THE EFFECT OF TERRAIN DATA RESOLUTION ON FLOOD MODELLING - A STUDY IN DOWNSTREAM OF KELANI RIVER BASIN, SRI LANKA

Abdul Careem Aslam Suja

188002V

Degree of Master of Philosophy

Department of Civil Engineering

University of Moratuwa

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Declaration

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A. C. A. Suja Date

The above candidate has carried out research for the M.Phil thesis under my supervision.

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

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Abstract

Frequent severe flooding in Colombo due to the overflow of the Kelani River emphasizes the necessity of flood modelling as inundation extents and flood depth can easily be identified for implementing effective flood control measures. The accuracy of flood modelling is primarily influenced by topographical data sources and their data resolution. Due to the unavailability of surveyed or Light Detection and Ranging (LiDAR) datasets in most regions of Sri Lanka, the accuracy and applicability of alternative topographical datasets need to be studied. The different topographical data sources, namely Shuttle Radar Topography Mission (SRTM) with 30 m and 90 m resolution, Advanced Spaceborne Thermal Emission (ASTER) with 30 m and 90 m resolution and 1:50,000 topographical map were chosen for this study. The 1 m resolution LiDAR dataset was used as a reference dataset to assess the accuracy of aforesaid datasets and was resampled to 30 m and 90 m to investigate the effect of resolution with the aforementioned datasets. This study was carried out downstream of Kelani River basin, Sri Lanka from Hanwella to Colombo, covering an area of 250 km^2. The 2-D hydraulic modelling was carried out using Internation River Interface Cooperative (iRIC), public domain software and Arc-GIS was used to carry out most of the analyses.

The results of the terrain attribute indicate that 1:50,000 topographical map has shown the complete erroneous elevation and slope variation: 70% of the area shows the constant elevation value of 20 m; 20% of the area shows the constant elevation value of 10 m; 93% of area shows as flat terrain (zero slopes). Therefore, 1:50,000 topographical map was not considered for further analysis and the rest of the datasets were considered. Moreover, results show that the accuracy of mean elevation variation is significantly affected by topographical data source rather than their data resolution. Nevertheless, slope variation is significantly affected by their data resolution rather than the topographical data source.

Flood events that occurred in May 2017 and May 2018 were used for calibrating and validating the model. The model developed in the study performed well in calibration and validation in terms of three objective functions, namely Percentage Bias (PBIAS), Nash-Sutcliffe and Mean Relative Absolute Error (MRAE). The values of PBIAS were 5.61% and 8.56%, Nash-Sutcliffe were 0.80 and 0.55, and MRAE were 0.11 and 0.13, for calibration and validation, respectively.

The accuracy of developed models was assessed with respect to the reference dataset in terms of two primary hydraulic contexts, namely flood depth and inundation extents. The results show that reduction in the resolution of LiDAR digital elevation model (DEM) does not significantly affect the model accuracy as even 90 m resolution LiDAR DEM produced higher accurate results (flood depth, root mean square error of 0.95 m; inundation extent, F-statistic of 70.21%) than the 30 m resolution SRTM and ASTER DEMs. Moreover, the 90 m resolution ASTER DEM produced the least accurate results in terms of both flood depth and inundation extents.

The method was developed to correct the SRTM DEM (30 m resolution) to improve the accuracy using high-resolution LiDAR elevation points. The results indicate that the accuracy of both hydraulic outputs produced by corrected SRTM DEM improved (flood depth, root mean square error of 0.91 m; inundation extents, F-statistic of 80.06%). Moreover, no correlations were found between errors and land use, and errors and terrain attributes. The proposed method may be applied in the areas where high-resolution LiDAR data are not available using surveyed elevation data.

Keywords: Accuracy of model results; LiDAR data; Open source topographic data sources; SRTM DEM error correction; 2-D Flood modelling.

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List of Abbreviations

1-D	One-dimensional
2-D	Two-dimensional
3-D	Three-dimensional
ASCII	American Standard Code for Information Interchange
ASTER	Advanced Space Borne Thermal Emission and Reflection Radiometer
D-8	Eight-direction pour point algorithm
DEM	Digital Elevation Model
DTM	Digital Terrain Model
EGM	Earth Gravitational Model
HEC-RAS	Hydraulic Engineering Center- River Analysis System
GDEM	Global Digital Elevation Model
GDEM1	1st version of the ASTER
GDEM2	2nd version of the ASTER GDEM
GPS	Global Positioning System
iRIC	International River Interface Cooperative
IfSAR	Interferometric Synthetic Aperture Radar
LiDAR	Light Detection and Ranging
ME	Mean Error
MRAE	Mean Relative Absolute Error
MSL	Mean Sea Level
NIMA	National Imagery and Mapping Agency
NSE	Nash-Sutcliffe Efficiency
NED	National Elevation Dataset
PBIAS	Percentage Bias
RMSE	Root Mean Square Error
SLD 99	Sri Lanka Grid 1999
SRTM	Shuttle Radar Topography Mission
USGS	United States Geological Survey
WGS	World Geodetic System