ANALYSIS OF RAINFALL TREND AND ITS IMPACT ON FUTURE HYDROPOWER GENERATION - CASE STUDY ON VICTORIA RESERVOIR

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DECLERATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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Name of the supervisor: Prof. R.L.H.L. Rajapakse

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ABSTRACT

Analysis of Rainfall Trend and Its Impact on Hydropower Generation

- Case Study on Victoria Reservoir

Mahaweli river basin is the major river basin for hydropower generation in Sri Lanka and it supplies about 1800 GWh annually to the national grid, but the expected generation is about 2400 GWh (2019). The annual hydropower generation in Sri Lanka is decreasing and the contribution of other nonrenewable sources are continuously increasing accordingly. There are eight reservoirs in the upper catchment of Mahaweli Basin which generate hydropower under the Mahaweli Complex. These reservoirs experience both drought periods and high flood periods as well throughout the year. As hydropower generation totally relies on the rainfall amount of the sub-catchment of the reservoirs, the planned hydropower generation cannot be achieved during the drought periods due to the failure in receiving expected rainfall to the sub-catchments of reservoirs. Hence, identifying the rainfall pattern, its peaks and troughs, and possible trend in future rainfall are crucial for managing and optimizing the reservoir operations such that hydropower generation can be maintained at the maximum possible capacity

This study is focused on the analysis of rainfall trends in the upper catchment of Mahaweli Basin and its impact on hydropower generation in Victoria reservoir according to the possible variations in future rainfall. The rainfall trend was analyzed for the Mahaweli Upper catchment considering rainfall data of seven rainfall stations with 30 years of monthly rainfall data. The base period for rainfall trend analysis was selected from the year 1981 to 2010 as per World Meteorological Organization (WMO) guideline. The missing rainfall data in selected rainfall stations were filled with the linear regression method. Rainfall trend was analyzed with the Mann Kendall test and the magnitude of the trend was estimated by Sen's Slope method which were performed using RStudio Software. According to the trend analysis, the rainfall trend is negative in dry periods and a positive trend is observed in rainy seasons and the negative trend is higher than the positive trend. It could be expected that dryer periods getting dryer with a high degree of variation and rainy periods getting even more rainfall to a lesser degree. This implies that overall annual rainfall has a negative trend in the study area. The future rainfall was estimated for further 30 years from 2020 to 2050 as monthly data with parameters obtained from Sens' slope method and Mann Kendall test. The average annual rainfall was about 2,390 mm in the study area for the selected base period and the estimated future mean annual rainfall for next 30 years will be around 1973 mm with a decrease of 18% compared to the last 30 years.

The catchment runoff was calibrated for Victoria reservoir with HEC HMS model for the five years from 2001 to 2005 and the model was validated for the period 2006-2010. The future inflows were predicted for the period 2021 - 2025 with generated monthly future rainfall data. The future annual inflow of Victoria reservoir in next 5 years will be reduced by 10% compared to recent 5 years of inflows of Victoria reservoir. The HEC ResSim model was developed and applied for Victoria reservoir to obtain the potential power generation and the analysis of reservoir operations of Victoria reservoir. HEC ResSim model was calibrated with reservoir operational data in the year 2015 and validated with reservoir operational data in the year 2016. Future power generation was obtained for the time period of 2021 - 2025. It was found that the future annual power generation of the Victoria power plant will be reduced by 23% compared to the last five years due to the predicted decrease in rainfall. This future scenario was analyzed based on monthly data, hence the peak events were not taken into account. Since the hydropower generation in the Victoria reservoir is decreased yearly, optimization of reservoir operations is necessary considering the variation of future rainfall trends.

Keywords: Catchment runoff, HEC ResSim, Mann Kendall, Reservoir simulation

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LIST OF ABBREVIATIONS

BBS	:	Block Bootstrap
CN	:	Curve Number
DEM	:	Digital Elevation Model
Est	:	Estimated
GIS	:	Geographic Information System
GWhr	:	Giga Watt hours
HEC HMS	:	Hydrologic Engineers Center - Hydrologic Modeling System
IPCC	:	Intergovernmental Panel on Climate Change
LR	:	Linear Regression
MAR	:	Missing at Random
MCAR	:	Missing completely at Random
MCM	:	Millions of Cubic Meter
MK	:	Mann Kendall
MLR	:	Multiple Linear Regression
MSL	:	Mean Sea Level
MW	:	Mega Watt
NCAR	:	Not Missing at Random
NSE	:	Nash – Sutcliffe Efficiency
Obs/ Ob	:	Observed
RF	:	Rainfall
RMSE	:	Root Mean Square Error
SCS	:	Soil Conservation Service
T_c	:	Time of Concentration
WMO	:	World Meteorological Organization

LIST OF APPENDICES