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Evaluation of topographic data sources for 2D flood modelling: case study of Kelani basin, Sri Lanka

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Abstract

Frequent flooding in Sri Lanka underscores the necessity of flood modelling as inundation extent and flood depth can easily be identified for implementing flood control measures. Accuracy of flood modelling is primarily influenced by topographic data sources and their resolution. Due to the lack of Light Detection and Ranging (LiDAR) data source in most regions of Sri Lanka, alternative topographic data sources need to be assessed. This paper investigates the accuracy of 2D flood model results in terms of flood depth and inundation extent developed based on open source topographic data sources, namely Shuttle Radar Topography Mission (SRTM) and Advanced Spaceborne Thermal Emission (ASTER) with 30 m and 90 m resolutions. This study was carried out at the downstream of Kelani river basin as it is prone to frequent flooding. The 1 m resolution LiDAR data were used as the reference data to assess the accuracy of aforesaid data sources, and were resampled to 30 and 90 m to investigate the effect of resolution with SRTM and ASTER data sources. The results show that reduction in the resolution of LiDAR data source does not significantly affect the model accuracy as even 90 m resolution LiDAR data source 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 data sources.

Materials and Methods

Study Area

Kelani basin is located between 6.78°N to 7.08°N latitudes and between 79.87°E to 80.72°E longitudes with a basin area of 2230 km^2. A downstream reach of about 25 km in length from Hanwella to Colombo covering an area of 250 km^2 was selected for this study.

Topographic data sources

Topographic data sources used in the study are depicted in Figures 1 and 2, respectively.

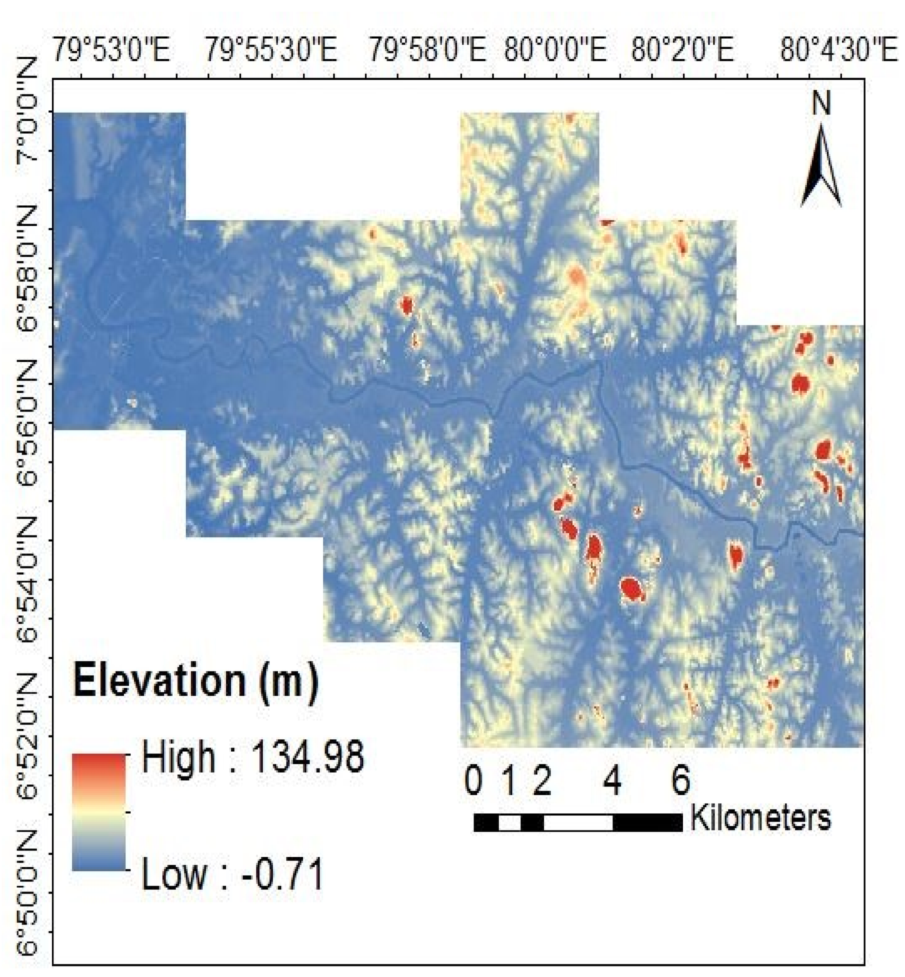

Figure 1. Reference data.

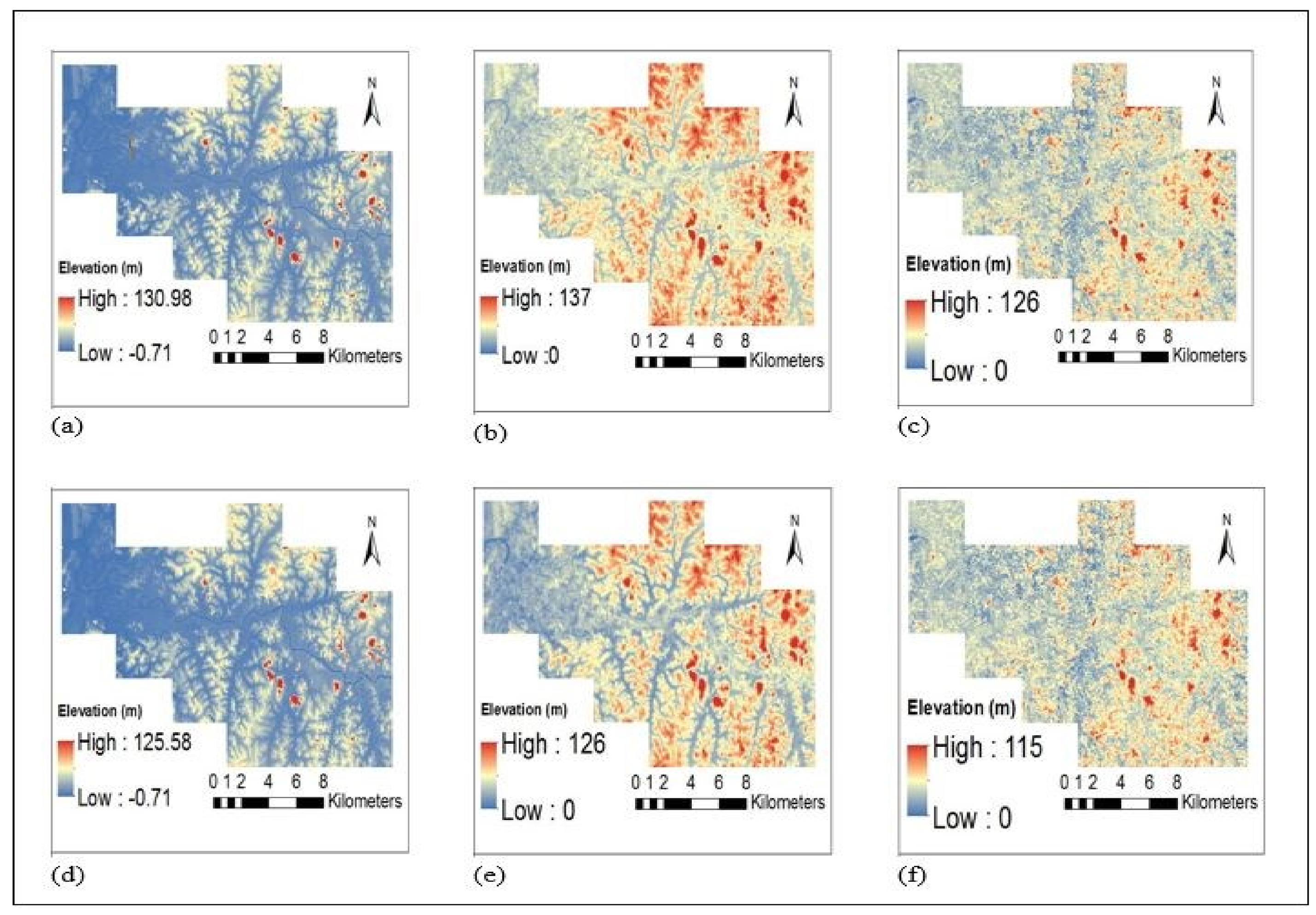

Figure 2. Datasets used in the study: (a) LiDAR 30 m; (b) SRTM 30 m; (c) ASTER 30 m; (d) LiDAR 90 m; (e) SRTM 90 m; f) ASTER 90 m.

2D Flood Modelling

The Nays2D Flood solver developed by the International River Interface Cooperative (iRIC)(Hokkaido University, Japan) was used in this study. Nays2D Flood is an open-source software that solves shallow water computations using the finite difference scheme.

Results and Discussion

Accuracy of flood depth simulated by different datasets was assessed with respect to reference dataset in terms of RMSE and those values are tabulated below.

Dataset	RMSE (m)
LiDAR - 30 m	0.69
LiDAR - 90 m	0.95
SRTM - 30 m	1.49
SRTM - 90 m	1.63
ASTER - 30 m	1.54
ASTER - 90 m	1.63

Accuracy of inundation extents simulated by different datasets was assessed with respect to reference dataset in terms of F-statistic and those values are tabulated below.

Dataset	F (%)
LiDAR - 30 m	88.12
LiDAR - 90 m	70.21
SRTM - 30 m	62.13
SRTM - 90 m	58.47
ASTER - 30 m	40.54
ASTER - 90 m	37.83

Among all six datasets, 30 m LiDAR dataset performed better than the SRTM and ASTER datasets with 30 m and 90 m resolutions. It is important to note that even the 90 m LiDAR dataset shows higher accuracy than the 30 m resolution SRTM and ASTER datasets

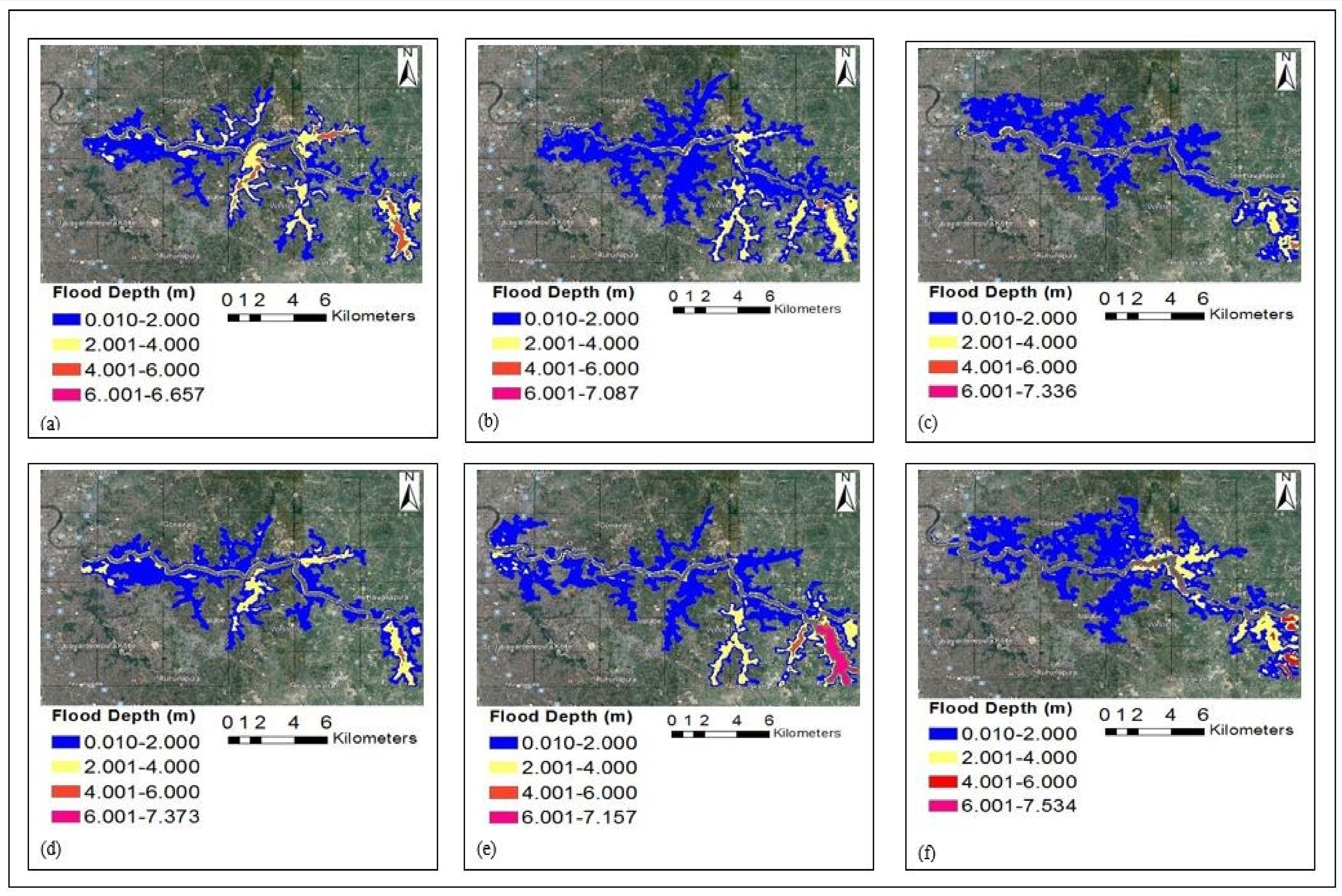

Figure 3. Inundation extent maps of all six models with different depth classifications: (a) LiDAR 30 m; (b) SRTM 30 m; (c) ASTER 30 m; (d) LiDAR 90 m; (e) SRTM 90 m; (f) ASTER 90 m.

Conclusions and Recommendations

This study primarily assessed how different topographical data sources and their resolution affect the accuracy of 2D flood modelling. This study was carried out at the downstream of Kelani basin, Sri Lanka where a 2D model was performed using Nays2D Flood solver. Six different datasets with resolutions of 30 m and 90 m derived from LiDAR, SRTM and ASTER were compared with a 1 m high resolution LiDAR dataset as reference, in terms of flood depth and inundation extent. Among all the datasets used in the study, 30 m resolution LiDAR dataset produced higher accurate results in terms of both hydraulic contexts, namely flood depth and inundation extents. Moreover, even 90 m resolution LiDAR dataset also showed higher accuracy than the SRTM and ASTER datasets with 30 m and 90 m resolutions.

In contrast, resolution variation from 30 m to 90 m does affect the model results of SRTM and ASTER datasets in terms of flood depth and inundation extents. Apart from the LiDAR dataset, 30 m resolution SRTM dataset performed better than other three datasets, namely 90 m resolution SRTM, 30 m resolution ASTER and 90 m resolution ASTER. Another notable result is the model developed from 90 m resolution ASTER dataset showed the least accuracy than all models in terms of flood depth and inundation extent. The findings of the present study are precisely limited to the specific site. However, this methodology can be applied to similar basins in Sri Lanka to verify the robustness of the results obtained.

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