FLOOD FORECASTING MODEL USING HEC-HMS FOR NAGALAGAM STREET HYDROMETRIC STATION WITH RELATIVE IMPACT OF ANTECEDENT RAINFALL IN KELANI RIVER BASIN

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DECLARATION

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Flood Forecasting Model using HEC-HMS for Nagalagam Street Hydrometric Station with Relative Impact of Antecedent Rainfall in Kelani River Basin

ABSTRACT

The recurrent occurrence of major floods around the world as well as in Sri Lanka has significantly increased in the recent past. Thus, flood forecasting models have been developed to provide reliable and accurate simulation results to mitigate risk and reduce damage. It has been established that antecedent rainfall is an important factor in the determination of runoff magnitude and required to be incorporated in flood forecasting systems, however, lack of quantitative data is a major issue. The Kelani river is 192 km long with a catchment area of 2,292 km^2 and the heavily populated downstream basin is highly flood prone due to its inherent low-lying characteristics. Water levels at downstream Nagalagam Street station with pre-established threshold values are traditionally used to forecast the flood risk to Colombo and suburbs, however with a minimum or no lead time. The present research is focused to better comprehend the adequacy of existing rainfall-runoff models and the effect of antecedent moisture content on flood forecasting models focusing on downstream Kelani Basin as the case study site.

The Nagalagam Street hydrometric station is the selected outlet measuring location which is situated in latitude 60° 57' E, longitude 79° 52' N close to the Kelani River estuary. Since measured flow data are not available at the downstream, the river flow time series was generated by measured stage data at the station with the establishment of a rating curve and verified against discharge values available in the literature. Digital elevation model and GIS applications for generating stream features and a HEC-HMS rainfall-runoff simulation model was formulated based on the delineated basin data and collected meteorological and calculated streamflow data focusing on Nagalagam Street sub-catchment. The model with daily resolution was initially calibrated and validated based on parameter data available in the literature using SCS Curve Number method as the loss method and Unit Hydrograph method as the transform method and fine-tuned until the best fit was obtained by adjusting the parameters following selected objective functions. The calibrated and validated model was then effectively used in the rainfall-runoff simulation of the downstream Kelani basin focusing on multiple scenarios of flood events with different antecedent rainfall conditions to analyze the effect of soil moisture on runoff generation.

The model performance was relatively strong with reported Nash-Sutcliffe Coefficient (NASH) values of 0.80 for calibration stage and 0.89 for validation. Similarly, the coefficient of determination (R^2) indicated 0.83 for calibration and 0.90 for validation. The scenario analysis revealed a significant increment of streamflow while increasing the number of days with antecedent rain and a tendency of increment of runoff was noted even though the total rainfall is decreased. The resultant runoff flow increment was simultaneously accumulated while the antecedent moisture condition of the ground was varied. The study demonstrates that with an increasing number of rainy days from A0 to A10 (in days), 50% to 100% increment in runoff is observed. Further, even when the rainfall is decreased by 85% to 90% for the tenth rainy day (A10) with compared to the first rainy day (A1), the runoff continued to increase.

The results of the study firmly and quantitatively indicate that basin streamflow generation is positively affected by antecedent rainfall. It further emphasizes and concludes the importance of incorporating a factor for antecedent rainfall while estimating catchment runoff. The model was capable of capturing the antecedent moisture condition as a criterion to improve model performance for flood forecasting in downstream Kelani Basin under extreme rainy conditions.

Keywords: Antecedent soil moisture, Flood forecasting, River flow model

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AMC	- Antecedent Moisture Content
ANN	- Artificial Neural Networks
API	- Antecedent Precipitation Index
AW	- Antecedent Wetness
CN	- Curve Number
DEM	- Digital Elevation Model
DOI	- Department of Irrigation
DS	- Divisional Secretariat
FFC	- Flood Forecasting Centre
GIS	- Geographic Information System
HBV	- HBV model (Swedish Met. and Hydrological Institute)
HEC-HMS	- Hydrologic Engineering Centre - Hydrologic Modelling System
HRS	- Hydrology Report Series
IFM	- Integrated Flood Management
MCM	- Million Cubic Meters
MLR	- Multiple Linear Regression
MW	- Megawatt
NOF	- Normalised Objective Function
NSE	-Nash-Sutcliffe-Efficiency
PRF	- Peak Runoff Factor
R	- Correction Coefficient
RMS	- Root Mean Squire
RMSE	- Root Mean Squire Error
R^2	- Coefficient of Determination
SA	- Sensitivity Analysis
SCS	- Soil Conservation Service
SMA	- Soil Moisture Account
TOPMODEL	- Topmodel Developed by Beven, University of Lancaster
USGS	- United State Geological Survey
Vol	- Volume
WMO	- World Meteorological Organization
$\&_b$	- Percentage Bias