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Coastal morphological changes and response to Typhoon Rai events in Pahang's coastline

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Abstract

Coastal erosion remains a major concern along the Pahang coastline, where monsoon-driven waves and episodic typhoon-generated swells accelerate shoreline retreat and endanger coastal communities. Notably, even though Pahang faces the South China Sea, it is located outside the primary typhoon corridor. This study integrates two decades of satellite-derived shoreline analysis with storm-scale numerical modelling to evaluate both chronic and event-driven coastal change. Geospatial Information System (GIS) tools analyzed shoreline changes over 21 years (2000–2022) using Landsat 5, Landsat 8, and Sentinel-2 MSI data, with shoreline positions quantified through the Digital Shoreline Analysis System (DSAS) using net shoreline movement (NSM) and linear regression rate (LRR). Results indicate persistent long-term erosion, particularly at Cherok Paloh, where retreat rates reached -3.5 to -5.2 m/yr. Beach profiling conducted before and after Typhoon Rai revealed short-term sediment losses of $21.69-72.12$ m³/m across four transects. A process-based XBeach model, calibrated using pre- and post-storm profiles, successfully reproduced storm-induced morphological change with Brier Skill Scores (BSS) between 0.82 and 0.97. The 2D simulation further identified erosion hotspots south of the Pahang Tua River mouth and localised deposition influenced by river–wave interactions. By linking long-term shoreline trends with storm-event hydrodynamics, this study demonstrates a multiscale framework capable of supporting early warning systems and informing nature-based coastal management strategies along Malaysia's storm-sensitive coastline. © 2026 Elsevier B.V.

Author keywords

Coastal erosion; Coastal morphological changes; Numerical modeling; Storm surge response; Typhoon events; XBeach model

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