PROJECT TITLE: **DEVELOPMENT OF METHODOLOGIES FOR THE UTILIZATION OF SEASONAL CLIMATE PREDICTION FOR FORECASTING HYDROPOWER GENERATION**

PROJECT DURATION: **6 MONTHS**

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INSTITUTION: **TANZANIA METEOROLOGICAL AGENCY (TMA)**

1.0 Introduction

The generation of electricity in Tanzania is mainly from both hydro and thermal power plants. The total installed capacity on the interconnected grid is about 757 MW of which 555 MW (73%) is hydro and the rest is thermal. The generation from the hydropower plants is dependent on flow of water in the rivers which, undesirably, is stochastic in nature, exhibiting spatial variability as well as temporal variations (daily, seasonal, annual and over-year variations). The two reservoirs at Mtera (3200 Mm^3 live storage) and Nyumba ya Mungu (580 Mm^3 live storage), located upstream from the power plants are meant to regulate such variations in natural uncontrolled flows.

The Tanzania Electric Supply Company Limited (TANESCO) is responsible for the generation, transmission, distribution and the selling of electricity to mainland Tanzania and bulk power to Zanzibar. The company also imports power from Uganda and Zambia. For the past five years, TANESCO has been faced with a severe supply shortage on the grid system, generally attributed to poor rains in the upper catchments of Ruaha and Pangani River Basins. Other reasons, apart from failure of rains include high abstractions and evaporation in the hydropower systems. TANESCO has been also forced to draw more energy from hydro system due to insufficient fuel to properly operate thermal plants. As a result, TANESCO has had to curtail and at times halt power production at the Mtera and Kidatu generating stations.

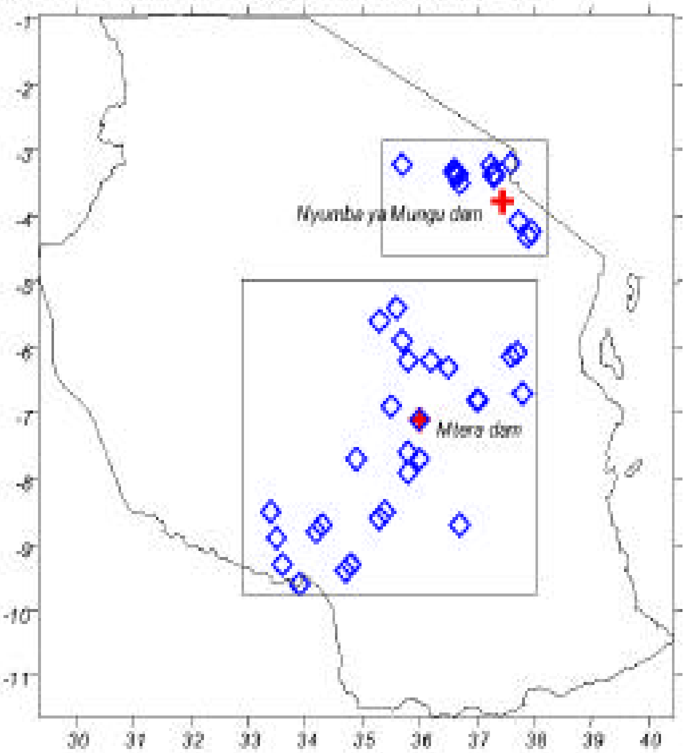
2.0 Project Goals

The project objective is to factor climate information in the planning and development of hydropower based on the use of climate information and seasonal climate predictions.

2.1 Data and Methodology

The data used in this study consisted of monthly rainfall totals and mean monthly dam levels (Nyumba ya Mungu and Mtera) of over than 30 years obtained from Tanzania Meteorological Agency (TMA) and Tanzania Electric Supply Company (TANESCO) respectively. The distribution of the rain gauges in both Nyumba ya Mungu and Mtera dams catchment are depicted in figure 1.1 below. Replacing them with long-term monthly averages did estimation of missing rainfall values.

Figure 1.1 Distribution of Rain gauges with respect to the Dams



The aerial average rainfall at each of the dams' catchment (Nyumba ya Mungu and Mtera) were computed for each month and then both aerial average rainfall and the dam levels standardised using the following equation: **Zi = (xi – µ)/d,** Where, **xi** is the aerial average rainfall or dam level, **µ** is the Mean and **d** is the Standard deviation. The level of statistical association between rainfall and dam levels were determined by computing simple Pearson correlation matrices while the developed simple linear regression models for use in forecasting dam levels were given by the general relation: **Y = C0 + C1 X,** Where, **Y** refers to the forecasted dam level, **X is the** Independent variable while **C0** and **C1** are the regression parameters (the intercept and the slope of the line of best fit).

The models developed were then evaluated using **cross validatio**n technique that involves computation of estimated dam levels after removal of one year. Finally, association and thus persistence between the generated and observed dam levels were measured by looking at the skills between them. Another approach also used in this study was the cross tabulation method of **contingency tables**.

3.0 Results and Accomplishments

The study was able to achieve its objective in that the predictive regression models were finally developed. Examples of the results obtained from correlation analysis between rainfall and Nyumba ya Mungu dam levels for the various months are shown in Tables 3.1 to 3.4. They show the significant correlation matrices between March – May Seasonal Rainfall and the dam levels of June, July, August and September while Tables 3.5 and 3.6 show correlation matrices between October – December Seasonal Rainfall and dam levels of January and February. The significant time lagged correlations are shown in red. It was evident from the results that although the mean variance explained were relatively low, the associations were quite strong during the extremely wet/dry years. Thus prediction and early warning products could be used to minimize the negative impacts of climate extremes on hydropower production in the country.

Table 3.1

	June Levels

Table 3.2

	July Levels

March_April Rain	0.344
April_May Rain	0.436
March_April_May Rain	0.471

March_April Rain	0.357
April_May Rain	0.417
March_April_May Rain	0.472

Table 3.3

	August Levels
April Rain	0.354
March_April Rain	0.395
April_May Rain	0.432
March_April_May Rain	0.490

Table 3.4

	Sept Levels
March Rain	0.302
April Rain	0.343
March_April Rain	0.402
April_May Rain	0.414
March_April_May Rain	0.487

Table 3.5

	January Levels
October Rain	0.311
November Rain	0.458
Oct_Nov Rain	0.418
Nov_Dec Rain	0.453
Oct_Nov_Dec Rain	0.439

Table 3.6

	Feb Levels
October Rain	0.371
November Rain	0.474
December Rain	0.395
Oct_Nov Rain	0.459
Nov_Dec Rain	0.528
Oct_Nov_Dec Rain	0.516

An example of the cross validation model for Nyumba ya Mungu Dam for the March to May seasonal rainfall if shown in figures 3.1 - 3.4 below:

Figure 3.1

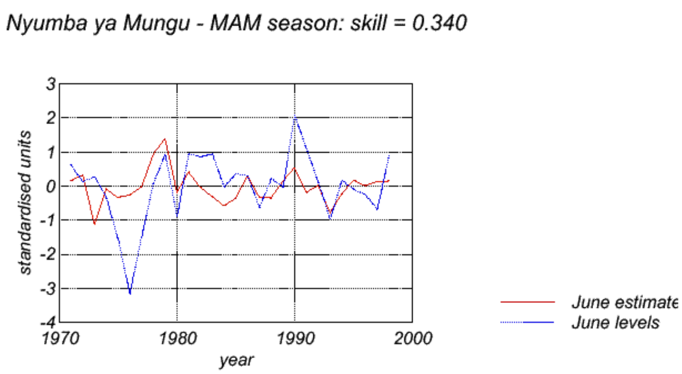


Figure 3.2

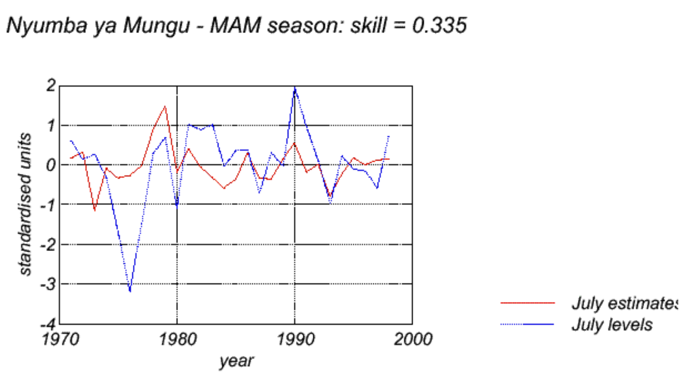


Figure 3.3

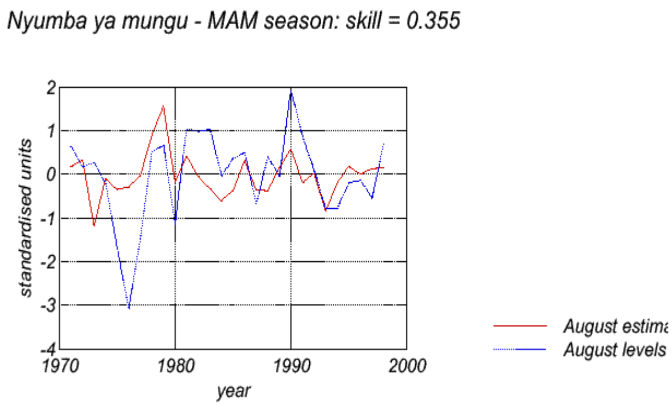
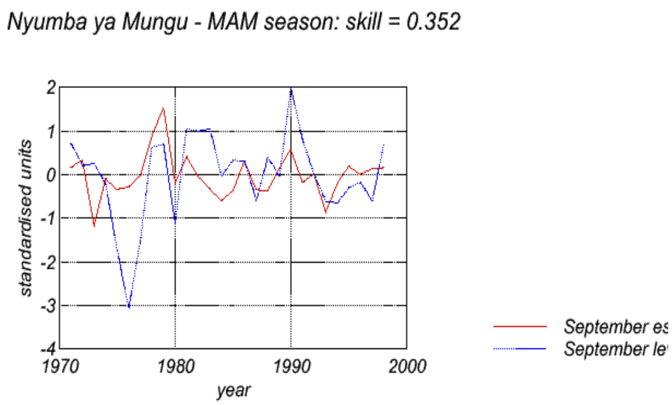


Figure 3.4



Reference

1. Ministry of Water Energy and Minerals, *Pangani Basin Water Management –Assessment of Inflow to Nyumba ya Mungu Reservoir.* NORPLAN A/S December 1994
2. Tanzania Electric Supply Company Ltd., *Water Balance Study for Nyumba ya Mungu Reservoir - Pangani River Basin.* NORPLAN A/S May 1995.
3. Tanzania Electric Supply Company Ltd., *Great Ruaha Project - Mtera Dam Water Management.* SWECO 1981.