AN ASSESSMENT OF THE RELATIONSHIP BETWEEN RAINFALL AND LAKE VICTORIA LEVELS IN UGANDA

BY

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INTRODUCTION

- Lake Victoria is the world's second largest freshwater lake and the largest in Africa.
- It is astride the equator between latitudes 0°21'N and 3°0'S and longitudes 31°39'W and 34°53'E .
- It sits on the Eastern African plateau at an altitude of 1,134m above sea level and lies in a shallow basin between the eastern and western rift valleys.
- It has an estimated surface area of 68,800km^2, an average depth of 40m and maximum depth of 80m (Nicholson, 1998).

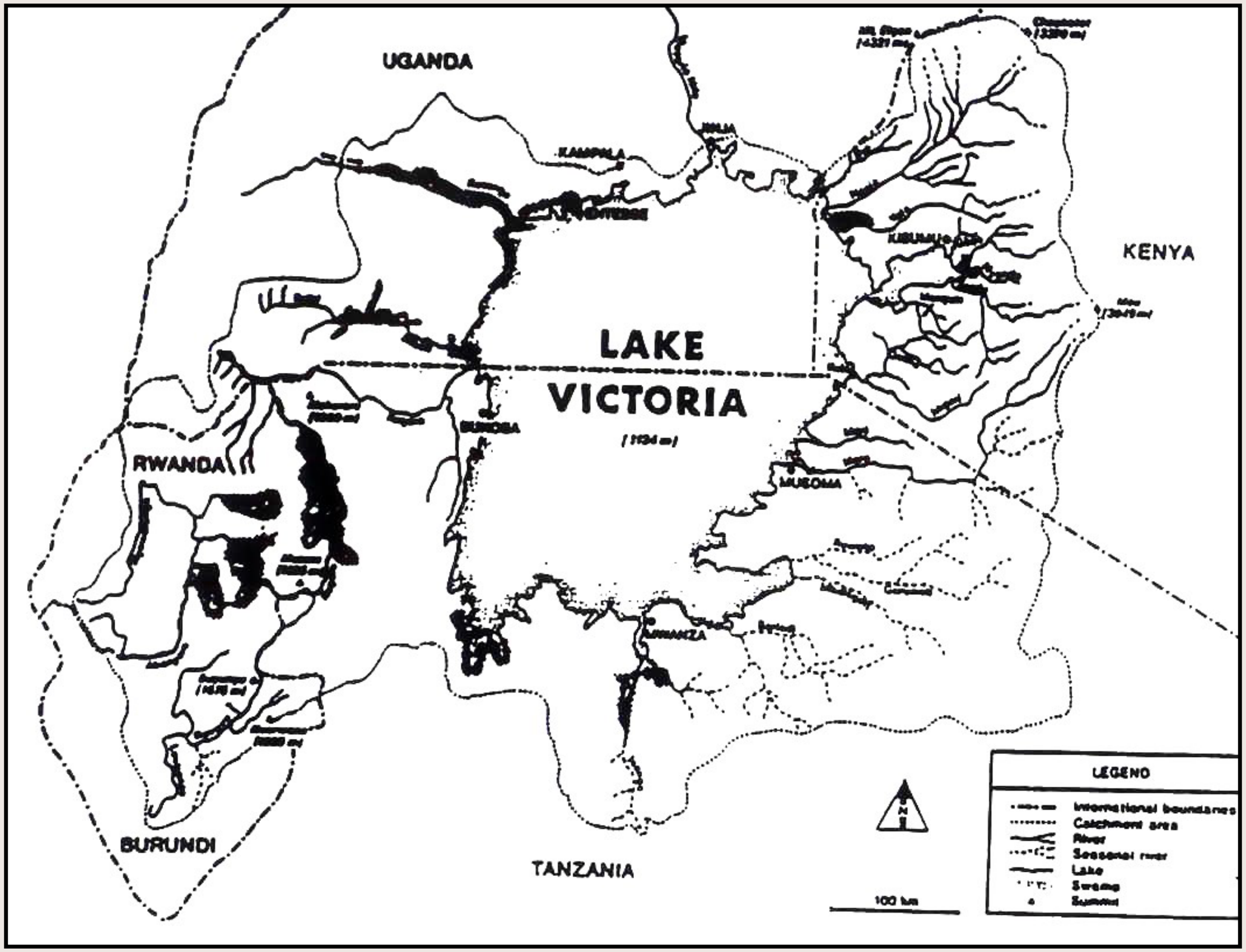
INTRODUCTION CONT’D

- The Lake Victoria basin, a shared resource between Kenya, Uganda and Tanzania (Map 1 and 2) is one of the most densely populated areas of East Africa (NARO, 2002).
- Over 40% of Uganda’s population derives considerable economic benefits from Lake Victoria in the form of fishing, water supply, transport and tourism, among others (Nicholson, 1998). However, of crucial importance is the generated hydroelectric power at Jinja in Uganda.
- Since time immemorial, Lake Victoria has acted as a natural reservoir for the River Nile, hence the basis for the construction of the Owen Falls hydropower station in the early 1950s to generate hydroelectric power for Uganda and partly Kenya

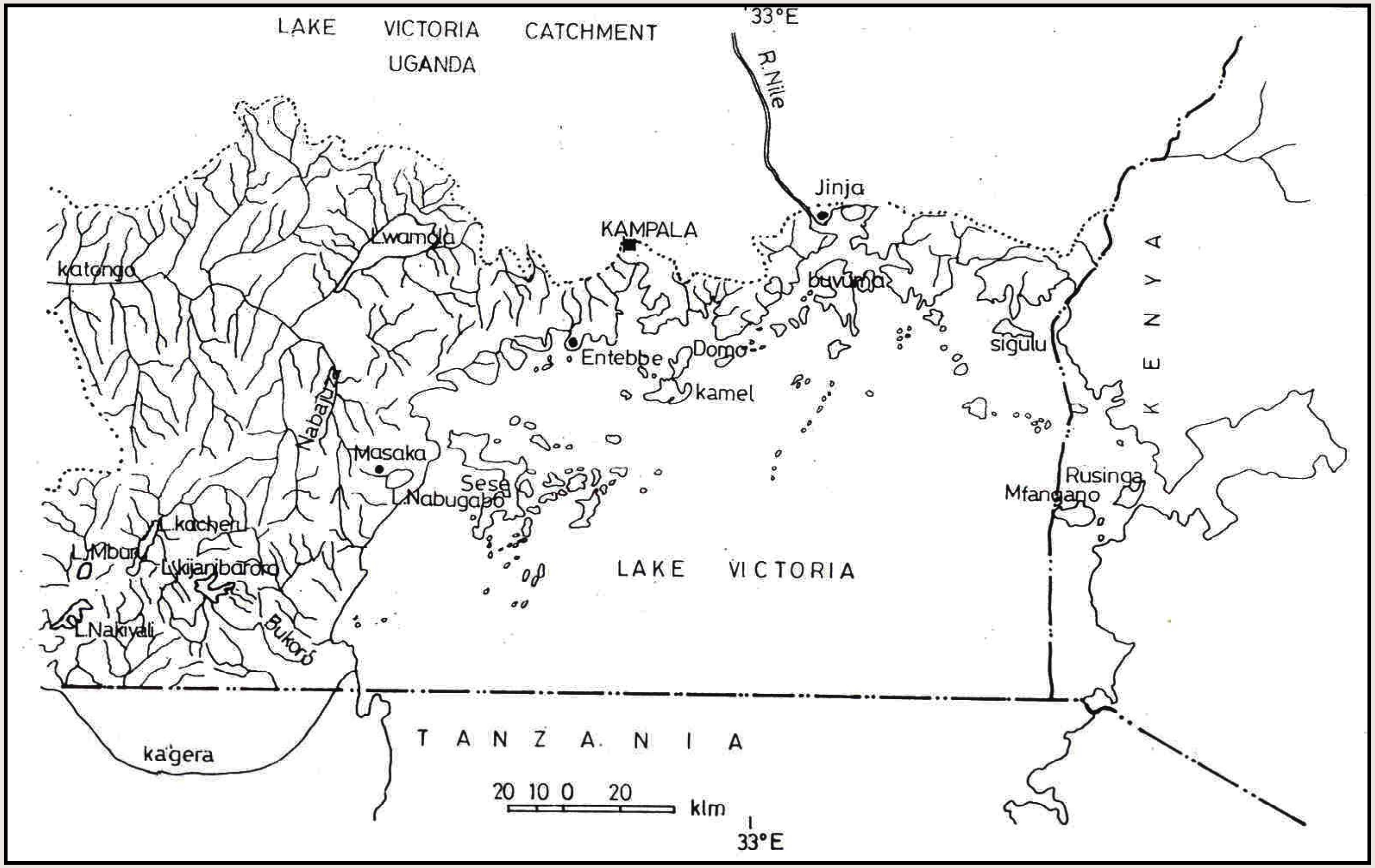
INTRODUCTION CONT'D

- Population and development growth resulted in an increase in the demand for more power in Uganda hence the construction of a second dam (Kiira Dam) a few kilometers from the existing Nalubaale dam.
- Because of this, there has been a question?? Does the introduction of the second outlet suggest a fall in the water levels of Lake Victoria or there are other factors as well?
- It is therefore important to investigate whether the fall in Lake Victoria levels is a result of climate variability or release of more water at the two outlets.
- This study therefore aimed at finding out whether there is a relationship between rainfall and lake Victoria levels in Uganda.

Map 1: Lake Victoria and its catchment in Uganda, Kenya, Tanzania, Rwanda and Burundi



Map 2: Lake Victoria and its catchment in Uganda



OBJECTIVE

The overall objective of the study was to assess the extent to which the Lake Victoria levels are dependent on rainfall by considering the time period from 1974 to 2005.

SCOPE

- The study considered the part of the lake and its catchment in Uganda only.
- The study considered meteorological data for the period from 1974 to 2005. The basis of this time period was for the study to assess the relationship between the lake levels and rainfall in the past thirty years.

SIGNIFICANCE

- Water is a basic necessity for all life and for most, if not all socio-economic activities and the welfare of the people in the Lake Victoria basin.
- Invariably, Lake Victoria is a natural source of fresh water for domestic, agricultural, industrial and other life-sustaining requirements.
- It is a medium for proliferation and sustenance of fish, which is a source of protein for local consumption and for, export, a source of hydropower generation, a medium for aquatic biodiversity, transportation, recreation and moderation of local climate.
- Ironically, it is also a medium of disposal of wastes and transmission of diseases.

SIGNIFICANCE CONT’D

- The study will provide baseline data for the future monitoring of fluctuations in the lake Victoria levels
- A robust methodology that can be applied to other lakes in the country.
- A better understanding of climate and climatic variability that can be used to monitor the effects on livelihoods of the people and economic productivity of the Nation.

SOURCES OF DATA

- The study largely used secondary data.
- Monthly rainfall data for the selected stations in the study area was got from the archives of the Uganda Meteorological Department
- Monthly lake levels from the archives of the Water Resource Management Department. The Entebbe water gauge station was considered whose zero datum elevation above mean sea level is 1123.432m.

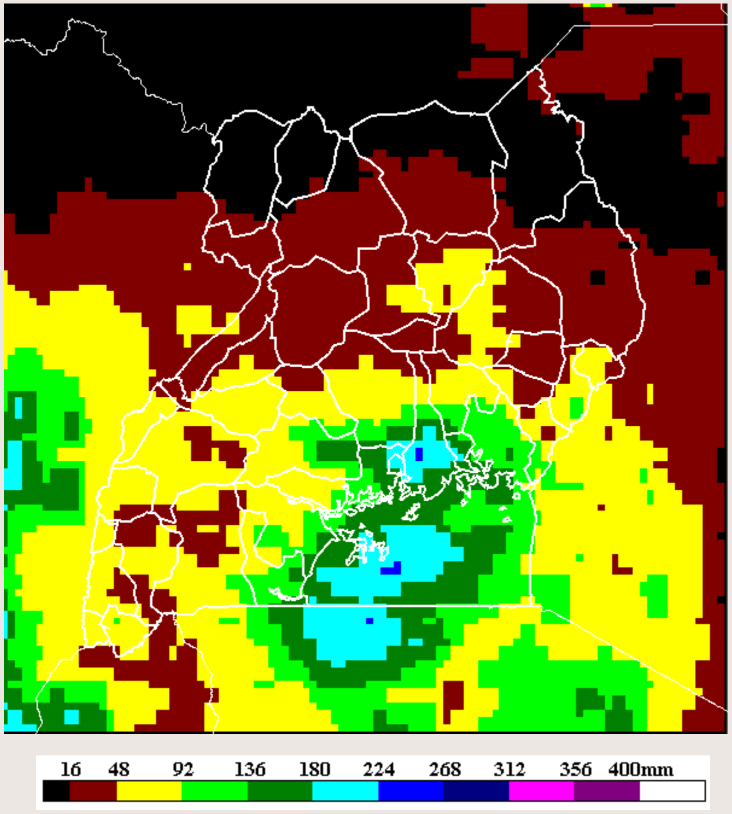
DATA QUALITY CONTROL METHODS

- One of the biggest challenges faced in the effective assessment of rainfall performance in the Lake Victoria basin was the sparse distribution or scarcity of rainfall stations in the region.
- This status quo prompted the application of satellite information to supplement the conventional rain gauge data.
- Interpolated rainfall estimates from the FAO–ARTEMIS satellite maps and products were used to supplement the rain gauge data from the synoptic stations that were operational in the lake basin region.

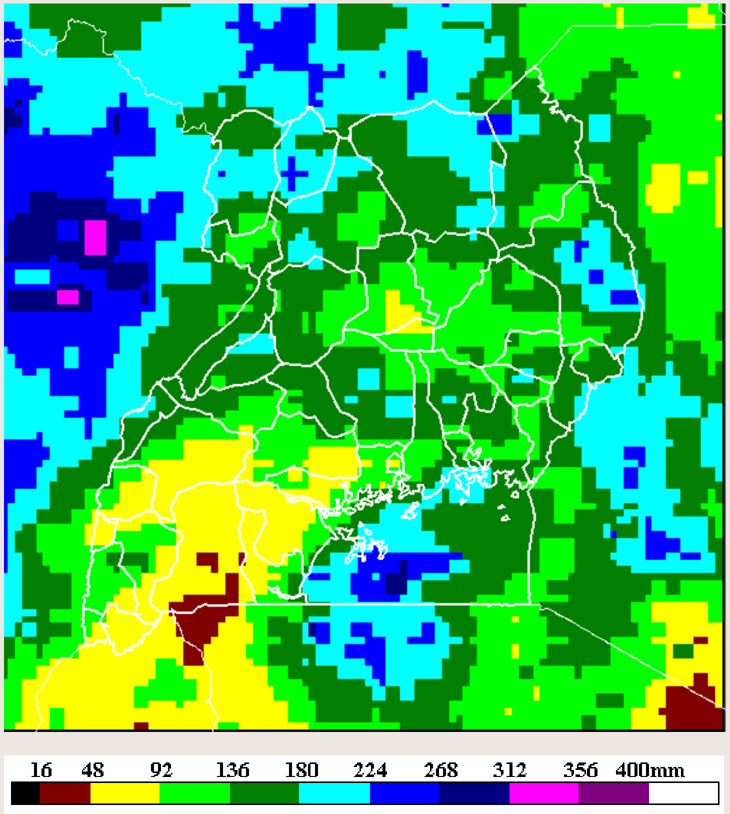
DATA QUALITY CONTROL METHODS CONT'D

Some examples of the images from FAO - ARTEMIS

January 2005 Precipitation



May 2005 Precipitation



DATA QUALITY CONTROL METHODS CONT'D

- The WMO relation, the ratio test as shown below, based on the ratios of arithmetic averages was also used to fill in rainfall missing data where X_t and Y_t represent any two stations significantly correlated with each other.

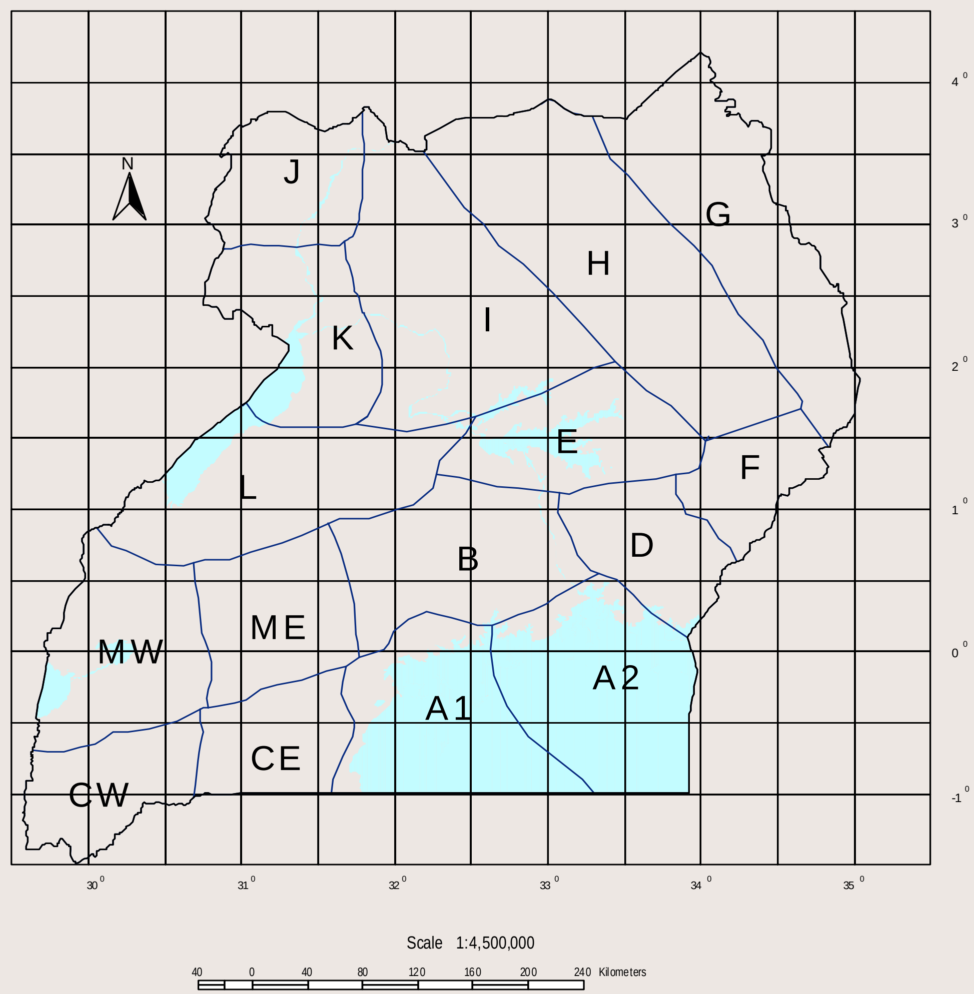
$$X_t = \frac{\overline{X}_t}{\overline{Y}_t} Y_t$$

DATA ANALYSIS

- The study used quantitative data analytical techniques.
- The area under study lies within different climatological homogeneous rainfall zones (Map 3); these regions are A1, A2, CE, CW and ME (Basalirwa, 1993).
- A1 and A2 are zones directly over the lake while CE, CW and ME are in the catchment area of the lake (including Bukora and Katonga rivers, the main rivers flowing into the lake from the Ugandan catchment).

Map 3: Delineation of Uganda into Climatological rainfall zones

Demarcated Rainfall Zones



Legend

Prepared by the GIS Sub Unit of the Water Resources Management Department, Entebbe

Rainfall over Lake Victoria and its catchment

Figure 1: Rainfall in zones A1 and A2

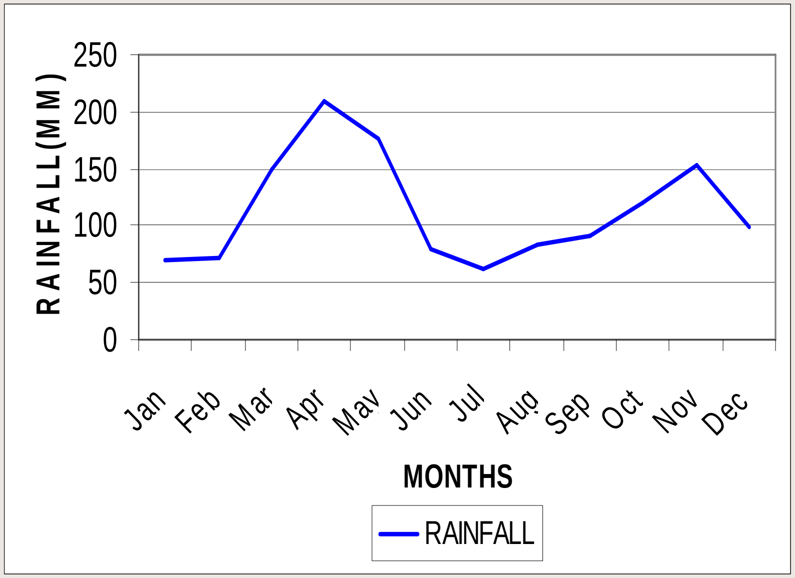
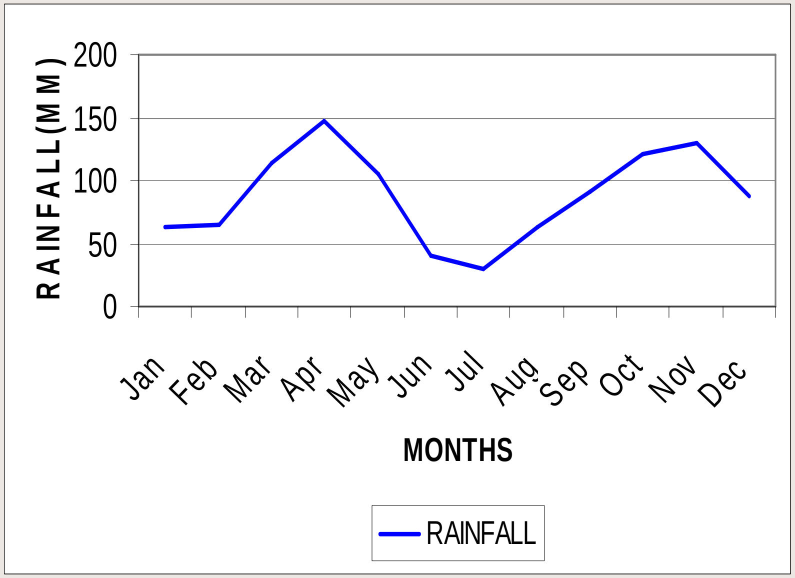


Figure 2:Rainfall in zones CE, CW and ME



The rainfall in the homogeneous regions; zones A1 and A2 varies between 1400-1800mm/yr (Figure 1) and that in zones CE, CW and ME varies between 800-1000mm/yr (Figure 2).

DATA ANALYSIS CONT'D

- To assess the relationship between the lake levels and rainfall, the "raw score method" of Pearson's Product Moment Correlation formula was used (Simple correlation) as shown in the equation below.

$$r = \frac{\Sigma XY - \frac{\Sigma X \Sigma Y}{N}}{\sqrt{\left(\Sigma X^2 - \frac{(\Sigma X)^2}{N}\right)\left(\Sigma Y^2 - \frac{(\Sigma Y)^2}{N}\right)}}$$

Where,

X – represents the independent variable X;

Y – represents the dependent variable Y;

N – the number of pairs; and

r – rho, Pearson's correlation coefficient.

DATA ANALYSIS CONT’D

- It is documented that the response of lake levels to precipitation can take anywhere from three months to two years (*Meadows et al, 1997)*.
- To examine this, for Lake Victoria, a time lag correlation analysis (autocorrelation) was employed at the 0, 1 and 3 months lag period, that is, correlating values of variable Y (Lake Levels) at the time lag period with the corresponding values of variable X (Rainfall) at earlier times.
- Seasonal rainfall for one rainy season, March, April and May (MAM) also referred to as the “long rains” was considered in the autocorrelation analysis.

RESULTS AND DISCUSSIONS

Variations in annual rainfall and Lake Victoria Levels (1974 – 2005)

Figure 3: Fluctuations in lake levels and annual rainfall over the lake

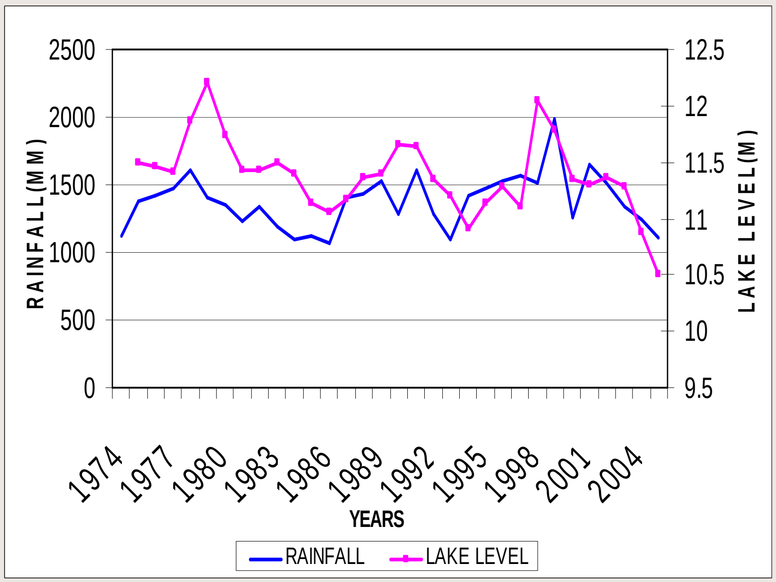
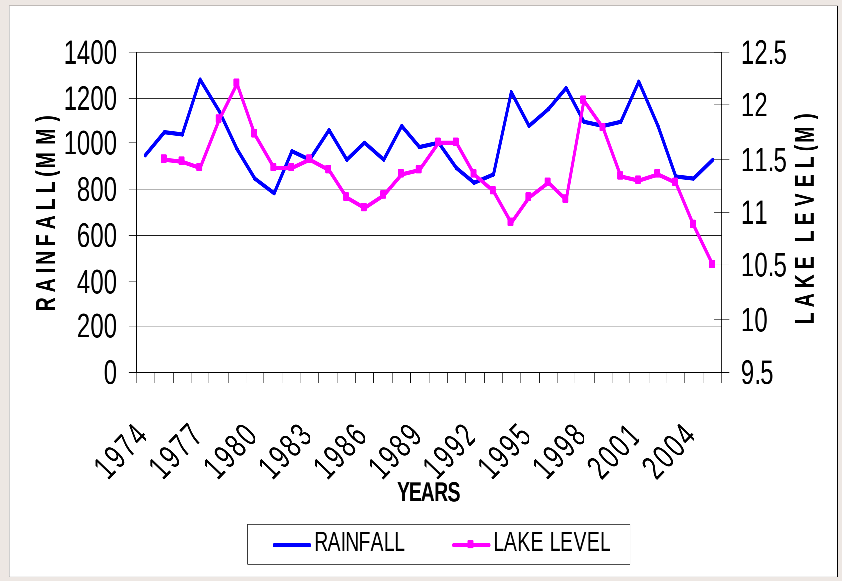


Figure 4: Fluctuations in lake levels and annual rainfall in the lake Victoria catchment



RESULTS AND DISCUSSIONS CONT'D

Assessment of the relationship between seasonal (March, April and May – MAM) rainfall and Lake Victoria Levels at different lag periods using Pearson's Product Moment Correlation method.

At zero months lag period

Figure 5: Fluctuations in rainfall over the lake and lake levels at zero months lag period

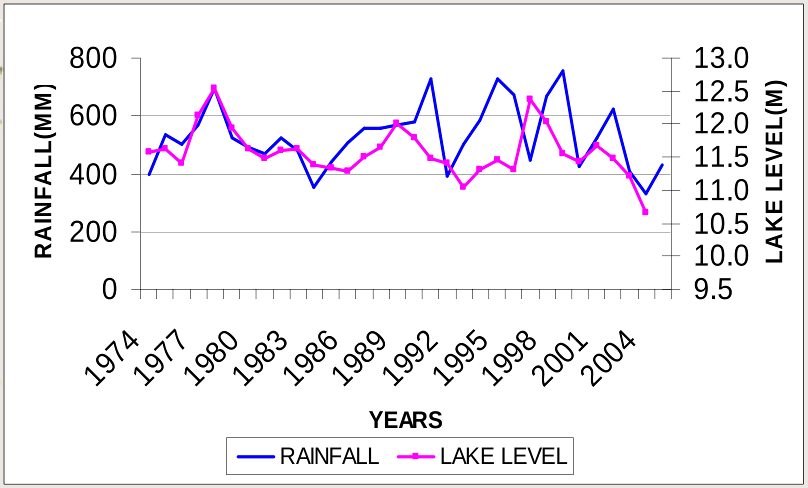
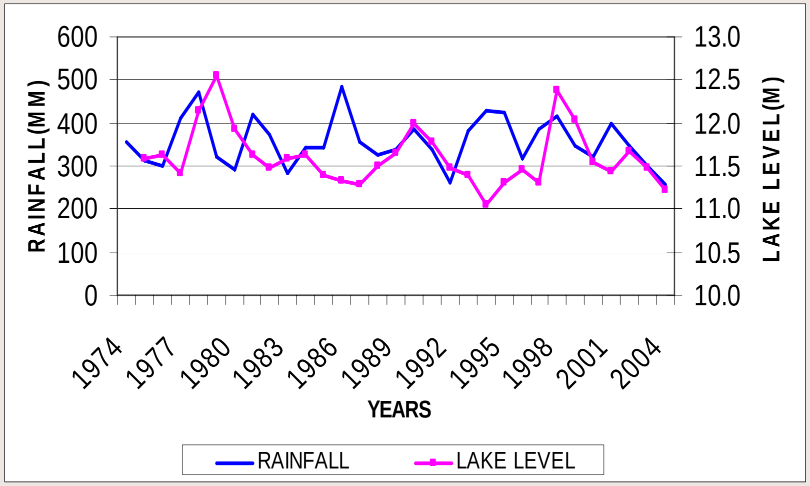


Figure 6: Fluctuations in Rainfall in the lake's catchment and Lake levels at zero months lag period



38.2% (r = 0.382) of the variations in the lake levels is explained by rainfall fluctuations over the lake (Figure 5) while 17.4% (r = 0.174) of the variations in the lake levels is explained by the rainfall fluctuations in the catchment (Figure 6).

RESULTS AND DISCUSSIONS CONT'D

At one month lag period

Figure 7: Fluctuations in Rainfall over the lake and Lake levels at one-month lag period

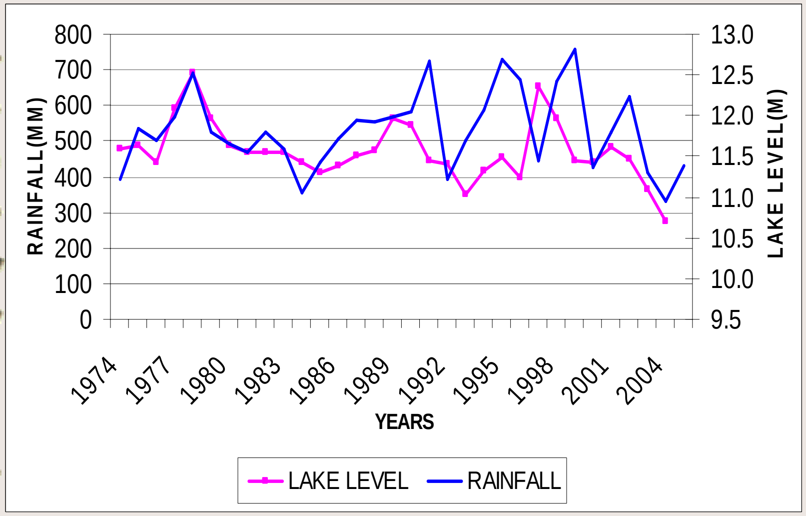
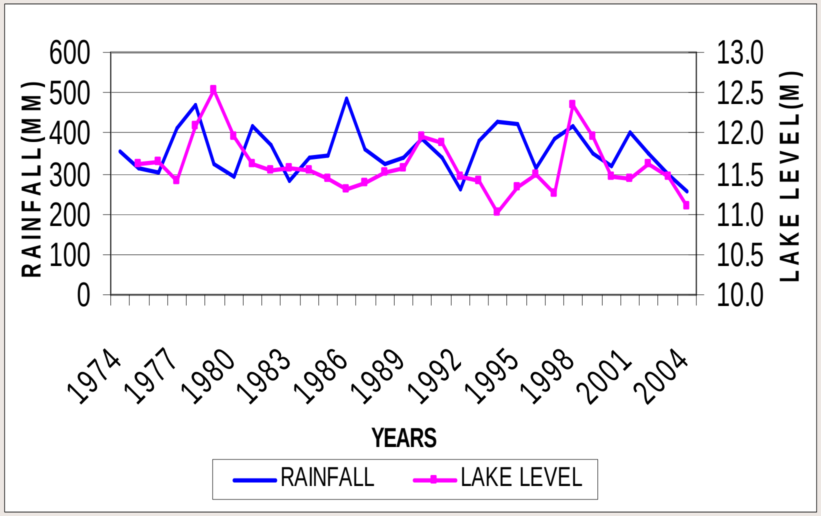


Figure 8: Fluctuations in Rainfall in the lake's catchment and Lake levels at the one-month lag period



42.4% (r = 0.424) of the variations in the lake levels is explained by rainfall fluctuations over the lake (Figure 7) while 20.6% (r = 0.1206) of the variations in the lake levels is explained by the rainfall fluctuations in the catchment (Figure 8).

RESULTS AND DISCUSSIONS CONT'D

At three months lag period

Figure 9: Fluctuations in Rainfall over the lake and Lake levels at three-month lag period

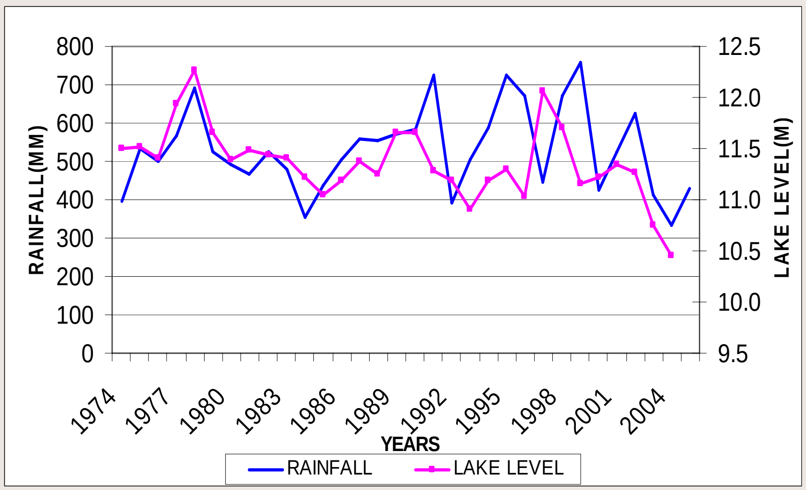
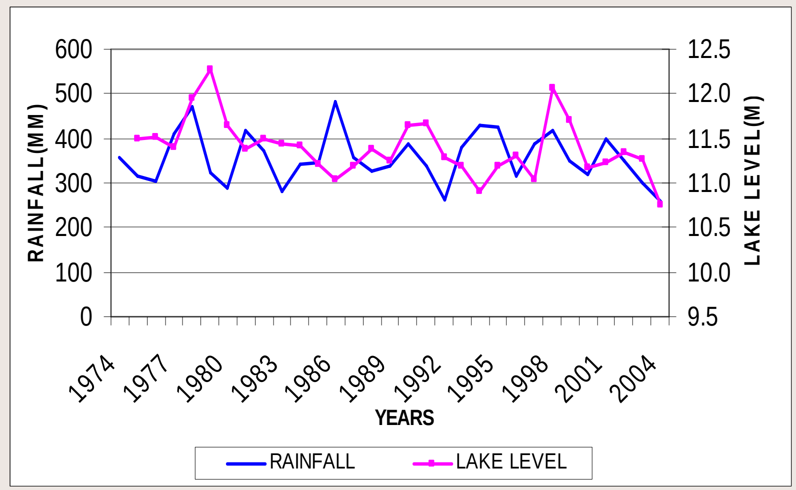


Figure 10: Fluctuations in Rainfall in the lake's catchment and Lake levels at three-month lag period



45% (r = 0.45) of the variations in the lake levels is explained by rainfall fluctuations over the lake (Figure 9) while 23.1% (r = 0.231) of the variations in the lake levels is explained by the rainfall fluctuations in the catchment (Figure 10).

SUMMARY OF RESULTS

Lag Period	Rainfall over the Lake	Rainfall in the catchment	Rainfall over the Lake and in the catchment
Zero Months	38.2%	17.4%	29%
One Month	42.4%	20.6%	32.7%
Three Months	45%	23.1%	35.7%

CONCLUSIONS

- Rainfall over Lake Victoria and that in its catchment displays a bimodal regime with rainy seasons in March to May (MAM); with a peak in April and September to December (SOND); with a peak in November.
- Water levels of Lake Victoria are more sensitive to changes in rainfall over the lake than that in its catchment. This is attributed to the large size of the lake, which is roughly one quarter of the whole catchment.
- There is a significant correlation between rainfall series and the Lake levels, with a time lag between the rainfall episodes and the water level peaks. For this study, it was found out that the relationship between rainfall and Lake Victoria levels was more significant at the three months lag period, with rainfall having an impact of about 36%.
- The remaining 64% is accounted for by other factors like anthropogenic factors as well as other natural factors like runoff, evaporation, inflow and outflow processes.

RECOMMENDATIONS

- From the analysis rainfall is not the only factor contributing to the variation in the lake levels. There is need therefore for research to be carried out, assessing the impact of each of those factors on the water levels of lake Victoria.
- A similar research should be conducted considering the Lake itself and its catchment as a whole.
- Satellite system technologies should be applied in the recording of Lake Victoria levels and data supplied to the riparian countries to supplement point data.

THANK YOU FOR YOUR ATTENTION!