

HEC-RAS-BASED SIMULATION OF LAND COVER EFFECTS ON TSUNAMI INUNDATION DYNAMICS

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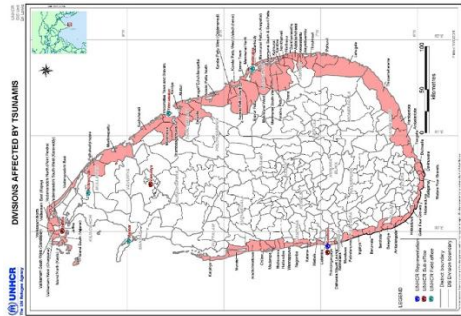
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Tsunamis are among the most devastating natural disasters, posing significant threats to coastal regions due to their sudden onset, long-range impact, and disastrous energy. One critical but often understated aspect in tsunami modelling is the influence of land cover on wave inundation. This study investigates the impact of land cover and land use types on tsunami wave behaviour using the HEC-RAS model in a selected 50 km² coastal area within the Galle District of Sri Lanka, an area that suffered substantial damage during the 2004 tsunami. The study aims to evaluate the role of land use and land cover in altering tsunami inundation characteristics, such as arrival time, depth, velocity, and extent. High-resolution topographic (0.5 m) and bathymetric (30 m) data, along with land cover classifications from 2004 and 2025, were used in the model setup. The incoming tsunami wave was modelled using the ComMIT model based on the 2004 Indian Ocean tsunami event. The incoming tsunami wave was introduced as a stage hydrograph at the seaward boundary. Seven scenarios were simulated using the HEC-RAS 2D model: bare land, forest cover, urban areas, 2004 historical land use and land cover, 2025 land use and land cover, 2025 land use and land cover with buildings modelled as elevated features, and 2025 land use and land cover with a vegetation belt along the coastline.

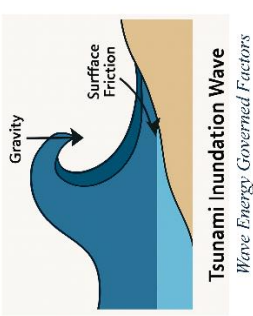
Model validation was conducted using the 2004 tsunami hazard map provided by the Disaster Management Centre of Sri Lanka for the study area. The validation produced a Fit Index of 0.717 and a depth classification accuracy of 63%, confirming the suitability of the HEC-RAS model for tsunami inundation simulations when high-resolution data is utilised. The results demonstrated a strong inverse relationship between Manning's roughness coefficient and both inundation depth and flow velocity. Areas with higher roughness, such as forests and urban regions, significantly reduced inundation characteristics compared to smoother surfaces like bare land. Moreover, modelling buildings as elevated features, rather than representing them solely through roughness values, enhanced inland wave resistance and reduced the extent of inundation, providing a more realistic depiction of urban environments. Additionally, the inclusion of a coastal vegetation belt was shown to significantly decrease the inundation extent, depth, and maximum flow velocity, while also delaying the arrival time of tsunami waves. These findings underscore the importance of incorporating both natural and built features into tsunami risk reduction strategies. The study concludes that land cover plays a vital role in modifying tsunami wave behaviour and should be carefully considered in hazard mapping and risk mitigation strategies. Future hazard maps should incorporate up-to-date land cover data instead of relying on outdated classifications. The scenario-based approach adopted in this study provides a practical framework for disaster preparedness and urban planning in tsunami-prone coastal areas. Incorporating elevation-based modelling for buildings and integrating vegetation buffers can significantly improve tsunami resilience. This research supports a more dynamic and spatially aware methodology in coastal hazard planning, particularly for vulnerable regions like southern Sri Lanka.

Keywords: Tsunami modelling, Hazard mapping, Coastal resilience, Manning's roughness, Wave propagation

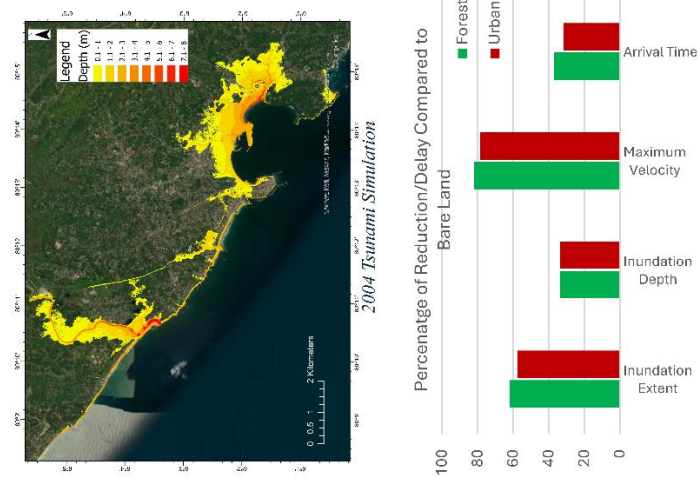
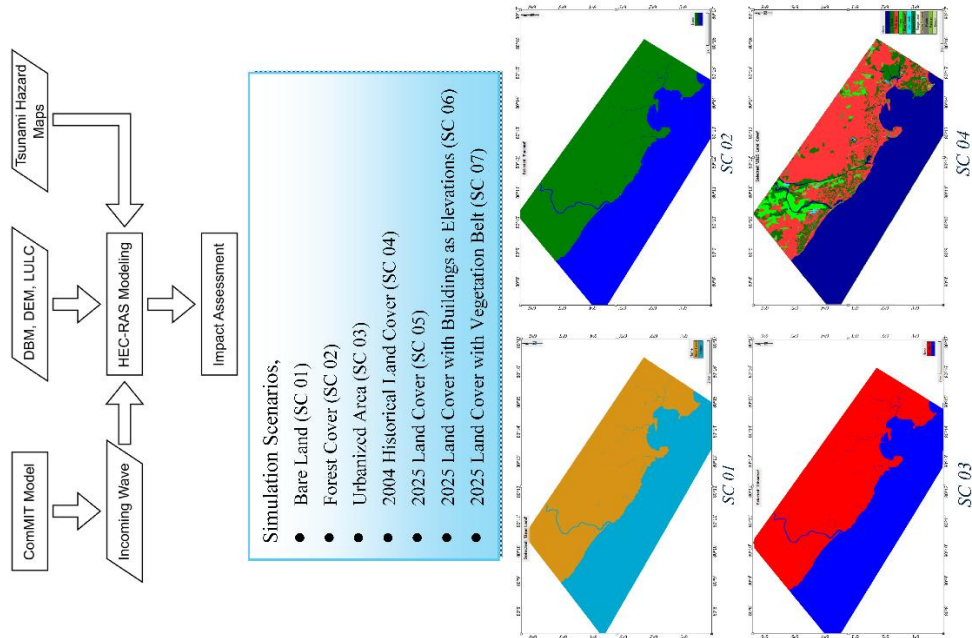
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2004 Tsunami Affected Areas of Sri Lanka



- Inundation Characteristics,
- Extent
 - Maximum Depth
 - Maximum Velocity
 - Arrival Time



- 50 m Wide Vegetation Belt,**
- Inundation extent reduced by 7.9%
 - Maximum flow velocity reduced by 13%
 - Inundation depth reduced by 10%
 - First wave arrival delayed by 6.6%

Conclusion: A validated HEC-RAS model incorporating detailed land cover and building elevation accurately simulates tsunami inundation scenarios. This improved approach assesses the critical role of surface roughness and vegetation in mitigating tsunami hazards.