

**CLIMATE EXTREMES AND PRECIPITATION
TRENDS IN KELANI RIVER BASIN, SRI LANKA AND
IMPACT ON STREAMFLOW VARIABILITY UNDER
CLIMATE CHANGE**

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Sri Lanka

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of Master of Science in Water Resources Engineering and Management

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February 2017

DECLARATION

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 knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in text.

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Climate Extremes and Precipitation Trends in Kelani River Basin, Sri Lanka and Impact on Streamflow Variability under Climate Change

ABSTRACT

The study region comprises a major river basin in the West of Sri Lanka namely Kelani River basin. The hydrological regime of this river differs significantly from that of the others because the basin features great geographical and climatic diversities over its latitudinal and longitudinal extent. Kelani River is the second largest river in Sri Lanka that originates from the central hills and flows to the west coast through Colombo city. The river basin is bound by northern latitudes from 6°47' to 7°05' and eastern longitudes from 79°52' to 80°13'. The river originates approximately 2,250 m above mean sea level and passes 192 km to reach the Indian Ocean. The river basin experiences an annual average rainfall of about 3,450 mm corresponding to a volume of about 7,860 MCM out of 43% discharges into the sea. However, changes in precipitation and temperature due to the climate change can cause more frequent extremes with extended droughts and floods with further impact to the reservoir storage resulting a significant threat to water resources. Therefore, the present study focuses on climate extremes with reference to the past, present and future behavior of rainfall, temperature and streamflow at watershed scale to identify climate change impact on the spatial and temporal variations of streamflow in the Kelani River Basin.

For this research, basin-wide future hydrology is simulated by using downscaled temperature and precipitation outputs according to RCP Scenarios of the Canadian Earth System Model - version 2 (CanESM2), Statistical Downscaling Model (SDSM) and the Hydrologic Engineering Centre's Hydrologic Modeling System (HEC-HMS). The case study further evaluates the long-term behaviour and trends of the climate extremes based on the observed historical temperature and precipitation data. The findings suggest that the temperature and precipitation extremes are on the rise while the annual average precipitation in the river basin is declining. It is also predicted with the application of statistical downscaling that temperature may rise annually for representative concentration pathways of RCP2.6, RCP4.5 and RCP8.5. The mean explained variance are 67, 86 and 13% for temperature maximum, temperature minimum and precipitation respectively, for calibration with NCEP predictors. During calibration, the R^2 value of the monthly and seasonal sub-model of RCP 2.6, RCP 4.5 and RCP 8.5 scenarios are lies between 80.1% and 99.4% for both maximum and minimum temperature and 50 to 90% for precipitation. During validation, R^2 value for both monthly seasonal sub-model followed by bias correction was between 76.9% and 99.2% for both maximum and minimum temperature, and 55% to 95.2% for precipitation. A detailed modelling approach is incorporated to Hanwella sub-watershed (1799.67 km²) of the Kelani River basin, to study the subsequent water resource management options with the varying streamflow of the Kelani River basin under the effect of the future (2020's, 2050's and 2080's) rainfall and temperature as impending climate change impacts for RCP scenarios. The paper reviews the current state of the catchment as well as the suitability of applying the GCM's rather than RCM's to Sri Lanka to assess this river basin, according to monthly, seasonal and annual variations of the climatology. Apart from the water resources management, a quantitative analysis was conduct to assess the change in the amount of surface water within the selected river basin as a function of the expected variations in precipitation and temperature. This study will set the baseline for commencing and continuing quantitative studies incorporating the behaviour of the basin-wide climatology and streamflow variability with the use of general circulation models

Key words: - Climate Change, GCM, RCP Scenarios, Statistical Downscaling, Water Resources Management

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LIST OF ABBREVIATIONS

| | |
|-------------------|--|
| ANN | - Artificial Neural Networks |
| AR4 | - Assessment Report 04 |
| AVGPRCP | - Annual Average Precipitation |
| BC | - Bias Correction |
| CanESM2 | - Canadian Earth System Model Version 02 |
| CCCMA | - Canadian Centre for Climate Modelling and Analysis |
| CDD | - Consecutive Dry Days (Maximum number of consecutive days with rainfall < 1 mm) |
| CE | - Coefficient of Efficiency |
| CGCM3 | - Coupled Global Climate Change Model Version 03 |
| CMIP | - Coupled Model Intercomparison Project |
| CORDEX | - Coordinated Regional Climate Downscaling Experiment |
| CWD | - Consecutive Wet Days (Maximum number of consecutive days with rainfall > 1 mm) |
| DS | - Dual Simplex |
| DTR | - Diurnal Temperature Range (Annual mean difference between TX and TN) |
| E | - Explained Variance |
| ENSO | - El Nino Southern Oscillation |
| ETR | - Extreme Temperature Range (Annual difference between highest TX and lowest TN) |
| GCM | - General Circulation Model |
| HadCM3 | - Hadley Centre Climate Model version 03 |
| HEC-HMS | - Hydrologic Engineering Centre - Hydrologic Modeling System |
| IDW | - Inverse Distance Weightage Method |
| IPCC | - Inter-governmental Panel for Climate Change |
| MCL | - Maximum Conservation Level |
| MCM | - Million Cubic Meters |
| MRAE | - Mean Ratio of Absolute Error |
| NAO | - North Atlantic Oscillations |
| NASA | - National Aeronautics and Space Administration |
| NCEP | - National Centre for Environmental Predictions |
| NCEP-M | - National Centre for Environmental Predictions - Monthly Model |
| NCEP-S | - National Centre for Environmental Predictions - Seasonal Model |
| NCER | - National Centre for Environmental Research |
| OLS | - Ordinary Least Squares |
| P _{CONT} | - Control Period Temperature |
| P _{deb} | - De-biased Precipitation |
| PEP | - Percent Error in Peak |
| PEV | - Percentage Error Volume |
| P _{obs} | - Observed Precipitation |
| PRCPTOT | - Annual Total Wet Say Precipitation |
| PRP | - Percentage Reduction of Partial Correlation |
| P _{SCEN} | - Scenario Period Precipitation |
| R10 | - Number of Heavy Precipitation Days (Daily Rainfall ≥ 10 mm) |
| R ² | - Goodness of Fit |
| R20 | - Number of Very Heavy Precipitation Days (Daily Rainfall ≥ 20 mm) |
| R95p | - Very Wet Days (Annual Total PRCP when daily rainfall > 95 th percentile) |
| R99p | - Extremely Wet Days (Annual Total PRCP when daily rainfall > 99 th percentile) |

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| RAEM | - Ratio of Absolute Error to Mean Error |
| RCM | - Regional Climate Model |
| RCP | - Representative Concentration Pathways |
| RE_{μ} | - Relative Error of Mean |
| RE_{σ} | - Relative Error of Standard Deviation |
| RMSE | - Root Mean Square Error |
| RR | - Rainfall Record |
| RX-1day | - Maximum 1-day precipitation (Annual maximum 1-day precipitation) |
| RX-5day | - Maximum 5-day precipitation (Annual maximum consecutive 5-day precipitation) |
| SAR | - Sum of Absolute Residuals |
| SDSM-M | - Statistical Downscaling Model - Monthly Model |
| SDSM-S | - Statistical Downscaling Model - Seasonal Model |
| SE | - Standard Error |
| SRES | - Special Report on Emission Scenarios |
| SSR | - Sum of Squared Residuals |
| SU25 | - Summer Days (Annual count when daily maximum temperature > 25°C) |
| T_{CONT} | - Control Period Temperature |
| T_{deb} | - De-biased Temperature |
| T_{max} | - Maximum Temperature |
| T_{min} | - Minimum Temperature |
| TN10p | - Cool Nights (Percentage of days when Temperature Minimum < 10 th percentile) |
| TN90p | - Warm Nights (Percentage of days when Temperature Minimum > 90 th percentile) |
| TN_n | - Minimum of Temperature Minimum (Annual minimum value of daily minimum temperature) |
| TN_x | - Maximum of Temperature Minimum (Annual maximum value of daily minimum temperature) |
| T_{obs} | - Observed Temperature |
| TR20 | - Tropical Nights (Annual count when daily minimum temperature > 20°C) |
| T_{SCEN} | - Scenario Period Temperature |
| TX10p | - Cool Days (Percentage of days when Temperature Maximum < 10 th percentile) |
| TX90p | - Warm Days (Percentage of days when Temperature Maximum > 90 th percentile) |
| TX_n | - Minimum of Temperature Maximum (Annual minimum value of daily maximum temperature) |
| TX_x | - Maximum of Temperature Maximum (Annual maximum value of daily maximum temperature) |
| UNEP | - United Nations Environment Program |
| UNESCO | - United Nations Educational, Scientific and Cultural Organization |
| UNFCCC | - United Nations Framework Convention on Climate Change |
| WMO | - World Meteorological Organization |
| μ | - Mean |
| σ | - Standard Deviation |

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