When do we leave?

Modelling coastal cliff erosion, human behaviour and property markets

Risk-based perception (Craig, 2023)

Amenity-based perception (Bayleys, 2022)

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- Climate change → more coastal hazards → human consequence (Pörtner et al., 2022)
- Cyclone Gabrielle led to ineffective reactive management. Further socio-environmental understanding needed for proactive management (Rouse et al., 2017)
- Simplified models for understanding and communication (Pindyck, 2017). Agent-based models suited for socio-environmental systems (Epstein, 2012; Werner and Mcnamara, 2007)
- Human behaviour within housing markets trigger decision-making (Anderson et al., 2019), particularly in A/NZ (Manning et al., 2015)
- Little understanding of coastal, cliff-top property dynamics

Build on understanding of the interactions between coastal cliff erosion, human behaviour and property markets

- Build a simple agent-based model
- Explore emergent behaviour through the complex systems approach
- Identify relative contributors to changes in behaviour

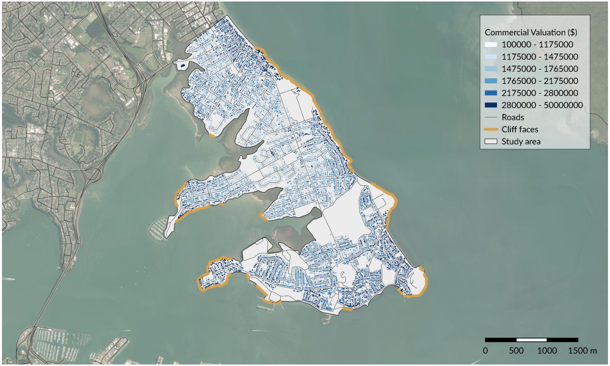
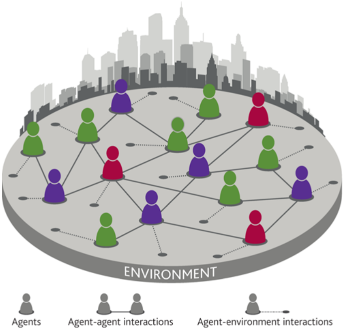


Figure 1: Commerical valuations of houses within AOI

Model individual processes

- Bottom-up, generative social science (lack of emperical data)
- Complex systems approach
- Emergent behaviour

Vectorized agent-based model (ABM) developed in Python/NumPy



Conceptual diagram of an ABM (Turrell, 2016)

Figure 2: Cliff erosion

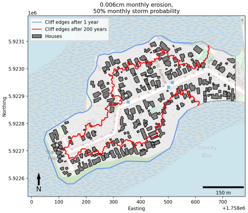


Figure 3: Risk categorisation

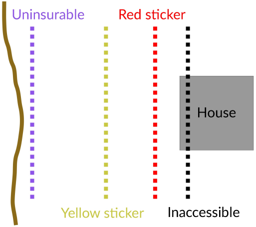
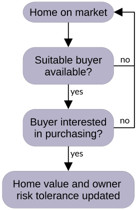


Figure 4: Home sales



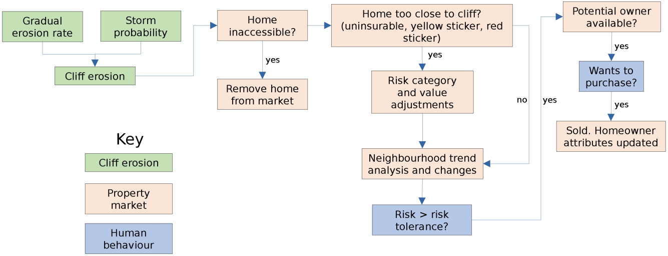


Figure 5: Process of ABM with coupling of components

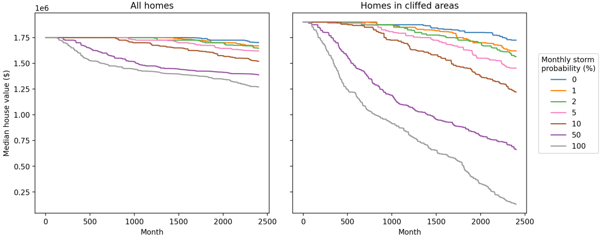


Figure 6: Median **value by storm probability** over time

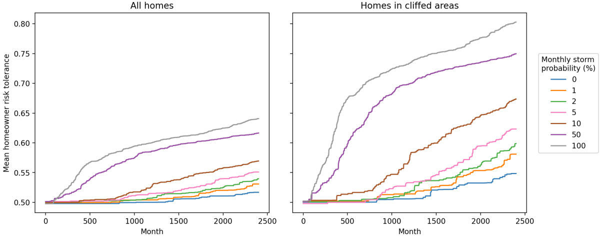


Figure 7: Average homeowner **risk tolerance by storm probability**

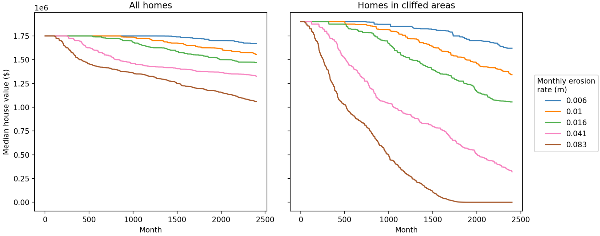


Figure 8: Median **value by gradual erosion rate** over time

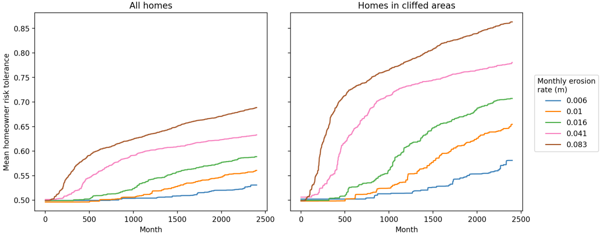


Figure 9: Average homeowner **risk tolerance by gradual erosion rate** over time

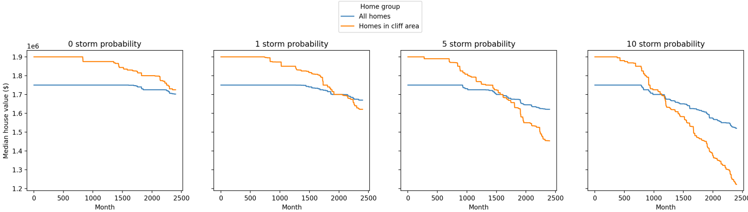


Figure 10: Median **value at selected storm probabilities** over time

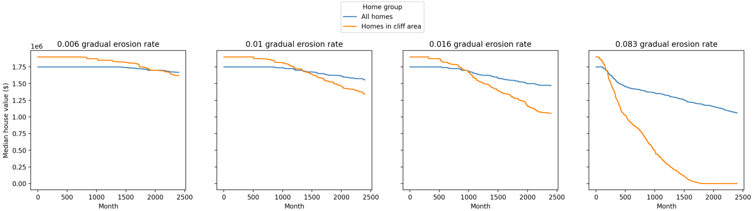


Figure 11: Median **value at selected gradual erosion rates** over time

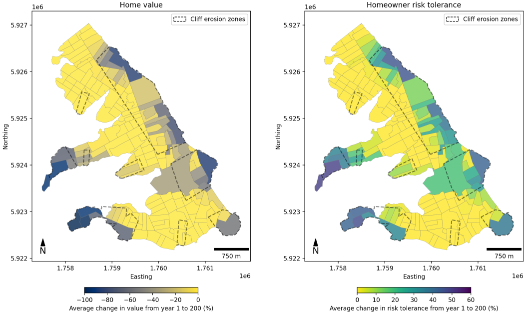


Figure 12: Average **increase in median value and risk tolerance** over model run by SA1 *where: erosion rate=0.006m/mth, storm probability=10%/mth*

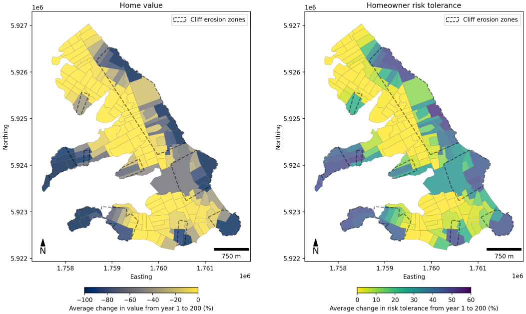


Figure 13: Average **increase in median value and risk tolerance** over model run by SA1 *where: erosion rate=0.041m/mth, storm probability=1%/mth*

What have we learnt?

- **Main relationship**: As storm frequency and/or gradual erosion increases risk tolerance increases and market value decreases → deprivation and risk implications
- **Risk and Behaviour**: Burden and perception of erosion spreads further across the market under gradual erosion than storm erosion. Leads to a more predictable trend due to higher frequency of house sales and spatial/economic homogeneity
- **Tipping points**: Cliff-adjacent properties are no longer priced higher for amenity, but priced down for risk under increasing erosion
- **Planning**: Storm erosion is a spatial phenomena → aggregating into gradual erosion planning rates may be problematic

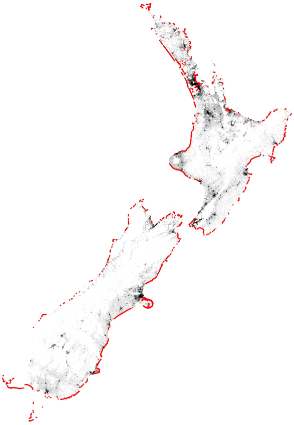


Figure 14: Cliffs* and buildings in A/NZ

*Different cliff data was used in this research project due to lack of coverage from official datasets

Open-source code and minimally-reproducible examples published next year

Contact sophie.kolston@auckland.ac.nz for more details

Data provided by: Auckland Council, Land Information New Zealand, Inland Revenue Department, OpenStreetMap contributors, Statistics New Zealand

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Gradual erosion rates and spatial homogeneity

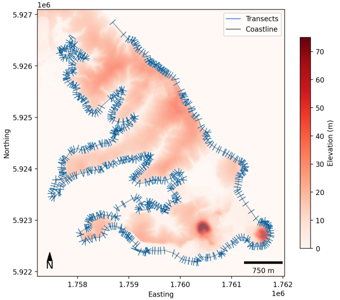
Auckland Council's Technical report Predicting Auckland's Exposure to Coastal Instability and Erosion:

> *Increased storminess and changes in rainfall patterns may also change rates of erosion in Auckland. However, as these effects are expected to be small relative to sea level rise and the techniques for forecasting the impact of these changes are not yet developed, storminess and rainfall changes were not considered in [calculating erosion rates]*
>
> *-Auckland Council (2021)*

[cliff toe erosion and cliff instability calculated separately]
cliff toe erosion = (historical rate + SLR effects) x timeframe (p27)

Cliff detection algorithm

1. Obtain DEM, coastline data
2. Generate perpindicular transects at each coastline segment centroid
3. Find elevation at each node of transect lines from DEM
4. Calculate slope
5. Retain coastline segments that have a high enough slope



Main issue is the requirement of extremely precise data for gradual erosion rates. And spatial complexity = high computation

Cliff erosion model

Buffering existing cliff edges by e_r, define boundary of buffer as new cliff edge

Additional buffers along boundary are slips

Fractal/geometric complexity issues with frequent storms

Precision must be extremely high