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Satellite-Driven Aboveground Biomass Mapping and Its Hydrological Implications in Sri Lankan Tropical Catchments

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Abstract

Sri Lanka lacks a nationally consistent, locally validated aboveground biomass density (AGBD) map, while hydrological models still represent vegetation through land-cover classes. This study produced a locally validated 1 km AGBD map and tested whether biomass-based curve numbers outperform conventional land-cover-based values in rainfall-runoff simulation. GEDI Level 4B AGBD (2019–2021) was modelled from 20 predictors derived from MODIS, Sentinel-1, Sentinel-2, PALSAR-2, SRTM and CHIRPS with a zone-stratified spatial validation design. Held-out performance was r = 0.776 and MAE = 19.46 Mg ha^{-1}. Against 70 published field sites, r was 0.519 overall, 0.624 for natural forests and 0.745 for post-2015 sites, with underestimation at high biomass. Land-cover class explained only 2.3% of biomass variance, against 30.2% for annual rainfall. NDVI, EVI, LAI and FPAR saturated above 150 Mg ha^{-1}, their biomass correlations becoming negative. Within tree cover, biomass varied by 57.1% but the curve number (CN) by only 4.8%. Vegetation-adjusted CNs were therefore tested in HEC-HMS across nine catchments. Differences among conventional, biomass-, NDVI- and LAI-based fields were negligible: validation NSE differed by 0.008 and logNSE by 0.002. Catchment mean AGBD was strongly related to mean slope (r = 0.956), indicating close coupling of vegetation, terrain and climate that limits isolation of an independent vegetation effect. Satellite-derived biomass therefore captures vegetation structure that land-cover classes miss, but introducing it through CN adjustment did not materially improve hydrological simulation, indicating that alternative process representations are needed to capture vegetation–hydrology interactions.

Keywords: *aboveground biomass density; curve number; GEDI; hydrological modelling; remote sensing; vegetation–hydrology interactions*