Mario A. Fernandez
mario.fernandez@dairynz.co.nz
Research and Monitoring Unit, Auckland Council; ESAI Business School, Universidad Espíritu Santo
Nancy E. Golubiewski
nancy.golubiewski@aucklandcouncil.govt.nz
Ministry for the Environment, Auckland, New Zealand

Jennifer L.R. Joynt
jennifer.joynt@kaingaora.govt.nz
Research and Monitoring Unit, Auckland Council
Lauren A. Rhodes
rhodes@espol.edu.ec
Facultad de Ciencias Sociales y Humanísticas, ESPOL

Hot or not? Developing a spectrum of indicators-based assessments in approaching vulnerability to climate change

Problem

- Vulnerability assessments to climate change are used as tools to identify, develop, and support adaptation strategies.
- Indicator based assessments (IbAs) are often used in local government contexts.
- IbAs may be non-robust to small (and reasonable) changes in modelling assumptions.

General Objective

- We develop a range of IbAs through the Ordered Weighted Average (OWA) approach.
- We account for the degree of substitution and or compensation between the constituent indicators, and consequently the risk attitudes of policy makers and stakeholders on selecting adaptation and mitigation strategies.
- We take Auckland, New Zealand as a case study.

Design & Data

The ordered weighted averaging (OWA) approach

- We implement the OWA approach using 20 constituent indicators representing 3 components of climate change vulnerability:
  - Adaptive capacity
  - Sensitivity
  - Exposure
- For each value of trade-off, estimated through the ORness value, the OWA is implemented as a nonlinear constrained optimization program:

$$Maximize\ Dispersion = -1 \times \sum (W_{k(i)} \times \ln(W_{k(i)}))$$

s.t.

$$ORness = 1 - \left(\frac{1}{n-1}\right)\sum(n - iW_{k(i)})$$

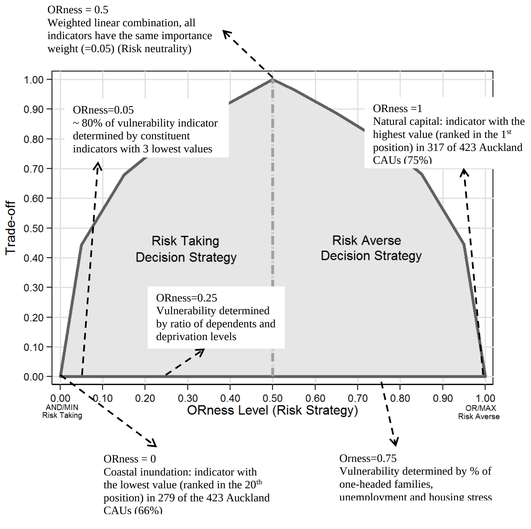
- The solution variables that maximize the Shannon's entropy measure are $W_{k(i)}$, the order weight assigned to each order $k(i)$ for the i^{th} constituent indicator.
- The order weights are used to construct a vulnerability index for each census area unit (CAU) in Auckland, NZ.

Index	Indicators	Functional relationship
Exposure	Coastal inundation - 1 meter sea level rise	Vulnerability ↑ as indicator ↑
	Dry days < 1 mm	Vulnerability ↑ as indicator ↑
	Total precipitation percentage change	Vulnerability ↑ as indicator ↑
	Heavy rainfall days > 25 mm	Vulnerability ↑ as indicator ↑
	Hot days > 25	Vulnerability ↑ as indicator ↑
	Mean temperature	Vulnerability ↑ as indicator ↑
	Mean wind speed	Vulnerability ↑ as indicator ↑
	Relative humidity	Vulnerability ↑ as indicator ↑
Sensitivity	Deprivation Index	Vulnerability ↑ as deprivation index ↑
	Unemployment rate*	Vulnerability ↑ as unemployment ↑
	Ratio of population under 15 and over 65 of age to the population between 19 and 64 years of age*	Vulnerability ↑ as rate of dependency ↑
	Percentage of populated area relative to CAU area	Vulnerability ↓ as % populated area ↑
	Percentage of one-headed families*	Vulnerability ↑ as % of one-headed families ↑
	Road density (Ratio of km of road per km^2 of populated area)	Vulnerability ↓ as ratio ↑
Adaptive Capacity	Average household income*	Vulnerability ↓ as income ↑
	Housing stress (ratio of rent payments to household income)*	Vulnerability ↑ as housing stress ↑
	Percentage of population that are owner-occupiers of house*	Vulnerability ↓ as % owning house ↑
	Percentage of area on crops production	Vulnerability ↓ as % on crops production ↑
	Percentage of area on grass production	Vulnerability ↓ as % on grass production ↑
	Percentage of forest cover to area of CAU	Vulnerability ↓ as % of forest cover ↑

- An ORness value of 0.5 represents full compensation or substitutability between indicators.
- An ORness value of 0 implies that the vulnerability position of the CAU is determined solely by the smallest value (risk taking pattern of vulnerability).
- An Orness value of 1 implies that vulnerability position of the CAU is determined solely by the highest value (risk averse pattern of vulnerability).

RESULTS

- We find that differnt trade-offs representing risk attitudes of policymakers imply spatial disparities in the identification of vulnerability hotspots.
- If risk averse, strategies would focus on minimizing vulnerability in areas with high exposure to coastal inundation due to sea level rise.
- Easing of risk aversion implies switching strategy focus to areas with relatively high levels of natural capital (and associated ecosystem services).



CONCLUSIONS

- We demonstrate the importance of developing a range of IbAs through the OWA approach.
- We recommend the use of OWA assessments, and through ORness values, incorporate the perspectives of multiple stakeholders to develop policies suited to the contexts and realities of a city or region.
- Vulnerability maps developed through the OWA may show that complementarities and synergies exist where policy goals previously appeared to be contradictory on face value.