

Asymmetric Bank Erosion Reveals Geomorphic Susceptibility in the Pattalasang River, Indonesia

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ABSTRACT

Riverbank erosion can alter channel geometry and progressively reduce bank support, yet reconnaissance studies often lack the hydraulic and geotechnical data required for formal stability modelling. This study evaluates whether simple field measurements can provide a defensible screening of geomorphic susceptibility along the Pattalasang River, South Sulawesi, Indonesia. Three cross-sections were examined: one comparatively stable baseline and two eroding sites. Cross-sectional areas were reconstructed by trapezoidal integration, erosion volumes were calculated from measured erosion dimensions, lateral concentration was expressed using an asymmetry index, and two grain-size distributions were compared descriptively. Quality control corrected a factor-of-four inconsistency in the original cross-sectional summaries, giving areas of 17.55, 14.70, and 13.25 m² for the baseline, Point I, and Point II. Erosion volume reached 74.96 m³ at Point I and 25.41 m³ at Point II. Left-bank erosion contributed 92.45% and 89.10% of site totals, with asymmetry indices of 0.849 and 0.782. Similar grain-size curves indicate that sediment gradation alone does not explain the 2.95-fold erosion contrast. The screening identifies Point I as the priority for repeat hydraulic and geotechnical assessment.

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1. Introduction

Riverbank erosion is a boundary-adjustment process through which flowing water, sediment transport, bank material, vegetation, and channel geometry jointly reshape the river corridor. At the reach scale, erosion can narrow or widen individual cross-sections, shift banklines, reorganize bars and thalwegs, and expose riparian land and infrastructure to progressive loss. At larger scales, multitemporal studies consistently show that bank erosion and channel migration are spatially heterogeneous rather than uniformly distributed. Recent work has documented pronounced reach-to-reach contrasts in bank retreat and channel morphology using satellite imagery, historical cross-sections, field surveys, and hydrodynamic observations [1-3]. This heterogeneity is central to river management because a reach that appears stable at one location may coexist with an adjacent erosion hotspot controlled by different local boundary conditions.

Hydraulic attack is a principal driver of this spatial variability. Flow concentration at bends, local acceleration, turbulence, elevated near-bank shear stress, and flood-stage fluctuations can promote bed and toe scour and increase the probability of bank retreat. Field and model evidence from different river settings indicates that near-bank hydraulics can control the location and magnitude of erosion even where broader reach-scale discharge remains similar [2,4,5]. Flood-related planform changes can also be strongly localized, with erosion preferentially affecting particular banks or concave margins [6-8]. Recent open-channel experiments in Makassar further show that increasing discharge intensifies local scour under unprotected

conditions and that porous flow-control devices can reduce near-bed velocity, vortex activity, and scour depth [9,10]. Although bridge-pier scour is not equivalent to riverbank erosion, these experiments provide regionally relevant evidence that local flow energy and turbulence govern sediment removal in open-channel settings.

Bank response, however, cannot be reduced to hydraulic forcing alone. Material composition, soil structure, density, cohesion, pore-water conditions, vegetation, and geometric configuration control the resistance available to oppose erosion and mass failure. Recent integrated studies show that bank stability and retreat reflect interactions among channel geometry, soil properties, hydrologic conditions, and geotechnical resistance [11-14]. Grain size is therefore informative but incomplete as a descriptor of erodibility. Experimental and field studies demonstrate that coarse-fraction characteristics, root reinforcement, and soil-biogeochemical properties can alter erosion resistance even when bulk textural classes appear similar [15-18].

The difficulty is that the most mechanistically complete approaches are also the most data-demanding. Process-based tools such as the Bank Stability and Toe Erosion Model and coupled hydro-morphodynamic or geotechnical models require information on hydraulic forcing, erodibility, bank geometry, soil strength, and in some cases groundwater conditions. Comparative modelling shows that model choice matters because simplified form-based indices can miss geotechnical failure or event-scale morphodynamic adjustments that process-based models represent more explicitly [19]. Integrated hydraulic and geotechnical investigations likewise depend on field and laboratory inputs that are rarely available during initial

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