USE OF SATELLITE-BASED DATA AND REAL-TIME RAINFALL DATA TO IMPROVE FLOOD PREDICTIONS IN THE LOWER KELANI RIVER BASIN

Dissanayaka Mudiyanselage Pavithra Sudeshika

208043B

Degree of Master of Science

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DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgment 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 acknowledgment is made in the text.

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The above candidate has carried out research for the Masters under my supervision.

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

Signature of the supervisor:  Date: 2021-09-06

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Use of Satellite-based Data and Real-time Rainfall Data to Improve Flood Predictions in the Lower Kelani River Basin

ABSTRACT

The downstream of the Kelani river with relatively flat terrain is extremely important as a region with high population density and semi/highly built-up areas. However, this part of the basin is highly flood-prone and frequently affected. Therefore, simulation of rainfall-runoff-inundation processes using hydrological modelling plays a vital role in flood management. However traditional distributed hydrological models are unsuitable due to higher computational time, uncertainties, and no link to accommodate actual and real-time data. The distributed hydrological models such as MIKE-SHE, LISFLOOD, and Rainfall-Runoff-Inundation model are considered to be informative and efficient models. Those have been applied to several event-based flood simulations and inundation analyses.

The research aims to develop a Rainfall-Runoff-Inundation model to improve model accuracy by using available real-time precipitation and satellite-based data for the Lower Kelani River Basin to enhance flood prediction and risk mitigation. It includes three major components named study on impacts of DEM products on RRI model, impacts of land-use change on RRI model, and improvement of RRI model using real-time data such as AWS rainfall data, and satellite-based data such as MODIS yearly global land cover data, and SMAP/ Sentinel-1 soil moisture data.

The RRI model using surveyed cross-sections and satellite-based land-use and soil moisture data shows the best performance with the lowest RMSE of 0.69 m and lowest ME of 0.18 m. The weakest performance indices were shown in the RRI model using AWS with the lowest R^2 of 0.65, and the highest RMSE of 2.4 m. The RRI models using 3-arc resolution SRTM and ALOS PALSAR DEMs performed well for flood modelling in the Lower Kelani River Basin compared to ASTER, and HydroSHEDS 3-arc resolution DEMs. The upstream flood shows an increasing trend while the downstream water depths and flood inundation show a decreasing trend for the 10 and 50 years return period floods of the Lower Kelani River Basin from 2001 to 2019. However, total flood inundation is in an increasing trend. This study concluded that the RRI performs well for the Lower Kelani River Basin when using SRTM 90-m DEM, surveyed cross-section data, and satellite-based data such as MODIS yearly global land cover and SMAP/Sentinel-1 soil moisture data.

Keywords: AWS, DEM, Event-based Flood Modelling, MODIS, Rainfall-Runoff-Inundation Modelling

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LIST OF ABBREVIATIONS

ANN	Artificial Neural Network
AWS	Automated Weather Station
CK	Co-Kriging
CMORPH	CPC Morphing Technique
CUrW	Center for Urban Water
DEM	Digital Elevation Model
GAM	Generalized Additive Model
GPM	Global Precipitation Measurement
GSMap	Global Satellite Mapping of Precipitation
GWR	Geographically Weighted Regression
HASM	High Accuracy Surface Modelling
IDW	Inverse Distance Weighting
KED	Kriging with External Trend
ME	Mean Error
OK	Ordinary Kriging
R^2	Coefficient of Correlation
RK	Regression-Kriging
RKNNRK	Regression Kriging and Neural Network Residual Kriging
RMSE	Root Mean Square Error
RRFA	Regional Frequency Analysis
SiB2	Simple Biosphere Model-2
STRFA	at-site frequency analysis
TRMM	Tropical Rainfall Measuring Mission
UK	Universal Kriging
WEB-DHM	Water and Energy Budget Distributed Hydrological Model
WEB-RRI	Water, and Energy Budget based Rainfall-Runoff-Inundation