LAKE VICTORIA WATER LEVELS

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1.0 Introduction

1.1 General Introduction

One of the principal objectives of the Water Quality and Ecosystem Management Components is to find the reasons for the changes observed in the lake water quality, quantity and ecosystem, and to suggest remedial measures. To identify the reasons for the changes, one requires knowledge of the changes in the pollution loadings to the lake, which in turn, depends on the discharges into the lake from the catchments and the atmosphere and lake outflow to River Nile. Provision of this information requires a network of river and lake monitoring stations in order to:

- Establish short and long term fluctuations in water quantity in relation to basin characteristics and climate.
- Determine the water quality criteria required to optimise and maintain water uses and
- Determine seasonal short and long-term trends in water quantity and quality in relation to demographical changes, water use changes and management interventions for the purpose of water quality protection.

From the data generated the components were also to calculate water mass balance for Lake Victoria. The total water balance for the lake over the past 50 years was computed in the first phase of LVEMP I and again during a resent water quality synthesis report preparation done by the components. It emerged that worrying downward trend of lake level was revealed. The period of 2002 through 2005 has revealed a dramatic downward trend to lake levels that have not occurred since 1961.The lake level responds to input and output parameters which are: direct rainfall onto and evaporation from the lake surface, discharges into the lake from all rivers and catchments around the lake and discharge from the lake into the Nile River at Jinja as independent variables that are measured or estimated over time. Historical hydro-meteorological data and data gathered during the LVEMP I (Hydro-meteorological data for the period running 1950-2005) were analysed, which form the basis for computing the pollution loadings (catchment and atmospheric) into the lake and lake water balance. Continuous rainfall and evaporation records were generated. Full records of land discharges were obtained through modelling.

1.1 Objectives of the Presentation

The purpose of this brief report is to explain the reasons behind the falling lake levels, predict future trends and suggest remedial measures.

2.0 Lake Victoria Hydrology

The hydrology of Lake Victoria includes water level, inflows from catchments, outflow at Jinja and meteorological data (Evaporation, rainfall).

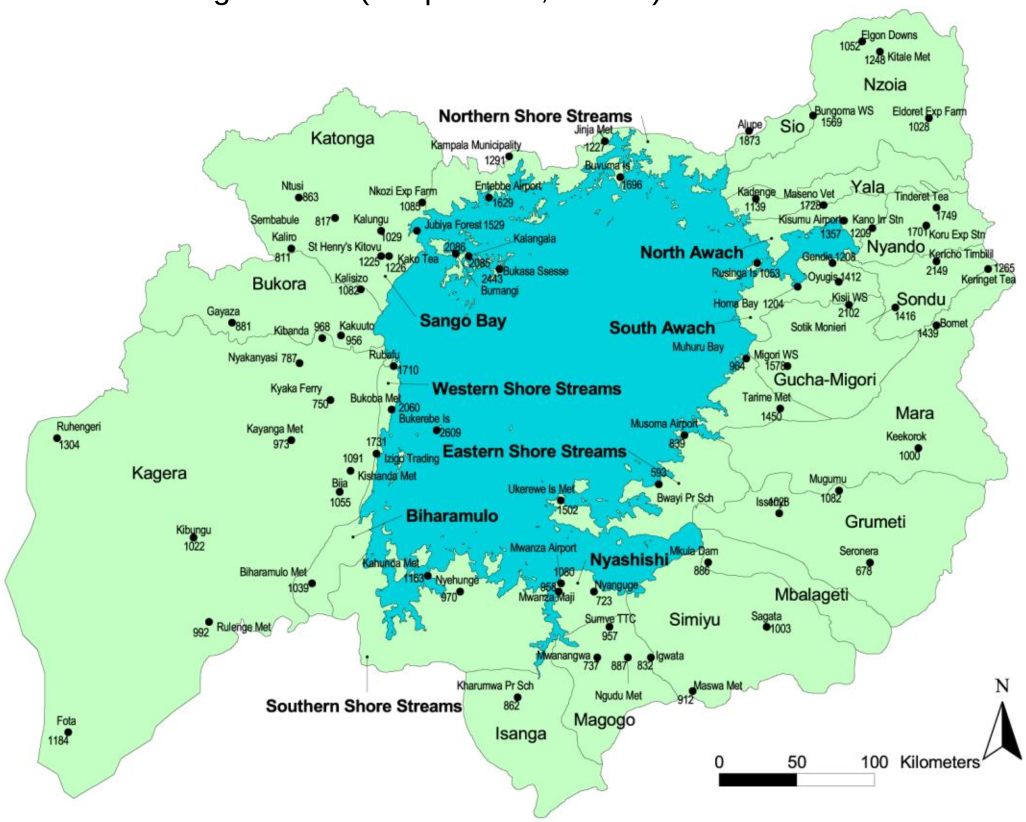

Figure 1: Locations of Rainfall Stations and catchments used in the water balance calculation

2.1 Water levels of Lake Victoria

The water levels of Lake Victoria over the last 104 years have exhibited striking changes in regimes that have baffled people so much. From 1900 to 1961, the lake was at a regime that was different from the 1961-2002 regimes. The post 2002 regime has tended towards the pre 1961 regime. What further baffles people is which direction the trend will head for!

Data on the levels of Lake Victoria has been collected consistently since 1896. But for this report, detailed analysis is for data from 1950 to 2005. During this period the levels have fluctuated in response to natural processes of input and output in and out of the Lake. Of the input and output variables, evaporation over Lake Victoria, is generally assumed to vary the least because the Lake lies astride the equator. Evaporation varies with temperature, wind speed, humidity, sunshine and can also be affected by climatic variation.

Rainfall is generally recognized as the most variable component in the water budget with the further assumption that changes in rain over the lake will be similar to changes in rain falling on the land catchment. With stable climate lake levels can be stable year after year as the lake level adjusts to the balance of those inputs and outputs. However, the long-term record shows variability from year to year and particularly higher levels in the latter part of the twentieth century compared to the earlier half.

2.2 Historical trends of major hydrologic processes in Lake Victoria

Lake levels have followed a general but variable downward trend since 1964's May 12th historic peak. But that long-term trend has reversed several times over the last half-century, e.g. the later 1970's, the early 1990's and the E*l Nino* rains of 1997 when periods of high rainfall occurred. Since the *El Nino* rains of 1997/98 when lake levels peaked in April of 1998 at 1135.77 metres above mean sea level (mamsl), the trend of the lake level has been dropping steadily.

The 2005 levels are the lowest experienced since the flood of 1961-62 though the current low level condition is still well above the recorded historic low level of the Lake in March 1923 (Table 1) shows some key low flow periods in order of ascent (but the lowest ever recorded level was in March 1923 followed by the October 2005 lows).

Table 1: Historical Lake Victoria water level scenarios

No.	**Year**	**Month**	**Level in m.a.m.s.l.**	**Height above 1923, m**
1	1923	March	1133.19	0.0
2	2005	October	1133.66	0.47
3	1961 (before the famous flood)	January	1133.70	0.51
4	2004	September	1133.99	0.8
5	1994	February	1134.18	0.99
6	1997	October	1134.21	1.02
7	1986	September	1134.26	1.07

High and low levels recur in an approximately cyclic manner both in the post-1961 level and earlier in the century. However, the most recent drop in level is a record for the post-1961 period.

2.3 Decline in levels from 2002 – 2005

Generally the period 2002 to 2005 has seen a rapid and worrying decrease in Lake Victoria water level thereby arousing the present concern. During the period 1950-1954, River Nile outflow was naturally occurring until the commissioning of the Owen Falls Dam in 1954. The Dam was built to operate on the "Agreed Curve" Policy that determines the amount of water to be released by using the prevailing water levels in order to maintain natural flow. The operationalisation of this policy maintained a natural pattern up to 2000. During the period 2001-2005, disparities began to occur between Lake levels and Nile outflow. The hydrograph in figure 2 for the period 2001-2005, show that Nile outflows have increased while Lake levels have fallen. This can partly be attributed to increasing outflow at Jinja that is used for the new hydropower units and other climatic factors, e.g. periods of lower rainfall than have occurred over the historic period.

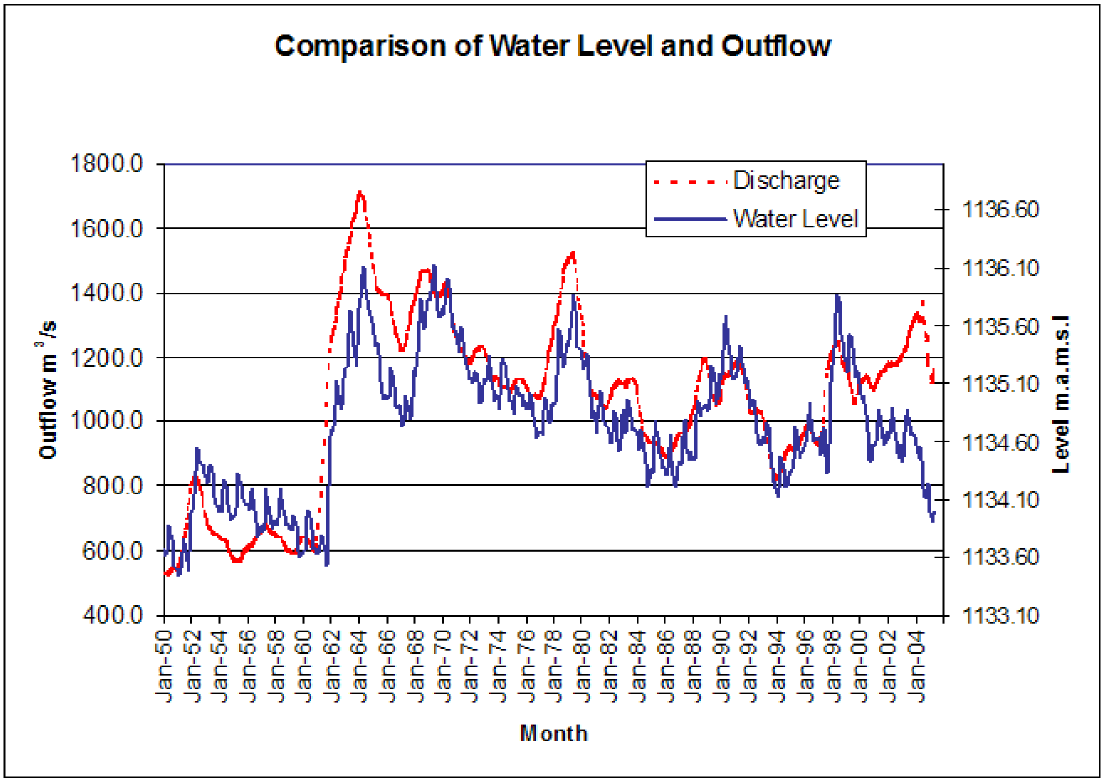

Figure 2: Hydrograph showing comparison of Nile outflow and Lake level, 1950-2005.

The flow characteristics for River Nile outflow indicate an increase in average flow out of the Lake by 15% to 1057.6 m^3/s in the period 2001-2004 as compared with the long term average of 1046 m^3/s in the period 1950-2000 including the per cent of all losses with the remaining loss being evaporation. Although the statistics has fewer samples than the long term, period, it nevertheless gives a general pointer to the new hydrologic trend that may emerge.

2.2.1 Causes of the decline in levels in the period 2002–2005

To understand the resent drop in water level, cumulative deviations from the normal regimes of rainfall, Nile outflow, evaporation and catchment discharges were developed. It was found that, of all the processes above, rainfall and Nile outflow varied significantly to warrant their use in explaining the drop in levels. The following summarizes the situation:

1. The lake system is such that the inputs (rainfall+river inflows+groundwater input) and output (Nile outflows+Evaporation+groundwater output) affect the lake level (lake storage). Increase/decrease of any of the components of the system, specifically, rainfall, river inflows or Nile outflows either raises or lowers the lake level.
2. After analysis it can be concluded that the observed fall in lake level is a result of a combination of two factors:
    a. Reduced input in terms of rain and inflows into the lake system and
    b. Increased outflows caused by excess releases at Jinja.
3. General absence/limited rains on the lake in recent years resulted in falling of lake levels by 1.64m from 1998 to November 2004 with the year 2004 having been severely hit by this shortage of input.

4. Increased outflows for power generation resulted in a further fall in lake levels by 0.34m for the period June 2001, when the lake was in balance, to 3rd November 2004, when the lake was at its lowest (refer to Table 1). Excess releases accounted for 45% of the total fall in the period 2001-2004. Years 2003 & 2004 accounted for 77% of the extra lake drop with over 50% occurring in 2004 alone.
5. Continued limited rainfall in 2005 and further increased release at Jinja caused a further reduction of the lake level to current lowest level since 1961 at 1133.66 mamsl in October 2005, only 0.47m above the historic lowest of March 1923.

2.3 Prediction of the levels in future

In summary, the drop being witnessed now is a result of below normal rainfall for most parts of 2004 and 2005 and an increase in outflow from the lake at Jinja. It is likely that if the releases are reduced and with above-normal rainfall, the level will pick up. Alternatively, it can also be said that since the current levels are within the flow regimes of the pre 1961 flood, the lake could have completed the dissipation of the great floodwaters and is resuming its normal regime.

Prediction of future water levels may be done using the water balance equation by getting annual averages of rainfall, evaporation, catchment inflows and Nile Outflow at Jinja. The water balance equation is given below:

$$\pm\Delta H = P + Q_{in} - E - Q_{nile} \quad (2.1)$$

where ΔH is change in water level;
P is rainfall over the lake;
Q_{in} is catchment inflow;
E is evaporation from the lake; and
Q_{nile} is Nile outflow from Jinja.

When the ΔH is positive, water levels in the lake rises over the period, and when it is negative, the level drops. For purposes of comparison, rainfall and evaporation that are normally expressed in millimetres were converted to flow units that are expressed as the amount of water that wound ordinarily flow into, for rainfall and out of the lake, for evaporation. Table 2 summarises the water balance for Lake Victoria in 3 different periods as indicated in the table. The table shows that in the period 2001-2004, the lake lost on average 95.9 mm from its storage. This accounts for the fall in levels in the same period amounting to 0.38m, as the model predicts and 0.38m, as from measured data.

Table 2: Summary of water balance for Lake Victoria

Process	**1950-2000 Flow (mm)**	**2001-2004 Flow (mm)**	**1950-2004 Flow (mm)**
Inflow			
Rainfall	1655.4	1670.3	1656.5
Catchment discharge	369.1	314.5	365.1
Outflow			
Evaporation from lake	1526.3	1529.8	1526.5
Victoria Nile	479.5	550.9	484.8
Sum	**18.7**	**-95.9**	**10.3**

Prediction of approximate water level for the next 2 years was done using trend analysis based on average water level data for the period 2002-2005. Here two assumptions were considered; current withdrawal policy including evaporation pattern is followed and inputs into the lake (rainfall and catchment inflows) will be similar on average.

A trend line is fitted to water level data using 4th order polynomial equation (equation 2.2) and quite reasonable results are obtained as can be seen in figure 2.2 below.

$$WL = 0.000006x^4 – 0.00008x^3 + 0.0013x^2 – 0.0108x + 1134.8$$

Where, WL – Water level
X month count from Jan 2002

The equation shows that lowest levels will be between December 2005 and January 2006; thereafter the levels will rise if conditions mention above will be realised.

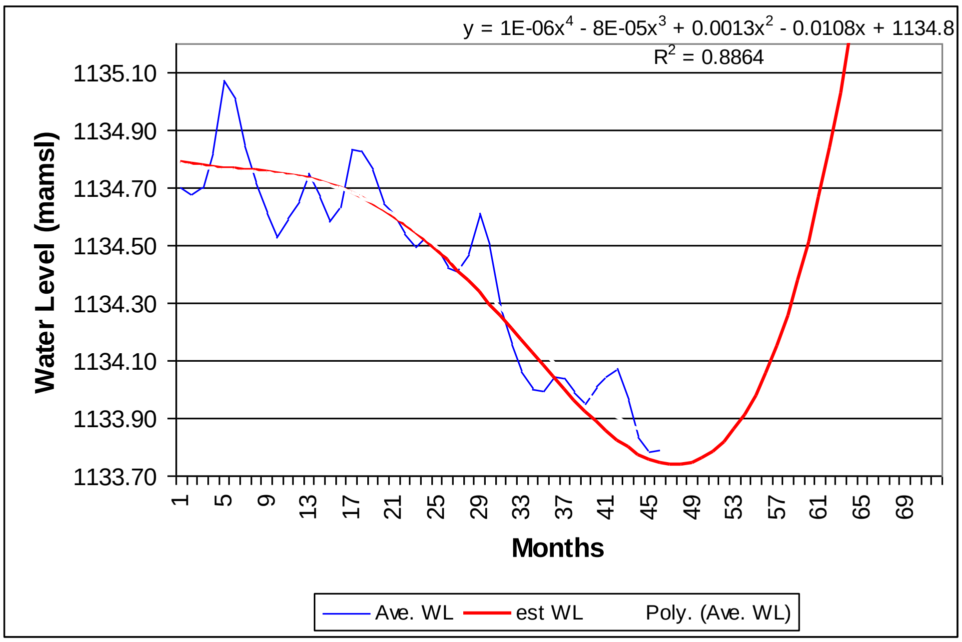

Figure 3: Water levels January 2002-October 2005 with projections up to December 2007.

3.0 Implication / effect of the decline in levels

Lake Victoria is very important to EAC Partner States. It has a highly productive fishery estimated at 500,000 metric tons annually and valued at US $ 600 m with over US $ 217 m in export. It provides high protein food, employment, income, and clean water. It had high fish species diversity of over 500 endemic fish species of ecological importance. The Lake is an avenue for transport, recreation, power generation and a modulator of regional climate. The invaluable services the Lake provides made the EAC to designate it and its basin as an economic growth zone.

The Lake is however facing insurmountable challenges including declining lake levels, commercial fish catches, and biodiversity. The ecological habitats and water quality have deteriorated and both have been compounded by the decline in quantity of water in the Lake. Below are highlights of effects and implications of the declining levels on ecological, environmental, social, economic and political aspects that can likely be faced if the decline progresses further.

3.1 Ecological / environmental

The habitat in and around the lake is zoned into shoreline, littoral and pelagic areas. Each zone supports a particular type of animal and/or plant life. The declining levels have slowly altered this zoning such that the fish breeding grounds and *refugia* (shelter from enemies) that existed in the littoral zones have been destroyed and turned into mud or very shallow waters. These areas are the most productive in fisheries. It is used for breeding, nursery, feeding and survival of a number of species, especially in rocky and sandy areas. The increased accessibility of these areas has exposed fish life to so many negative external factors.

A recent photograph taken from one of the exposed shoreline tells it all as indicated in the figure 4 below. Conflicting uses have cropped up ranging from water supply through livestock watering to car washing, all compounding the water quality situation at many shoreline areas. The falling levels have caused all these.

Figure 4: Conflicting uses facilitated by shallow shorelines as a result of low lake levels.

3.2 Social

The social values of Lake Victoria can be innumerable and invaluable, and can range from water supply, transportation, fishing etc. These services are getting disrupted as a result of declining levels of the Lake. Fisher folks who used to land their fish catch on the shorelines now dock in the lake and drag fish catch through muddy waters to the dry ground. Fish landing structures that were constructed during LVEMP I in order to ensure good fish quality have been rendered less useful as fish catch has to be transported ashore through dragging by hired men and women to the landing structure. This has increased the cost of production and undermined income of fisher folks. Well-constructed fish landing structures at some beaches have been left on dry land, figure 5 below, due to receding Lake levels.

Figure 5: Majanji Fish landing site, left on dry land due to lowering of lake level.

3.3 Economic

Lower water levels affect fishing as an economic activity around Lake Victoria as the landing sites are almost disconnected to the lake and fish breeding areas are also affected and this leads to probably reduction in fish population in the long run.

Transportation is also affected as the vessels that operate between ports of the three states fail to dock at the port due to shallow water; extra smaller vessels are used to enable passengers to access the vessels.

Power generation is definitely affected. Agreed amount of power production, may not be realised leading to loss of revenues for the power utility company and consequently loss of production in factories.

3.4 Political

The three East African states are currently enjoying good political relationship that aims at future political federation. Violation of agreements such as The Lake Victoria Protocol on Sustainable Development could very much jeopardise these prospects as it will lead to mistrust among the nations.

3.5 Hydrological

The diminishing quantity and deteriorating quality of Lake Victoria waters have compromised the ability of the Lake water resources to provide the basic functions of a water body. The sum total of all these is the reduced benefits of having a water body that should accrue to man and other life forms.

4.0 Conclusions:

The current drop in Lake water level is very severe and worrying. Although the outcome of the water balance in the long-term period is still positive, (that is why current levels are still above the pre 1961 mean levels), however, the severity of the 2001-2005 trends may tilt the balance to an all time low in the next few years.

It is also concluded that the water budget method is a very important tool for monitoring and revealing the changes that are occurring in the water quantities of the lake. This means that there should be continuous and increased monitoring of the lakes hydrologic processes in order to address the management challenges of the lake basin.

5.0 Recommendations

The following recommendations should be adopted so that the Lake levels may possibly pick up.

1. There is need for a closer interest on the lake level trends by all the riparian states in order to address the causes of the levels fall.
2. The states need to put in place concerted efforts to reverse the factors causing the decline like, better watershed management to increase flow from catchments, resumption of the natural flow practice (agreed curve) at Jinja and a political will to conserve Lake Victoria.
3. There should be increased and consistent relevant data collection in all the three countries.
4. There is need for the three countries to continue cooperating in updating the water budget for Lake Victoria.
5. Efforts should be made to determine the role played by groundwater in the water budget of Lake Victoria although work to date including isotopic analysis suggest the role of ground water is minimal in the budget.
6. Data collection equipment and instruments should be standardized so that uniform data can be collected and used.
7. Stations should be established in un-gauged catchments so that actual data is used in the balance other than estimates.
8. Undertake intensive studies on the possibility of regulating the lake to optimize its multiple but potentially conflicting uses to achieve maximum and sustainable socio-economic benefits for the riparian states.
9. The release operations at the existing dams should follow the natural regime of the lake. A short-term management strategy for Lake Victoria based on equilibrium lake level and mean agreed curve outflow should be adopted.

6.0 Way Forward

To realize sustainable social economic benefits from Lake Victoria, it is necessary to adopt sustainable release models and associated regulation limits of the lake through means of integrated water resources management.

The Lake Victoria Protocol on Sustainable Development was signed and ratified by Governments of Uganda, Kenya and Tanzania. Partner states should establish mechanism to notify each other of any of their activities, which may have adverse impacts on other partner states. This obligation to notify must be read together with the provisions on environmental Impact Assessment, which require partner states to exchange EIA impact statements and to comment on projects with likely trans-boundary effects.