Slope instability caused by ex-tropical cyclones

**Jack McConchie**1, Gary McKenzie2, Jamie Botes2, Kevin Ford2 and Andrew Shelton

1SLR Consulting (NZ) Ltd

2Te Kaunihera o Te Tairāwhiti (Gisborne District Council)

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* **Geomorphic hazards/risk management**

# ABSTRACT

Extreme rainfalls and their effects are a recognized hazard on the East Coast (Tairāwhiti) e.g., the ANZAC Storm (April 1935) and Ex-tropical Cyclone Bola (March 1988). Following Cyclone Bola, and in response to the large number of slope failures experienced, extensive areas of Tairāwhiti were reafforested. These forests have now reached maturity and are being harvested.

The summers of 2021-22 and 2022-2023 were characterized by La Niña conditions, with a greater frequency and persistence of easterly winds. When easterly moving, moisture-laden, weather systems meet the ranges of the East Coast, orographic enhancement causes heavy rainfall with the potential to cause erosion, slope instability, and flooding. During early 2023, Tairāwhiti was affected by Ex-tropical Cyclones *Hale* (7-12 January) and *Gabrielle* (11-15 February) which brought strong winds and heavy rainfall. A national state of emergency was declared on 14 February.

Slope characteristics and environmental conditions triggered thousands of slope and infrastructure failures. Thin soils and steep slopes also led to considerable runoff in the ranges, causing flooding of rivers which overflowed their banks, inundating floodplains and depositing silt and other debris.

Slope failures were triggered when the regolith became at least partially saturated. While saturation of the regolith is controlled by rainfall, the risk of saturation can be increased by forestry operations. These operations can increase the effective slope angle, regolith thickness, and porosity and permeability while reducing bulk density and cohesion. These changes reduce the shear strength and relative stability of the regolith. A smaller rise in pore-water pressure is then required to trigger failure.

Forestry operations can also create hydraulic discontinuities, while often concentrating rainfall and runoff on concave slopes and within colluvial-filled bedrock depressions and poorly compacted fill. These effects are exacerbated by changes to the drainage network which may result in more water being delivered to a slope. This water is delivered quickly generating a greater, and more rapid, rise in pore-water pressures.

The steep slopes on the East Coast mean that there is a direct hydraulic connection between slope and fluvial processes. The impacts of slope failures therefore extend a considerable distance downslope, potentially to the coast.