

## Integrated Lake Management Project

# SUPPORT TO THE MANAGEMENT OF SUDD BLOCKAGE ON LAKE KYOGA

## Executive Summary

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## EXECUTIVE SUMMARY

### Introduction

Lake Kyoga is part of the Kyoga lake complex which includes a set of lakes and numerous wetlands in Central Uganda, Eastern Africa. The catchment size is about 60,000 km<sup>2</sup> while the open water area in Lake Kyoga averages out around 3750 km<sup>2</sup>. The main inflow to the lake is coming from Lake Victoria through the regulated Owen Falls Dam in Jinja, Uganda.

Abnormally heavy El Niño rains during years 1997-1998 led to a raising water level in Lake Kyoga and Victoria which dislodged the papyrus beds, floating suds, and water hyacinth mats. The weeds accumulated into the outlet of Lake Kyoga and fully blocked the outlet which led to even higher water level in Lake Kyoga. Within one year, the water level rose over two meters in the lake. This flooded altogether some 580 km<sup>2</sup> and the floods displaced population, destroyed infrastructure, caused diseases and in some cases death, paralyzed all socio-economic activities of the region (DWD, 2002). Up to date, the lake outlet is still blocked and only one channel goes through it, which has to be maintained regularly.

This project aims to:

1. understand the impact of the sudd presence in regulating the lake flow of Lake Kyoga and the outflow of water into the Nile downstream of the lake
2. provide indicative estimates of the sudd impact on the lake water levels
3. clarify the role of different factors affecting the water levels (hydrology, hydrodynamics, vegetation). Water balance calculations and hydrodynamic modelling will be used to help understand and plan possible management interventions aimed at reducing the sudd blockage.

### Methods

The water balance calculations are done for the Lake Kyoga with the available data. Inflow from the Victoria Nile and tributaries, and precipitation are used as incoming water to the system, and outflow to Kyoga Nile and evaporation as outgoing water from the system. The effects of sudd blockage on the hydrological characteristics are studied with the help of water balance calculations and hydrological analysis.

The 3D EIA Flow Model is set up for Lake Kyoga to simulate the hydrodynamic characteristics of the lake such as water levels and currents, and as well as studying the effect of the sudd blockage on the lake's hydrodynamic and water level. With the model, it is possible to run different scenarios on managing the sudd and simulate the effects of those on the water levels, currents, and outflow. Although the model is 3-dimensional, the lake simulations have been run in 2D mode for speed up the model study within the quite restricted time available.

### Water balance calculation results

Impacts of the sudd blockage on the water levels, discharges and evaporation were analysed during the project. After the blockage, the water level in Lake Kyoga rose dramatically. The differences in water level between the stations in the lake (Bugondo) and outlet (Masindi Port) were 0.23 m and 1.20 m before and after the blockage, respectively. Thus, the lake level has been around one meter higher after the formation of the blockage compared to the previous situation.

The outflow during the years 1998-2003 has been 93% of the outflow before that era. The inflow has also decreased but the change is bigger in outflow. The outflow has decreased on the average 56 m<sup>3</sup>/s more than the inflow. The volume of the lake increased from 7.7 km<sup>3</sup> (average for year 1997) to 13.6 km<sup>3</sup> (average for year 2003). Transferring this to m<sup>3</sup>/s divided to six years (time after the blocking) we get for the average rate of increased volume of 31.1 m<sup>3</sup>/s. Subtracting this lake volume increase from the net outflow decrease, we get **25.4 m<sup>3</sup>/s** for the real water loss increase after the blockage which is 2% of the total outflow. This correlates very well with the calculated increased evaporation because of the increased lake surface area. Also, the relationship between Victoria Nile inflow and Lake Kyoga outflow has remained naturally also after the blockage.

The total average inflow and outflow in Lake Kyoga (including Nile, tributaries, precipitation, and evaporation) have been both 1420 m<sup>3</sup>/s. Victoria Nile has 85% portion of the total inflow while the flow from tributaries and precipitation have portions of 4% and 11%, respectively. In outflow, the portions of Kyoga Nile and evaporations are 87% and 13%, respectively.

The water balance calculations didn't correlate very well with the measured balances in either, before or after the blockage, time periods. Also, only limited amount of data is available in the recent years what makes the calculation even harder. The probable error sources in the water balance calculations are:

- Unmeasured catchment input to the model
- Wetland's contribution
- Inaccuracies in Masindi Port's rating curve
- Inaccuracies in the bathymetry data
- Possible inaccuracies in other data
- Evaporation data not available for Lake Kyoga and data from Lake Victoria used instead

Thus, more study and data cross checking would be needed to enhance the calculations.

### **Modelling results**

The EIA 3D Flow Model applied to Lake Kyoga is stable and working well. According to the undertaken validation process, it can model well the different situations in the lake before and during the blockage in the Kyoga outlet. Thus, it is appropriate to use the model to run different scenarios on managing the sudd blockage on the outlet.

Model output, as water depth, flood arrival time, flood duration, flow fields and velocities in different depths, and water levels can be plotted and also stored as GIS applicable file to use in further analysis. Also, timeseries can be calculated in any depth and point the model grid.

Two scenarios were applied on the sudd management. In the first scenario, the two channels through the blockage were both widen and cleared from the vegetation and in the second scenario, the sudd blockage was totally cleared out. Data for year 2002 were used for the calculation. Both scenarios result the measured water level in Masindi Port. The water levels in Bugondo (Lake Kyoga) are 0.49 and 0.92 m lower in scenario 1 and scenario 2, respectively, than the measured water levels. Thus, the scenario 2 results about the same water level than the situation before the blockage would have done. In scenario 1, the water level would be still some 0.40 m higher compared to the situation before the blockage formation.

In third scenario, increasing flow from Victoria Nile was assumed to last four months assuming the sudd blockage remaining as it is at the present time. The extreme flow (1650 m<sup>3</sup>/s) from Victoria Nile results, according to the model, almost one meter rise in the water level in the Lake Kyoga and around 0.8 m higher water level in Masindi Port. The result is compared to average water level in 2002.

### **Conclusion**

Practically the only effect to the discharge in the long run is the increased water level and water area which increases evaporation. At the beginning, when the lake is not in balance and the lake volume increases, the outflow from the lake decreases. In the long run balance is attained and the yearly average through-flow is established minus the increased evaporation. The timing of the outflow however has change because of the increased storage volume.

The EIA 3D Flow Model was found to be able to model the Lake Kyoga in rather accurate and appropriate to use for scenario simulations. The removing of the sudd would decrease the water level towards the level before the blockage formation. By widening and clearing the channels and clearing would decrease the water level some 0.5 m compared to year 2002 situation while the total remove of the blockage would put the water level 0.9 m lower.