CHAPTER THIRTEEN

Capacity building in water quality in the Lake Victoria basin, Uganda

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INTRODUCTION

Lake Victoria is the second largest lake in the world. It is recognized as an immense geographical and economic entity covering a surface area of 68,800 km^2. The lake is believed to support about 40 M people within and around its catchments. The gross economic product from the lake approximates 30% of the combined GDP of the East-African countries. Major economic activities include fishing and crop husbandry, with coffee and tea being the principal export crops.

The lake and its catchment commands world-wide scientific interest not only for its massive size and economic importance, but also because it is a home of diverse ecosystems whose existence has increasingly become threatened, manifested by loss of diversity, over fishing, eutrophication, proliferation of invasive weeds, siltation, toxic contamination and over extraction of water. These observable changes lead to sentiments like 'Lake Victoria is in danger of becoming the world's largest pool of dead water'. It is also believed that half its native fish are extinct, and the 40 million people who eke out a living from its troubled waters are facing an eminent calamity.

To ensure sustainable use of resources of this unique and fragile ecosystem there was need to collect quantitative and qualitative information to assist in formulation of policy and management strategies. Generation of this information necessitated building capacity that was lacking in water quality and quantity studies and management.

To address and in attempt to reverse the above situation, a comprehensive water quality and quantity component study was designed with the following specific objectives:

- To provide detailed and usable information on the characteristics of the waters of Lake Victoria.
- To establish and operationalise integrated water quality monitoring network so as to generate information on the physical status, chemical characteristics and biological composition of the lake.
- To develop and operationalise a water quality management model to be used as a planning tool in the management scenarios of Lake Victoria and its ecosystem in a bid to establish historical trends and future projections more especially where concrete data is missing.
- To develop and continuously update the mass water balance of Lake Victoria.
- To contribute on the social benefits which the community can accrue as a result of accessing lake water of good quality
- Identify impacts on the beneficial uses of Lake Victoria
- To develop, enforce and regularize water quality standards and monitor compliance.
- Build human capacity to manage lake resources.

It was, however, realized that there were big gaps of capacity in handling the study more especially in data generation and interpretation in the country. Therefore the component identified human resources, laboratory and field infrastructure, monitoring network, and database development as capacity building areas. In return specific capacity building objectives were developed.

Specific Objectives

- To train scientists to various formal levels and short tailored courses.
- To improve the respective technical skills
- To enable the laboratories in Uganda (and also Kenya and Tanzania) to handle efficiently an increased number of analyses, and water quality parameters.
- To establish reliable data generation mechanism, handling and management tools.
- To institute both Internal and Regional Quality Assurance Mechanism in terms of data generation

Capacity Building Achievements

Human resources, laboratory and field infrastructure, monitoring network, and database development were targeted for building capacity in the Water Quality and Quantity component with the support of LVEMP with emphasis in establishment of internal and regional quality assurance mechanism, enhancement of laboratory performances and efficiency, and data generation and management. Modeling was also identified among highlighted areas of concern with inadequate skilled capacity.

Human Resource Building

During the seven years of LVEMP, 10 MSc and 1 PhD candidates were trained, and several specialized short courses were offered to a number of scientists on the component of water quality and quantity.

- A number of specialized training consultancies were procured including outreach through workshops relevant to water quality management.

Other specialised and knowledge upgrade areas that have been addressed include hydraulic conditions training using “wet lease equipments” procured from the United Nations Institute of Water Research, Canada. In order to evaluate the nature and dynamics of the lake ecosystem, detailed information on the characteristics of the lake should be provided. This requires time series data capture equipment, which was supplied in form of “wet lease contract”. It consists of the following equipment.

- RDI Acoustic Doppler Current Profiler (ADCP) for obtaining a time series of profiles of water currents at selected locations (Figure 1).

- ii) RBR Temperature and Temperature / Depth loggers for collecting time series data on temperature from selected locations (Figure 2).

- CSI Data logging system and peripherals for collecting a time series of climatological variables from a moving on *IBIS* vessel on the lake (Figure 3).

- Sediment traps moored with the temperature loggers to collect information on rates of sedimentation within the water column.

TABLE 1. Formal Higher level training with LVEMP support, Water quality and quantity.

Level of training	**Area of Research**	**Institution**	**Number of people trained**
Ph.D Water Quality Management	Lake Victoria water quality dynamics	IHE, Delft The Netherlands	1
M.Sc. Water Quality Management	Sediments and modeling Water quantification and networks	IHE, Delft The Netherlands IHE, Delft The Netherlands	2 1
M.Sc. Environmental and sanitary Engineering (NWSC)	Water Quality Wastewater management Wastewater Reuse Wastewater Treatment Eng	IHE, Delft The Netherlands WEDC UK Leeds UK Makerere University	2 1 1 1
M.Sc. Environmental Water Resources Management	Catchment environmental impacts on water bodies	IHE, Delft The Netherlands	1
M.Sc. Water pollution chemistry	Atmospheric deposition	Makerere University, Chemistry Department	1

FIG. 1. Acoustic Doppler Current profiler, for current and depth determination.

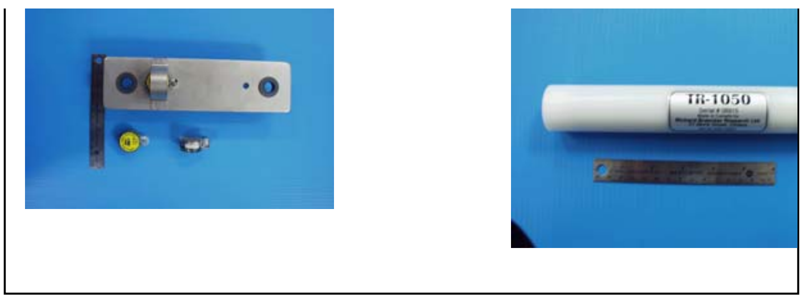

FIG. 2. Temperature and Temperature/ Depth loggers.

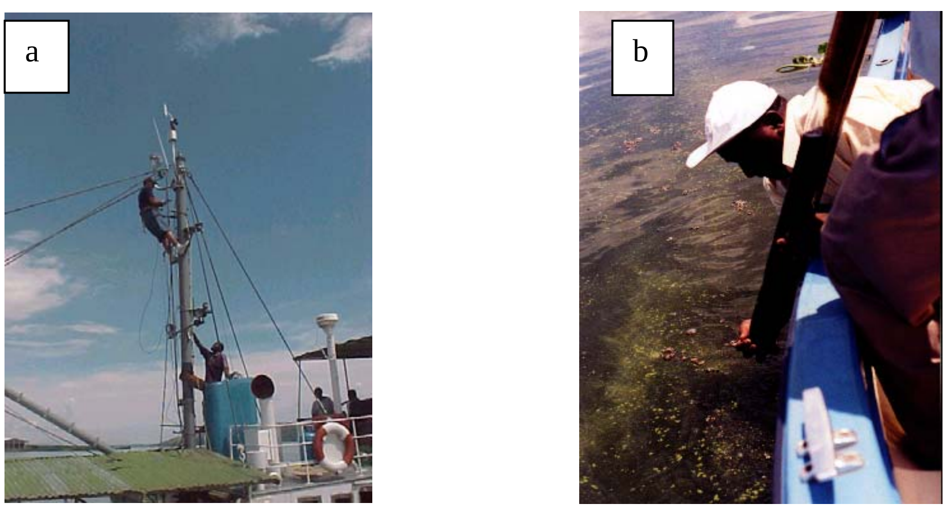

FIG. 3. Training on installation of mobile meteorological station on IBIS vessel b) Offshore lake station sediment coring.

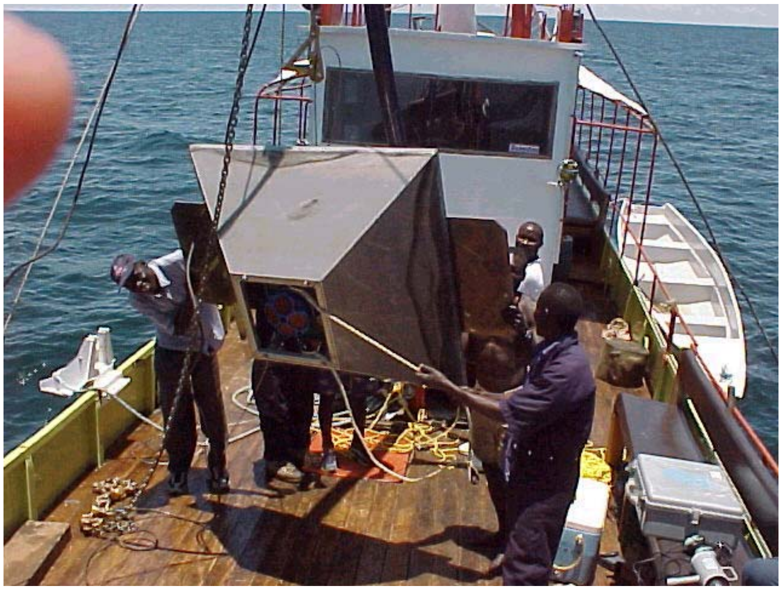

FIG. 4. Training on hydraulic conditions equipments-Deployment of bottom top ADCP.

A short limnology course was held at Makerere University in February 2001 with focus on expected levels and variations in water quality parameters in Lake Victoria. Six scientists attended the training. The course improved the capacity of scientists in limnological data generation, interpretation and quality assurance. Other on job-trainings were organised with LVEMP support including the COWI and DHI training. This training was conducted during the integrated water quality and limnology study. It aimed at improving laboratory analysis and operations to handle big numbers of samples and parameters from the lake and its catchment.

Laboratory and field infrastructure

Improvement on the efficiency of analysis to generate reliable and comparable data was achieved through implementation of an inter-laboratory calibration using international certified reference material and inter-laboratory comparison scheme.

The Entebbe Laboratory was equipped during the seven years of LVEMP support. In addition to improving the skills of scientists and staff using the laboratory, the latter was monitored and evaluated for compliance to the agreed harmonized procedures for in-lake water quality analysis adopted during the 18-month consultancy on integrated water quality/limnology study. Samples were collected in August and September 2002 during the regional lake cruise and submitted to the three labs of Entebbe, Kisumu and Mwanza for analysis. Samples submitted were from the following stations: KL1, KL3, TP12 and UP2. Results revealed some variability between labs. This may have been due to errors in analysis, varying grades of reagents and chemicals and varying periods of sample storages before analysis. To rectify this scenario, a number of strategies were put in place.

Some of the strategies used to improve capacity in water quality and quantity were as follows: Preparation of a set of field forms with instructions for field data collection and for recording both field data and laboratory analysis results and subsequently harmonised with the other riparian states. Emphasis was put on on-board training of field staff in monitoring procedures, methods and routines. Checking and adjustment of the laboratory analysis methods was also addressed to improve the efficiency of analysis and capacity to handle a big number of samples.

Four regional working sessions on data collation, verification and hands-on validation were conducted. During these sessions, all the data from the three countries was subjected to intensive quality assurance procedures acceptability to be retained on the respective national databases.

Regional Laboratory Performance Evaluation exercise for the three participatory laboratories of Mwanza, Kisumu and Entebbe was initiated, and agreed to be held on quarterly basis, to further improve on the credibility of the data generated in the laboratories. One regional laboratory performance evaluation exercise has been held and subjected to statistical analysis to check whether there was any scientific significant difference in the data generated. It was clearly found out that there was no significant difference in the parameters of analysis.

Laboratory Quality Assurance Mechanism

The laboratory quality assurance mechanisms encompass good performance of staff, sample handling, laboratory fabric and paraphenarhia (building, facilities and equipment) and analysis methods.

Staff

All technical staff working in the water quality laboratories are well trained with relevant qualifications and have gained experience over the years regarding water and wastewater analysis. In-house training programmes are continuously carried on as part of the routine activity whereby skills are passed over from one analyst to another enhancing continuous improvement. Analysts are given training levels on any specific method of analysis a condition which enhances healthy competition among analysts and thus improving their competence. Quality performance of the analysts is monitored through use of reference materials, spiked performance evaluation exercises and involvement in external international proficiency schemes (*GEMS* USA and *AQUACHECK* UK) and inter-laboratory comparison exercises (for example NIVA laboratory in Norway and Makerere University Department of Zoology laboratory). Professional technical and managerial capacities were also improved through attendance of short training courses, workshops, and seminars where knowledge and experience was shared and exchanged.

Sample handling

Proper samples handling and documentation ensures that deterioration and damage to the samples is avoided or minimised before analysis as much as possible so as to be representative to the actual sources situation. This was done through clear sample control and documentation procedures where samples are given unique identification, state of conditions including field treatment recorded and method of preservation indicated. Lake sampling expeditions, most of the samples required freezing and 2,500 litres freezers would be used on the lake cruises for this purpose.

Methods Validation

Analytical methods used in analysis were published methods mostly from *Standard Methods for Water and Wastewater* (APHA 1998). Laboratory methods were drawn from these methods to suit the laboratory equipment and then method performance tested to ascertain precision, accuracy, specificity, sensitivity, applicability and range. Analysts establish the limits of detection which are well documented and used to guide in analysis and reporting of results. In the process of method validation, repeated analyses of certified reference materials (CRM) is carried to characterise the performance of the method including the equipment.

Field Data Generation

The water quality component acquired 4 vehicles, 2 dinghes and 4 outboard boat engines for its catchment and in-lake sampling and monitoring activities. Through inter-institutional linkages with collaborating institutions, the component was able to access a vessel from FIRRI Jinja for offshore operations.

Monitoring Networks and Data Bases

Lake wide monitoring networks

The Lake wide network designing and operationalisation with geo-referencing of sampling stations training was done through consultancy training of COWI. Through the training a comprehensive national lake wide sampling network map was developed (Figure 5). The sampling network was operationalised with specific protocols developed including the scheduled regimes of sampling and data collection. Two sampling regimes were instituted as quarterly and monthly sampling stations. During the quarterly cruise all stations were sampled, however during the monthly cruises only a few selected stations were sampled (Table 2.).

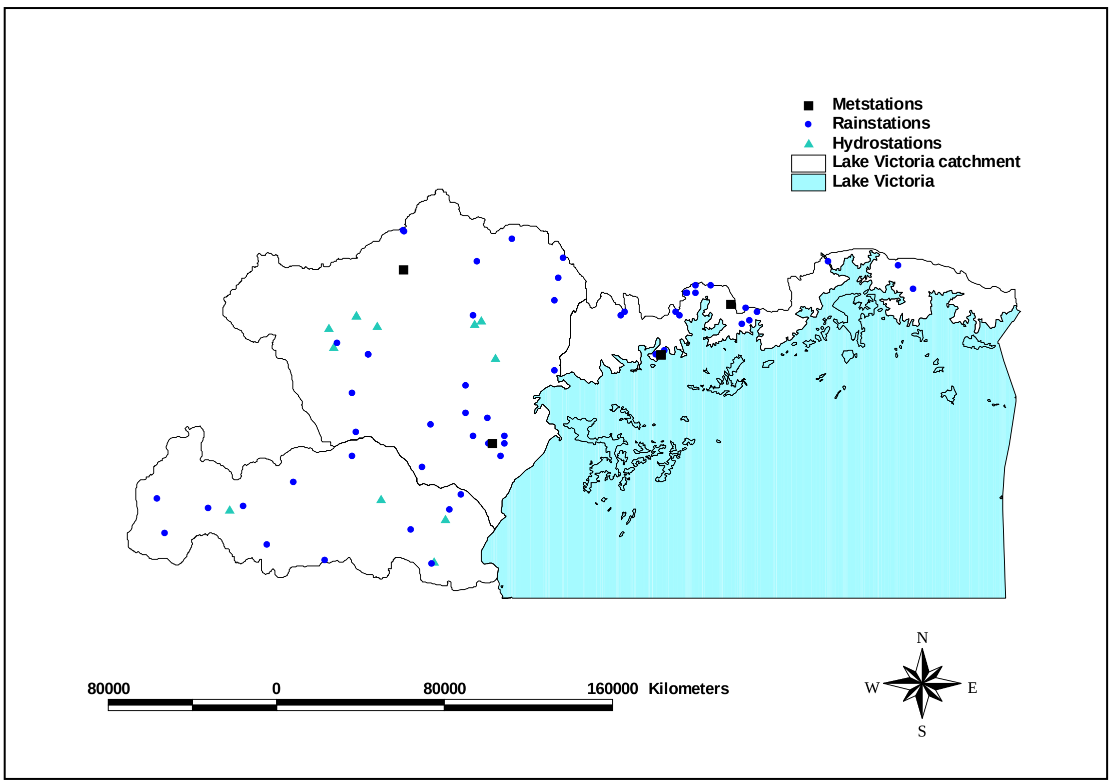

FIG. 5. Lake-wide sampling network map.

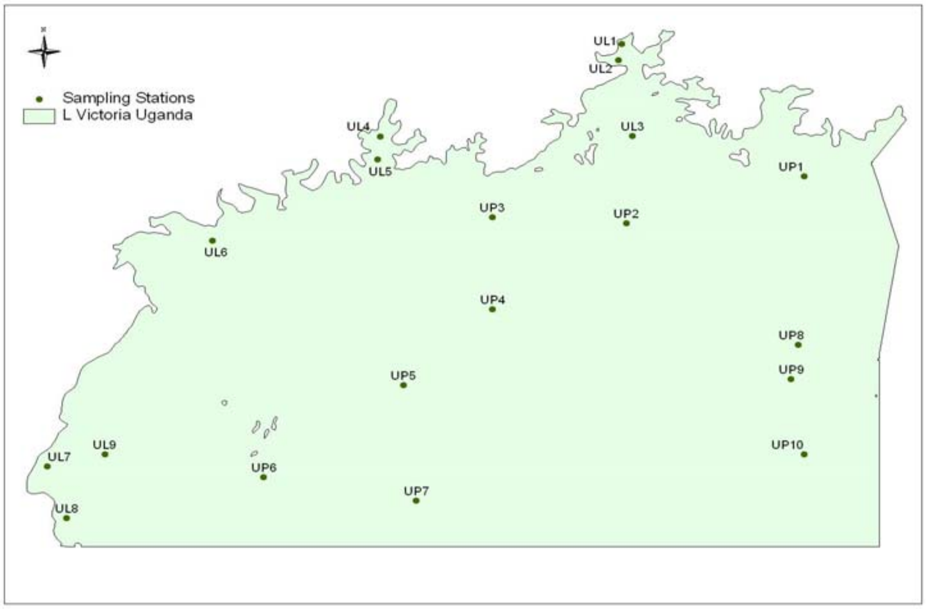

FIG. 6. Lake monitoring networks on Lake Victoria, Uganda.

TABLE 2. Description of the in-lake monitoring points on the Ugandan part of Lake Victoria.

Station Code	Station Name	LONGITUDE	LATITUDE
UL1	Wanyange	33,15'22.6"E	00,26'59.6"N
UL2	Napoleon	33,14'52.0"E	00,24'10.4"N
UL3	Buvuuma	33,17'00.9"E	00,20'56.3"N
UL4	Gaba	32,37'05.1"E	00,11'02.0"N
UL5	Gaba	32,37'01.6"E	00,07'01.4"N
UL6	Katonga	32,11'05.9"E	00,07'01.1"S
UL7	Bukora	31,45'05.4"E	00,46'02.1"S
UL8	Kagera	31,48'07.9"E	00,55'04.9"S
UL9	Sango Bay	31,54'05.9"E	00,44'01.1"S
UP1	Open – Sigulu	33,44'01.6"E	00,04'00.3"N
UP2	Bugaia	33,16'07.9"E	00,04'07.8"S
UP3	Open	32,55'03.4"E	00,03'03.6"S
UP4	Open	32,55'05.4"E	00,19'01.9"S
UP5	Open	32,41'06.2"E	00,32'03.5"S
UP6	Open	32,19'03.1"E	00,47'56.4"S
UP7	Open	32,43'05.4"E	00,52'01.6"S
UP8	Open	33,19'02.0"E	00,25'01.3"S
UP9	Open	33,42'03.5"E	00,31'02.2"S
UP10	Open	33,26'00.3"E	00,44'01.2"S

Key

Monthly Monitoring Cruise Station (highlighted)

Atmospheric Deposition Monitoring Stations

Atmospheric deposition refers to elements deposited from the atmosphere in the lake as part of the non point source pollution. The deposition is in two forms, that is wet and dry. The study established 3 wet depositions stations at Entebbe, Bukasa Island and Lolui Island. Data was generated to estimate the nutrients, mostly nitrogen and phosphorus, input from the atmosphere in the lake.

Databases and Modeling Efforts

Currently LVEMP operates two central databases of water quality and hydrology housed in the Water Resources Management Department, Entebbe. During the project period, the Lake Victoria Water Quality Model (LVWQM) which is a model framework for simulation of the physical processes and water quality in Lake Victoria was developed. The model was developed by a consortium of scientists from Delft Hydraulics, HydroQual and IHE.

The framework model is a preliminary or pilot model since it was based on existing data which was insufficient to support a full calibration or verification of the models. The model was intended to serve as a working example of how data from LVEMP can be used to predict responses to possible management actions for the remediation of water quality problems in view of sustainable economic development.

Lake Victoria is a large and complex system, and it is hard to determine the effective measures for environmental management of the lake basin and to select measures that are in good balance with the (economic) needs of the people, who are living in its catchment. In view of this, it is clear that the formulation of common environmental policies is a demanding task and models can effectively support the process of optimising and tuning these policies.

However, the use of models for environmental management and decision making is a relative new science understood by a few people. It is, therefore, to be expected that government staff and staff of many organisations may not have clear expectations regarding the usefulness of modeling. The same applies to the continued collection of data and the related development of insight in the behaviour of aquatic ecosystems. Modeling has its own demands for monitoring, data collection, and knowledge development.

A number of on-job training has been conducted using local experts on model basics including the data requirements and formats. Among the topics covered in the orientation/training were:

- the usefulness and possible uses of the modeling framework for lake basin management and decision making.
- the need to develop monitoring, data collection and research programmes adequate for modeling and which are at the same time cost-effective and sustainable.
- introduction to some basics in water quality modeling and day to day usage of the existing LVWQM in its form.

Other Modeling Efforts Contributing to this Report

Two conceptual models, SMAP and NAM were used to generate information and also quality assurance through comparisons with the real data. These are conceptual models that are used to simulate rainfall events and how they are converted into runoff. Details of these models are discussed under the hydro-meteorological conditions of Lake Victoria, Uganda.

Constraints

- Inadequate well trained staff to handle modeling
- Slow procurement process of the necessary equipment and infrastructure.
- Unreliable flow of funds for the planed activities.
- Lack of scientific research vessel capable of carrying out open water operations.
- Limited staff to handle increased work load.
- Limited land transport facilities.
- Constrained central laboratory for all national and regional analyses.

Recommendations

A research vessel suitable to install and retrieve the moorings will need to be procured especially for the offshore operations and sampling.

- Lake operations safety equipment and software should be procured for the scientists involved in the research to achieve the goals of this project and also to minimise the on board risks. These should include head helmets, heavy duty boots and gloves, effective communication gadgets.

- The scientific staff still requires additional training on safe and productive mooring retrieval and deployment and subsequent data analysis and interpretation. The training can be done in Canada at the United Nations Water Research Institute, the suppliers of the specialised moorings equipment.

- A Water Quality Model Framework as been developed using dummy data in the early years of the project. Now that sufficient data has been generated for the entire project time there is urgent need to use the actual data to calibrate and simulation runs.

- A second water quality laboratory is recommended for the next phase of LVEMP.

References

APHA. 1998. Standard methods for the examination of water and waste waters. 20th edn. American Public Health Association, Washington, D.C.