Research Needs

Sub-Research Area/Theme			Research Needs/Gaps			Research Capacity Gaps			Remarks
No	Area	Priority	No	Need/Gap	Priority	No		Priority	
1.	Community Participation	High	1	Effective methodologies for community participating	High	1	Inadequate research skills especially at the local level	High	
			2	Assessment of CP impacts	High	2	Inadequate information	Moderate	
2.	Gender aspects	High	1	Gender methods	Moderate	1	Inadequate gender research skills	High	
			2	Gender roles	High	2	Inadequate information	High	
			3	Gender impacts	High				
			4	Gender mainstreaming	High				
			5	Gender and resources management	High				
3.	Social cultural issues	High	1	Cultural values and beliefs in relation to sustainable resource use	High				
			2	Conflict over use and management of resources	High				
			3	Demographic trends and sustainable utilization of resources	Moderate				
			4	Urbanization and its impacts	High				

[13] Kolstad, C. D. (2000) "Environmental Economics" Oxford University Press. New York

Sub-Research Area/Theme			Research Needs/Gaps			Research Capacity Gaps			Remarks
No	Area	Priority	No	Need/Gap	Priority	No		Priority	
4.	Poverty and Environment	High	1	Factors linking poverty to environmental stress	High				Work closely with MKUKUTA Secretariat, NEMC and REPOA
			2	Indigenous/local knowledge systems for sustainable environmental management and poverty reduction	High				
			3	Best practices for environmental conservation and livelihoods improvement	High				
			4	Poverty - environment relationship indicators	High				
			5	Decision support tools for pov-env assessment in LVB (GIS, SIA, EIA and SEA)	Moderate				
5.	Environmental Economics	High	1	Sustainable production and consumption	High	1	Inadequate research skills in environment economics	High	
			2	Costing of environmental management interventions	High	2	Inadequate environmental economics data	High	
			3	Environmental economic instruments (market based and fiscal)	High				
			4	Environmental accounting	High				
6.	Environmental Governance	High	1	Effectiveness of existing policies and laws	High	1	Environment governance research skills	High	Work closely with NEMC
			2	Effective institutional arrangements	High	2			

Sub-Research Area/Theme			Research Needs/Gaps			Research Capacity Gaps			Remarks
No	Area	Priority	No	Need/Gap	Priority	No		Priority	
			3	Effective/efficient environmental information management	High				
			4	Effective environmental monitoring and evaluation (frameworks, tools)	High				

CHAPTER 3: LVB APPLIED RESEARCH AGENDA

3.1 *Introduction*

The agenda for LVB research is an intended contribution towards efforts aimed at conservation and sustainable development. The agenda provides guidance and motivation for research whose results will make substantial and relevant impacts on formulating policies, action plans and strategies with regards to environmental conservation and related socio-economic development. It thus aims at promoting informed decision making in the overall development agenda of the basin. In achieving this, it focuses on the need to improve research coordination, information sharing as well as prioritizing research that enhances growth and reduction of poverty.

3.2 *LVB Applied Research Vision*

Decisions and plans for sustainable development, growth and poverty reduction in the Lake Victoria Basin are increasingly informed by sound research data.

3.3 *Priority Research Areas and Implementation Strategies*

3.3.1 Specific Research Issues

Research that is targeted at the needs of the LVB has to focus on the following specialised priority areas:

1. Fisheries Research and Management
2. Water Resource Management
3. Atmospheric deposition of phosphorus and meteorology
4. Aquatic weeds including hyacinth
5. Forests, Wetlands and Watershed Management, Soil and water Conservation
6. Pests and Diseases
7. Waste Management
8. Economic Growth, Private Sector and Sustainable Market Driven Development
9. Cross- cutting issues

For each of the priority areas, key research themes have been identified in the in Table 3.1. It is expected that researchers and research institutions will be guided by these themes when formulating research projects and programmes.

Table 3.1: Research Themes for Fisheries Research and Management

S/N	Priority Research Theme	Priority Research Issues
1	Sustainability of target species	• Development of recruitment indices for key species
		• Understanding of the ways in which exploited stocks (e.g. Nile tilapia, Dagaa) may respond as they are fished down
		• Understanding of behavioural, reproductive and limnological influences on recruitment
		• Determination of movement rates and patterns of major fish species, within and between the lake and rivers
		• Continued refinement of existing stock assessment methods, particularly developing models that include finer spatial resolution
		• Evaluation of current and alternative methods to assess the stock structure and migratory dynamics of key species, as appropriate
2	Sustainability of fish habitats and	• Application of GIS-based habitat mapping methods for monitoring of important habitats

S/N	Priority Research Theme	Priority Research Issues
	the ecosystem	• Introduction and development of innovative technologies such as stable isotope analysis, otolith microchemistry and real-time data acquisition of environmental parameters to help identify relationships between fish and their supporting ecosystems
		• Identification of key ecosystem indicators and development of cost-effective monitoring protocols
		• Determination of the trophic relationships within key commercial and artisanal fisheries
		• Development of ecological modeling capabilities and approaches that have predictive capacity
		• Development of meaningful and practicable ecosystem indicators, reference points and performance measures for key species and fisheries
3	Aquaculture	• Development of more efficient and economical feeds and feeding strategies
		• Development of programmes to ensure maintenance of the genetic diversity of broodstock
		• Development of closed life cycles for high-value species
		• Development of more efficient growout and husbandry methods
		• Development of systems to enhance agri-aquaculture production
		• Development of environmental indicators, reference points and performance measures for aquaculture operations
		• Development of guidelines and protocols for assessing potential aquaculture sites
		• Assessment of the carrying capacity of terrestrial and aquatic systems in relation to the impact of aquaculture activities

Table 3.2: Research Themes for Water Resource Management

No	Theme	Priority Research Issues
1.	Nutrient input to the lake	• Partitioning sources of nutrients from the catchment
		• Benthic regeneration of nutrients
		• Significance of atmospheric deposition of nutrients
		• Nutrient levels and potential sources of aquatic weeds
2.	Eutrophication	• Influence of anaerobiosis on fish behaviour
		• The role of nitrogen fixation in nutrient budget
3.	Lake productivity and Phytoplankton blooms	• Studies on new and regenerated production
		• Strategies for enhancing Lake productivity.
		• Studies on algal toxins
4.	Bio-indicators of pollution	• Search for Bio-indicators
5.	Hydraulic condition	• Influence of thermal stratification on fish behaviour
6.	Sedimentation, palaeoclimatology and pollution history	• Estimation of sedimentation rates
		• Tracing pollution history of the lake
		• Establishment of palaeoclimate
7.	Persistent pollutants	• Biogeochemistry of mercury in the Lake.
		• Assessment of pollution retention ability of soil types
		• Fate of organochlorine pesticides in the lake basin
8.	Groundwater	• Assessment of groundwater quantity and quality

No	Theme	Priority Research Issues
	resource evaluation	• Determination of recharge capacity of major aquifers
		• Establishment of groundwater dynamics in the lake basin

Table 3.3: Research Themes for Atmospheric deposition of Phosphorus and Meteorology

No	Priority Research Theme	Priority Research Issues
1	Wet deposition of Nitrogen and Phosphorous	• The effects of nitrogen fixation by blue-green algae
		• Assessment of magnitude of nutrient loading from wet atmospheric depositions
		• Source characterisation
		• Assessment of source and magnitude of transboundary deposition
2	Dry deposition of Nitrogen and phosphorous	• Effect of land use changes (population pressure, deforestation etc.)
		• Assessment of magnitude of nutrient loading from dry atmospheric deposition
		• Source characterisation
		• Assessment of source and magnitude of transboundary deposition
3	Atmospheric deposition of other pollutants	• Assessment of magnitude of other pollutants loading (especially heavy metals) from atmospheric deposition
		• Source characterisation
		• Assessment of source and magnitude of transboundary deposition
4	Meteorology	• Impact of climate change on LVB ecosystem
		• Continuous monitoring of metrological parameters
		• LV mass balance updating

Table 3.4: Research Themes for Aquatic Weeds

No	Priority Research Theme	Priority Research Issues
1	Water hyacinth	• Characterization of water hyacinth at molecular level in the Lake basin
		• The causes and dynamics of resurgence and proliferation of water hyacinth
		• Succession of water hyacinth
		• Persistence of water hyacinth in hot spot areas
		• Assessment of socio-economic and environmental impacts of water hyacinth
		• Improved ways of managing the water hyacinth
2	Weevils	• Life cycle of weevils
		• Ecological factors influencing performance of weevils in the lake Victoria basin
3	Bio-control agents	• Search for Alternative bio-control agents
4	Other aquatic weeds	• Occurrence, threats and appropriate control measures of other aquatic weeds, such as Azolla and Trapa natans
5	Eutrophication	• Regional development practices that significantly contribute to eutrophication
		• Transboundary driving factors behind nutrient loading into the Lake
		• Influence of social economic developments and needs on nutrients loading into the lake
		• Influence of the attitudes and behavior of riparian communities on eutrophication of the lake

No	Priority Research Theme	Priority Research Issues
		• Extent and volume of nutrients sources, especially Nitrogen and Phosphorous
		• Regional integrated methods for controlling water hyacinth proliferation
		• Extent of cross boarder recharge of fresh water hyacinth into the lake

Table 3.5: Forests, Wetlands and Watershed Management, Soil and Water Conservation: Priority Research Themes and Needs

1- Forestry Management

S/N	Priority Research Theme	Priority Research Issues
1.1	Impact of Globalization	• Targeted species & quantities of forest products involved in export market from LVB and effect to the environment and livelihood of local communities
1.2	Wood energy	• Quantity of wood consumed by different stakeholders in terms of charcoal & firewood in urban and rural areas
		• Production capacity of existing forests of existing forests
		• Wood energy conservation technologies (improved kilns, charcoal & fire stoves)
1.3	Tree species site matching	• Assessment of tree species suitable for different ecological zones.
		• Impacts of existing tree species planted in inappropriate ecological zones.
		• Appropriate tree species for vegetation restoration
1.4	Appropriate Agroforestry Systems in subcatchments	• Agroforstery systems used in the LVB
		• Potential of agreforest systems in meeting household needs
		• Constraints facing available systems and possible improvements
1.5	Forest Inventory/ Forest stock Assesment	• Establishment of the rate of natural vegetation regeneration in the region for various tree species
		• Determination forest growth
		• Assessment tree species diversity
		• Assessment of tree damage
		• Assessment of occurrence of fire
		• Assessment of forest encroachment
1.6	Surface runoff	• Determination surface run-off and soil erosion in forest areas
		• Assessment water infiltration capacity

2- Wetlands and Watershed management

S/N	Priority Research Theme	Priority Research Issues
2.1	Wetlands Biodiversity	• Research on the biodiversity of wetlands in different localities in the basin • Assessment of impact of human activities on wetland biodiversity (i.e., grazing, bush fire, shifting cultivation) • Biodiversity search on the restoration of wetland plants of socio-economic importance • Effects of soil erosion on wetlands biodiversity
2.2	Social - Economic	• Economic valuation of lake Victoria wetlands

S/N	Priority Research Theme	Priority Research Issues
	aspects of lake Victoria wetlands	• Socio-economic and cultural aspects of wetlands communities and their impact on wetlands utilization Guidelines and preliminary investment proposals for wetland rehabilitation and artificial wetland construction • Alternative projects/interventions that will reduce dependency to wetlands •
2.3	Buffering capacity of major LVB wetlands	• Determining buffering capacity of major wetlands • Wetland hydrology studies • Predictive model to determine response of wetlands to various pressures/threats • Modeling of spatial and temporal degradation of lake Victoria fringing wetlands •
2.4	Long term changes of major wetlands	• Mapping wetland coverage in different years in order to detect changes • Changes of vegetation communities in selected major wetlands of Lake Victoria for the past 20 years • Carrying capacity of major lake Victoria wetlands • Application of remote sensing and GIS for land use/cover studies in major wetlands

3. Soil and Water Conservation

S/N	Priority Research Theme	Priority Research Issues
3.1	Scaling up of SWC measures over wider areas (subcatchment)	• Land degradation is still a serious threat to LVB. Land conservation measures need to be enhanced and expanded to cover other parts. The measures adopted in the pilot areas need to be scaled up. • Effectiveness of soil and water conservation can be achieved by using a combination of practices e.g. contours bund farming, tie-ridging and farmyard manure.
3.2	Water harvesting	• water harvesting/irrigation technologies
3.3	Improved agriculture	• Agro-forestry/cover crops • Management of agricultural inputs • Assessment of soil and water resources • Assessment of farming systems
3.4	Improved livelihood in rural areas	• research on livelihood issues such as alternative energy sources that are environmentally friendly, changes in livelihood patterns
4	**Land Use and Sedimentation**	
4.1	Landuse	• Trends in temporal land cover/use changes so as to identify hotspot areas for intervention
		• Management of micro-catchments in the river basins
		• Effect of micro-catchments on river hydrology
		• Influence of social economic developments and needs of riparian communities on regional land use change
		• Assessment of pollution levels associated with various human activities (e.g. mining, illegal fishing by using chemicals)
4. 2	Conflict Resolution	• Research on different types of conflicts and conflict resolution measures
		• Land tenure systems and natural resources management
		• Basin wide water resources management

4.3	Social Impacts/livelihoods	• Establishing the relative contribution of different natural resources to community livelihood in the basin
		• Establishing the distribution of heavy metals in the different portions of the environment (water sources, food growing areas, etc)
		• Market research of wetlands products as an approach towards poverty reduction strategy in rural areas

5. Indigeneous Knowledge

S/N	Priority Research Theme	Priority Research Issues
5.1	Indigenous Technical knowledge (ITK)	• ITK used in natural resources management
		• Applicable ITK in forest cover improvement
		• Potentials and Constraints of the system and improvements required
		• Indigenous knowledge in Wetlands and Wetlands Resources management

Table 3.6: Pests and Diseases: Priority Research Themes and Needs

S/N	Priority Research Theme	Priority Research Issues
1	Human Diseases	• Best approach to self medication to treat malaria
		• Study on the health impacts of ITNs
		• Studying causes of the observed malnutrition and intervention measures.
		• Study of effective modalities to translate HIV/AIDS knowledge into concrete behavior change.
2	Crop Pests and Diseases	• Study the extent of crop pests and diseases as well as their impacts.
		• Breed for cassava varieties resistant to cassava pests and diseases but with farmer desired qualities
		• Alternative control measures of pests including promotion of predators of banana weevils and nematodes
		• Banana varietal differences in resistance and or tolerance to banana wilt disease
		• Study of regional patterns of pests
3	Livestock diseases	• Alternative/back-up disease control measures and mechanisms
		• Extent of zoonotic livestock diseases and plant pests and their impacts
		• Appropriate feed resources and feeding systems
4	Transboundary Impacts of pests and diseases	• Development practices (within all riparian countries) which significantly contribute to transboundary disease burden
		• Study of regional pattern of pests
		• The driving factors for transboundary diseases transmission within the region
		• Influence of social economic developments and needs on disease transmission
		• Extent of resistance of target vector in the region
		• The climate change impact on regional pest trends

Table 3.5: Research Themes for Waste Management

Priority Research Theme		Priority Research Issue
1.	Solid Waste Management in LVB	• Intergrated Solid Waste Management in the LVB towns and municipalities
		• Energy recovery from solid waste
		• Processing of fisheries waste into useful by products
		• Processing of fish heads "mapanki" for human consumption
2	Decentralised systems for domestic and industrial wastewater treatment	• Constructed Wetlands should be used for decentralized treatment in combination with Communal Septic Tanks or Stabilization Ponds.
		• Integrated Algal Ponding System (IAPS) for LV basin.
		• Soft and appropriate technologies for industrial wastewater (with emphasis on fish processing, textile manufacturing and beverage industries)
3	Sanitation for the Unplanned Urban and Rural Areas	• Condominial sewer system for unplanned urban areas of LVB
		• Promoting affordable VIP latrines for use in the LV basin.
		• Standards for placement of latrines in relation to water wells
4	Waste oil management	• Waste oils handling, treatment and reuse in the LVB.
5	Cleaner Production	• Promoting Cleaner Production in LVB

Table 3.6: Research Themes for Economic Growth, Private Sector and Sustainable Market Driven Development Research

No	Priority Research Theme	Priority Research Issue
1	Improvement of Land Productivity and Farming systems	• Development and promotion of improved seeds adapted to the semiarid and other agro-ecological conditions of the lake basin
		• Management of agrochemicals
		• Prevention of soil erosion and soil load in the water systems and improvement of soil fertility
		• Soil and water conservation measures over a large pilot area (river basin)
		• Suitability/performance of different crops under different soil and water conservation measures.
		• Upgrading of farming technologies
		• Gender access to emerging technological innovations
2	LVB Indigenous knowledge for economic growth	• Indigenous knowledge for soil and water conservation in the Lake Victoria basin.
		• Sustainable Management and Promotion of traditional woodlot 'ngitiri'
3	Water Harvesting and Water Abstarction	• Development of Sustainable rainwater harvesting techniques for livestock and agriculture
		• Appropriate technologies for drawing and distributing water for irrigation (windmill vs mechanical pumps, proper design of delivery channels etc)
		• Water abstraction techniques and their socio- economic and environmental impact
4	Post harvest handling, processing and Value addition	• Appropriate harvesting, storage and preservation methods for common food crops i.e cassava, sweet potatoes.
		• Diversification of food products from common food crops (banana, cassava, sweet potatoes)
		• Economical Scale Solar dryers for agricultural products and fish (dagaa) drying
		• Improvement of agro-processing of milk products (cheese and margarine) and milk collection infrastructure (collection points and cold mobile)

No	Priority Research Theme	Priority Research Issue
		• Development of appropriate fish preservation technologies for artisanal fisheries
		• Fish Processing diversification for local consumption
		• Capacity building among the fisher folk to reduce post harvest losses
		• Development of fish marketing systems for fisherfolks
4	Improvement of livestock productivity	• Development and promotion of zero grazing technology in LVB
		• Improvement of domestic livestock breeds.
		• Develop cross-breeding of available diary animals (cows and goats) to improve local animals
		• Create appropriate management practices for animals(feeding and health).
5	Improvement in Small Scale Mining	• Development of appropriate technologies to assist artisanal miners in exploration, mining and processing
		• Development of appropriate technologies for environmental management in small scale mining operations (e.g. use of retort where mercury is used for extraction of gold etc.)
6	Development and Improvement of Energy Systems and Sources for LVB	• Research on alternative sources of energy so as to reduce dependence on wood fuel and manure
		• Energy conservation technologies (Jiko Bora)
		• Renewable energy technologies (solar, wind)
		• Promotion of Biogas use in LVB
		• Biofuels (bio-dieasel, gasohol, co-generation)
		• Development of pilot historical sites under private public partnership arrangement
		• Comanagement of touristic sites
8	Innovative Clusters for the major production sectors of LVB	• Establishment of baseline data for the existing clusters
		• Assessement of strengths and weaknesses of anticipated cluster initiative
		• Awareness creation on the concept of Clusters (change of mindset)
		• Introduction of Innovative Clusters Concept for the Fishing, Artisanal Fish Processing, Horticulture growers, Handcraft makers, Dairy Processing and Agro Processing Bio energy

Table 3.9: LVB Cross-Cutting Aspects: Priority Research Themes and Issues

No	Priority Research Theme	Priority Research Issues
1	Community Participation Gender aspects	• Effective methodologies for community participation
		• Assessment of CP impacts
2	Gender aspects	• Gender methods
		• Gender roles
		• Gender impacts
		• Gender mainstreaming
		• Gender and resources management
3	Social cultural issues	• Cultural values and beliefs in relation to sustainable resource use
		• Conflict over use and management of resources
		• Demographic trends and sustainable utilization of resources
		• Urbanization and its impacts
4	Poverty and	• Factors linking poverty to environmental stress

No	Priority Research Theme	Priority Research Issues
	Environment	• Indigenous/local knowledge systems for sustainable environmental management and poverty reduction
		• Best practices for environmental conservation and livelihoods improvement
		• Poverty -environment relationship indicators
		• Decision support tools for pov-env assessment in LVB (GIS, SIA, EIA and SEA)
5	Environmental Economics	• Sustainable production and consumption
		• Costing of environmental management interventions
		• Environmental economic instruments (market based and fiscal)
		• Environmental accounting
6	Environmental Governance	• Effectiveness of existing policies and laws
		• Effective institutional arrangements
		• Effective/efficient environmental information management
		• Effective environmental monitoring and evaluation (frameworks, tools)

3.3.2 Research Capacity Building

Table 3. indicates the key research capacity building interventions which are needed to facilitate effective and efficient implementation of the LVB Research Agenda. Implementation of the interventions will be coordinated by the LVEMP/LVBMA(T) but all key stakeholders especially research and training institutions will be expected to participate by including the relevant ones in their research plans.

Table 3.10: LVB Research Capacity Building Interventions

S/N	Research Area	Capacity Building Interventions
1.	Fisheries Management	• Increase the ICT facilities of research institutions in fisheries management predictive models and databases management • Train fisheries staff in research methodology and data analysis. • Enhance the capacity of stakeholder institutions (equipment and skills) in fisheries data collection and frame surveys. • Procure field and lab equipment (including fish tracking equipment)
2	Water resources management	• Update, upgrade and increase water resources management research facilities. • Train water resources management staff in research methodology, modern data collection and data analysis.
3	Atmospheric deposition of phosphorus and meteorology	• Procure/provide special sampling equipment for dry deposition • Procure/provide increased monitoring equipment and instruments to all meteorology monitoring stations • Establish river gauging stations for all un-gauged catchments • Train research staff in key stakeholder institutions research methods appropriate for atmospheric deposition and meteorology
4	Aquatic weeds including hyacinth	• Recruit adequate research staff with skills to work in the area of aquatic weeds including the water hyacinth • Train exist staff in modern research methods in the area of aquatic weeds (e.g., expertise in modeling and use of remote sensing and GIS techniques, appropriate research methods for trans-boundary assessments, etc.)
5	Forests, Wetlands and Watershed Management, Soil and water	• Undertake training needs assessment • Train of research scientists at different levels • Train technicians in data collection and analyses techniques (laboratory and data)

S/N	Research Area	Capacity Building Interventions
	and water Conservation	• Sensitize various stakeholders including local communities on the role of research in environmental management • Equip existing (strategic) laboratories in the country with appropriate equipment for research in forests, wetlands and watershed Management, soil and water Conservation
6	Pests and Diseases	• Update and upgrade facilities appropriate research in pests and diseases • Train staff in research methodology, modern pests and diseases data collection and data analysis appropriate for pests and diseases issues
7	Waste Management	• Training of laboratory personell in advanced analytical skills • Replacement of old/obsolete analytical equipment
8	Economic Growth	• Train communities, especially women (individuals and groups) in construction of low firewood and charcoal consumption stoves
9	Cross- cutting issues	• Cross-cutting issues of environmental governance, information management, gender aspects, HIV/AIDS, indigenous knowledge and poverty
10	General Capacity Building Needs	• Comprehensive mapping of research institutions and researchers relevant to the LVB Research Agenda • Conduct a broad research training needs assessment • Conduct and document comprehensive research capacity assessment focused on all key research institutions • Train and sensitize decision makers on using LVB research data in informing policies and decisions • Train of scientists on scientific information packaging and dissemination strategies • Provide modern facilities for documenting, packaging and disseminating research related to the LVB Research Agenda • Promote sharing of research laboratories, equipment and staff • Step up LVEMP/LVBMA(T) and research institutions' measures to mobilize funding/resources for research

3.4 Funding Strategies

The LVB Research Agenda has been translated into an LVB Research Programme (See Chapter 4). Funding and implementation of the Research Agenda/Programme will require the collective efforts of all key stakeholders and well-wishers of the LVB. The LVEMP/LVBMA (T) will therefore promote the Research Agenda/Programme widely amongst the stakeholders.

The LVB Commission is expected to fund some elements of research programme from its regular annual budgets. The LVEMP/LVBMA(T) will take steps to advocate for predictable and significant allocation of funds for research by the LVB Commission.

The LVEMP/LVBMA(T) will take concrete steps to convince research institutions in the country to include activities in the LVB Research Agenda/Programme in their research plans and budgets.

The funding of the LVB Research Agenda/Programme is expected to be through support from the development partners, which have worked closely with LVEMP since its inception. These include the World Bank, and Governments of Sweden, Norway, and Finland.

The Government of Tanzania, in addition to continued recurrent budget and moral support, will be approached to fund some of the components/sub-components of the Programme. This will take place through the EAC framework. Furthermore, as LVEMP's fund-raising measures take roots, some funding is also expected to be raised from the private sector and local institutions in support of the Programme.

CHAPTER 4: APPLIED RESEARCH PROGRAMME FRAMEWORK

4.1 Introduction

The design of the new LVB Research Programme for the period 2007 – 2011 includes the long term goal of LVB, the research programme purpose and programme components. It also includes detailed implementation action plans for each research programme component. The programme is one of the important mechanisms for implementing the LVB Research Agenda which was presented in Chapter 3.

4.2 Programme LFA Matrix and Implementation Action Plan

4.2.1 Overall Programme Goal

The overall, long-term goal of the research programme is:

Sustainable development, growth and poverty reduction of the LVB achieved

4.2.2 Programme Purpose

The purpose of research programme's purpose is:

Increased availability of sound research data to facilitate informed decisions and plans for sustainable development, growth and poverty reduction in the LVB

4.2.3 Overall Programme Logframe Matrix

Table 4.1 contains the research programme's logframe matrix. This matrix essentially provides a summary of the design of the programme. In addition to the overall goal, purpose and components of the programme, the matrix shows the main projects to be implemented under each component. It presents the list of measurable indicators for monitoring and evaluation of the overall goal, purpose and components. It also includes the verifiable sources of information for each indicator and the major assumptions underlying the programme design.

4.3 Component Level Logframe Matrices

Tables 4.2 – 4.10 provide the programme components' logframe matrices. They show for each research component, the main research projects to be pursued, implementation time frame, key actors to be involved in each component, list of key resources needed and indicative costs.

The Department responsible for research coordination at LVEMP/LVBMA (T) will identify and contract experts to develop detailed and comprehensive proposals on the proposed research projects in the programme framework (See Table 4.2-4.10). These proposals will then be either submitted to interest funders or funded by resources mobilized by LVEMP/LVBMA (T).

On the basis of Tables 4.2- 4.10 the **overall programme cost is US$ 12,311,000** as summarized in Table 4.11. This amount includes a 10% surcharge to cover efforts to prepare detailed research proposals and looking for funds.

Table 4.1: Overall Logical Framework for LVB Research Programme: 2007 – 2011

OBJECTIVES (HIERARCHY)	INDICATORS	MEANS OF VERIFICATION	ASSUMPTIONS
OVERALL GOAL			
Sustainable development, growth and poverty reduction of the LVB achieved	• Use environmental and socio-economic indicators defined in M&C Framework[14] •	Refer to the M&C Framewor for the indicators and respective data sources	Political will and commitment continues The LVB Monitoring and Communication System is operational and captures the information listed in column 2 – at all levels of this framework
PROGRAMME PURPOSE			
Increased availability of sound research data to facilitate informed decisions and plans for sustainable development, growth and poverty reduction in the LVB	• Number of research dissemination workshops/fora • Number of research reports on LVB disseminated • % of key decision makers in Government and private sector indicating that they have access to needed research data • % of Government and stakeholders decisions based on research undertaken on the LVB	• LVEMP/LVBMA(T) Research Monitoring and Evaluation reports • Proceedings of research conferences and workshops	Strong commitment by decision makers and other LVB stakeholder to use research data in informing decisions and policies
PROGRAMME COMPONENTS			
1. Fisheries Research and Management **Objective:** To generate information for	*Primary productivity* • Nutrients • Oxygen • Secchi depth • Temperature • Primary production (Chl-a)	• LVEMP/LVBMA(T) Research Monitoring and Evaluation reports • Institutional research reports • Proceedings of	• Funds will be available to implement the research agenda. • Information produced through the research

[14] LVEMP (2006): Monitoring and Communication Framework

OBJECTIVES (HIERARCHY)	INDICATORS	MEANS OF VERIFICATION	ASSUMPTIONS
sustainable exploitation and management of the Lake Victoria fisheries	• Species composition of micro algae *Secondary productivity* • Lake flies (abundance) • *Caridina* (abundance) • Zooplankton (abundance) *Biodiversity, community, food web* • Species composition (experimental trawls) • Slope of the biomass size spectrum *Life history* • Mean size, maximum size, length frequency • Growth parameter estimates • Length at 50% maturity *Stock* • Experimental catch rates (trawls, gillnets) by species • Fishery catch rates (by species) *Catch and effort* • Catch • Effort (nr. fishermen, boats, types of gear) • Spatial distribution of fishermen • MSY estimates *Social and economic* • Contribution of the fisheries to GDP • Contribution Nile perch to domestic food supply • Export volumes and values • % level of education by age group • Total earnings in the fishery • Per capita fish consumption • Landing sites and	research dissemination conferences and workshops	activities will be used to inform managers of the fisheries resources in Lake Victoria. • Cooperation among institutions working within Lake Victoria basin will be forged to optimize utilization of project resources.

OBJECTIVES (HIERARCHY)	INDICATORS	MEANS OF VERIFICATION	ASSUMPTIONS
	factories *Control and surveillance, co-management, fish quality assurance* • Number of BMU's • Enforcement statistics • Number of inspectors at landing sites • Number of certified landing beaches *Aquaculture* • Number of technologies generated (feeding regimes, pond siting, cultures developed, cultured species) • Number of farmers adopting generated technologies • Number of fry produced and distributed per annum • Fish yield per unit area and per annum • Total number/area of ponds		
2. Water Resources Management **Objective:** Enhanced quality and quantity of Lake water for ecological function and other beneficial uses	• Nutrients level • Dissolved oxygen level • Secchi depth • Primary productivity level • Chemical pollutants concentrations • Water level • Sedimentation rate	• LVEMP/LVBMA(T) Research Monitoring and Evaluation reports • Institutional research reports • Proceedings of research dissemination conferences and workshops	• Strong commitment by decision makers to use research data in informing decisions and policies • Co-operation of research institutions and other stakeholders will be there

OBJECTIVES (HIERARCHY)	INDICATORS	MEANS OF VERIFICATION	ASSUMPTIONS
3. Atmospheric Deposition of N and P **Objectives:** ○ Improved understanding of factors, extent of wet and dry deposition of N and P ○ Development of management strategy for wet and dry deposition of N and P	• Number of researchers • Number of research reports • Number of papers published • Management strategies in place • Quantity of needed research facilities acquired • Number of research staff trained in line with established needs • Number of research proposals received • Number of new research projects funded/initiated • Total number of on-going research projects – disaggregated in terms of those funded through LVEMP and those funded by institutions and	• LVEMP/LVBMA(T) Research Monitoring and Evaluation reports • Institutional research reports • Proceedings of research dissemination conferences and workshops	• Co-operation of research institutions and other stakeholders will be there • LVEMP/LVBMA(T) capacity to coordinate will be adequate
2. Atmospheric deposition of heavy metals **Objectives:** ○ Improved understanding of factors, extent of atmospheric deposition of heavy metals ○ Developing management strategy for heavy metal atmospheric deposition			

OBJECTIVES (HIERARCHY)	INDICATORS	MEANS OF VERIFICATION	ASSUMPTIONS
3. Meteorology **Objectives** ○ Improved understanding of impact and extent of climate change on LVB ecosystem including resources ○ Improve understanding of vulnerability and adaptation to climate change ○ Develop management strategies of the factors influencing climate change ○ Improved monitoring of metrological parameters ○ Updating of LV mass balance	institutions and other means		
5. Aquatic weeds including water hyacinth **Objective:** Improved understanding of the status, impacts and control of aquatic weeds	• Number of research reports • Number of published papers • Number of researchers • Management strategies in place • Alternative bio-control agents identified • Number of research staff recruited • Number of research staff trained • Number of BMUs established and trained • Number of research equipment acquired • Number of new research projects initiated/funded • Reduced levels of infestation	• LVEMP/LVBMA(T) Research Monitoring and Evaluation reports • Proceedings of research dissemination conferences and workshops • Individual and institutional research reports	• LVEMP/LVBMA(T) will have adequate capacity to coordinate the research • Cooperation of research institutions and other stakeholders, e.g. communities, will be there.

OBJECTIVES (HIERARCHY)	INDICATORS	MEANS OF VERIFICATION	ASSUMPTIONS
Forests, Wetlands and Watershed Management, Soil and water Conservation **Objectives:** Improved understanding on how to manage the Forests, Wetlands and Watershed Management, Soil and water Conservation	• Quantity of needed research facilities acquired • Number of research staff trained in line with established needs • Number of research proposals received • Number of new research projects funded/initiated • Total number of on-going research projects – disaggregated in terms of those funded through LVEMP and those funded by institutions and other means • Number of research projects completed • Number of research reports published	• LVEMP/LVBMA(T) Research Monitoring and Evaluation reports • Institutional research reports • Proceedings of research dissemination conferences and workshops	• Co-operation of research institutions and other stakeholders will be there • LVEMP/LVBMA(T) capacity to coordinate will be adequate
Pests and Diseases **Objectives:** • Improved understanding of the extent of pests and diseases related to human health, crops and livestock and their impacts • Developing management strategy and alternative control measures for addressing the problems	• Total number of on-going research projects – disaggregated in terms of those funded through LVEMP and those funded by institutions and other means • Number of research projects completed • Number of research reports published	• LVEMP/LVBMA(T) Research Monitoring and Evaluation reports • Institutional research reports • Proceedings of research dissemination conferences and workshops	• Co-operation of research institutions and other stakeholders will be there • LVEMP/LVBMA(T) capacity to coordinate will be adequate

Waste Management **Objectives:** • Improved waste management in LVB	• • Number of towns adopting ISWM strategies • Number of successful useful products recovered	• Scientific Reports • Progress Reports	

• Improved access to waste treatment technologies • Improved awareness on waste management	from fish waste • Number of new soft technologies developed for Industrial wastewater treatment • Number of decentralized waste treatment systems adopted		
Economic Growth, Private Sector and Sustainable Market Driven Development **Objectives:** • Improved incomes • Improved involvement of the private sector in development activities	• Number of Scientific publications • Number of technologies developed • Number of technologies adopted • Number of reports •	• Scientific Reports • Progress Reports	
Cross-Cutting Aspects **Objective:** • Improved practical understanding of community participation, gender, socio-cultural, poverty, economics and governance aspects of LVB environmental management	• Number of active research institutions/researchers • Number of research reports • Number of papers published • Number of policies, plans, laws informed by research under this component • Number of research staff trained in line with established needs • Number of research proposals received • Number of new research projects funded/initiated • Total number of on-going research projects – disaggregated in terms of those funded through LVEMP and those funded by	• Annual research reports of LVEMP • Journals • Conference proceedings	

	institutions and other means • % of implementers of environmental management aware of/using new research evidence regarding community participation, gender, socio-cultural, poverty, economics and governance aspects of LVB environmental management		

Research Components' Log Frameworks

Table 4.2: Research Component 1: Fisheries Research and Management

S/N	Research Project	Project Objectives	Project Measurable Indicators	Key Project Research Activities/Interventions	Time Frame (Year)					Estimated Costs (in US$)	Key Research Institutions
					1	2	3	4	5		
1	Investigations into the sustainability of target species	• To gain understanding on the ecology of target species • To refine stock assessment methods	• Number of research proposals • Number of research reports • Number of published papers • Number of new models	1. Developing recruitment indices for key species						20000	TAFIRI, FAST (UDSM)
				2. Improving understanding of the basic biology of less abundant species						40000	TAFIRI, FAST (UDSM)
				3. Understanding of the ways in which exploited stocks (e.g. Nile tilapia, Dagaa) may respond as they are fished down						30000	TAFIRI, FAST (UDSM)
				4. Identifying under-utilised fish resources						30000	TAFIRI, FAST (UDSM)
				5. Understanding of behavioural, reproductive and limnological influences on recruitment						35000	TAFIRI, FAST (UDSM)
				6. Determining movement rates and patterns of major fish species, within and between the lake and rivers						30000	TAFIRI, FAST (UDSM)
				7. Investigating the potential of restocking to rehabilitate depleted fish stocks						20000	TAFIRI, FAST (UDSM)
				8. Refining of existing stock assessment methods, particularly developing models that include finer spatial resolution						50000	TAFIRI, FAST (UDSM)
				9. Evaluating current and alternative methods to assess the stock structure and migratory dynamics of key species						40000	TAFIRI, FAST (UDSM)
2	Investigations into the sustainability of fish habitats and the ecosystem	• To map fish habitats • To gain understanding on the relationship between fish and their habitats • To develop ecological models and indicators	• Number of habitats mapped • Number of new fishing gears • Number of ecosystem indicators • Number of ecosystem monitoring protocols	1. Applying GIS-based habitat mapping methods for monitoring of important habitats						50000	TAFIRI, FAST (UDSM)
				2. Introducing and developing innovative technologies to help identify relationships between fish and their supporting ecosystems						70000	TAFIRI, FAST (UDSM)
				3. Characterizing benthic communities in fished and unfished areas						30000	TAFIRI, FAST (UDSM)
				4. Developing fishing gear and practices that minimize impacts on biodiversity and habitats						80000	TAFIRI, FAST (UDSM)
				5. Identifying key ecosystem indicators and development of cost-effective monitoring protocols						30000	TAFIRI, FAST (UDSM)
				6. Determining the trophic relationships within key commercial and artisanal fisheries						35000	TAFIRI, FAST (UDSM)
				7. Developing ecological modeling capabilities and approaches that have predictive capacity						25000	TAFIRI, FAST (UDSM)

S/N	Research Project	Project Objectives	Project Measurable Indicators	Key Project Research Activities/Interventions	Time Frame (Year)					Estimated Costs (in US$)	Key Research Institutions
					1	2	3	4	5		
				8. Developing meaningful and practicable ecosystem indicators, reference points and performance measures for key species and fisheries						25000	TAFIRI, FAST (UDSM)
3	Studies on the impacts of habitat modification on fishery resources	• To gain an understanding on the impacts of habitat alteration on fish populations	• Number of research reports • Number of published papers • Water management guidelines	1. Assessing the critical linkages between riverine and lake systems for sustainable fishery resources and the impacts of changes to flow regimes						20000	TAFIRI, FAST (UDSM)
				2. Developing science-based guidelines for water management to maintain fishery resources						25000	TAFIRI, FAST (UDSM)
				3. Assessing the effectiveness of restoration and rehabilitation of fish habitats						30000	TAFIRI, FAST (UDSM)
				4. Assessing the responses of fish populations to human-induced disturbances						40000	TAFIRI, FAST (UDSM)
				5. Investigating the relationship between sedimentation, turbidity and wetland macrophyte dieback						25000	TAFIRI, FAST (UDSM)
4	Studies on the impacts of climate variation of fishery resources	• To develop comprehensive understanding of the impacts of climate on fishery resources	• Monitoring protocols • Number of published papers • Drought management strategies • Number of research reports	1. Developing cost-effective monitoring protocols for collecting long-term environmental and biological data sets for key species						20000	TAFIRI, FAST (UDSM)
				2. Determining the relationships between environmental factors and reproductive success, recruitment and availability of key species and assessment of the mechanisms that drive them						30000	TAFIRI, FAST (UDSM)
				3. Developing methods to enable “natural” versus anthropogenic changes to be distinguished						20000	TAFIRI, FAST (UDSM)
				4. Developing modeling approaches that explicitly account for natural variability in fish stocks						30000	TAFIRI, FAST (UDSM)
				5. Developing drought management strategies for fishery resources						20000	TAFIRI, FAST (UDSM)
				6. Assessing risk on the impact of climate change on Lake Victoria’s aquatic resources to identify high-risk species/areas and future research requirements						30000	TAFIRI, FAST (UDSM)
5	Investigations into market development for fishery products	• To develop marketing strategies for fishery products	• Marketing strategies • Number of research reports • Number of research proposals	1. Developing marketing and promotion strategies to maximize the value of fisheries and aquaculture products						25000	ERB, FAST (UDSM), TAFIRI
				2. Developing methods for more innovative marketing to creating niche products						20000	ERB, FAST (UDSM), TAFIRI
				3. Investigating methods to promote cultural changes to take market from being price driven to quality driven						20000	ERB, FAST (UDSM), TAFIRI
				4. Conducting a study to establish the size, extent and capabilities of the post-harvest sector and its economic and social contribution to the Lake Victoria fish industry						35000	ERB, FAST (UDSM), TAFIRI

S/N	Research Project	Project Objectives	Project Measurable Indicators	Key Project Research Activities/Interventions	Time Frame (Year) 1	2	3	4	5	Estimated Costs (in US$)	Key Research Institutions
6	Studies on the economic and social assessments of fisheries and aquaculture	• To conduct economic assessment of fisheries and aquaculture • To conduct social assessment of fisheries and aquaculture	• Number of assessment reports • Number of published papers • Number of research reports	1. Periodically assessing the economic performance of major fishery and aquaculture sectors						30000	ERB, FAST (UDSM), TAFIRI
				2. Economic evaluation of prospective aquaculture species and integrated aquaculture systems						20000	ERB, FAST (UDSM), TAFIRI
				3. Assessing the social benefits of fisheries and aquaculture and the social costs of management decisions						25000	ERB, FAST (UDSM), TAFIRI
				4. Investigating public perceptions of fisheries and aquaculture, and their origins, and development of methods to influence and improve perceptions						20000	ERB, FAST (UDSM), TAFIRI
7	Investigations into sustainable aquaculture development	• To develop modern aquaculture techniques • To develop cost effective breeding programmes • To develop efficient and economical feeds	• Number of feeds • • Number of feeding strategies • Number of husbandry methods • Number of published papers • Numbers of research reports • Site selection guidelines and protocols	1. Developing more efficient and economical feeds and feeding strategies						30000	SUA, TAFIRI, FAST (UDSM)
				2. Developing programmes to ensure maintenance of the genetic diversity of broodstock						20000	
				3. Initiating cost-effective selective breeding programmes for growth, disease resistance and other preferred traits to produce high performance strains						40000	SUA, TAFIRI, FAST (UDSM)
				4. Developing closed life cycles for high-value species						35000	SUA, TAFIRI, FAST (UDSM)
				5. Developing more efficient grow-out and husbandry methods						35000	SUA, TAFIRI, FAST (UDSM)
				6. Developing systems to enhance agri-aquaculture production						30000	SUA, TAFIRI, FAST (UDSM)
				7. Developing environmental indicators, reference points and performance measures for aquaculture operations						20000	SUA, TAFIRI, FAST (UDSM)
				8. Developing guidelines and protocols for assessing potential aquaculture sites						25000	SUA, TAFIRI, FAST (UDSM)
				9. Determining methods to minimize nutrient discharges						20000	FAST (UDSM)
				10. Assessing the carrying capacity of terrestrial and aquatic systems in relation to the impact of aquaculture activities						30000	SUA, TAFIRI, FAST (UDSM)
TOTAL FOR FISHERIES RESEARCH AND MANAGEMENT										**1,410,000**	

Table 4.3: Research Component 2: Water Resources Management

S/N	Research Project	Project Objectives	Project Measurable Indicators	Key Project Research Activities/Interventions	Time Frame (Year)					Estimated Costs (in US$)	Key Research Institutions
					1	2	3	4	5		
1	Nutrient input to the lake and Eutrophication	•Improved control of nutrients loss resulting from human activities in the catchment. •Improved management strategy for the water hyacinth •Improved understanding of the significance of *in situ* processes in nutrient enrichment.	•Number of research proposals •Number of published reports and papers •Coverage of water hyacinth •Number of researchers	1. Partitioning of sources of nutrients in the catchments (deforestation, agriculture, fires, grazing, etc).						50000	UDSM (FAST) SUA UCLAS
				2. Linkages between nutrient levels and the potential sources of aquatic weeds						20000	
				3. Benthic regeneration of nutrients in littoral and open lake areas						50000	UDSM (FAST)
				4. Location analysis of areas of severe anaerobiosis in the lake bottom as well as the timing for these incidents and influence on fish behaviour						50000	MoW UDSM (FAST)
				5. Significance of nitrogen fixation in nutrient budget of Lake Victoria.						30000	UDSM (FAST)
				6.The significance of atmospheric deposition on the nutrient budget of the lake						50000	UDSM (FAST; COET)
2	Lake productivity and Phytoplankton bloom S	•Developing strategies for enhancing Lake productivity •Developing strategies for controlling algal blooms	•Number of research proposals •Number of published reports and papers •Incidents of algal blooms	1.Assessment of new and regenerated production in the lake						30000	UDSM (FAST; IMS)
				2.Determination of the most limiting nutrient in primary productivity of littoral and pelagic zones of the lake						30000	UDSM (FAST)
				3.Environmental factors associated with the triggering of toxic cyanobacteria						50000	UDSM (FAST; FoS)
				4.Mapping of lake areas that have a potential for growth of toxic microalgae						30000	MoW; UDSM (FAST; IRA)
				5.Establishing management measures for algae toxins						20000	MoW; MNRT; TAFIRI; UDSM (FAST)
3	Persistent pollutants	•Developing strategies for minimizing persistent pollutants in the Lake •Improved management of persistent pollutants	•Number of research proposals •Number of published reports and papers •Levels of persistent pollutants	1.Regional/global atmospheric transport as a possible route for mercury deposition to Lake Victoria						50000	UDSM (FAST; COET)
				2.Establishment of the biogeochemistry of mercury in the Lake						30000	UDSM (FAST; FoS)
				3.The fate of organochlorine pesticides in the lake basin environment						40000	UDSM (FAST; FoS)
				4.Assessment of pollutant retention ability of various soil types in the lake basin						20000	UDSM (FAST; FoS) SUA

S/N	Research Project	Project Objectives	Project Measurable Indicators	Key Project Research Activities/Interventions	Time Frame (Year)					Estimated Costs (in US$)	Key Research Institutions
					1	2	3	4	5		
4	Groundwater resource evaluation	•Developing strategies for management of groundwater resource	•Number of research proposals •Number of published reports and papers	Assessment of groundwater quantity and quality						30000	MoW; UDSM (FoS)
				Determination of recharge capacity of major aquifers						50000	MoW; UDSM (FoS)
				Establishment of groundwater dynamics in the lake basin						50000	MoW; UDSM (FoS)
5	Bioindicators of pollution in the lake	•Developing pollution monitoring strategies using simple, less expensive approaches	•Number of published reports and papers •Indicator organism in place	Search for suitable pollution bio-indicators						30000	UDSM (FAST; FoS; IMS)
				Establishing management guideline for a suitable pollution indicator						30000	MoW; MNRT; UDSM (FAST; FoS; IMS)
6	Sedimentation, palaeoclimatology and pollution history	•Improved management strategies for control of suspended sediments and pollutants from the catchment •Improved understanding of lake level dynamics	•Number of research proposals •Number of published reports and papers	Estimation of sedimentation rates at prominent depositional areas of the lake						100000	MoW; MNRT; UDSM (FAST; FoS; IMS)
				Retrieval of long sediment cores for tracing pollution history of the lake						50000	MoW; MNRT; UDSM (FAST; FoS; IMS)
				Retrieval of long sediment cores for establishment of palaeoclimate of the lake						50000	MoW; MNRT; UDSM (FAST; FoS; IMS)
7	Water quantity and Lake levels	•Updated information on the lake depth •Refined information on Lake Victoria water balance •Improved understanding of factors causing water loss	•Number of research proposals •Number of published reports and papers	Verifying the bathymetry of Lake Victoria and mapping						200000	MoW; UDSM (IMS)
				Establishing water balance based on accurate data on precipitation, evaporation, discharge, abstraction etc. (based on data from the monitoring programme)						100000	MoW; UDSM (COET)
				Investigating the possibility of Global and Micro climate change as factors in the declining lake levels.						50000	MoW; UDSM (IMS)
8	Hydraulic condition in the lake	•Improved knowledge on pollution management •Improved understanding of fish behaviour in the lake	•Number of published reports and papers •Size of fish landings	Lake Hydrodynamics in relation to pollutants dispersal.						50000	MoW; UDSM (FAST; COET)
				Lake Hydrodynamics in relation to fish migration						75000	MoW; UDSM (FAST; COET)
				Influence of thermal stratification on fish behaviour						50000	MoW; UDSM (FAST; COET)
	TOTAL FOR WATER RESOURCES MANAGEMENT COMPONENT									**1,465,000**	

Table 4.4: Research Component 3: Atmospheric Deposition and Meteorology

S/N	Research Project	Project Objectives	Project Measurable Indicators	Key Project Research Activities/Interventions	Time Frame (Year) 1	2	3	4	5	Estimated Costs (in US$)	Key Research Institutions
1	Wet and dry deposition studies of N and P	○ Improved understanding of factors, extent of wet and dry deposition of N and P • Developing management strategy for wet and dry deposition of N and P	• # of researchers • # of research reports • # of papers published • Management strategies in place • Quantity of needed research facilities acquired • # of research staff trained in line with established needs • # of research proposals received • # of new research projects funded/initiated • Total # of on-going research projects – disaggregated in terms of those funded through LVEMP and those funded by institutions and other means • # of research projects completed	1. The effects of nitrogen fixation by blue-green algae						200,000	• **MoW** • COET • RWRI • MNRT • TMA • NEMC • Regional and District Commissioners • Municipalities in the basin • District Councils in the basin • Private Sector • UWSAs
				2. Assessment of magnitude of nutrient loading from wet atmospheric depositions							
				3. Source characterisation							
				4. Assessment of source and magnitude of transboundary deposition							
				Modelling of atmospheric deposition							
2	Wet and dry deposition studies of heavy metals	○ Improved understanding of factors, extent of atmospheric deposition of heavy metals • Developing management strategy for heavy metal atmospheric deposition		5. Assessment of magnitude of other pollutants loading (especially heavy metals) from atmospheric deposition							
				6. Source characterisation							
				7. Assessment of source and magnitude of transboundary deposition							

S/N	Research Project	Project Objectives	Project Measurable Indicators	Key Project Research Activities/Interventions	Time Frame (Year) 1	2	3	4	5	Estimated Costs (in US$)	Key Research Institutions
				8. Assessment of magnitude of other pollutants loading (especially heavy metals) from atmospheric deposition							
3	Meteorology studies	○ Improved understanding of impact and extent of climate change on LVB ecosystem including resources ○ Improve understanding of vulnerability and adaptation to climate change ○ Develop management strategies of the factors influencing climate change • Improved monitoring of metrological parameters • Updating of LV mass balance		9. Impact of climate change on LVB ecosystem						200,000	
				10. Continuous monitoring of metrological parameters							
				11. LV mass balance updating							
	Total for Atmospheric deposition and Metereology									**400,000**	

Table 4.5: Research Component 4: Aquatic Weeds

S/N	Research Project	Project Objectives	Project Measurable Indicators	Key Project Research Activities/Interventions	Time Frame (Year) 1	2	3	4	5	Estimated Costs (in US$)	Key Research Institutions
1	Water Hyacinth Studies	To understand the character, dynamics and impacts of water hyacinth in order to come up with improved control measures	i) Number of research reports i) Number of published papers v) Number of researchers v) Management strategies in place i) Number of alternative bio-control agents identified i) Number of research staff recruited i) Number of research staff trained k) Number of BMUs established and trained k) Number of research equipment acquired i) Number of new research projects initiated/funded i) Reduced levels of infestation i) Number of people affected positively or negatively	12. Characterization of water hyacinth at molecular level in the Lake basin						300,000	Ministry of Agriculture, Food Security and Cooperatives – Plant Protection Division, SUA, Ministry of water, University of Dare s Salaam
				13. Assess the causes and dynamics of resurgence and proliferation of water hyacinth;							
				14. Study succession of water hyacinth;							
				15. Study thepPersistence of water hyacinth in hot spot areas							
				16. Assessment of socio-economic and environmental impacts of water hyacinth							
				17. Study improved ways of managing the water hyacinth							
2	Bio-control agents development	Develop alternative bio-control agents along with practical implementation guidelines		18. Search for Alternative bio-control agents						300,000	Ministry of Agriculture, Food Security and Cooperatives – Plant Protection Division, TPRI, SUA
3	Weevils and Other aquatic weeds	• To provide an understanding of the dynamics and long-term sustainability of weevil-plant association • To understand the nature and threats posed by other aquatic weeds, such as *Azolla,*and *Trapa natans* and measures to control them		19. Study life cycle of weevils						300,000	Ministry of Agriculture, Food Security and Cooperatives – Plant Protection Division, TPRI, SUA, University of Dar es Salaam
				20. Study ecological factors influencing performance of weevils in the lake Victoria basin							
				21. Study occurrence, threats and appropriate control measures of other aquatic weeds, such as Azolla and Trapa natans							

S/N	Research Project	Project Objectives	Project Measurable Indicators	Key Project Research Activities/Interventions	Time Frame (Year)					Estimated Costs (in US$)	Key Research Institutions
					1	2	3	4	5		
4	Eutrophication	Provide an understanding of the management of transboundary eutrophication and water hyacinth proliferation issues in the LVB	v) Total number of on-going research projects – disaggregated in terms of those funded through LVEMP and those funded by institutions and other means v) Number of research projects completed i) Number of research reports published	22. Study regional development practices that significantly contribute to eutrophication						200,000	UDSM, UCLAS, SUA, NIMR, UKiriguru ARI, TPRI, AMANI
				23. Study transboundary driving factors behind nutrient loading into the Lake							
				24. Assess the influence of social economic developments and needs on nutrients loading into the lake							
				25. Assess the influence of the attitudes and behavior of riparian communities on eutrophication of the lake							
				26. Assess the extent and volume of nutrients sources, especially Nitrogen and Phosphorous							
				27. Assess the txtent of water hyacinth seed bank in the region							
				28. Assess the extent of cross boarder recharge of fresh water hyacinth into the lake							
				29. Study regional integrated methods for controlling water hyacinth proliferation							
	Total for Aquatic Weeds									**1,100,000**	

Table 4.6: Research Component 5: Forests, Wetlands and Watershed Management, Soil and water Conservation
Research Sub- Component: Forestry management

S/N	Research Project	Project Objectives	Project Measurable Indicators	Key Project Research Activities/Interventions	Time Frame (Year)					Estimated Costs (in '000 US$)	Key Research Institutions
					1	2	3	4	5		
1	Impact of Globalization	Development of improved management strategy for forest resources	Reports on SPP and quantities	Targeted SPP & quantities of forest products involved in export market from LVB and effect to the environment and livelihood of local communities						100,000	
2	Wood energy	Improved understanding of woodfuel production and need in LVB.	Reports	Quantity of wood consumed by different stakeholders in terms of charcoal & firewood in urban and rural areas						50,000	
				Production capacity of major forests						100,000	
				Wood energy conservation technologies (improved kilns, charcoal & fire stoves)	Dealt with in Chapter 2.8						
3	Tree species site matching	Development of appropriate afforestation	Reports	Spp suitable for different ecological zones						50,000	
				Appropriate tree species for vegetation restoration						50,000	
4	Appropriate Agroforestry Systems in subcatchments		Reports	Assesment of agroforstery systems used in the LVB						30,000	
				Potential of agroforestry systems in meeting household needs						20,000	
5	Forest Inventory/ Forest stock Assessment		Report	Establishment of the rate of natural vegetation regeneration in the region for various tree species						60,000	
				Assess tree species diversity in major forests						100,000	
6	Surface runoff			Determine surface run-off and soil erosion in forest areas						50,000	
	Total for Forest Management									**360,000**	

Sub- Component: Wetlands and Watershed Management, Soil and water Conservation

S/N	Research Project	Project Objectives	Project Measurable Indicators	Key Project Research Activities/Interventions	Time Frame (Year)					Estimated Costs (in US$)	Key Research Institutions
					1	2	3	4	5		
	Wetlands and Watershed Management										
	Wetlands Biodiversity	To document the biodiversity of major wetlands To link the impact of anthropogenic activities on wetland biodiversity	i) Report	Biodiversity of major wetlands in different localities in the basin						50,000	FoS- UDSM IRA
				Assessment of impact of human activities on wetland biodiversity (i.e., grazing, bush fire, shifting cultivation)						50,000	FoS-UDSM IRA
				Biodiversity search on the restoration of wetland plants of socio-economic importance						30,000	FoS-UDSM IRA
				Effects of soil erosion on wetlands biodiversity						50,000	FoS-UDSM IRA
	Social - Economic aspects of lake Victoria wetlands	To establish the economic value of LVB major wetlands To establish a treatment wetland for municipal wastewater	i) Report x) Number of alternative projects/interventions developed x) Constructed wetland unit	Economic valuation of lake Victoria wetlands						100,000	IRA
				Socio-economic and cultural aspects of wetlands communities and their impact on wetlands utilization						50,000	IRA
				Alternative projects/interventions that will reduce dependency to wetlands						200,000	IRA
				Guidelines and preliminary investment proposals for wetland rehabilitation and artificial wetland construction						150,000	UDSM WSP & CW Research Project
	Buffering capacity of major LVB wetlands	To apply the DUFLOW model to estimate the buffering capacity of major wetlands To develop predictive wetland models	i) Report i) Models developed	Determining buffering capacity of major wetlands						200,000	CoET
				Wetland hydrology studies						30,000	CoET
				Predictive model to determine response of wetlands to various pressures/threats						60,000	CoET
				Modeling of spatial and temporal degradation of lake Victoria fringing wetlands						100,000	CoET
	Long term changes of major wetlands	To establish long term changes in LVB major wetlands	i) Maps v) Reports	Mapping wetland coverage in different years in order to detect changes						100,000	UDSM
				Changes of vegetation communities in selected major wetlands of Lake Victoria for the past 20 years						150,000	UDSM
				Carrying capacity of major lake Victoria wetlands						100,000	UDSM

S/N	Research Project	Project Objectives	Project Measurable Indicators	Key Project Research Activities/Interventions	Time Frame (Year)					Estimated Costs (in US$)	Key Research Institutions
					1	2	3	4	5		
				Application of remote sensing and GIS for land use/cover studies in major wetlands						50,000	UDSM
				Total for Wetlands and Watershed Management						1,470,000	

	Sub Componenet Soil and Water Conservation										
	Scaling up of SWC measures over wider areas (subcatchment)	Dealt with under Research Component 8									
	Water harvesting	Dealt with under Research Component 8									
	Improved agriculture	Dealt with under Research Component 8									
	Improved livelihood in rural areas	Dealt with under Research Component 8									

Table 4.7: Research Component 6: Pests and Diseases

S/N	Research Project	Project Objectives	Project Measurable Indicators	Key Project Research Activities/Interventions	Time Frame (Year)					Estimated Costs (in US$)	Key Research Institutions
					1	2	3	4	5		
1	Human disease Studies	Improved understanding of key human diseases in the basin and related management strategies	• Total number of on-going research projects – disaggregated in terms of those funded through LVEMP and those funded by institutions and other means • Number of research projects completed • Number of research reports • Number of papers published	10. Best approach to self medication)						200,000	a. NIMR – Mwanza and London School of Tropical Medicine b. TANESA c. MUCHS d. BUCHS
				11. Study on the health impacts of ITNs							
				12. Studying causes of the observed malnutrition and intervention measures.							
				13. Study of effective modalities to translate HIV/AIDS knowledge into concrete behavior change.							
2	Crop Pests and Diseases Studies	Understanding the extent of crop pests and diseases as well as their impacts and management strategies	• Quantity of needed research facilities acquired • Number of new research projects funded/initiated • Number of research staff trained in line with established needs	1. Study the extent of crop pests and diseases as well as their impacts.						200,000	a. ARI Ukiriguru b. Maruku Livestock Research Institute c. SUA, d. Plant Protection
				2. Breed for cassava varieties resistant to cassava pests and diseases but with farmer desired qualities							

S/N	Research Project	Project Objectives	Project Measurable Indicators	Key Project Research Activities/Interventions	Time Frame (Year)					Estimated Costs (in US$)	Key Research Institutions
					1	2	3	4	5		
			needs • Alternative control measures identified • New breeds of crops resistant to pests and diseases introduced	3. Alternative control measures of pests including promotion of predators of banana weevils and nematodes							Services Zonal Centre at Shinyanga e. HORTI-Tengeru f. TPRI g. National Biological Control Centre, Kibaha h. VIC Mwanza and Tabora
				4. Banana varietal differences in resistance and or tolerance to banana wilt disease							
				5. Identify new approaches to empower farmers to take more of the pest control action							
3	Livestock Diseases	Understanding the extent of livestock diseases and plant pests as well as their impacts and management strategies		1. Alternative/back-up disease control measures and mechanisms						200,000	• Livestock Research Institute, Mabuki • Veterinary Investigation Centre, Mwanza and Tabora • SUA • National Livestock Research Institute
				2. Extent of zoonotic livestock diseases and plant pests and their impacts							
				3. Appropriate feed resources and feeding systems							
4	Transboundary Impacts of pests and diseases	To understand the patterns, processes and impacts of transboundary pests and diseases		1. Development practices (within all riparian countries) which significantly contribute to transboundary disease burden						200,000	• UDSM • SUA • UCLAS • NIMR • ARI UKIRIGURU • VIC • TPRI • AMANI • Maruku
				2. Study of regional pattern of pests							
				3. The driving factors for transboundary diseases transmission within the region							

S/N	Research Project	Project Objectives	Project Measurable Indicators	Key Project Research Activities/Interventions	Time Frame (Year)					Estimated Costs (in US$)	Key Research Institutions
					1	2	3	4	5		
				4. Influence of social economic developments and needs on disease transmission							Research Centre • Mabuki Livestock Research Centre
				5. Extent of resistance of target vector in the region							
				6. The climate change impact on regional pest trends							
	Total for Pests and Diseases									800,000	

Table 4.8: Research Component 7: Waste Management

Sub- Component: Solid Waste Management in LVB

S/N	Research Project	Project Objectives	Project Measurable Indicators	Key Project Research Activities/Interventions	Time Frame (Year)					Estimated Costs (in US$)	Key Research Institutions
					1	2	3	4	5		
1	Intergrated Solid Waste Management in the LVB towns and municipalities	Reduce environmental pollution caused by solid waste	Number of towns adopting Integrated Solid Waste Management Strategies; Number of proper solid waste disposal sites established Number of solid waste	1. Establishing solid waste recycling plants and support participation of communities at household level;						50,000	▪ Department of Environmental Engineering, UCLAS ▪ Chemical and Process Engineering Department, UDSM
				2. Strengthening capacity for urban planning and development;						30,000	Department of Urban Planning and Regional Development, UCLAS
				3. Establishing proper solid waste disposal sites;						150,000	▪ Department of Environmental Engineering, UCLAS ▪ Chemical and Process Engineering Department, UDSM
2	Energy recovery from solid waste	Supplement enrgy requirements using solid waste	Number of energy recovery options developed	1. Development of appropriate energy from waste recovery system						30,000	Department of Energy, UDSM Department of Chemical and Process Engineering, UDSM
3	Processing of fish waste into useful by products	Recover useful by products from fish waste	▪ Number of useful by products developed ▪ Number of technologies developed and adapted	Evaluation of the potential to utilize Nile Perch by-products (fish skin, bladder)						15,000	▪ CPE, UDSM ▪ University of Dar es Salaam Entrepreneurship Centre (UDEC)
				Development of appropriate technology for tanning fish skin						40,000	
				Development of appropriate technology to process fish silage for animal feed						20,000	
				Dissemination and marketing of developed technologies						30,000	
				Development of appropriate fish oil processing technology						20,000	
				Development of technology for processing of fish heads “mapanki” for human consumption						50,000	
	Total for Solid WasteManagement									435,000	

S/N	Research Project	Project Objectives	Project Measurable Indicators	Key Project Research Activities/Interventions	Time Frame (Year) 1	2	3	4	5	Estimated Costs (in US$)	Key Research Institutions
Sub- Component: Waste Water Management in LVB											
1	Decentralised systems for domestic and industrial wastewater treatment	Reduce environmental pollution caused by domestic and industrial discharges	Number of technologies developed	Developing appropriate soft technologes for treatment of wastewater from fisheries, textile, beverage manufacturing indutries	■	■	■	■	■	100,000	▪ WSP & Constructed Wetland Research Project, UDSM ▪ Department of Environmental Engineering, UCLAS ▪ Water Resources Engineering, UDSM
				Introducing Constructed Wetlands in combination with other water treatment technologies for municipal wastewater treatment	■	■	■	■		100,000	
				Developing a demonstartion pilot Integrated Algal Ponding System (IAPS).		■	■			50,000	
				Dissemination and marketing of developed technologies				■	■	40,000	
2	Sanitation for the Unplanned Urban and Rural Areas	Provision of appropriate waste water treatment technologies for unplanned areas	Number of municipalities adopting the developed technology Standards developed	Development of a demonstration Condominial sewer system in peri-urban area	■	■				150,000	▪ Department of Environmental Engineering, UCLAS ▪ WSP & Constructed Wetland Research Project, UDSM ▪ Water Resources Engineering, UDSM
				Developing Standards for placement of latrines in relation to water wells			■			15,000	
				Sensitization of LVB communities	■	■	■	■		10,000	
				Dissemination of developed Technology and Standards			■	■	■	30,000	
	Total for Wastewater Management									495,000	
Sub- Component: Waste Oil Management in LVB											
1	Waste oil management	Reduce environmental pollution from waste oils	▪ System developed ▪ Number of municipals sensitized ▪ Developed Technology adopted	Establish waste oil collection system		■	■			30,000	▪ Chemical and Process Engineering Department, UDSM ▪ University of Dar es Salaam Entrepreneurship Centre (UDEC) ▪ Department of Environmental Engineering, UCLAS
				Develop/adapt appropriate technology for processing used oil ito useful byproduct	■	■	■			200,000	
				Identify potential uses of used oil		■				15,000	
				Establish disposal method for residues			■			10,000	
				Establish baseline information on waste oils in LVB	■					10,000	
	Total for waste oil management									265,000	

Table 4.9: Research Component 8: Economic Growth, Private Sector and Sustainable Market Driven Development

Research Sub- Component: Improvement of Land Productivity and Farming systems

S/N	Research Project	Project Objectives	Project Measurable Indicators	Key Project Research Activities/Interventions	Time Frame (Year)					Estimated Costs (in US$)	Key Research Institutions
					1	2	3	4	5		
	Development and promotion of improved seeds adapted to the semiarid and other agro-ecological conditions of the lake basin	Provide high yield seeds that are adapted to LVB agro ecological zones	Number of crops improved agroecological maps	Identification and documentation of LVB agroecological zones						20,000	SUA, UKIRIGURU MARUKU
				Identification and documentation of commonly used seeds						20,000	
				Establish agroecological zone experimental sites						50,000	
				Experimentation with combination of variety of seeds and Agroecological zone						150,000	
				Promotion and Dissemination of results						60,000	
2	Management of agrochemicals	Provide appropriate handling, storage use and disposal procedures for agrochemicals	Guidelines for Agrochemicals used in LVB	Establishing the updated status of agrochemical in the LVB						10,000	UKIRIGURU, SUA, TPRI, MARUKU MoAFS
				Developing guidelines for agrochemilas						15,000	
				Dissemination						10,000	
3	Prevention of soil erosion and soil load in the water systems and improvement of soil fertility	Lower sol erosion and increase soil fertility	▪ Guidelines For soil erosion control ▪ Guidelines for improvement of soil fertility ▪ Publications in Journals	Establishment of pilot areas						5,000	UKIRIGURU, SUA, TPRI, MARUKU MoAFS
				Mobilization of communities						10,000	
				Training of communities in SWC measures						5,000	
				Training on soil fertility improvement						5,000	
				Implementation of soil conservation and soil fertility improvement						50,000	
				Dissemination							
4	Soil and water conservation measures over a large pilot area (river basin)	Scale up WSC measures developed under LVEMP-1	▪ Demonstration area established ▪ Increased production of major crops ▪ Publications in Journals ▪ No. of districts adopting the SWC	Estabishment of the demonstration basin						20,000	
				Mobilization of local authorities and communities						50,000	UKIRIGURU, SUA, TPRI, MARUKU MoAFS
				Training of farmers on SWC mesures						200,000	
				Impact monitoring						30,000	

S/N	Research Project	Project Objectives	Project Measurable Indicators	Key Project Research Activities/Interventions	Time Frame (Year) 1	2	3	4	5	Estimated Costs (in US$)	Key Research Institutions
			adopting the SWC measures	Dissemination						20,000	
5	Suitability/performance of different crops under different soil and water conservation measures.	To establish the crops yield under various SWC measures		Establish study sites						10,000	
				Mobilization of communities						20,000	
				Training farmers						40,000	
				Dissemination						10,000	
6	Upgrading of farming technologies	To develop/adapt new technologies to assist farming	▪ Number of farming technologies improved ▪ Publications in Journals	Documentation of the status of LVB farming technologies						10,000	UKIRIGURU, SUA, TPRI, MARUKU MoAFS
				Mobilization of farmers in pilot areas						20,000	
				Improvement of technologies						150,000	
				Training of farmers						50,000	
				Dissemination						20,000	
7	Gender access to emerging technological innovations	Ensure equal opportunities for technological innovations	Number of women trained Number of technology innovations adopted	Selection of emerging technologies						10,000	UKIRIGURU, SUA, TPRI, MARUKU MoAFS
				Mobilization and training of women groups						30,000	
	Total for Improvement of Land Productivity and farming Systems									690,000	

Sub- Component: LVB Indigenous knowledge for economic growth

S/N	Research Project	Project Objectives	▪ Project Measurable Indicators	Key Project Research Activities/Interventions	Time Frame (Year)	Estimated Costs (in US$)	▪ Key Research Institutions
1	Indigenous knowledge for soil and water conservation in the Lake Victoria basin.	Promote indigeneous knowledge on SWC	▪ Number of Indigenous Knowledge identified ▪ Publications	Documentation and Assessment of Indigenous Knowledge for SWC		5,000	IRA GE-UDSM WRE-UDSM UKIRIGURU MARUKU
				Development of Indigenous knowledge		10,000	
				Dissemination of Indigenous Knowledge		15,000	
2	Sustainable Management and Promotion of traditional woodlot *'ngitiri'*		▪ Ngitiri Management Strategy Report ▪ Number of new woodlots established	Documentation of status of traditional woodlots management		5,000	IRA GE UKIRIGURU MARUKU
				Developing management strategy in collaboration with communities		5,000	
				Promotion of Ngitiri		10,0000	
	Total for Indigeneous Knowledge for Economic growth					110,000	

Research Sub- Component: Water Harvesting and Water Abstarction

Research Sub- Component Objective : To develop and promote sustainable water harvesting techniques for LVB													
S/N	**Research Project**	**Project Objectives**	**Project Measurable Indicators**	**Key Project Research Activities/Interventions**	**Time Frame (Year)**					**Estimated Costs (in US$)**	**Key Research Institutions**
1	Development of Sustainable rainwater harvesting techniques for livestock and agriculture	To ensure sustainable availability of water for irrigationa and livestock	Number of techniques developed	Update and inventory of water harvesting techniques	■					5,000	WRE RWRI
				Estabishment of the study areas	■					10,000	
				Mobilization of local authorities and communities	■	■				10,000	
				Training of farmers and livestock keepers on waterharvestig techniques		■	■			100,000	
				Impact evaluation			■	■		5000	
				Dissemination			■	■	■	15000	
2	Appropriate technologies for drawing and distributing water for irrigation (windmill vs mechanical pumps, proper design of delivery channels etc)	To provide sustainable water water abstraction and distribution to smallholder farmers	Number of successful technologies introduced	Update and inventory of water abstraction techniques	■					5,000	
				Estabishment of the study areas	■	■				10,000	
				Mobilization of local authorities and communities	■	■				10,000	
				Development/adaptation of technologies	■	■	■	■		150,000	
				Training of farmers and on waterharvestig techniques			■	■	■	50,000	
				Evaluation of socio economic and environmental Impact				■	■	15,000	
				Dissemination					■	10,000	
3	Water abstraction techniques and their socio- economic and environmental impact	To assess the impact of water abstraction techniques	Covered in 2							0	
										395,000	

Sub- Component: Post harvest handling, processing and value addition

Research Sub- Component Objective : To reduce post harvest losses and value addition through processing into semi and finished products

S/N	Research Project	Project Objectives	Project Measurable Indicators	Key Project Research Activities/Interventions	Time Frame (Year)	Estimated Costs (in US$)	Key Research Institutions
1	Appropriate harvesting, storage and preservation techniques for common food crops	Reduce post harvest losses of common food crops	Number of techniques introduced Publications	Inventory of common food crops, farm and post harvest losses, common storage and preservation methods		5,000	SUA CPE
				Assessment of storage techniques, storage facilities both currently applied and that can be adopted from somewhere else		5,000	
				Mobilization of communities		5,000	
				Pilot development of suitable techniques		30,000	
				Training of farmers		15,000	
				Dissemination		10,000	
2	Diversification of food products from common food crops (banana, cassava, sweet potatoes)	Development of new food products from common food crops	Number of new food products developed Number of new food products adopted	Inventory of common food crops and food products		10,000	CPE SUA TFNC
				Development of new food products, processes		150,000	
				Dissemination and sensitization of food processing groups		30,000	
3	Economical Scale Solar dryers for agricultural products and fish (dagaa) drying	Development of commercial scale solar dryer to be adopted by entreprenurs	Commercial scale dryer developed Number of entrepreneurs adopting the technology	Evaluation of potential for solar dying of fish and agricultural crop drying		30,000	CPE TDTC TIRDO
				Development of a commercial scale dryer for 'dagaa', fruits and vegetable		40,000	
				Dissemination and marketing of the dryer		30,000	
4	Improvement of processing of dairy products (cheese and margarine) and milk collection infrastructure (collection points and cold mobile)	Adding value to dairy products	Number of products improved	Assessment of status of dairy processing in the LVB		10,000	SUA CPE
				Development of dairy processing techniques		50,000	
				Dissemination		5,000	
5	Development of appropriate fish preservation technologies for artisanal fisheries	Reduce fish losses	Number of technologies developed	Assessment of fish preservation techniques and fish loses among the artisanal fisher folk		5,000	FAST TAFIRI
				Mobilisation of fisherfolk		5,000	
				Developing of fish preservation technique		100,000	
				Training of fisherfolk		20,000	
				Dissemination		15,000	
6	Fish Processing diversification for local consumption	Producing new fish products fro local consumption	Number of new products developed	Assesment of various potential fish products for local consumption		10,000	FAST TAFIRI CPE TFNC
				Dvelopment of processes/new fish products		30,000	
				Dissemination		10,000	
7	Capacity building among the fisher folk to reduce post harvest losses	Covered in 5 above				0	

Sub- Component: Post harvest handling, processing and value addition

Research Sub- Component Objective : To reduce post harvest losses and value addition through processing into semi and finished products

S/N	Research Project	Project Objectives	Project Measurable Indicators	Key Project Research Activities/Interventions	Time Frame (Year)	Estimated Costs (in US$)	Key Research Institutions
8	Development of fish marketing systems for fisherfolks	Increasing income among the fishing communities	Markting system developed Increase in income	Assesment of current fish marketing system		5,000	UDEC FCM
				Proposal and Development of new marketing system		20,000	
				Mobilisation of fisher folk		20,000	
				Dissemination		15,000	
				Total for Post harvest handling , processing and value addition		680,000	

Sub- Component: Improvement of livestock productivity

Research Sub- Component Objective : To increase production from the livestock sector

S/N	Research Project	Project Objectives	Project Measurable Indicators	Key Project Research Activities/Interventions	Time Frame (Year)	Estimated Costs (in US$)	Key Research Institutions
1	Development and promotion of zero grazing technology in LVB	To reduce pressure on land resulting from uncontrolled grazing	Number of people adopting zero grazing technology	Mobilization of communities		10,000	SUA
				Training of livestock keepers		15,000	
				Development of pilot area for zero grazing		20,000	
				Dissemination		20,000	
2	Improvement of domestic livestock.	Increase productivity of local livestock breeds	Number of breeds improved Publications	Inventory of available breeds		5,000	
				Mobilization of livestock keepers		10,000	
				Training of livestock keepers		15,000	
				Improvement of breeds (Crossbreeding etc)		50,000	
				Appropriate management practices (feed, health		40,000	
				Dissemination		20,000	
3	Develop cross-breeding of available diary animals (cows and goats) to improve local animals	Dealt with in 2 above				0	
4	Develom appropriate management practices for animals (feeding and health).	Dealt with in 2 above				0	
				Total for Improvement of Livestock		205,000	

Sub- Component: Improvement in Small Scale Mining

Research Sub- Component Objective : To increase productivity in small scale mining and reduce environmental impacts caused by small scale mining operations

S/N	Research Project	Project Objectives	Project Measurable Indicators	Key Project Research Activities/Interventions	Time Frame (Year)	Estimated Costs (in US$)	Key Research Institutions

1	Development of appropriate technologies to assist artisanal miners in exploration, mining and processing	Increase productivity in small scale mining operations	▪ Number of technologied developed/ adopted ▪ Number of artisanal miners adopting new technologies	Assessment of available technologies						10,000	CPE MMPE TDTC Geology Dept-UDSM SEAMIC
				Mobilization of small scale miners						15,000	
				Training of small scale miners in exploration, mining and processing						20,000	
				Development/adoption of technologies						150,000	
				Dissemination						20,000	
2	Development of appropriate technologies for environmental management in small scale mining operations	Reduce environmental impact caused by small scale mining operations	▪ Number of technologied developed/ adopted ▪ Number of artisanal miners adopting new technologies	Assessment of available technologies						10,000	
				Mobilization of small scale miners						15,000	
				Training of small scale miners in environmental management						20,000	
				Development/adoption of technologies						100,000	
				Dissemination						20,000	
	Total for Improvements in small scale mining									380,000	

Sub- Component: Development and Improvement of Energy Systems and Sources for LVB

S/N	Research Project	Project Objectives	Project Measurable Indicators	Key Project Research Activities/Interventions	Time Frame (Year)					Estimated Costs (in US$)	Key Research Institutions
1	Research on alternative sources of energy so as to reduce dependence on wood fuel and manure	Increase energy availability and reduce dependency on wood fuel	▪ Number of alternative sources of energy developed ▪ Number of publications	Inventory of potential energy sources						5,000	TDTC CPE TIRDO SUA FoS-UDSM CARMATEC ME-E UDEC
				Development of fuel sources						20,000	
				Dissemination						10,000	
2	Energy conservation technologies (Jiko Bora)	Provide efficient energy conversion systems	Number of energy efficient systems developed Increased fuel efficiency	Inventory of energy conservation technologies						5,000	
				Development/improvement of energy conservation technologies						30,000	
				Dissemination						10,000	
3	Renewable energy technologies (solar, wind)	Promote use of renewable energy sources	Number of renewable energy systems introduced	Inventory of potential renewable energy technologies for LVB						5,000	
				Development/adoption of renewable energy technologies						25,000	
				Dissemination						10,000	
4	Promotion of Biogas use in LVB	Develop biogas systems in LVB	Number of biogas systems developed Number of people adopting use of biogas	Assess biogas potential in the LVB						10,000	
				Establish pilot areas for Biogas demonstration project						5,000	
				Development of biogas energy system						30,000	
				dissemination						10,000	
5	Biofuels (bio-diesel, gasohol, co-generation)	improving energy security, diversifying the rural economy	Number of villages growing biofuels Number of people using biofuels	Assess biofuel potential of LVB region						10,000	
				Identify key biofuel crop							
				Mobilize and train farmers for the bio energy crop						10,000	

			Number of processes developed	Develop energy systems for the biofuel	100,000	
				Develop processing techniques	50,000	
				Dissemination	10,000	
	Total Development and Improvement of energy systems and sources				355,000	

Sub- Component: Innovative Clusters for the major production sectors of LVB														
Research Sub- Component Objective :														
S/N	**Research Project**	**Project Objectives**	**Project Measurable Indicators**	**Key Project Research Activities/Interventions**	**Time Frame (Year)**								**Estimated Costs (in US$)**	**Key Research Institutions**
1	Introduction of Innovative Clusters Concept for the Fishing, Artisanal Fish Processing, Horticulture growers, Handcraft makers, Dairy Processing and Agro Processing Bio energy	Establishing close linkages and working on functional niche among producers	▪ Clusters Baseline data ▪ Number of clusters formed	Establishment of baseline data for the existing clusters									10,000	**CoET UDEC FCM**
				Assessement of strengths and weaknesses of anticipated cluster initiative									10,000	
				Awareness creation on the concept of Clusters (change of mindset)									10,000	
				Establishment of the clusters									200,000	
				Training										
				Implementation of the Clusters										
												Total for Innovative Clusters	**230,000**	

Table 4.10: Research Component 9: Cross-Cutting Environment Aspects

S/N	Research Project	Project Objectives	Project Measurable Indicators	Key Project Research Activities/Interventions	Time Frame (Year)					Estimated Costs (in US$)	Key Research Institutions
					1	2	3	4	5		
1	Community Participation	Improved understanding of efficacy and strategies for enhancing community participation in LVB environmental management	• # of research papers and reports • # of research findings disseminated	14. Mapping of existing researchers in the areas						1,000	• LVEMP • Universities • Environmental Civil Society organisations
				15. Researching effective methodologies for community participating in the LVB						50,000	
				16. Assessment of existing approaches and interventions to promote community participation						50,000	
2	Gender aspects	Improved understanding of the gender	• # of research papers	• Study and establish effective methods for promoting gender equity and mainstreaming in LVB environmental management strategy						10,000	• LVEMP • Universities

S/N	Research Project	Project Objectives	Project Measurable Indicators	Key Project Research Activities/Interventions	Time Frame (Year)					Estimated Costs (in US$)	Key Research Institutions
					1	2	3	4	5		
		perspective on LVB in LVB environmental management	papers and reports • # of research findings disseminated	• Study gender roles in LVB environmental management strategy						15,000	• Gender Civil Society organizations • Local Government Authorities in the LVB
				• Assess gender impacts in LVB ecosystem health						30,000	
				• Assess existing efforts on gender mainstreaming						30,000	
				• Study the relationship between gender and resources management						50,000	
3	Social cultural issues	Improved understanding of the socio-cultural perspectives on LVB in LVB environmental management	• # of research papers and reports • # of research findings disseminated	1. Study cultural values and beliefs in relation to sustainable resource use						100,000	• LVEMP • Universities • Civil Society organizations • Local Government Authorities in the LVB • Ministry responsible for land
				2. Study conflict over use and management of resources						50,000	
				3. Study demographic trends in relation to sustainable utilization of resources						30,000	
				4. Study urbanization and its impacts						30,000	
4	Poverty and Environment	Improved knowledge of the link between poverty and environmental degradation in LVB	• # of research papers and reports • # of research findings disseminated	1. Research factors linking poverty to environmental stress						20,000	• LVEMP • Universities • Civil Society organizations • Local Government Authorities in the LVB • Ministry responsible for the Environment • NEMC • MKUKUTA Monitoring Group
				2. Study the role of indigenous/local knowledge systems in sustainable environmental management and poverty reduction in the LVB						100,000	
				3. Study and establish good/best practices for environmental conservation and livelihoods improvement						50,000	
				4. Research to establish appropriate poverty -environment relationship monitoring indicators						20,000	
				5. Research on decision support tools for pov-env assessment in LVB (GIS, SIA, EIA and SEA)						50,000	
5	Environmental Economics	Improved understanding of how to address environmental economics issues in the LVB	• # of research papers and reports • # of research findings disseminated	1. Study strategies for promoting sustainable production and consumption in the LVB						150,000	• LVEMP • UDSM Economic Research Bureau • Ministry responsible for the Environment • NEMC • MKUKUTA Monitoring Group
				2. Research to facilitate the costing of environmental management interventions						30,000	
				3. Research environmental economic instruments (market based and fiscal)						30,000	

S/N	Research Project	Project Objectives	Project Measurable Indicators	Key Project Research Activities/Interventions	Time Frame (Year)					Estimated Costs (in US$)	Key Research Institutions
					1	2	3	4	5		
			disseminated	4. Research to facilitate environmental accounting in LVB						50,000	Monitoring Group • ESRF • IRA-UDSM • UCLAS
6	Environmental Governance	Improved understanding of how to address environmental governance issues in the LVB	• # of research papers and reports • # of research findings disseminated	1. Study the effectiveness of existing policies and laws in promoting sustainable environmental management of the LVB						30,000	• LVEMP • Ministry responsible for the Environment • Ministry responsible for Regional Adminstration and Local Government • EAC • NEMC • MKUKUTA Monitoring Group
				2. Study to determine effective institutional arrangements for promoting sustainable environmental management of the LVB						30,000	
				3. Study to determine effective/efficient environmental information management for promoting sustainable environmental management of the LVB						30,000	
				4. Study to determine effective environmental monitoring and evaluation (frameworks, tools) for promoting sustainable environmental management of the LVB						30,000	
	Total for Cross Cutting Issues									1,066,000	

Table 4.11: Applied Research Programme Cost

	RESEARCH AREA/SUB-AREA	Total Estimated Costs in US$	
1	**FISHERIES RESEARCH AND MANAGEMENT**		**1,410,000**
2	**WATER RESOURCES MANAGEMENT COMPONENT**		**1,465,000**
3	**ATMOSPHERIC DEPOSITION AND METEREOLOGY**		**400,000**
4	**AQUATIC WEEDS**		**1,100,000**
5	**FORESTS, WETLAND AND WATERSHED MANAGEMENT, SOIL AND WATER CONSERVATION**		**1,830,000**
	Forest Management	*360,000*	
	Wetlands and Watershed Management	*1,470,000*	
	Subtotal	*1,830,000*	
6	**PESTS AND DISEASES**		**800,000**
7	**WASTE MANAGEMENT**		**1,195,000**
	Solid Waste Management	*435,000*	
	Wastewater Management	*495,000*	
	waste oil management	*265,000*	
	Subtotal	*1,195,000*	
8	**Economic Growth, Private Sector and Sustainable Market Driven Development**		**3,045,000**
	Improvement of Land Productivity and farming Systems	*690,000*	
	Indigeneous Knowledge for Economic growth	*110,000*	
	Water Harvesting and Water Abstraction	*395,000*	
	Post harvest handling , processing and value addition	*680,000*	
	Improvement of Livestock	*205,000*	
	Improvements in small scale mining	*380,000*	
	Development and Improvement of energy systems and sources	*355,000*	
	Innovative Clusters	***230,000***	
	Subtotal	***3,045,000***	
9	**CROSS CUTTING ISSUES**		**1,066,000**
	TOTAL		**12,311,000**

CHAPTER 5: LINK OF THE APPLIED RESEARCH AGENDA WITH SUSTAINABLE ECONOMIC GROWTH IN THE LAKE VICTORIA BASIN

5.1 Introduction

The objective of applied research is to inform and support the sustainable economic growth in the LVB. In the context of this chapter sustainable economic growth is defined as a process whereby future generations receive as much capital per capita as, or more than, the current generation has available (Serageldin, 1996a, 1996b). This includes natural capital, physical (or produced) capital, and social (including human) capital. Together, their measurement provides indicators of the wealth of the riparian communities in the basin and they are considered as forming the basis of evaluating successes of sustainable economic development and growth[3]. In this process the composition of capital changes: some natural capital, such as forestry products, could be depleted and transformed into physical capital e.g. furniture. The latter will depreciate, and it is expected that technological change will generate more efficient replacements. It is the effects of this transformation process on human health and well-being that are at the heart of public interest concerns about both achieving a sustainable economic growth and the related role of corporate environmental and social responsibility.

The United Nations Development Programme (UNDP, 1994) described sustainable development as a process for realising human development "… in an inclusive, connected, equitable, prudent and secure manner." (Bansal and Howard, 1997) (see Box 1). By extrapolation, any form of development which fails to satisfy each of these elements could be deemed to be unsustainable.

Box 1: Key Elements of Sustainable Economic Development and Growth

- Connectivity embraces ecological, social and economic interdependence;
- Equity suggests fairness, within and across generations and species;
- Prudence connotes duties of care and prevention, technologically, scientifically and politically;
- Security demands safety from chronic threats and protection from harmful disruption.

Adapted from: Bansal and Howard [Eds] "Business and the Natural Environment", Butterworth-Heinemann, 1997, pp16

Literature review so far suggests that these four elements are currently not sufficiently acknowledged by the investment drive and general management of the Lake Victoria environment.

Documentary review of past research activities it can be concluded that industry, agriculture, fishery, animal husbandry are the key engines of economic growth of the LVB. Other sectors which are also important include forestry, energy production, and transportation. Corporate environmental and social responsibility (CESR) plays a critical role in developing a sustainable economic growth of the LVB. As such applied research initiatives in above attributes and linking them with CESR will significantly enhance sustainable economic growth.

5.2 Impact of Globalisation, Liberalisation and Privatisation on Sustainable Growth

On one hand, during the last decade Tanzania has embarked on liberalization of her economy which resulted into privatisation of previously state-owned industry and institutions. On the other hand globalization has been exerting pressure to the national economy including the LVB economy. These two factors may have two opposing results if not properly managed, namely

a) on the positive side, they may lead to social development and growth, through provision of jobs, paying taxes, building an industrial base, building infrastructure, enhancing efficiency, earning foreign exchange, poverty reduction and technology development
b) on the negative side liberalization, privatisation and globalization may bring interference in sovereign affairs (as the control of economy will not be in the hands of nationals), deepening disparities in wealth, poor labour conditions, corruption, transfer pricing, environmental pollution, depleting and or degradation of environmental resources, health and safety failings, child labour, and the disrespect of human rights.

The proposed applied research agenda should ensure that a balance of the two opposing possible outcomes of investment drive in the lake basin is essential.

The privatisation of previously state-owned industry, such as Mwatex, Mutex, Tanzania Breweries, Mining etc, has been a central part of the liberalisation of investment regimes. These pose several implications which warrant further applied research[8]: in order to answer the following questions

a) who takes responsibility for 'sins of the past' and potential environmental liabilities resulting from the generation of past pollution, like acid mine drainage for the case of mining industry;
b) what methodologies can better assist in the valuation of past environmental damage and solutions for its remediation;
c) how should the balance between return on investment for new shareholders and re-investment of profits in environmental protection and clean technology be defined.

Research under LVEMP-1 focused mainly on understanding the problems facing the Lake and its environs. The project components included water quality, water hyacinth, wetlands etc. However, the link of lake Victoria basin resources exploitation and sustainable development or growth of the basin were not intensively covered. In order for the applied research to inform sustainable development initiatives, research should look at the impact of lake resources degradation on sustainable development. The Applied research for examples may establish a link between industrial expansion on development, and in particular, detailed effects on social development indicators such as health and well-being, education and community participation. Moreover, there is still insufficient research comparing the environmental, social and economic effects of production across LVB and public and private owned firms, at the micro-level. While there is some research on costs there is less on benefits and how LVB has benefited or have suffered growing poverty, for different reasons, following liberalisation, which resulted in increase in mining activities, fish processing industry and other industrial development. Research that exists has not compared the perspectives and experiences of different stakeholder groups nor has it analysed of the trade-offs.

The liberalisation of world trade signified by NAFTA, GATT and the subsequent creation of the World Trade Organisation in 1995 have provoked a number of important and unanswered research questions with regard to a concept of sustainable economic

growth/development. The agreements are considered by some researchers to be essentially deregulatory instruments designed to promote global trade by allowing businesses easier access to new markets, new opportunities to invest and disinvest and the ability to relocate production facilities to low-wage economies (Bohman and Lindsey, 1997; Cameron, 1997; DeZeeuw, 1997; Edwards and Lester; Esty and Geradin, 1997; Hossein and Zadeh, 1997; LeHeron, 1997; Mayer et al, 1998; Piazolo et al, 1997; Weyerbrock, 1998; Wirth et al, 1997).

However, some concerns have been raised regarding the extent to which these agreements may enable companies to bypass other international agreements and the ability of developing countries, such as Tanzania, to impose investment barriers and restrict foreign ownership of local resources. There are also problems regarding the extent to which firms may be able to undermine corporate accountability i.e. attempts to impose conditionality to evade employing local experts. The agreements have also raised concerns about trade liberalisation acting as a stimulus for economic growth detrimental to improved environmental protection by restricting (a) national sovereignty; and (b) the right of individual nation states to introduce their own environmental measures including the utilisation of subsidies/incentives to encourage producers to satisfy higher environmental standards as part of a sustainable economy.
While it can be argued that companies are only legally responsible to shareholders, there remains the question of whether they are in any way morally responsible for advancing social goals, given the trans-boundary nature of their operations and the concomitant reduction of the role of the state that is the corollary of the process that facilitated their investment.

The Oxfam Global Charter for Basic Rights provides a useful working framework for addressing human rights in a research agenda aimed at contributing to a sustainable economy. It states: ‘Poverty is made by people and can be defeated. It is wrong that tens of millions of people continue to live in poverty’. It suggests that every person has a basic right to:

- Equality of opportunity
- Enough to eat
- Protection from violence
- Clean water
- A safe environment
- A livelihood
- An education
- A home
- Health care
- A say in the future

By proposing that human rights and in particular, fulfilling development rights and needs, are central to a sustainable economy, a number of questions for research are raised.

(a) If one considers that the fulfilment of those basic needs at a qualitative level are development rights and therefore human rights, an important research question still to be answered is: whose responsibility is it to observe those rights, to protect those rights or to provide for those needs.

(b) And, as part of the process of developing a sustainable economy, how should those responsibilities be distributed between individuals, the community, government and companies, in different situations, particularly where political power is not equal.

(c) Moreover, if human rights cannot be given – if they are given they can be taken away - how can peoples’ capacity be strengthened to determine their own values and priorities, to

organise themselves to act on these, to become empowered to realise their inherent potential and to participate fully in society and the development process in ways that leave them neither inadequate nor deny them their human rights.

5.3 The Effects of Industrial, Agricultural and Energy Production on Environmental, Social and Economic Development: Understanding the Impacts and the Implications for Different Stakeholders

Understanding the Heterogeneous Nature of Effects within a Sustainable Economy

The effects of production activities on environmental protection and social development generally, and development rights specifically, can be categorised within three spheres: economic, social and bio-physical. In other words corporate social responsibility should not be considered independently of the effects of production within the bio-physical and economic spheres. Recent research has shown that interactions between industry, for example, and communities do not occur in isolation but affect one another, with both the bio-physical and economic effects having the potential to cause indirect social impacts on development rights. Environmentally and economically responsible production could therefore be considered an essential component of overall corporate social responsibility within a sustainable economy (O'Faircheallaigh,1991), and therefore worthy of multidisciplinary research that considers them together, respecting their links rather than considering each in isolation from a single disciplinary perspective.

The industrial, energy, utility or agricultural project can be considered the 'input' and the economic and development rights impacts on affected stakeholders are 'outputs'. Research suggests that these social impacts are both positive and negative, and numerous and varied, in nature, with the capacity to either substantially enhance or diminish the economic and development rights profiles of stakeholders in the process of developing a sustainable economy.

(i) The Biophysical Sphere includes effects over time on the health of the ecosystem, on biodiversity conservation, on clean air and water, and the physical base of healthy livelihoods: marine resources, minerals, forests and agricultural soils. Ecosystem health and ecosystem approaches to human health (Costanza, 1992; Rapport, 1995; Cairns et al, 1993; Haskell et al, 1992) are receiving renewed attention in the research literature, but requires further multidisciplinary investigation.

(ii) The Economic Sphere includes effects over time on relative economic benefits, wages/salary rates, the distribution of natural resource-based commodity rents (taxes, royalties etc.) between central and regional administration agencies, and economic effects on local and remote community livelihoods. It specifically includes the concept of 'trade-offs', and there exists few systematic research studies of the effects of industrial projects' investment in the internalisation of previous external environmental damage costs, or indeed human health costs, for the national economy in terms of reduced revenue. There are important research questions to be answered regarding who is responsible – business or government – for the delivery of qualitative development needs, and general environmental protection, in the transition process towards a sustainable economy.

(iii) The Social Sphere includes:

- Socio-political effects over time on individuals and groups, and their capacity to organise. It also includes effects on human health and working conditions, and effects relevant to processes of empowerment.

- Socio-cultural effects over time on the cultural heritage of individuals and groups, on their spiritual and cultural well-being, on their attitudes and behaviour and with respect to their education.
- Constraints on developing a sustainable economy and human or development rights 'violations' can become manifest either directly or indirectly through the medium of all three spheres.

5.4 Drivers of Environmental and Social Responsibility and Factors Shaping the Sustainable Economy

The proposed multidisciplinary research agenda will address the following questions:

- what are the elements of corporate strategy that define and promote best-practice?
- what are the elements of public policy that promote best-practice – pollution prevention and waste minimisation rather than post-facto clean-up?
- cost effective clean-up technologies for ongoing operations;
- planning for pollution-prevention and waste-minimisation from the outset.

5.5 Drivers and Imperatives of Environmental and Social Responsibility and the Sustainable Economy

5.5.1 Regulatory drivers

Whether environmental regulation, and this fundamental shift from the paradigm of command control 'single-medium' pollution clean-up to market incentives for integrated pollution prevention, will prove an effective driver for moving towards a sustainable economy, requires a renewed and detailed multi-disciplinary research effort.

In determining how the productive sector might address these issues, three inter-related themes could be considered:

(a) Comparative analysis of environmental/social performance and its relationship with production efficiency

There is a need for multidisciplinary network research to evaluate and benchmark environmental performance within and across companies and to understand the determinants of environmental performance and the relative role of regulation. Research to date suggests: sound environmental practices is most likely to result from production efficiency and capacity to innovate rather than regulatory compliance alone; high levels of environmental degradation and negative social impacts result from high cost operations utilising obsolete technology, limited capital and poor human resource management; such problems are characteristic of mineral extraction activities in developing countries; hence there is a need to undertake applied research to investigate the determinants of environmental/social performance.

(b) Analysis of international environmental regulations and the definition of improved policy options

There is a need to undertake an extensive and comparative international assessment of environmental regulation and the factors explaining success in terms of both enforcement

and results. There is also need to evaluate the success and failure of different policy approaches designed to achieve:

a) sustained and competitive improvements in environmental management and
b) (b) pollution prevention rather than pollution treatment so as to disseminate the lessons from other regulatory regimes' experiences. This could include an evaluation of improved technology transfer and training with particular regard to joint-venture agreements intended to facilitate the wider development and application of environmental management practices and clean technology.

(c) Towards corporate social and environmental 'best practice'

There is a need for research to assist the planning process through the development of improved impact assessment techniques. For example, to examine the interface between the productive sector and the social environment in direct relation to social and environmental impact prediction, prevention, analysis and mitigation. This applied research agenda should also incorporate the setting of environmental and social goals and targets, and the development of appropriate monitoring programmes, all of which would be essential parts of developing a sustainable economy.

5.5.2 Voice of society concerns:

As noted above, companies are increasingly being subject to scrutiny from public interest groups and environmental organisations. These evaluations are often not undertaken in accordance with sound research methods, nor are they verified systematically. Such public pressure is likely to result in companies determining their own environmental and social responsibility targets. However, research suggests that it is imperative that they define robust strategies in pursuit of these objectives and introduce verifiable performance measures over time. It is also important for industry to report their results coherently and comprehensively to their different stakeholders both within and external to the firm, at the local, national and international level. Research is needed to support the methodologies required to do this.

This action may well require a substantial conceptual shift on the part of industry and collaboration with universities in an 'honest broker' research role. Moreover the acceptance of corporate social responsibility challenges existing assumptions regarding the extent of industry's societal obligations i.e. the need to move beyond their legal and contractual obligations to employees and shareholders towards some responsibility for promoting environmental and social goals. As such it is important to distinguish between 'rights' and pro-active 'corporate social responsibility' (Warhurst 1998a).

Whereas 'rights' implies regulatory compliance, pro-active corporate social responsibility' implies compliance plus - the active development and implementation of social responsibility within mainstream business strategy, supported by technological and organisational innovation, to prevent negative environmental and social impacts and optimise social benefits from the outset. It also involves, through socially responsible management, the mitigation, on an ongoing basis, of negative effects, if and when they occur. This approach is synonymous with the notion of preventing rather than minimising pollution.

Pro-active corporate social responsibility (Warhurst, 1998) as a pre-cursor to developing a sustainable economy represents a departure from the traditional model of social responsibility first advocated by Friedman, 1970. He argued that, providing the company is able to demonstrate sound economic and resource management, it has fulfilled its social responsibility. However, research has shown that Friedman's model failed to account for the

invariably complex conflicts of interest over time and amongst different stakeholders regarding what constitutes an efficient use of resources.

Moreover, pro-active corporate social responsibility requires the firm to adopt a forward-looking integrative approach towards social responsibility by actively anticipating, preventing and/or minimising any adverse social impacts across the bio-physical, economic and social spheres. To achieve this, research suggests that within a sustainable economy the firm needs to consult closely with its stakeholders and ensure their concerns and recommendations form an integral part of the company's plans from the outset as well as future policies and activities (Warhurst, 1998). This will require new research in the area of "stakeholder mapping" regarding methodological tools to identify and 'map-out' different stakeholder concerns and to ascertain representativeness and relative significance. Again, this suggests 'operationalisation' is now key for transforming commitment and vision regarding sustainable development into reality and verifiable progress.

It is suggested that improved environmental education – both informally through the media and popular literature and formally through the greening of the curriculum at schools and higher and further education institutions, could be a major factor in supporting the increasing articulation of the public environmental concerns. More research is needed to support the role of teachers/lecturers and to evaluate progress in increasing environmental awareness and related critical faculties.

5.5.3 Financial drivers

As a result of increased competitive pressures, financial institutions are rising to environmental challenges. While international banks now undertake environmental financial risk assessment of their borrowers this is not done in Tanzania. The international banks incorporate environmental liability into loan terms and monitor environmental risks (Vaughan, 1995). There is a need to recognise that environmental risks should be part of the normal checklist of risk assessment and management. Research may include environmental response e.g. in case of accidents and spills, compensation and liability e.g. liability for cleanups costs. If banks can include these conditions in their loan requirements, they may improve corporate responsibility.

Other issues for research include:
- Environmental management systems and strategies as pre-conditions for loans
- Environmental bonds
- Debt for nature swaps

Applied Research is needed to identify financial drivers of environmental and social performance by considering which mechanisms offer the potential for enhancing a company's environmental performance, for example, the attachment of environmental conditions to the provision of credit, equity investment and social and political risk insurance.

Research is also needed to consider the extent to which financial conditionality as a driver enhances the regulatory and monitoring capacity of developing countries within a sustainable economy and how improved collaboration between various stakeholders might best be achieved.

Research is needed to inform social and environmental impact analysis methodologies, which still need improvement with reference to predictive capacity and public participation.

5.5.4 Environmental Change

The world faces a number of very real bio-physical environmental challenges. Many of the world's ecosystems are threatened by human activity and there is increasing evidence of climate change driven by fossil fuel consumption, escalating biomass consumption and depletion, and the introduction of trace gases primarily from industrial sources. Rapid population growth coupled with continuously rising incomes and global economic activity are further serving to intensify the scale of the environmental problems requiring resolution.
These events have caused the OECD, amongst others, to recommend

- the global implementation of sustainability indicators thereby enabling the economic, environmental and social policies of individual nations to be evaluated; and
- establishing two new international consultative bodies, forums for the development of effective policies to promote sustainable development.

There is also a need to undertake more systematic applied research into naturally occurring pollution hazards, for example: acid mine drainage, environmental change, for example: biodiversity changes that may well have occurred independently of human intervention. The Convention on Biological Diversity (CBD) arose primarily from attempts by UNEP to establish a legal instrument for the sustainable use and biodiversity conservation.

Article 1 of the convention outlines the objectives of the document and is a clear indication of the broad nature and significance of the tasks faced by nation states, it states:
"The objectives of this Convention to be pursued in accordance with its relevant provisions, are the conservation of biological diversity, the sustainable use of it's components and the fair and equitable sharing of benefits arising out of the utilisation of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding".

More research needs to be undertaken to map out existing biodiversity in the lake basin. This will involve collaborative research between the natural/applied bio-science, social science and business research communities.

CHAPTER 6: IMPLEMENTATION (INSTITUTIONAL) FRAMEWORK

6.1 Introduction

Initially LVEMP, but later the LVB Management Authority in Tanzania or LVBMA (T) once established, has the mandate to coordinate research aimed at implementation of the Research Agenda. Implementation of the research programme (its components, projects and activities) will, however, be the responsibility of research institutions or institutions with mandate for undertaking research as well as contracted individual researchers. An LVB research fund shall be established to facilitate implementation of strategic LVB research.

LVEMP/LVBMA (T) will provide leadership in the dissemination of environmental research findings in the country, principally through:

- An Annual Scientific Conference
- A Research Website backed by an e-Library
- An LVB research journal
- Other means of communication as defined in the Monitoring and Communication Framework
- Facilitating the presentation of and publications of research articles in scientific conferences and journals respectively

6.2 Establishment of a Research Department at LVEMP/ LVBMA (T)

Within the LVEMP/LVBMA (T) a department of research will be established. The department will have a lean structure since its role will mainly be that of coordination of LVB research – with the actual implementation of research projects being done by specialized research institutions and individual researchers. The staffing of the department will include:

- Department Head – Principal Research Coordinator
- Two Research (Coordinating) Officers – to manage the implementation of the LVB Research Agenda/Programme
- An Officer responsible for managing the E-Research Library and Website
- Editor – LVB Research Journal
- An Officer responsible for managing the LVB Ree

6.3 LVB (T) Research Advisory Committee

In order to effective link with all key LVB research stakeholders, an LVB(T) Research Advisory Committee will be established as a body to further advise LVBMA (T) on how to strengthen research coordination and ensure an effective implementation of the LVB research agenda/programme. The composition of the committee will be drawn from the Government, research institutions, civil society and strategic development partners and be determined by LVEMP/LVBMA (T). The Department of Research will be the secretariat to the committee.

The Research Advisory Committee (RAC) will be chaired CEO of LVEMP/ LVBMA (T). Its main functions will include:-

- To advise on the implementation of the Agenda for LVB Research and Research Programme
- To review and update the Agenda and Programme
- To promote the Research Agenda and Programme
- To assist in research fund raising activities
- To assist in the scrutinizing research applications – for funds mobilised by LVBMA(T);
- To monitor and evaluate the implementation of the the Research Agenda and Programme
- To advise on any other emerging research issue.

6.4 An Annual National LVB Scientific Conference

LVEMP/LVBMA (T) with the support of RAC will organise an annual National LVB Scientific Conference. The conference will be a forum for stakeholders to receive and deliberate on reports on the research activities carried-out with the framework of LVB Research Agenda and Programme. It will provide strategic feedback on the management of LVB research in the country in line with the Research Agenda and Programmme. It will also provide input in the review and updating of the Research Agenda and Programmme.

6.5 National LVB Research Fund

LVEMP/LVBMA (T) will establish a "National LVB Research Fund" focussed on the Research Agenda and mobilise funds accordingly. All funders of LVB research (EAC, Governments, development partners, private sector and civil society) will be strongly encouraged to do so through the Fund since all necessary measures will be taken to ensure professional and efficient management of the Fund.

A fulltime (highly competent and motivated) officer will be recruited to managed all activities related to the Fund. Implementation will be through competitive application for research funds for activities in the LVB Research Programme or in-line with the Agenda by research institutions and individual researchers. The following criteria will provide guidance in granting research funding under the Fund:

- The research topic must address a priority research theme which is in the Agenda.
- The research proposal must be scrutinized by the RAC and approved.
- The research proposal must focus on, among other things, improving the livelihoods of communities and sustainable management of the environment in the LVB
- The research must show mechanisms for M& E including indicators.

LEMP/LVBMA (T) will develop detailed operational policies and procedures to guide funding, implementation and monitoring of research activities under the Fund.

CHAPTER 7: MONITORING AND EVALUATION FRAMEWORK

7.1 Organization for the M&E Function

Monitoring of the LVB Research Agenda and Programme will be the overall responsibility of RAC. The committee will periodically audit the implementation of the research programme.

The LVEMP/LVBMA (T) Research Department will prepare detailed annual research operational plans showing quarterly targets – for strategic research funded by through the LVB Research Fund. The implementing actors (the funded research institutions and individual researchers) will report on the implementation of respective activities in the operational plans on a quarterly basis using a reporting format to be designed and issued by the Department. Institutions and individual researchers during research funded through other non- LVEMP/LVBMA(T) arrangements will also be encouraged and requested to report on other activities on quarterly basis or to share the progress/research reports as they become available.

7.2 Indicators and Data Sources

Monitoring and evaluation of the Research Agenda and Programme will make use of the indicators defined in the Logical Framework Matrix (Chapter 4). Data sources for computing the indicators will be the survey and programme activity reports submitted by research institutions/individual researchers and official Government, LVBMA (T) and EAC data sets.

The computerized database management system proposed in the LVB Monitoring and Communication Framework will be used to assist with the attendant data capturing, storage, analysis and packaging the analysed into defined information products.

7.3 Monitoring Reports

LVEMP/LVBMA(T) will prepare and disseminate quarterly research monitoritng reports. The quarterly monitoring reports will comprise:

- The approved strategic research actions for the year and their target indicators;
- Achievements in terms of outputs, the deviations in the planned activities and outputs. Achievements should reflect both the qualitative and quantitative achievements;
- Constraints in the implementation of the respective operation plan activities and any internal and external factors which have affected implementation;
- Proposed remedial actions and the way forward for solving the problems faced, indicating clearly the planned activities to be carried out in the next quarter.

7.4 Evaluation

There will be two types of evaluation of the five-year Research Agenda and Programme - once every two and half years using internal evaluators, and once every five years using an external evaluation team.

The internal and external evaluations will have similar Terms of Reference and will focus on:

- Assessing the reasons for success or failure of specific aspects of the Research Agenda and Programme;
- Assessing whether the Research Agenda and Programme are achieving thier objectives and targets;
- Finding out whether the effects of the Research Agenda and Programme are contributing to a better fulfilment of the Vision of the LVB;
- Assessing the adequacy of resources being mobilised to implement the Research Agenda and Programme;
- Determining whether available resources are being utilised efficiently to achieve the targets set for the Research Agenda and Programme;
- Determining whether the process of coordinating LVB research is facing any problems that need immediate or long-term solutions.

7.5 Reviewing and Rolling Forward the Research Agenda/Programme

The Research Agenda and Programme will be reviewed and updated once every three years. The review will be based on the internal and external evaluation reports.

CHAPTER 8: COMMUNICATION AND DISSEMINATION PLAN[15]

8.1 Key Audiences

The key targeted group for communication audience and user groups of the research information are summarized below:

- Group I: National/Regional Administration;
- Group II: Local Authorities;
- Group III: LVB MA;
- Group IV: Wider Community; and

Group V: Cross Sector Stakeholders

Target audience ranked by importance	Preferred/appropriate channel of communication
Priority I: Wider Community	Newsletter, networking lunch, workshop, an evening reception, cultural entertainments, dances, songs, drama,
Priority II: National/Regional Administration	Reports, Newsletter, conference, networking lunch, workshop, press release, website, regional seminars
Priority III: Local Authorities	Newsletter, conference, networking lunch, workshop, an evening reception, press release,
Priority IV: LVB MA	Reports, Newsletter, conference, networking lunch, workshop, an evening reception, email alerts, press release, website, promotional literature, regional seminars
Priority V: Cross Sector Stakeholders	Reports, Newsletter, conference, email alerts, website, promotional literature, regional seminars

8.2 Stakeholders and Partners

⇒ The LBV MA needs to communicate with diversity and number of people regarding Applied Research issues. These are:

National/Regional Administration

- Ministry Responsible for Water
- Ministries of Responsible for Agriculture, Food Security and Cooperatives
- Ministry Responsible for Industry, Trade and Marketing;
- Ministry Responsible for Health
- Ministry Responsible for Energy and Minerals

[15] BICO(2006), National Framework: Monitoring and Communication for the Lake Victoria Basin

- Ministry Responsible for Livestock Development
- Ministry Responsible for Local Government (District Authorities)
- Ministry Responsible for Lands and Human Settlement
- Ministry Responsible for Natural Resources,
- Ministry Responsible for Defense,
- Ministry Responsible for Home Affairs
- Vice President's Office
- Prime Minister's Office
- City, Municipal and Town Councils

Local Authorities

- Local Leaders
- Chief Executives
- Members of Parliament
- Councillors
- Social Services Providers
- Senior Management
- Urban and Rural Water supply/Water and Sanitation Authorities
- Other Staff
- Independent Sector

LVB MA
Staff and management

Wider Community

- Private sector (Industries including mining industries)
- NGOs/CBOs/BMUs
- Farmers
- Foresters
- Pastoralists
- Fisher folks
- The media

Cross Sector Stakeholders

- Professional bodies
- Trade/cooperative unions
- Academic and research institutions
- Tourism Board,
- Manufacturing Associations,
- Chamber of Commerce

8.3 Key Messages

Key messages will fall into two categories; a set of core messages for the programme and audience specific messages.

Core Messages

The following are the key themes:

- Helping you to look after the health of LVB ecosystem and well-being of riparian communities
- Fighting poverty while protecting LVB ecosystem

- Taking advantage of the investment opportunities in the LVB for sustainable development
- Improving and modernising LVB resource extraction
- Making the best possible use of LVB resources
- Responsibility for conservation of the ecosystem health of LVB and well-being of riparian communities is shared between the Government, all organisations in the public, private and voluntary sectors, the media and the public
- Protecting the LVB ecosystem though public and private participation
- Individuals, NGOs, CBOs, BMUs playing major and pro-active role in LVB ecosystem management

Target audience messages are shown in Table 8.1.

Table 8.1: Stakeholders Groups in LVB and their information requirements

Stakeholder Group	**Information Requirement**	**Source of Information**	**Communication Channels**
Group I: National/Regional Administration			
Ministry Responsible for Water	▪ Information about water quality and quantity ▪ Conservation of water sources ▪ Wetlands management ▪ Climate change and precipitation ▪ Water abstraction ▪ Water pollution trends ▪ Types and trends on industrial activities within the basin ▪ River flows and general hydrology of the LVB ▪ Water hyacinth and other aquatic water weeds trends and status ▪ Eutrophication status ▪ Water transport trends ▪ Fisheries and Fishing practices	LVB MA, Research and Academic Institutions, Sector Ministries Resource User, NGOs, Private Sector, International, Researchers	Official Communication (e.g. Annual/quarterly reports) Ministerial meetings Inter-ministerial meetings Newsletter, conference, networking lunch, workshop, press release, website, e-mails, regional seminars; Research reports; Brochures and Leaflets

Stakeholder Group	Information Requirement	Source of Information	Communication Channels
Ministry Responsible for Agriculture and Food Security	▪ Pests and diseases (types and trends) ▪ Immigrant pests ▪ Soil types ▪ Agricultural practices in the LVB ▪ Soil erosion tendencies and data ▪ Climatic conditions (rain, climate) ▪ Land use trends ▪ Pesticide and fertiliser needs (types and quantity) ▪ Impacts of agricultural practices ▪ Land productivity ▪ Water availability/use/conservation measures ▪ Investment opportunities and trends in agricultural sector ▪ Market trends of agricultural produce		
Ministry Responsible for Livestock Development	▪ Livestock carrying capacity of different priority villages and districts ▪ Grazing land ▪ Pastoralists immigration trends ▪ Pests and diseases types and trends ▪ Water availability ▪ Dipping and veterinary services ▪ Market trends of livestock and livestock products		
Ministry Responsible for Local Government (District Authorities):	▪ Agricultural activities ▪ Forestry ▪ Urban waste management ▪ Industrial activities and trends ▪ Animal husbandry ▪ Town planning and development ▪ Conservation areas ▪ Fisheries ▪ Animal husbandry and trends ▪ Climate change and its impact to natural resources		
Ministry Responsible for Lands and Human Settlement	▪ Demographic trends ▪ Squatter development ▪ Town city planning and development ▪ Social service provision		
Ministry Responsible for Industry, Trade and Marketing	▪ Industrial activities and trends ▪ Investment opportunities ▪ Industrial wastewater treatment facilities ▪ Industrial effluent monitoring reports and trends		

Stakeholder Group	Information Requirement	Source of Information	Communication Channels
Ministry Responsible for Health	▪ Demographic trends ▪ Water quality and trends ▪ Human diseases and trends ▪ Diseases vectors and trend ▪ Nutritional status of riparian communities ▪ Health care provisions and trends ▪ Types and quantities of chemicals used		
Ministry Responsible for Energy and Minerals	▪ Mining activities in the LVB ▪ Technologies used ▪ Mining waste treatment ▪ Mining site remediation activities		
Vice President's Office	▪ Industrial effluent (standards, quantity, trends) ▪ Environmental conservations ▪ Chemicals waste management ▪ General environmental management ▪ Policies and legislations		
Prime Minister's Office	▪ Contingency plans ▪ Disaster management plans ▪ Policies		
Ministry Responsible for Infrastructure Development	▪ Marine vessels (types, quantity, status) ▪ Disaster management plans ▪ Sectoral policies ▪ Road Transport (types and trends)		
Ministry Responsible for Natural Resources	▪ Conservation areas ▪ Climate change and its impact to natural resources ▪ Transboundary resources management ▪ Investment opportunities and trends in fisheries and agricultural sector ▪ Investment opportunities and trends in the Mining sector ▪ Investment opportunities and trends in the forestry sector		
Ministry Responsible for Defense	▪ Human migrations in the LVB especially the refugees movement		
Ministry Responsible for Home Affairs	▪ Human migrations in the LVB especially the refugees movement ▪ Number of vessels plying the Lake ▪ Policies and legislations		

Stakeholder Group	Information Requirement	Source of Information	Communication Channels
City, Municipal and Town Councils	▪ Solid and wastewater management system ▪ Waste treatment systems ▪ Policies and legislations	LVB MA, Research and Academic Institutions, Sector Ministries Resource User, NGOs, Private Sector, International Researchers, Cooperative Unions,	Official Communication (e.g. Annual/quarterly reports) Newsletter, conference, networking lunch, workshop, press release, website, e-mails, regional seminars; Research reports; Brochures and Leaflets
Group II: Local Authorities			
Local Leaders	▪ Investment opportunities ▪ Social economic status of the LVB ▪ Contribution of LVB resources to sustainable development of the riparian communities ▪ Implementation on national policies and legislations on conservation of LVB ecosystem ▪ Pest and diseases in the LVB (in particular (HIV/AIDS) ▪ Number of schools and hospitals	LVB MA, Councils, Resource User, NGOs, Private Sector, Cooperative Unions	Official Communication (e.g. Annual/quarterly reports) Newsletter, conference, networking lunch, workshop, press release, website, e-mails, regional seminars; Research reports; Drama and traditional dances; Brochures and Leaflets
Chief Executives	▪ Investment opportunities ▪ Implementation on national policies and legislations on conservation of LVB ecosystem	LVB MA, Research and Academic Institutions, Sector Ministries Resource User, NGOs, Private Sector, International, Researchers, Investors	Official Communication (e.g. Annual/quarterly reports), Board Meetings Newsletter, conference, networking lunch, workshop, press release, website, e-mails, regional seminars; Research reports; Brochures and Leaflets

Stakeholder Group	Information Requirement	Source of Information	Communication Channels
Members of Parliament and Councillors	▪ Investment opportunities ▪ Social economic status of the LVB ▪ Contribution of LVB resources to sustainable development of the riparian communities ▪ Implementation on national policies and legislations on conservation of LVB ecosystem ▪ Pest and diseases in the LVB (in particular (HIV/AIDS) ▪ Number of schools and hospitals	LVB MA, Research and Academic Institutions, Sector Ministries Resource User, NGOs, Private Sector, International Researchers, Cooperative Union	Official Communication (e.g. Annual/quarterly reports) Council meetings Newsletter, conference, networking lunch, workshop, press release, website, e-mail, regional seminars; Research reports; Brochures and Leaflets
Social Services Providers	▪ Social economic status of the riparian communities ▪ HIV/AIDS status and other diseases (such as malaria, cholera etc.) ▪ Number of schools ▪ Number of children attending school and drop out rates ▪ Number of hospitals ▪ Income levels ▪ Fish catch ▪ Type and number of people engaged in different social economic activities within the basin	LVB MA, Research and Academic Institutions, Sector Ministries Resource User, NGOs, Private Sector, International Researchers, Cooperative Union, Schools, Hospitals	Official Communication (e.g. Annual/quarterly reports) Council meetings Newsletter, conference, networking lunch, workshop, press release, website, e-mail, regional seminars; Research reports; Brochures and Leaflets
Senior Management (social economic entity) and Other staff	▪ Best available technologies ▪ Best environmental practices ▪ Effluent and other environmental standards ▪ Policies and legislations ▪ Investment opportunities	LVB MA, Research and Academic Institutions, Sector Ministries Resource User, NGOs, Private Sector, International, Researchers, Investors	Official Communication (e.g. Annual/quarterly reports), Board Meetings Newsletter, conference, networking lunch, workshop, press release, website, e-mails, regional seminars; Research reports; Brochures and Leaflets
	LVB MA		

Stakeholder Group	Information Requirement	Source of Information	Communication Channels
Staff and management	▪ Effluent standards ▪ Types and quantity of pesticides used by riparian farmers ▪ Land use change ▪ Agricultural practices in the lake basin ▪ Animal husbandry activities ▪ Number of vessels plying the Lake ▪ Forest cover and forest conservation activities ▪ Wetlands and extent of wetland conservation ▪ Investment opportunity ▪ Social economic status of the riparian ▪ Climate Change ▪ Pest and diseases	Research and Academic Institutions, Sector Ministries, Resource User, NGOs, Private Sector, International, Researchers	Official Communication (e.g. Annual/quarterly reports) Newsletter, conference, networking lunch, workshop, press release, website, e-mails, regional seminars; Research reports, Brochures and Leaflets
	Wider Community		
Private sector (Industries including mining industries, manufacturing associations, chamber of commerce)	▪ Investment opportunities ▪ Effluent standards ▪ Policies and legislations ▪ Private sector participation in sustainable development ▪ Waste treatment technologies ▪ Impact of industrial activities on LVB ecosystem health ▪ Best available technologies ▪ Best environmental practices ▪ Occupation health ▪ Impact of HIV/AIDS on their workforce	LVB MA, Research and Academic Institutions, Sector Ministries Resource User, NGOs, Private Sector, International, Researchers, Investors	Official Communication (e.g. Annual/quarterly reports), Company meetings Newsletter, conference, networking lunch, workshop, press release, website, e-mails, regional seminars; Research reports; Brochures and Leaflets
NGOs/CBOs/BMUs	▪ Best practices in fisheries/ agricultural practices / animal husbandry ▪ Community participation in LVB management ▪ Impact of unsustainable fishing /agricultural / animal husbandry practices on LVB ecosystem ▪ Pets and disease (HIV/AIDS in particular), types and spread ▪ Investment opportunities ▪ Market trends and opportunities ▪ Aquaculture / Horticulture / ▪ Transboundary resources management	LVB MA, Research and Academic Institutions, Sector Ministries Resource User, NGOs, IGO, Private Sector, International, Researchers, Investors, Cooperative Unions	Official Communication (e.g. Annual/quarterly reports), Newsletter, conference, networking lunch, workshop, press release, website, e-mails, regional seminars; Research reports; Brochures and Leaflets; Drama and traditional dances; Outreach services

Stakeholder Group	Information Requirement	Source of Information	Communication Channels
Farmers	▪ Best practices in agriculture ▪ Community participation in LVB management ▪ Impact of agricultural practices on LVB ecosystem ▪ Impact of agricultural practices to soil erosion, deforestation ▪ Sustainable agricultural practices ▪ Pets and disease ▪ Suitable pesticides and fertilisers ▪ Investment opportunities. ▪ Market trends and opportunities ▪ Importance of wetland and forestry on ecosystem management ▪ Safe handling and storing of pesticides ▪ Horticulture ▪ Soil conservation measures, such as conservation tillage, rainwater harvesting, and agro-forestry	LVB MA, Research and Academic Institutions, Sector Ministries Resource User, NGOs, IGO, Private Sector, International, Researchers, Investors, Cooperative Unions	Official Communication (e.g. Annual/quarterly reports), Newsletter, conference, networking lunch, workshop, press release, regional seminars; Research reports; Brochures and Leaflets; Drama and traditional dances; Outreach services
Foresters	▪ Forest conservation ▪ Sustainable forestry management ▪ Impacts of deforestation on LVB ecosystem management ▪ Community participation in forestry management	LVB MA, Research and Academic Institutions, Ministry Responsible for Natural Resources and Tourism, NGOs, IGO, Private Sector, Investors, Cooperative Unions	Official Communication (e.g. Annual/quarterly reports), Newsletter, conference, networking lunch, workshop, press release, website, regional seminars; Research reports; Brochures and Leaflets; Drama and traditional dances; Outreach services

Stakeholder Group	Information Requirement	Source of Information	Communication Channels
Pastoralists	▪ Carrying capacity of grazing land ▪ Pests and diseases ▪ Best available technologies in animal husbandry ▪ Based environmental practices in animal husbandry ▪ Impact of overstocking/overgrazing on environmental degradation ▪ Community participation in environmental management ▪ Impact of animal husbandry on catchment areas ▪ Co-existence of farmers and pastoralists	LVB MA, Research and Academic Institutions, Ministry Responsible for Live Stock Development, NGOs, Private Sector, Councils, Investors, Cooperative Unions	Official Communication (e.g. Annual/quarterly reports), Newsletter, conference, networking lunch, workshop, press release, website, regional seminars; Research reports; Brochures and Leaflets; Drama and traditional dances; Outreach services
Fisher folks	▪ Better fishing methods and on how to curb illegal fishing ▪ Best fishing practices ▪ Appropriate fishing technologies ▪ Fishing and non fishing seasons ▪ Impact of exotic fish species on LVB ecosystem ▪ Breeding areas	LVB MA, Research and Academic Institutions, Ministry Responsible for Natural Resources and Tourism, NGOs, IGO, Private Sector, Investors, Cooperative Unions	Official Communication (e.g. Annual/quarterly reports), Newsletter, conference, networking lunch, workshop, press release, website, regional seminars; Research reports; Brochures and Leaflets; Drama and traditional dances; Outreach services
The media	▪ State of environmental ▪ Impact of human activities on LVB ecosystem ▪ Effluent and other environmental standards ▪ Policies and legislations ▪ Best available technologies ▪ Best environmental practices ▪ Community and private sector participation ▪ Investment opportunities	LVB MA, Research and Academic Institutions, Sector Ministries Resource User, NGOs, IGO, Private Sector, International, Researchers, Investors, Cooperative Unions	Official Communication (e.g. Annual/quarterly reports), Newsletter, conference, networking lunch, workshop, press release, website, e-mails, regional seminars; Research reports; Brochures and Leaflets
	Cross Sector Stakeholders		

Stakeholder Group	Information Requirement	Source of Information	Communication Channels
Riparian Universities – for the case of Tanzania, the University of Dar es Salaam, Sokoine University of Agriculture, Mzumbe University,	▪ Research needs ▪ Number of fish catch ▪ Size of fish ▪ Pests and diseases ▪ Ecological indicators ▪ Pressure indicators ▪ Status indicators ▪ Socio – economic indicators	LVB MA, Research and Academic Institutions, Sector Ministries Resource User, NGOs, IGO, Private Sector, International, Researchers, Investors, Cooperative Unions	Official Communication (e.g. Annual/quarterly reports), Newsletter, conference, networking lunch, workshop, press release, website, e-mails, regional seminars; Research reports; Brochures and Leaflets
Tanzania Fisheries Research Institute (TAFIRI)	▪ Research needs ▪ Number of fish catch ▪ Size of fish ▪ Pests and diseases ▪ Ecological indicators ▪ Pressure indicators ▪ Status indicators ▪ Socio – economic indicators	LVB MA, Research and Academic Institutions, Sector Ministries Resource User, NGOs, IGO, Private Sector, International, Researchers,	
Nyegezi Fisheries Training Institute Maruku Research Institute, TAFORI	▪ Research needs ▪ Number of fish catch ▪ Size of fish ▪ Pests and diseases ▪ Ecological indicators ▪ Pressure indicators ▪ Status indicators ▪ Socio – economic indicators	LVB MA, Research and Academic Institutions, Sector Ministries Resource User, NGOs, IGO, Private Sector, International, Researchers,	
NIMR,COSTECH , St Augustine university	▪ Research needs ▪ Pests and diseases ▪ Ecological indicators ▪ Pressure indicators ▪ Status indicators ▪ Socio – economic indicators	LVB MA, Research and Academic Institutions, Sector Ministries Resource User, NGOs, IGO, Private Sector, International, Researchers	Official Communication (e.g. Annual/quarterly reports), • Newsletter, conference, networking lunch, workshop, press release, website, e-mails, regional seminars; Research reports; Brochures and Leaflets

Stakeholder Group	Information Requirement	Source of Information	Communication Channels
Bureau of statistics	▪ Socio – economic indicators ▪ Demographic trends ▪ Market trends of agricultural produce ▪ Market trends of livestock and livestock products ▪ Industrial activities and trends ▪ Number of schools ▪ Number of children attending school and drop out rates ▪ Number of hospitals ▪ Income levels ▪ Fish catch ▪ Type and number of people engaged in different social economic activities within the basin	LVB MA, Research and Academic Institutions, Sector Ministries Resource User, NGOs, IGO, Private Sector, International, Researchers	Official Communication (e.g. Annual/quarterly reports), Newsletter, conference, networking lunch, workshop, press release, website, e-mails, regional seminars; Research reports; Brochures and Leaflets

Table 8.2: Quarterly Progress Report Format

Project:_____

Reporting Entity: FROM: _____ TO: _____

SN	Strategic Objective	Activity Description	Target Group	Desired Results	Actual Results	Budget	Actual Spent	Remarks

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