

**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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August - 2021

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Declaration

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

.....
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 km². 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.

Acknowledgement

I wish to express my sincere gratitude to my supervisor Prof. R. L. H. Lalith Rajapakse for his invaluable guidance and continuous support throughout the period. Without his dedicated supervision and continuous guidance, this thesis would not be successfully completed within the time frame. My appreciation is further extended to Dr. Nimal Wijerathna, Chairperson of the progress review panel and Senior Lecturer, Department of Civil Engineering for his valuable suggestions and comments during the presentation.

I am especially indebted to Prof. N. T.S. Wijesekera, Senior Professor, Department of Civil Engineering for his advice and guidance during the taught course module.

I would like to acknowledge the support from the Department of Irrigation, Survey Department of Sri Lanka, Sri Lanka Navy and Disaster management of Sri Lanka for their support in providing the required data for the research.

My sincere thank extends to the Vice Chancellor of South Eastern University of Sri Lanka, for granting study leave to pursue Master of Philosophy in Civil Engineering.

I mention my sincere gratitude to my parents, siblings, wife, daughter and friends for their encouragement and unconditional love.

Finally, I would like to thank all those who are involved directly or indirectly in the completion of the research work.

Table of Contents

Declaration	i
Abstract	ii
Acknowledgement	iii
Table of Contents	iv
List of Figures	viii
List of Tables	xi
List of Abbreviations	xii
1 INTRODUCTION	1
1.1 Background	1
1.2 Problem Statement	3
1.3 Objectives	5
1.3.1 Overall objectives	5
1.3.2 Specific objectives	5
1.4 Scope and Limitations of the Study	5
1.5 Thesis Outline	6
2 LITERATURE REVIEW	8
2.1 Introduction	8
2.2 Previous studies related to the effect of Topographical Data Sources on Flood Modeling	10
2.3 Previous Studies Carried out in Sri Lanka on Flood Modelling	15
2.4 Topographical Data Sources	19
2.4.1 Light Detection and Ranging (LiDAR)	20
2.4.2 Shuttle Radar Topography Mission (SRTM)	21
2.4.3 Advanced Space Borne Thermal Emission and Reflection Radiometer (ASTER)	22
2.5 Terrain Attributes	24
2.6 Modelling Approaches (1-D & 2-D modelling)	26
2.7 Commonly available software packages for Flood Modelling	27
2.7.1 MIKE	28

2.7.2	FLO-2D	28
2.7.3	SOBEK	28
2.7.4	LISFLOOD-FP	29
2.7.5	HEC-RAS	30
2.7.6	iRIC	30
2.7.6.1	<i>iRIC related case studies</i>	33
2.8	Model Uncertainty and Sensitivity Analysis	35
2.8.1	Model Uncertainty	35
2.8.2	Sensitivity Analysis	35
2.9	Parameter optimization for model calibration	36
3	MATERIALS AND METHODS	40
3.1	Study Area	40
3.2	Data	41
3.2.1	Discharge	42
3.2.2	Water level	43
3.2.3	Flood protection structures.....	43
3.2.3.1	<i>Details of embankments</i>	43
3.2.3.2	<i>Details of gates</i>	44
3.2.4	Digital elevation models	46
3.2.4.1	<i>LiDAR DEM</i>	46
3.2.4.2	<i>SRTM DEM</i>	49
3.2.4.3	<i>ASTER DEM</i>	53
3.2.4.4	<i>1:50,000 Topographical maps</i>	56
3.2.5	River cross-sections	57
3.2.6	Land use map	58
3.3	Data Checking.....	60
3.3.1	Identifying the presence of sinks in DEMs.....	60
3.3.1.1	<i>Identifying sinks in LiDAR DEM</i>	61
3.3.1.2	<i>Identifying sinks in SRTM DEM</i>	63
3.3.1.3	<i>Identifying sinks in ASTER DEM</i>	65
3.3.1.4	<i>Identifying sinks in 1:50,000 Topographic map</i>	66

3.3.2	Checking of discharge and water levels measured at gauge station	67
3.4	Statistical analysis through comparison of different Terrain	69
3.4.1	Terrain attribute analysis.....	69
3.4.2	Cut & fill volume analysis	70
3.4.3	Spot- height analysis	70
3.5	Model Approach	70
3.5.1	Model equations of iRIC-NAYS2D Flood	70
3.5.1.1	<i>Basic flow equations in a rectangular coordinate system</i>	70
3.5.1.2	<i>2-D unsteady flow equations in the Cartesian coordinate system</i>	71
3.5.2	Work steps of iRIC-NAYS2D Flood.....	73
3.6	Model Development.....	74
3.6.1	Model schematization	74
3.6.2	Boundary conditions	76
3.6.3	Warm-up period	76
3.6.4	Surface roughness	76
3.6.5	Model calibration	77
3.7	Method to correct the SRTM data source (30 m resolution) to improve the accuracy.....	77
3.8	Overall Methodology Flowchart.....	80
4	RESULTS AND DISCUSSION.....	82
4.1	Statistical analysis through comparisons of DEMs	82
4.1.1	Terrain attribute analysis.....	82
4.1.1.1	<i>Comparative analysis of elevation variation</i>	82
4.1.1.2	<i>Comparative analysis of slope variation</i>	84
4.1.2	Cut and fill volume analysis	89
4.1.3	Spot- height analysis	91
4.2	Evaluation of accuracy of river channel cross-sections derived from LiDAR (1 m resolution) datasets.	92
4.3	Results of Model Calibration and Validation	96
4.4	Effect of topographical data sources and resolution on Flood Model Accuracy.....	99
4.4.1	Flood depth	99

4.4.2	Inundation extents	101
4.5	Results of method developed to improve the SRTM DEM Accuracy.....	104
4.5.1	Normality test assessment of errors	104
4.5.2	Relationship between errors and land use.....	106
4.5.3	Relationship between errors and terrain attributes.....	108
4.5.4	Evaluation of SRTM DEM accuracy	111
5	CONCLUSIONS AND RECOMMENDATIONS	115
5.1	Conclusions.....	115
5.2	Recommendations.....	117
6	REFERENCES	118
	APPENDIX-A: Details of Embankments	129
	APPENDIX-B: Details of Gates	131
	APPENDIX-C: Elevation Detatils of Embankments.....	134
	APPENDIX-D: Cross-sections	146
	APPENDIX-E: Return Period Calculation	169

List of Figures

Figure 1.1: Regions of LiDAR data availability in Sri Lanka	4
Figure 2.1: The categories of flood loss potential (Smith et al., 2003).....	9
Figure 2.2: System components of LiDAR (Haile, 2005)	20
Figure 3.1: Study area showing Kelani River basin with stream network and river gauging stations.	41
Figure 3.2: Flood hydrograph- 2017	42
Figure 3.3: Flood hydrograph- 2018	43
Figure 3.4: Location of embankments	45
Figure 3.5: Location of gates	45
Figure 3.6: LiDAR in ASCII Gridded XYZ format (1 m resolution).....	47
Figure 3.7: LiDAR DEM (1 m resolution)	47
Figure 3.8: LiDAR DEM (30 m resolution)	48
Figure 3.9: LiDAR DEM (90 m resolution)	48
Figure 3.10: Tiles of SRTM DEM (30 m resolution)	50
Figure 3.11: Tiles of SRTM DEM (90 m resolution)	51
Figure 3.12: SRTM DEM (30 m resolution)	52
Figure 3.13: SRTM DEM (90 m resolution)	52
Figure 3.14: Tiles of ASTER DEM (30 m resolution)	54
Figure 3.15: ASTER DEM (30 m resolution).....	55
Figure 3.16: ASTER DEM (90 m resolution).....	55
Figure 3.17: Base DEM source used to extract study area	56
Figure 3.18: 1:50,000 Topographical map.....	57
Figure 3.19: Locations of cross-sections	58
Figure 3.20: Land use map.....	59
Figure 3.21: Profile view of sink	60
Figure 3.22: Eight possible directions of flow from a cell (D-8Algorithm).....	61
Figure 3.23: Flowchart to identify sinks in Arc-GIS	61
Figure 3.24: Flow direction raster before filling the sinks (1 m resolution LiDAR). ..	62
Figure 3.25: Flow direction raster after filling the sinks (1 m resolution LiDAR)....	62
Figure 3.26: Flow direction raster before filling the sinks (30 m resolution SRTM) ..	63

Figure 3.27: Flow direction raster after filling the sinks (30 m resolution SRTM)...	64
Figure 3.28: Flow direction raster before filling the sinks (90 m resolution SRTM)	64
Figure 3.29: Flow direction raster after filling the sinks (90 m resolution SRTM)...	65
Figure 3.30: Flow direction raster before filling the sinks (30 m resolution ASTER)	65
Figure 3.31: Flow direction raster after filling the sinks (30 m resolution ASTER).	66
Figure 3.32: Flow direction raster before filling the sinks (1:50,000 Topo map).....	66
Figure 3.33: Rating curve at Hanwella station.....	68
Figure 3.34: Rating curve (log scale) at Hanwella station.....	68
Figure 3.35: Procedure for operating the Nays2D Flood solver with iRIC (iRIC User Manual, 2014).	73
Figure 3.36: 1 m LiDAR DEM in iRIC pre-processing window.....	75
Figure 3.37: Scattered plot between SRTM DEM and reference DEM	79
Figure 3.38: Methodology flowchart	81
Figure 4.1: Elevation variation of 1:50,000 topographical map	82
Figure 4.2: Slope map of 1:50,000 topographical dataset	83
Figure 4.3: Slope map of 1 m LiDAR DEM.....	85
Figure 4.4: Slope map of LiDAR: a) 30 m; b) 90 m.....	86
Figure 4.5: Slope map of SRTM: a) 30 m; b) 90 m.....	86
Figure 4.6: Slope map of ASTER; a) 30 m; b) 90 m	87
Figure 4.7: Absolute error in an area covered by different slope ranges.....	88
Figure 4.8: Cut & Fill volume map of LiDAR: a) 30 m resolution; b) 90 m resolution	89
Figure 4.9: Cut & Fill volume map of SRTM: a) 30 m resolution; b) 90 m resolution	90
Figure 4.10: Cut & Fill volume map of ASTER: a) 30 m resolution; b) 90 m resolution.....	90
Figure 4.11: Locations of cross-sections	93
Figure 4.12: Cross-sectional profile at location- 1.....	93
Figure 4.13: Cross-sectional profile at location- 10.....	94
Figure 4.14: Cross-sectional profile at location- 20.....	94
Figure 4.15: Cross-sectional profile at location- 30.....	95

Figure 4.16: Cross-sectional profile at location- 40.....	95
Figure 4.17: RMSE variation of cross-sections derived from LiDAR (1 m resolution)	96
Figure 4.18: Water level variation at calibration	97
Figure 4.19: Water level variation at validation	98
Figure 4.20: Inundation extent map with depth classification of reference data	102
Figure 4.21: Inundation extent maps with depth classification of LiDAR data: a) 30 m resolution; b) 90 m resolution	102
Figure 4.22: Inundation extent maps with depth classification of SRTM data: a) 30 m resolution; b) 90 m resolution	103
Figure 4.23: Inundation extent maps with depth classification of ASTER data: a) 30 m resolution; b) 90 m resolution	103
Figure 4.24: Histograms of errors	105
Figure 4.25: Q-Q plot of errors	105
Figure 4.26. Spatial cluster analysis of absolute errors (local Morans I).....	106
Figure 4.27. Hot spot and cold spot analysis of absolute errors (local Getis Ord G*)	108
Figure 4.28: Spatial distributions of regression parameters in OLS analysis: a) Slope; b) aspect; c) curvature; d) combination of all three (slope, aspect & curvature).....	109
Figure 4.29: Spatial distributions of regression parameters in GWR analysis: a) Slope; b) aspect; c) curvature; d) combination of all three (slope, aspect & curvature)	110
Figure 4.30: Relationship between the elevation of original DEM and corrected DEM with reference DEM.....	112
Figure 4.31: Histogram of absolute errors	113

List of Tables

Table 1.1: Flood impacts from 2016 to 2018 (Disaster Management Center, 2018) ..	2
Table 1.2: Flood impacts from 2011 to 2015 (Disaster Management Center, 2018) ..	3
Table 2.1: Summary of case studies of DEM impacts on flood modelling	14
Table 2.2: Summary of case studies on flood modelling carried out in Sri Lanka	18
Table 2.3: Characteristics of DEMs sources	24
Table 3.1: Land Use Coverage	59
Table 4.1: Absolute error of average elevation of DEMs from the reference dataset	84
Table 4.2: Statistics derived from slope maps of different DEM sources and resolution	87
Table 4.3: Statistics of Cut & Fill volume	91
Table 4.4: RMSE of elevation points corresponding to different DEMs	92
Table 4.5: Values of objective functions at calibration and validation	98
Table 4.6: Manning's roughness coefficients	99
Table 4.7: Summary of statistic values	106
Table 4.8: Summary of clustering (%)	107
Table 4.9: Coefficient of determination of GWR and OLS models	111
Table 4.10: Accuracy of DEMs	113
Table 4.11: Values of RMSE	114
Table 4.12: Values of F-statistic	114
Table 4.13: Average vertical error of SRTM DEM	114

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	1 st version of the ASTER
GDEM2	2 nd 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