

# The Effect of Climate Change on Landslides

Nathasya Christien

*Based on Crozier (2010)*

# Today's Relevancy: Recent news from Indonesia



Landslide disaster in North Sumatra  
(December 6, 2025)

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- Cyclone-induced floods and landslides impacted Sumatra.
- Public has pointed out how this disaster is also human-induced.

# Influential Papers on This Topic

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## Landslides in a changing climate

Gariano S. L., Guzzetti F.

*Earth-Science Reviews* (2016), [10.1016/j.earscirev.2016.08.011](https://doi.org/10.1016/j.earscirev.2016.08.011)

of the projected impact of climate change on landslide activity and abundance ... That climate changes affect the stability of natural and engineered slopes and have consequences on landslides

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## Deciphering the effect of climate change on landslide activity: A review

Crozier M. J.

*Geomorphology* (2010), [10.1016/j.geomorph.2010.04.009](https://doi.org/10.1016/j.geomorph.2010.04.009)

Increased landslide activity is commonly listed as an expected impact of human-induced climate change ... climate change in affecting the temporal and spatial occurrence of landslides. © 2010 Elsevier B.V

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# Physics of Slope Stability

## Definition

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with shear strength  $s$  and shear stress  $\tau$  on a potential surface of rupture.

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## Interpretation:

- If  $FOS > 1$ , slope is stable.
- If  $FOS = 1$ , slope is at point of failure.
- If  $FOS < 1$ , slope will slide.

# Physics of Slope Stability

Let

- $c$  : cohesion
- $\gamma$  : bulk density
- $z$  : vertical depth
- $\beta$  : slope angle
- $u$  : porewater pressure
- $\phi$  : angle of internal friction

We expand the terms, such that the **resisting force** becomes

$$s = c + (\gamma z \cos^2 \beta - u) \tan \phi$$

and **driving force** becomes

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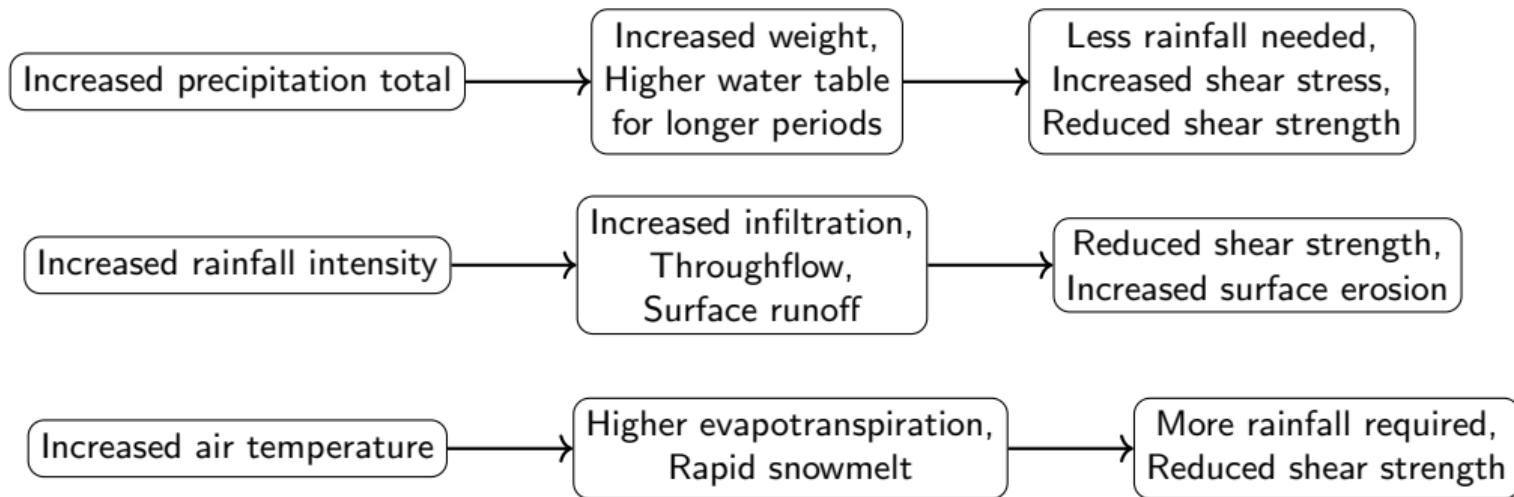
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## How heavy rainfall reduces shear strength:

- Increases water weight
- Increases porewater pressure
- Reduces soil suction
- Weathering cycles

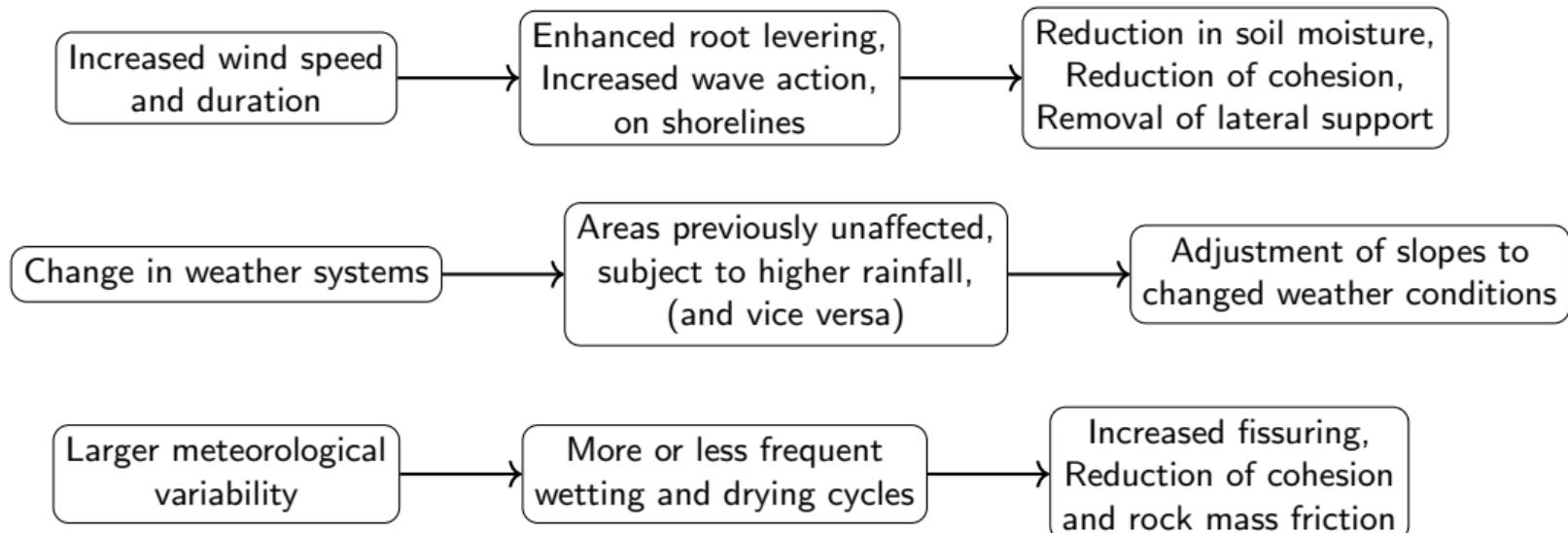
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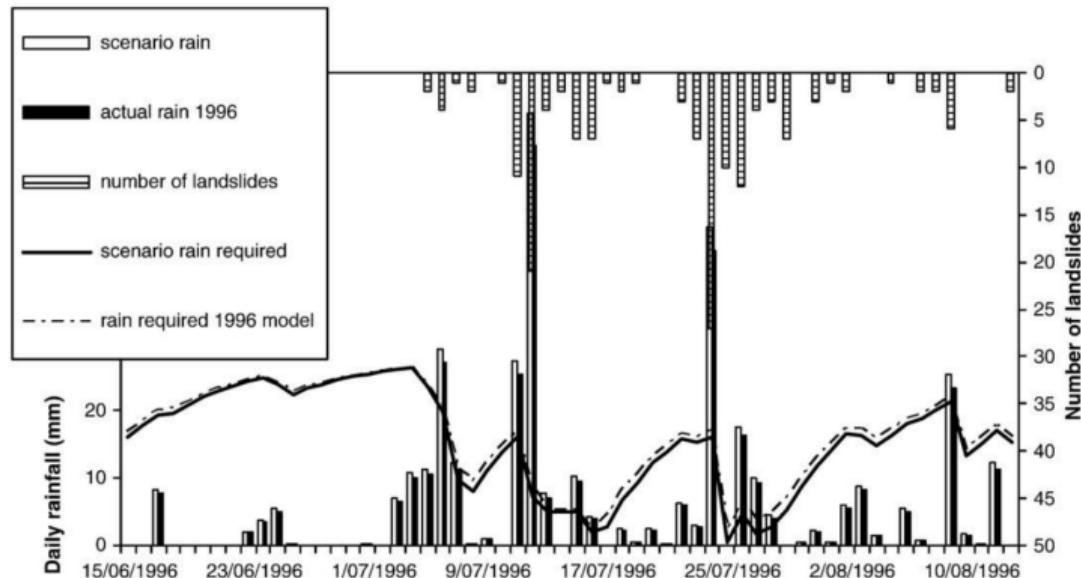
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*Example in Hong Kong (So, 1971):*

- ~702 landslides triggered by ~400 mm rainfall in one day.
- 35% occurred in forested areas, despite covering only 8% of the affected region.

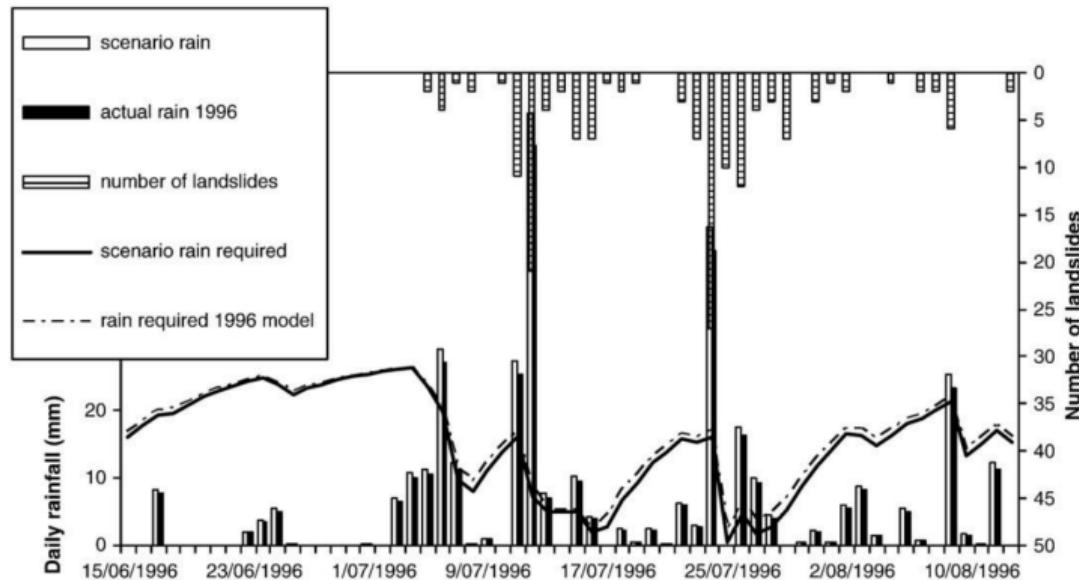
# Climate-Landslide Model Results: Antecedent water status model



Author's model applied in Wellington City, New Zealand

- The model empirically estimates the amount of event rainfall required to initiate landslides for the next 24 hour periods.

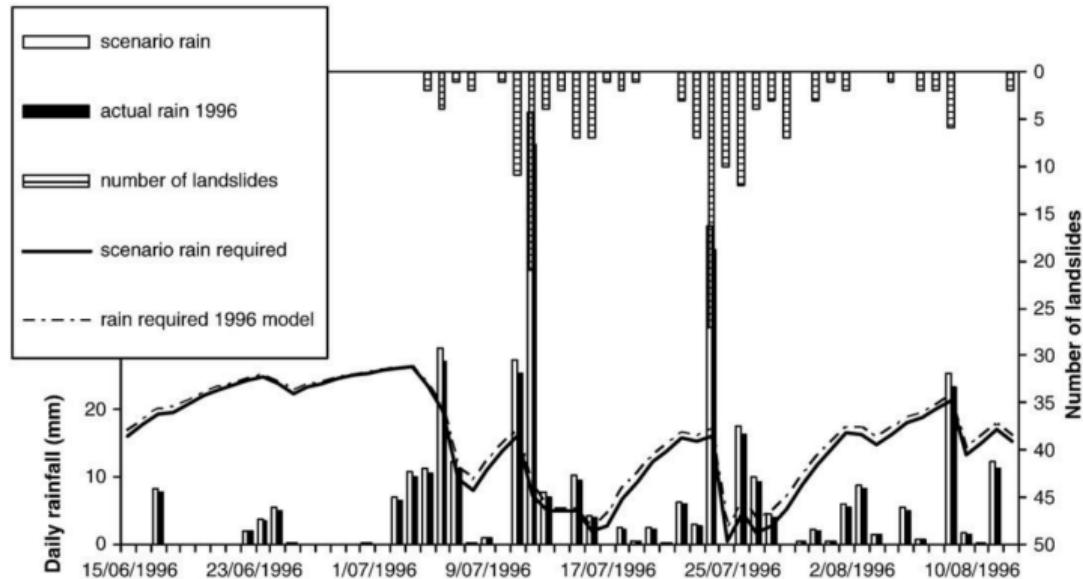
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- From IPCC downscaled prediction, we expect 8% increase of a 100-year daily rainfall in 2040.

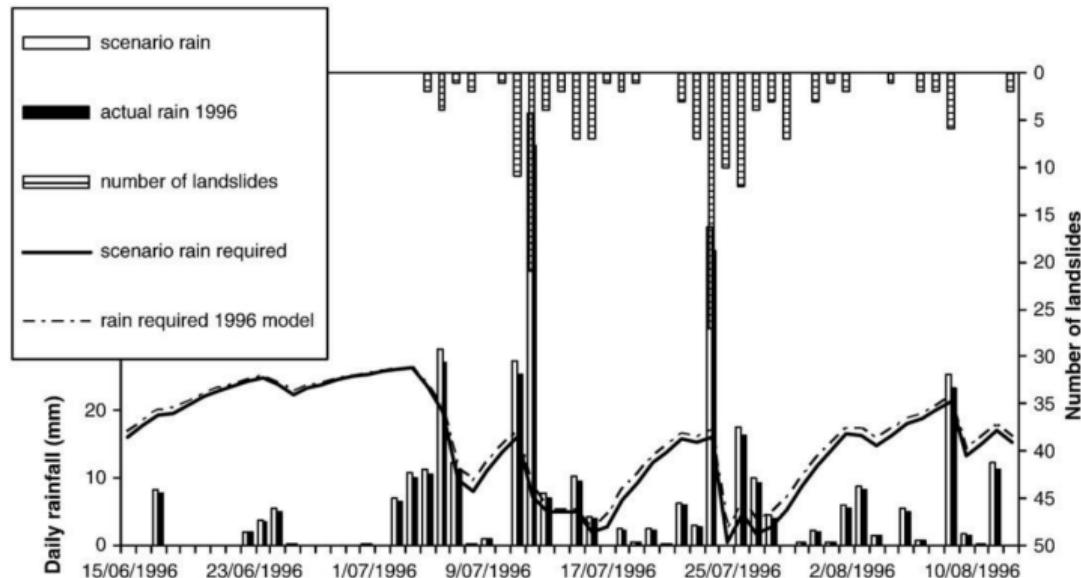
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Author's model applied in Wellington City, New Zealand

- With climate change scenario, two extra days of landslides could occur.
- Limitation: Downscaled rainfall data had too many uncertainties.

# The Human Factor



Contrast in landslide distribution  
between forested and pasture slopes in  
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- Examples from New Zealand:
  - Conversion from forest to pasture increases landslide probability by 3x.
  - Complete deforestation will increase runoff by 28%, whereas climate-driven runoff increase is 15% by 2080.

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- ② However, prediction is extremely uncertain.
- ③ Human land-use changes often dominate.
- ④ We need collaboration between climate and landslide modellers.