POTENTIAL OF INCORPORATING SATELLITE SOIL MOISTURE OBSERVATIONS IN FLOOD MODELING IN KELANI RIVER BASIN, SRI LANKA

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Degree of Master of Science

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Degree of Master of Science
in Water Resources Engineering and Management

Thesis submitted in partial fulfillment of the requirements for the degree
Master of Science in Water Resources Engineering and Management

UNESCO Madanjeet Singh Centre for
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DECLARATION OF THE CANDIDATE AND SUPERVISOR

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R.M.K.C. Rajapaksha Date

Thesis submitted in partial fulfillment of the requirements for the degree of Master of Engineering in Water Resources Engineering and Management

The above candidate has carried out research for the Master's Thesis/Dissertation under my supervision.

2023-06-30

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Prof. R. L. H. L. Rajapakse Date

ABSTRACT

Potential of Incorporating Satellite Soil Moisture Observations in Flood Modeling in Kelani River Basin, Sri Lanka

Floods are frequent and devastating natural disasters, causing significant social and economic losses worldwide. Flood modelling plays a crucial role in predicting and mitigating the impacts of floods. In recent years, satellite remote sensing technology has emerged as a valuable tool for flood modelling, especially in estimating soil moisture, a critical parameter for flood forecasting.

The potential of incorporating satellite soil moisture observations in flood modelling within the highly flood-prone Kelani River Basin up to Glencourse in Sri Lanka was investigated in this study. The study utilizes ESA CCI Soil moisture data and employs the Pearson correlation coefficient to evaluate the linear correlation between the modified Antecedent Precipitation Index (API) and the European Space Agency's Climate Change Initiative for Soil Moisture (ESA CCI SM). The Hydrologic Engineering Center's Hydrologic Modelling System (HEC-HMS) is taken as the preferred hydrological model, with the Green-Ampt loss method, Clark's unit hydrograph method, and recession constant baseflow method chosen for the lumped daily resolution event-based model.

Twelve flood events are carefully selected for model calibration and validation. Events EI to E6 are used for calibration, while events E7 to E12 are utilized for model validation. Nash-Sutcliffe efficiency (NSE), percent bias (PBIAS), and the ratio of root mean square error to the standard deviation of measured data (RSR) is employed to assess the predictive accuracy of the model in comparison to observed streamflow.

The findings indicate a robust association between the modified API and the soil moisture data from ESA CCI SM. The calibrated HEC-HMS model exhibits an NSE of 0.76, an RSR value of 0.45, and a PBIAS of 5% during calibration, while validation yields an average NSE of 0.726, RSR of 0.51, and a PBIAS of 6%. The incorporation of ESA CCI SM data leads to marginal improvements in model performance for some events while showing negative impacts for others.

The study reveals that incorporating ESA CCI SM observations results in minor enhancements in the model's predictive accuracy. Furthermore, the integration of ESA CCI SM data has the potential to improve the accuracy of total stream flow predictions and peak flow predictions. These findings contribute to the advancement of flood modelling techniques, providing valuable insights for flood mitigation efforts in the Kelani River Basin and similar flood-prone regions globally.

Keywords: API, ESA CCI SM, HEC- HMS, Nash-Sutcliffe efficiency, Pearson correlation coefficient

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LIST OF ABBREVIATIONS

AMC - Antecedent Moisture Content

API - Antecedent Precipitation Index

ABFI - Antecedent Baseflow index

CN - Curve Number

CUrW – Centre for Urban Water

DEM - Digital Elevation Model

DOI - Department of Irrigation

ESA CCI SM- European Space agency climate change initiative soil moisture

GIS - Geographic Information System

HEC-HMS - Hydrologic Engineering Centre Hydrologic Modelling System

ISM - Initial Soil Moisture

NSE -Nash-Sutcliffe-Efficiency

RMSE - Root mean square error

SCS - Soil Conservation Service

SMA - Soil Moisture Account

SMI- Soil Moisture Index

WMO - World Meteorological Organization