Modelling coseismic landslide impacts to infrastructure systems in Wellington

Julia Harvey[1], Thomas Robinson[1], Liam Wotherspoon[2] & Robin Lee[3]

[1]School of Earth and Environment, University of Canterbury
[2]Department of Civil and Environmental Engineering, University of Auckland
[3]Department of Civil and Natural Resources Engineering, University of Canterbury

QuakeCoRE
NZ Centre for Earthquake Resilience
Te Hiranga Rū

Connect on LinkedIn

Julia Harvey
University of Canterbury
jha350@uclive.ac.nz

PRELIMINARY RESEARCH

01 CONTEXT

A **M_W 7.5 earthquake** has been posited on the **Wellington-Hutt Valley segment of the Wellington Fault**, with an estimated probability of 10-15% occurrence in the next century (Beban et al., 2012, Sadashiva et al., 2021). This event is considered to **pose the highest risk** of all known active faults in Aotearoa (Rhoades et al., 2011), with **potential shaking intensities of MM 10 or greater in Wellington's city centre** (Cousins, 2013).

Whilst coseismic landsliding is a known secondary hazard during a Wellington Fault Rupture Scenario (WFRS), little research has focused on this issue. This work aims to **model coseismic landslides from a scenario earthquake** to explore the potential losses of such an event.

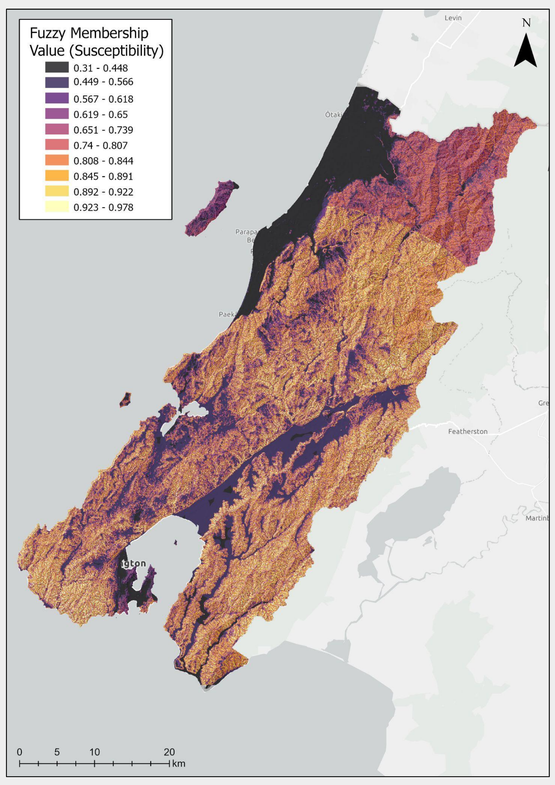

Figure 1 *Coseismic landslide susceptibility of research area, as determined by fuzzy membership.*

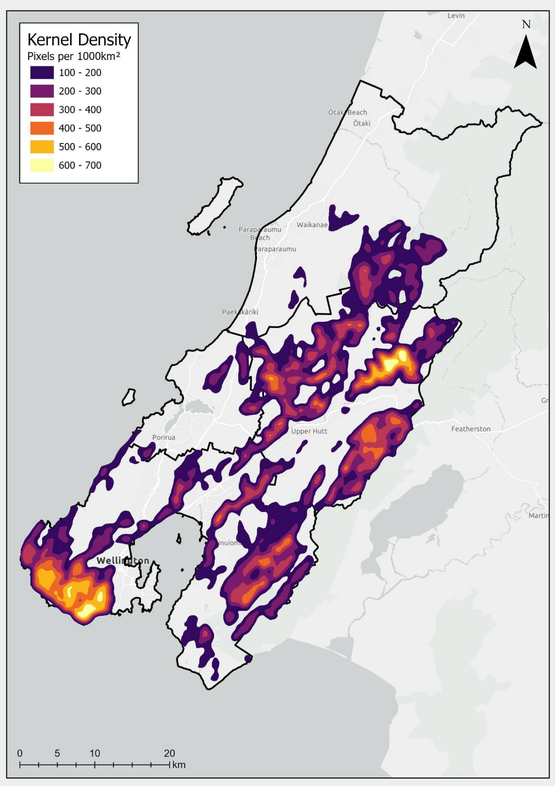

Figure 2 *Kernel density map of highest 10% of landslide susceptibility values, that is > 0.933.*

02 RESEARCH QUESTIONS

1. What is the **coseismic landsliding susceptibility** in the Wellington Region in a M_W 7.5 Wellington Fault Rupture Scenario?
2. Which **assets and areas** within the Wellington Region are situated on **areas of high coseismic landslide susceptibility**?
3. What is the **potential runout of coseismic landslides** initiated by a Wellington Fault Rupture Scenario?

03 METHODS

Susceptibility Modelling

- A **fuzzy logic model** derived from Kritikos et al. (2015) was applied using the MMI shake map from Dowrick & Rhoades (2011) (Figure 1)
- Fuzzy membership values were then classified into the 99th, 95th and 90th percentile of susceptibility values, whereby **the top ten percent of values represent plausible landslide hazard** (Figure 2)

Exposure Modelling

- **Buildings and roads** located on areas with landslide susceptibility values within the 90th, 95th and 99th percentile were identified
- Analysis was undertaken to **establish the viewshed of potential landslides**, using DEM and building data, to identify the extent of exposure to potential runout
- Finally, identification of **viewsheds exceeding 10,000 buildings** were compared with areas within the 90th percentile of susceptibility values

04 KEY FINDINGS

- **High susceptibility** (90th percentile) across all five districts in a WFRS
- Plausible estimates of **slope failure** over an area **between 3 and 138km²**
- **~1500 buildings** situated **within 90th percentile of values**, with ~1000 of these situated in Wellington City
- Areas susceptible to **slope failure across key transport routes**, including SH 2 between Wellington City and the Hutt Valley.
- **~13km² total area of viewsheds** with >10,000 buildings

CURRENT RESEARCH

01 OBJECTIVES

1. **Model coseismic landslide susceptibility** across the Wellington Region in an updated M_W 7.5 Wellington Fault Rupture Scenario
2. Examine the **influence of different statistical models on estimates** of coseismic landslide hazard in a Wellington Fault Rupture Scenario
3. Assess the likely resultant **impacts of coseismic landsliding on infrastructure systems** in the Wellington Region

02 PROPOSED METHODS

Gaps in Preliminary Research	Response in Current Research
Susceptibility modelling • Failed to distinguish between anthropogenic and natural slopes when identifying hazard	**Susceptibility modelling** • Fuzzy Logic + *SLIDE Model*: Updated approach will consider implementing SLIDE project (GNS, n.d.) to ensure model is appropriate for the highly modified slopes of the Wellington Region
Exposure modelling • Runout modelling limited to viewshed estimates	**Exposure modelling** • Flow-R: Updated approach will model runout in Flow-R (as per Kincey et al., 2022), to assess plausible exposure to runout
• Only determined exposure of infrastructure situated *within* areas susceptible to slope failure, without consideration of those impacted by potential runout (Figure 3, Figure 4)	• Quantitative assessment of exposure determined through consideration of flow runout and direction (as per Robinson et al., 2015) will allow for a more comprehensive understanding of the infrastructure impacted by potential slope failure

03 EXPECTED OUTPUTS

- An **updated approach to assessing coseismic landslide susceptibility** at a **regional level** in Aotearoa
- Estimated **susceptibility of the Wellington Region to slope failure**, and runout pathways of potential landslides, in a plausible WFRS
- **Exposure and impact analysis for infrastructure** vulnerable to coseismic landsliding across the Wellington region

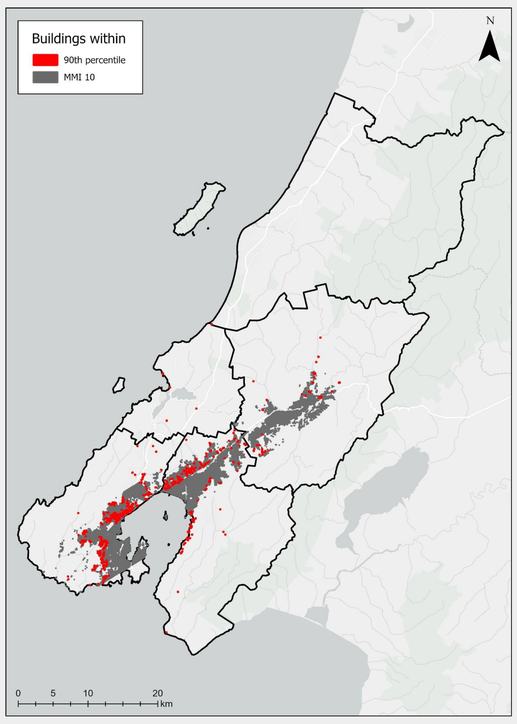

Figure 3 *Buildings situated on areas of MM 10 shaking in the WFRS and buildings situated within the 90th percentile of landslide susceptibility values.*

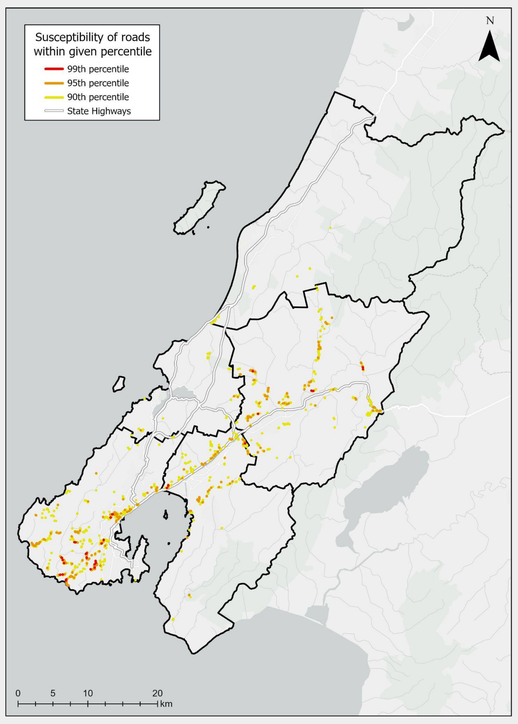

Figure 4 *Roads situated within the 90th, 95th and 99th percentile of landslide susceptibility values.*

References

Beban et al. (2012). Addressing earthquake hazards – a review of council policy and plans within the Wellington region. GNS Science Report 2012/31. 52p.

Benites et al. (2003). Modelling realistic ruptures on the Wellington fault. GNS Science Report 2003/85.

Cousins, W. J. (2013). Wellington without water – impacts of large earthquakes. GNS Science Report 2012/30. 124p.

GNS. (n.d.). SLIDE – Stability of Land in Dynamic Environments. Retrieved August 29, 2022, from https://www.gns.cri.nz/research-projects/slide-stability-of-land-in-dynamic-environments/.

Kincey et al. (2022). Modelling post-earthquake cascading hazards: Changing patterns of landslide runout following the 2015 Gorkha earthquake, Nepal. Earth Surf. Process. Landforms, 48, 537-554.

Kritikos et al. (2015). Regional coseismic landslide hazard assessment without historical landslide inventories: A new approach. J. Geophys. Res. Earth Surf., 120. DOI 10.1002/2014JF003224.

Rhoades et al. (2011). Re-evaluation of conditional probability of rupture of the Wellington-Hutt valley segment of the Wellington Fault. BNZSEE, 44(2).

Robinson et al. (2015). Evaluation of coseismic landslide hazard on the proposed Haast-Hollyford Highway, South Island, New Zealand. Georisk: Assessment and Management of Risk for Engineered Systems and Geohazards. DOI 10.1080/17499518.2015.1077974.

Sadashiva et al. (2021). Improving Wellington Region's resilience through integrated infrastructure resilience investments. BNZSEE, 54(2).