ASSESSING THE IMPACTS OF CLIMATE CHANGE/VARIABILITY ON WATER RESOURCES IN UGANDA

Presented
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Introduction

- Uganda’s population is vulnerable to climate change/variability, including extreme climatic events such as droughts and flooding, due, in part, to reliance upon rain-fed agriculture, water supplies and hydro-electric power (HEP).
- The need to provide safe water to rural communities means dependence on groundwater
- This demand for groundwater is expected to increase given the expected population growth to over 50 million by 2025.
- The impacts of climate change on water resources in tropical Africa have been a subject of relatively few studies and remain poorly resolved.

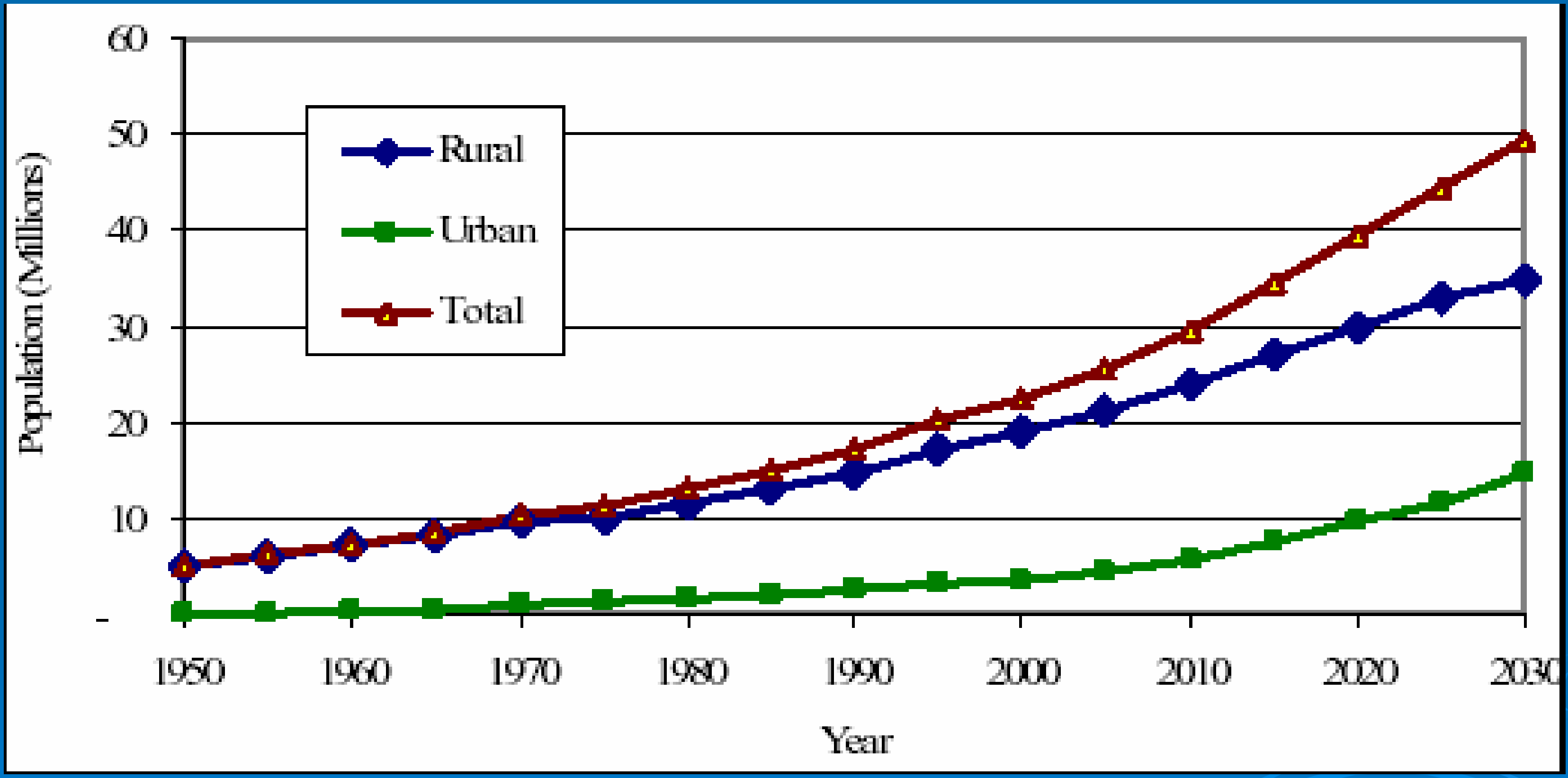

Fig 1 Estimated Uganda Population up to 2030 (*after World Water Assessment Programme (2006)*)

Introduction Continued

- The assessment of the impact of climate change and climate variability on water resources is in its infancy in Uganda
- There is a need for enhanced capacity to develop integrated assessment of water resources and the response to climate change/variability events and forecasts.
- In 2005 START provided funding to support studies to test a PC-based RCM, PRECIS (Providing Regional Climates for Impacts Studies) model developed by the Hadley Centre (UK) which specifically addresses the need for countries' to make regional-scale climate predictions. The PRECIS model was thus used in Uganda to determine its potential in generating forecasts of precipitation, on which groundwater levels depend

Atmospheric and meteorological systems that control weather and climate over Uganda

- The ITCZ

  The ITCZ is a broad zone of low surface pressure into which the low-level equator-ward moving air masses from both hemispheres converge, is closely linked to the position of the overhead sun and is the main synoptic scale feature that controls the intensity and migration of the seasonal rainfall over the East African region.

- The Monsoons

  The most fully developed phases of monsoons that affect East Africa are the North East (December to February) and the South East monsoons (June to August). These phases correspond to the maximum positions of the ITCZ to the South (Southern summer) and to the North (Northern summer) and correspond to the two major dry seasons in the bimodal rainfall areas.

Atmospheric and meteorological systems over Uganda continued

- **Meso-scale circulations**

  Topographic features like the Rwenzori and Mt Elgon and the large inland Lake Victoria introduce vigorous meso-scale circulations such as land - sea breeze phenomenon of lake Victoria basin that results in rains almost throughout the year that are only enhanced by the synoptic scale features during the main rainy seasons.

- **Teleconnections (El Niño Southern Oscillation (ENSO))**

  ENSO is the inter-annual weather variability in the global tropics. ENSO impacts on weather include the modulation of the global monsoon system manifested in modification and displacement of large-scale precipitation patterns including episodes of both floods and droughts which may occur at various

The Spatial and Temporal Seasonal Distribution of Water Resources of Uganda

In general the spatial distribution of weather and climate characteristics in East Africa are largely determined by the interaction between the quasi-stationary meso-scale circulation systems and the seasonally varying large-scale monsoonal flows.

Table 1: Percentage of land receiving selected amounts of annual rainfall in four years out of five

Rainfall (mm)	Kenya	Tanzania	Uganda	East Africa
<500	72	16	12	35
500 – 750	13	33	10	20
750 -1250	12	47	72	41
>1250	3	4	6	4

After Griffiths, 1972

- From Table 1, it can be observed that Uganda is the best endowed with the water resource in the region. However, the actual rainfall amounts received is below expectation. There are great variations in the spatial and temporal rainfall characteristics on the monthly, seasonal and annual scales.

- Figure 2 shows the mean annual rainfall over Uganda and it can be seen that some areas are among those global climates described by Trewartha as the "Earths problem climates" which are regions that have prolonged dry spells of 5 months or more and yet are located in areas where wet climates normally prevail.

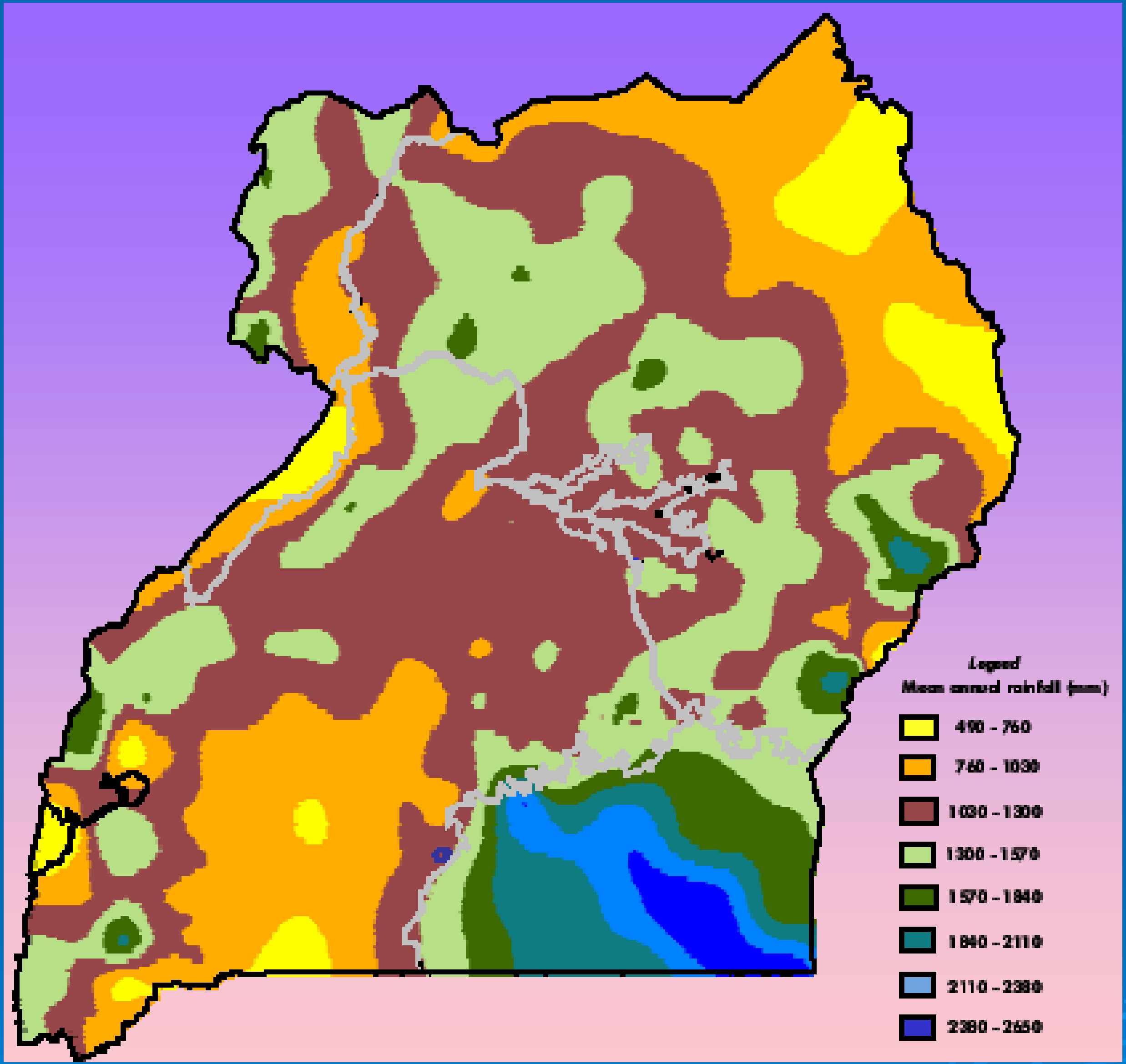

Fig 2 Distribution of Mean Annual Rainfall Amounts in Uganda (*after World Water Assessment Programme (2006)*)

The homogeneous rainfall zones of Uganda

- For effective water resources planning, homogeneous spatial and temporal rainfall zones must be identified and water resources provision accordingly planned.
- Figure 3 shows Uganda's homogeneous rainfall zones.
- These homogeneity delineations benefit spatial and temporal zonal evaluations of water availability . An example of this is shown in figure 4 where Entebbe station in zone A2 with a Bimodal rainfall distribution pattern is clearly different from that of Gulu a unimodal rainfall regime of zone I, although both stations have the same mean annual total rainfall.

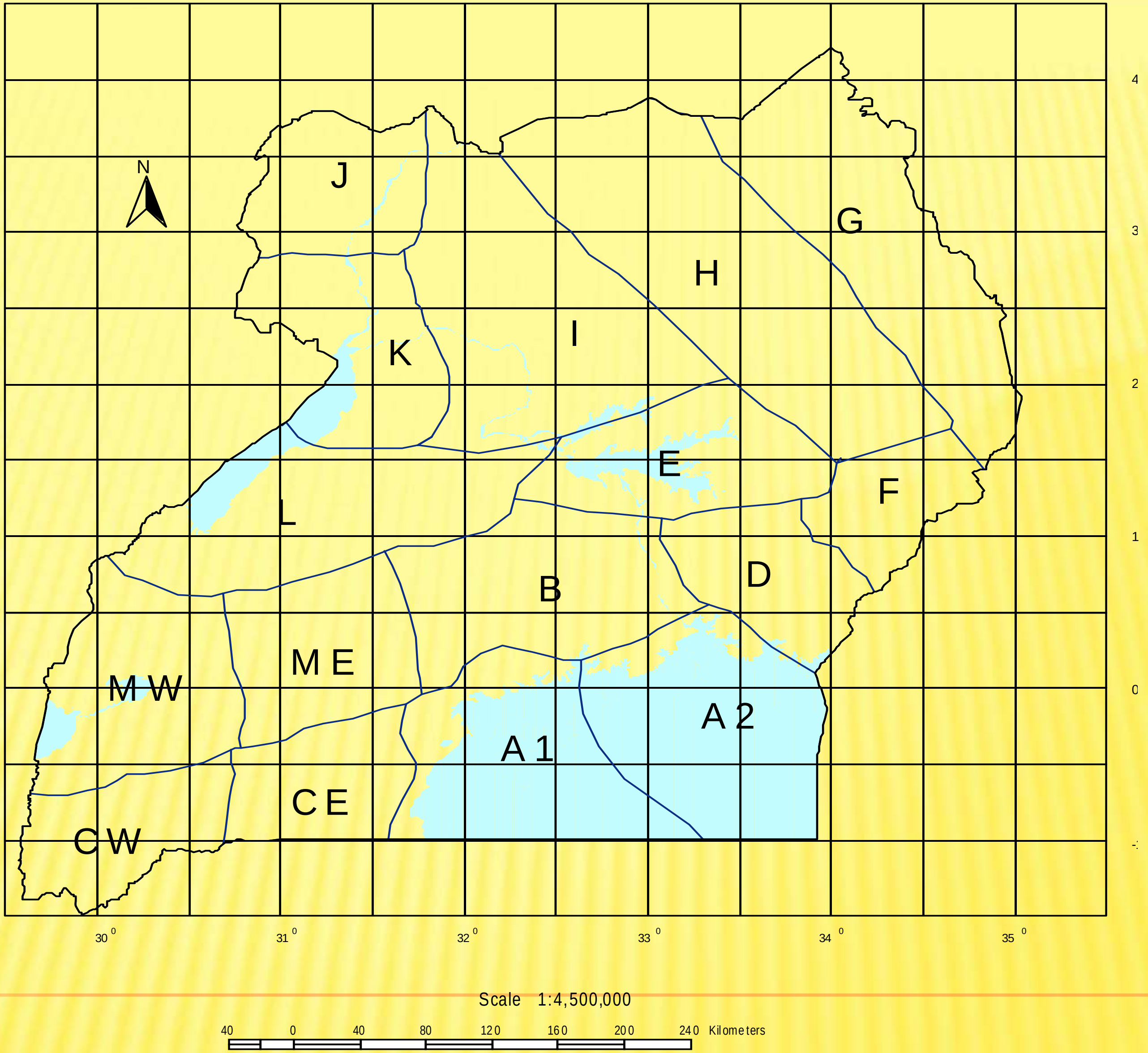

Fig 3 Delineated Climatological Zones in Uganda *(after Basalirwa et al. (2006))*

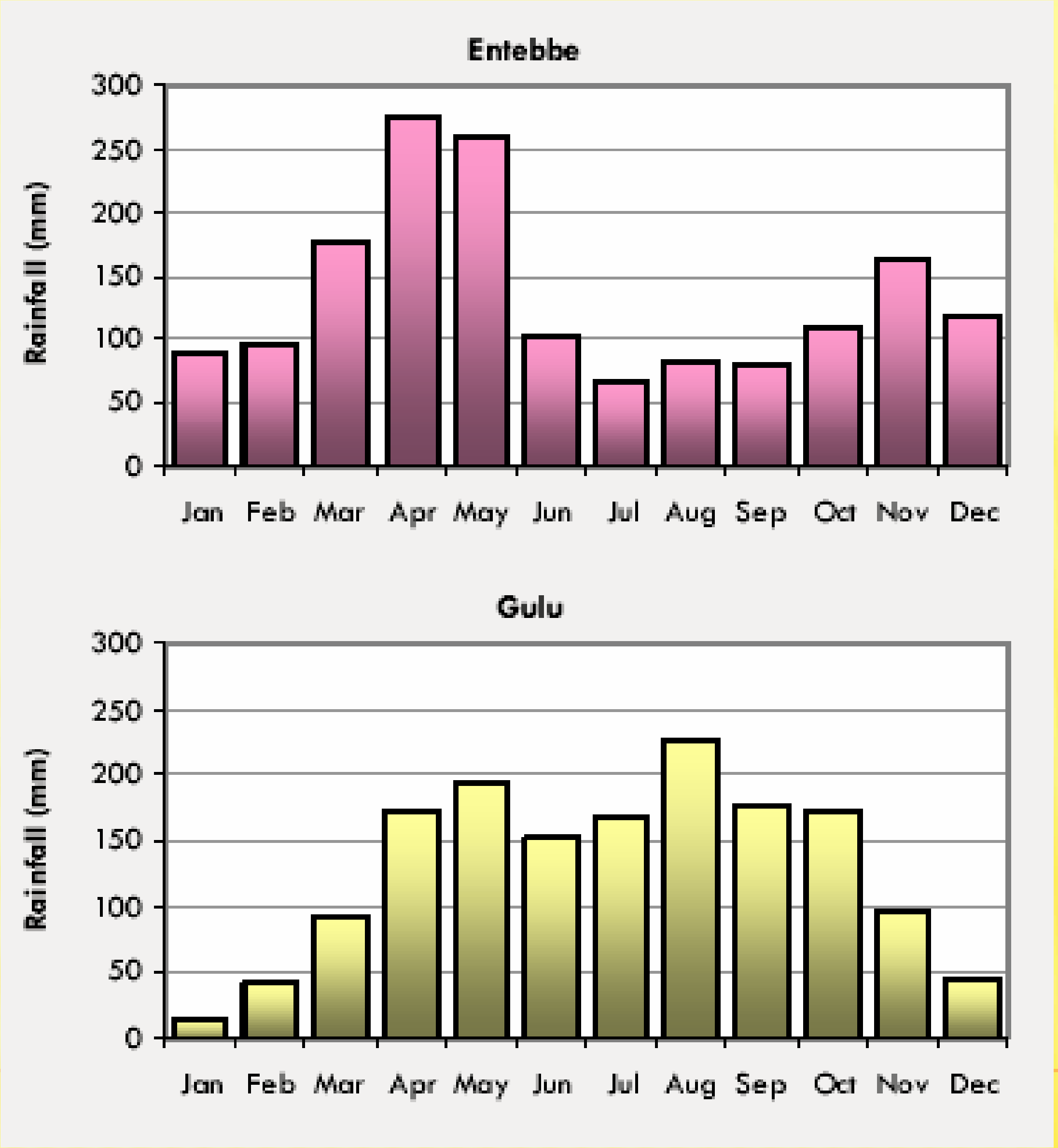

Fig 4 Long term mean monthly rainfall at Entebbe and Gulu – Bimodal and Unimodal rainfall distribution patterns dominant in Uganda

Climate Change/Variability and Water Resources in Uganda

- There is a need to highlight and identify areas of spatial climate homogeneity in relation to the spatial and temporal rainfall patterns.

- The homogeneity delineations benefit spatial and temporal zonal evaluations of water availability.

- An example of this is shown in Figure 4 where Entebbe station in zone A1 with a bimodal rainfall distribution pattern is clearly different from that of Gulu a unimodal rainfall regime of zone I in terms of temporal water availability

- When any zonal rainfall amounts receipts, for example, fall drastically below the climate normal (Figure 2) serious consequences can be expected given Uganda’s economic and social dependence on rain fed agriculture, hydroelectric power (HEP), rainwater harvesting and surface water supplies.

Climate Change/Variability and Water Resources in Uganda (Contd)

- The rural peoples concerns and anger at the failure of the rains during a rainy season due to climate change/variability occasionally leads to physical threats to the so-called "rainmakers" in the affected areas.

- These concerns in the variations of the spatial and temporal rainfall amounts receipts are not limited to Uganda but extend over the whole of the Eastern Africa sub-region.

- As regards surface water sources a widespread debate persists as to the relative contributions of climate and dam management to water-level decline in fresh water bodies.

Climate Change/Variability and, Surface and Groundwater variations (continued)

- The recent decline in the water level of Lake Victoria (Figure 5), for example, has led to a significant reduction in the capacity of the Owen Falls Dam at the northern outlet of Lake Victoria at Jinja to generate electricity.

- As the dam generates almost all of Uganda's Hydro-electricity, the reduction in the lake's level has dramatically affected the livelihoods of people throughout Uganda.

- Due to the shallowness of the second largest lake in world, Lake Victoria (<90m at it deepest), and low topographical gradients, shorelines have retreated up to 50m and consequently affected shipping and fishing industries.

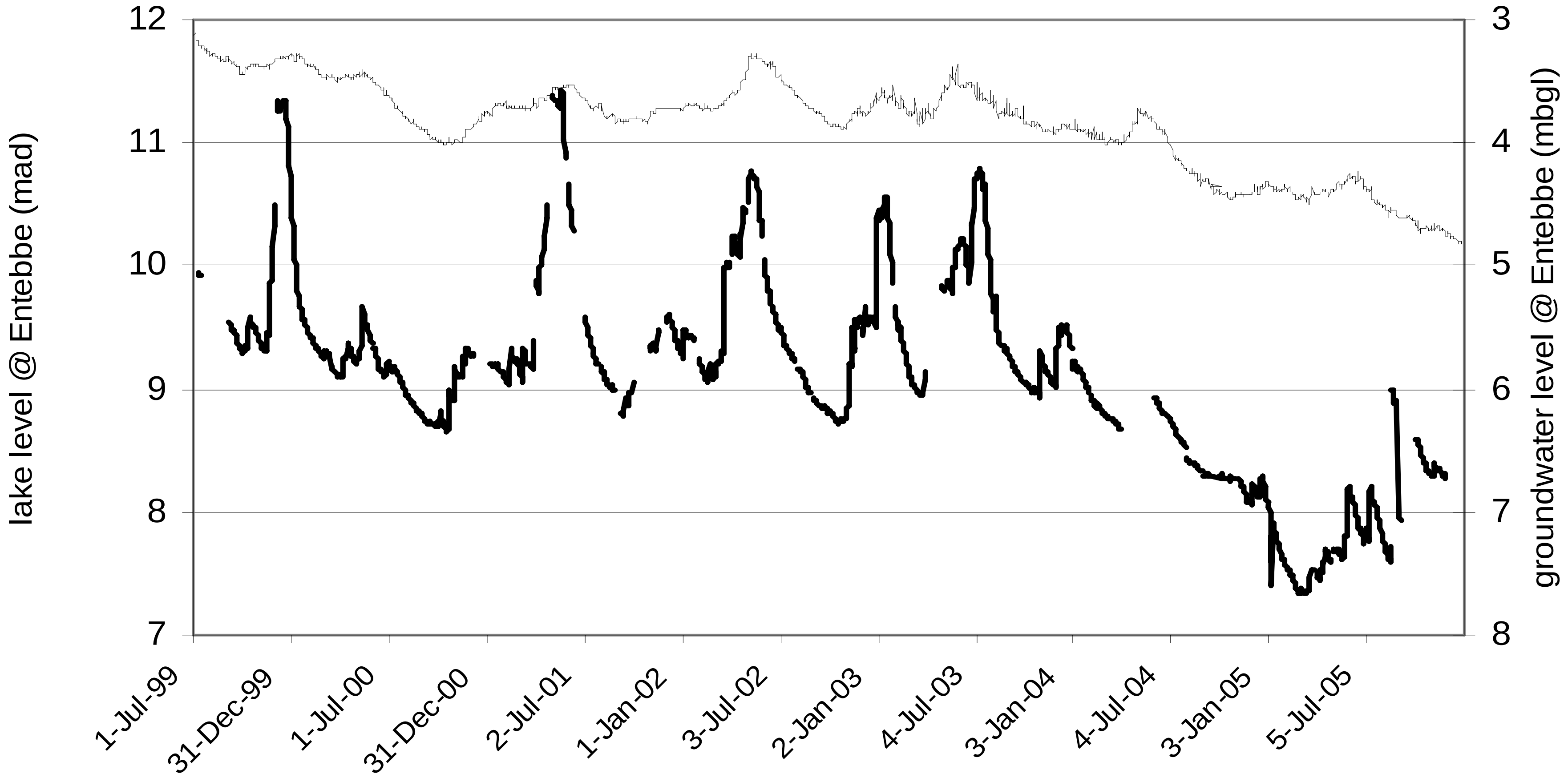

Fig 5 Recent water level fluctuations in Lake Victoria (thin line) and in ground water at Entebbe (thick line) 32.5^0E, 0.2^0N *(after Basalirwa et al. (2006))*

PRECIS Predictions of Rainfall

- Currently predictions of natural climate change/variability, is largely based on General Circulation Models (GCMs) which suggest that in East Africa including Uganda through the 21st century will tend to have:
  - An increase (≈10-20%) in rainfall. Unfortunately, this increase will not be over the whole country. High ground areas will experience increased rainfall while low areas like Uganda's cattle corridor (figure 6) may become even drier. The cattle corridor of Uganda is very significant because there is a high frequency of water shortages here which often generates acrimony among the herders with their cattle when they invade the neighbouring farmers' lands in search of pasture and water.

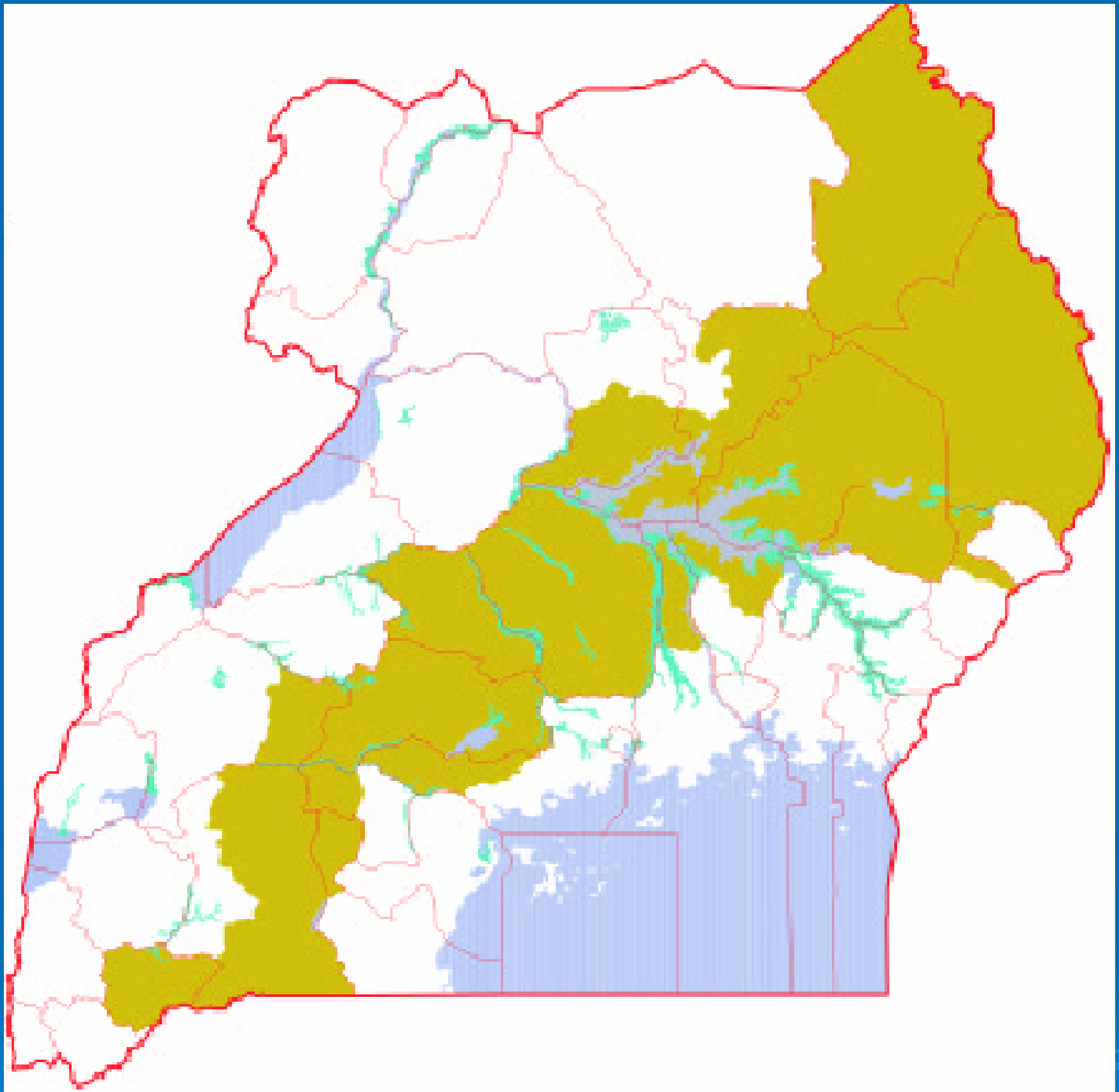

Fig 6 The Uganda Cattle Corridor

(*after Mugasi et al. 2002)*

PRECIS Predictions of Rainfall (continued)

- A change in the seasonal rainfall distribution with an increase from December to February and a decrease from June to August.

- An increase in air temperature of 0.3°C to 0.5°C per decade This unfortunately may have already started with the melting of the icecaps on tropical mountain ranges like the Rwenzori and has also created the most unfortunate impact of a wider spread in the Malaria vector disease in areas of south western Uganda where it was relatively unknown.

PRECIS Predictions of Rainfall continued

- However, there is a great deal of uncertainty in GCM predictions because of a number of reasons including the resolution of climate information provided by GCMs being too coarse (typically about 300km^2 to enable assessment of the regional impacts of climate change particularly in regions such as East Africa with complex regional climate characteristics.

- The coarse resolution problem of the GCMs leads the use of Regional climate models (RCMs) with a higher grid resolution (typically tens of km^2) which provide more detailed and more realistic simulations of predictions of climate change/variability for particular areas of interest.
- These informed forecasts of rainfall amounts can be used to forecast groundwater levels. The PRECIS model used in 2005 to forecast rainfall used RCM data.

- Preliminary validation of PRECIS model results showed that both seasonal and monthly rainfall trends for some areas of Uganda could be simulated for some seasons.

- Figures 7 (i) and 7(ii), for example, for Masindi and Gulu stations in homogeneous rainfall regions K and I respectively, the PRECIS model for the tested period of 1991-1994 the simulated rainfall amounts for the dry seasons' months of June to August and December to February were overestimated while those of the rainy months of March to May and September to November were underestimated.

- However, as already observed above, these results are an indicator that the PRECIS model can be calibrated differently to improve these rainfall amounts forecasts.

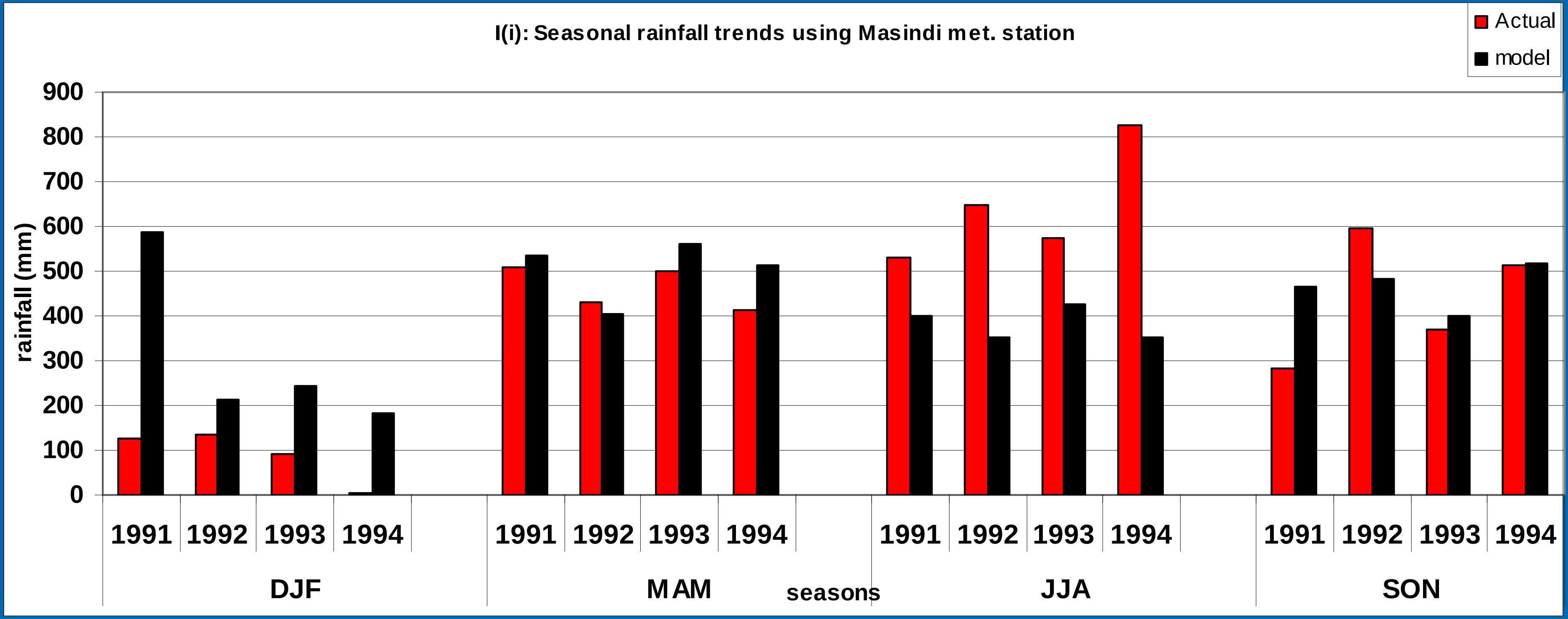

Fig 7 (i) Seasonal rainfall trends for both the model and actual rainfall between 1991 – 1994 for Masindi (after Sabiiti 2006))

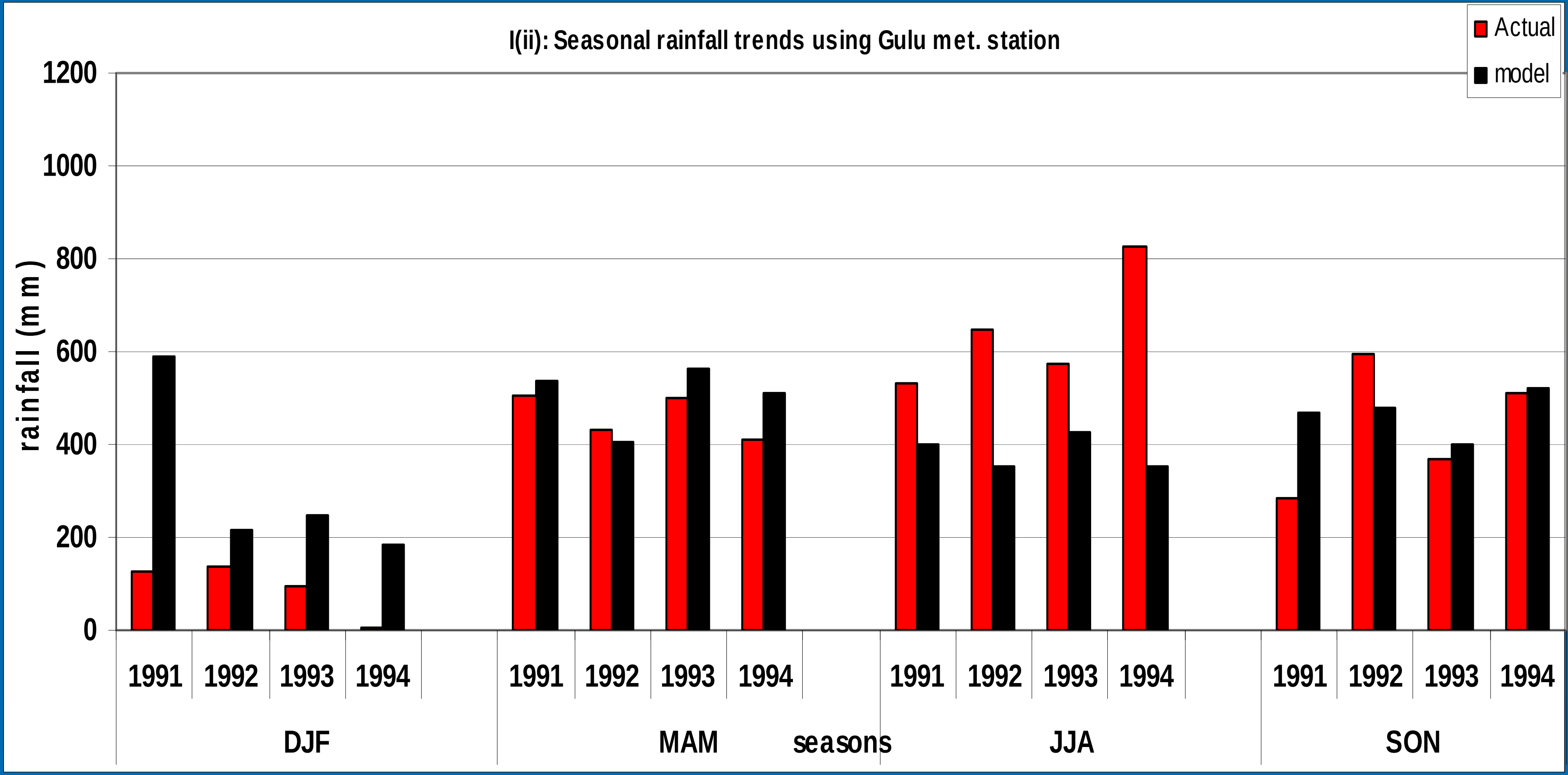

Fig 7 (ii) Seasonal rainfall trends for both the model and actual rainfall between 1991 – 1994 for Gulu *(after Sabiiti (2006))*

Conclusion

- There is a great need for more rigorous investigations of the PRECIS model apart from recalibration.
- Unfortunately, today there are only one or two meteorologists in Uganda capable of using the PRECIS Model, hence a very urgent need for training of personnel.
- This is beside the unfortunate reality that the operations of the PRECIS model need a stable power source currently unavailable in Uganda.
- There is also an added need for suitable large RAM and CPU desk top computers which cost money.
- These needs must clearly be addressed if we are to predict future rainfall climate change/variations to focus on the available water resources.

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Thank you for your attention