



Vulnerability of Norwegian Municipalities to Natural Hazards

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Project: Geography of social vulnerability,
environmental hazards, and climate change
(VULCLIM)

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Vulnerability

‘the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist, and recover from the impact of a natural hazard (an extreme natural event or process).’

Wisner et al. 2004

→ Social vulnerability perspective

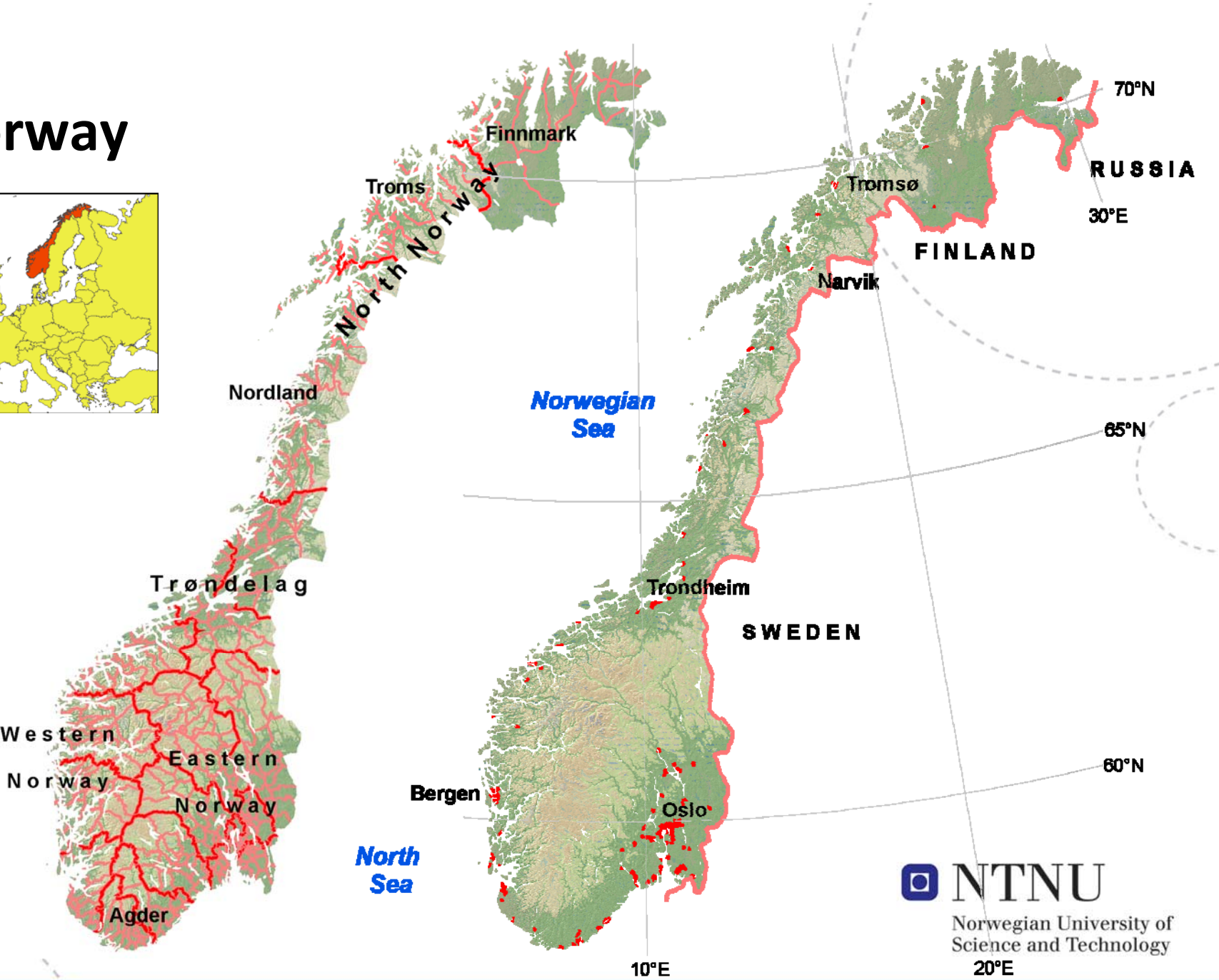
→ Only people are vulnerable (a house is unsafe, a slope is unstable etc.)



Objectives

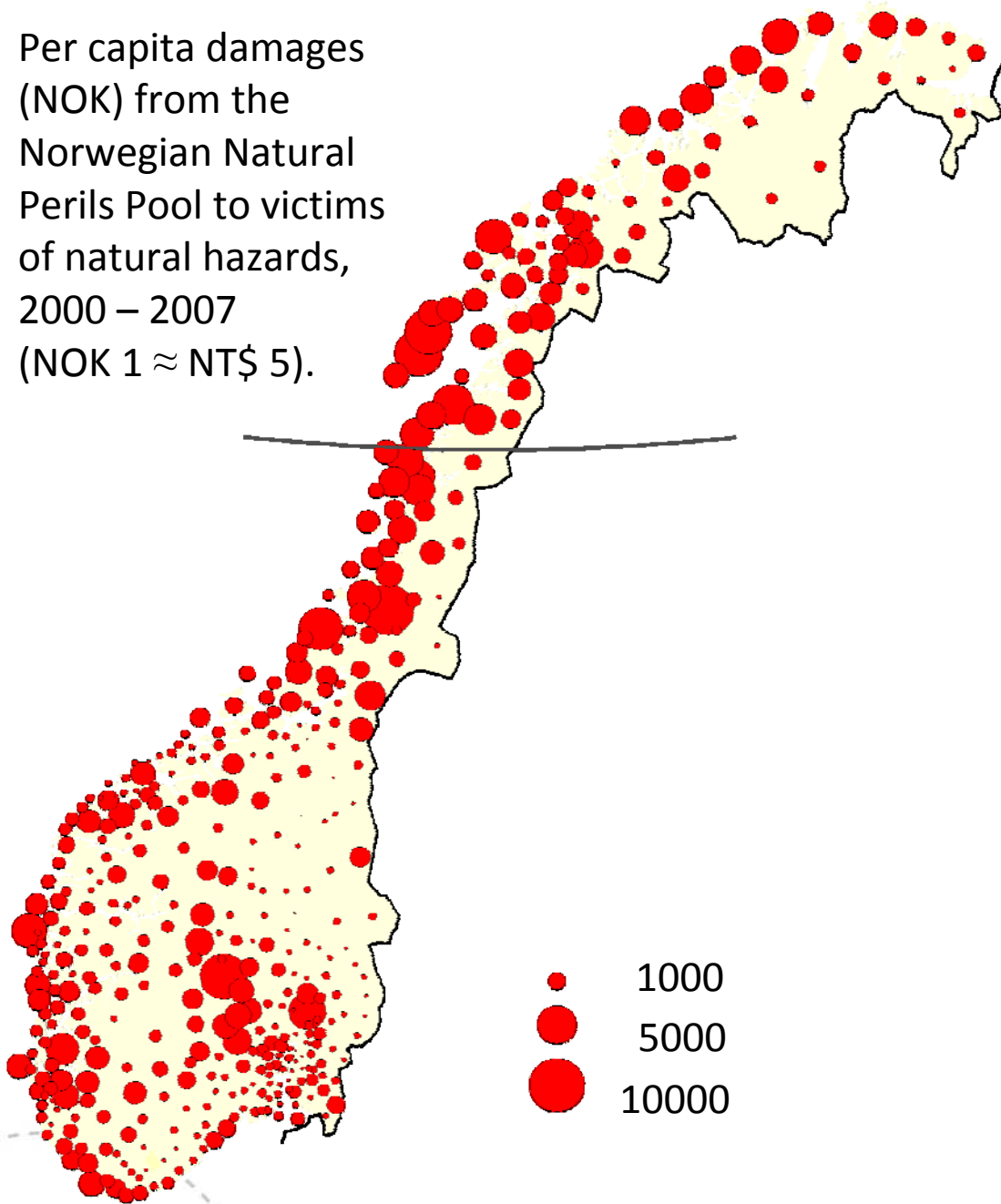
- Quantify social vulnerability to natural hazards in Norwegian municipalities
- Map differences in relative vulnerability between municipalities.
- A secondary objective is to establish a knowledge basis that facilitates further in-depth analyses of social vulnerability to natural hazards in selected regions at a lower geographical level, and for analyses of future vulnerability.

Norway



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20°E

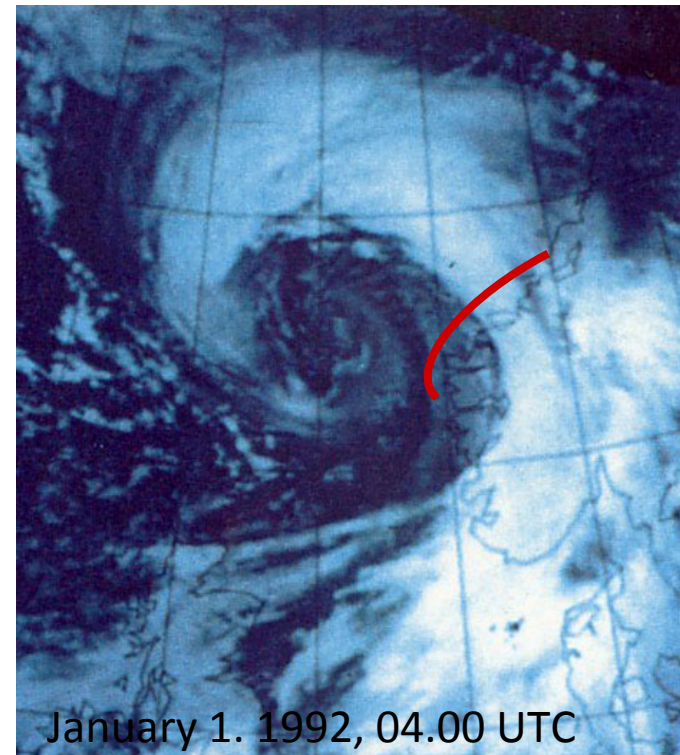
Per capita damages
(NOK) from the
Norwegian Natural
Perils Pool to victims
of natural hazards,
2000 – 2007
(NOK 1 \approx NT\$ 5).



Situation New Year's Morning 1992:
Sustained wind – 70 knots in cities
close to the coast (hurricane 1),
90 knots in lighthouses on the coast
(major hurricane 3). Gusts up to 120
knots.



Large damage, small casualties





The Fjørå community before and after the 1934 Tafjord accident (3 million m³ rockslide → tsunami)



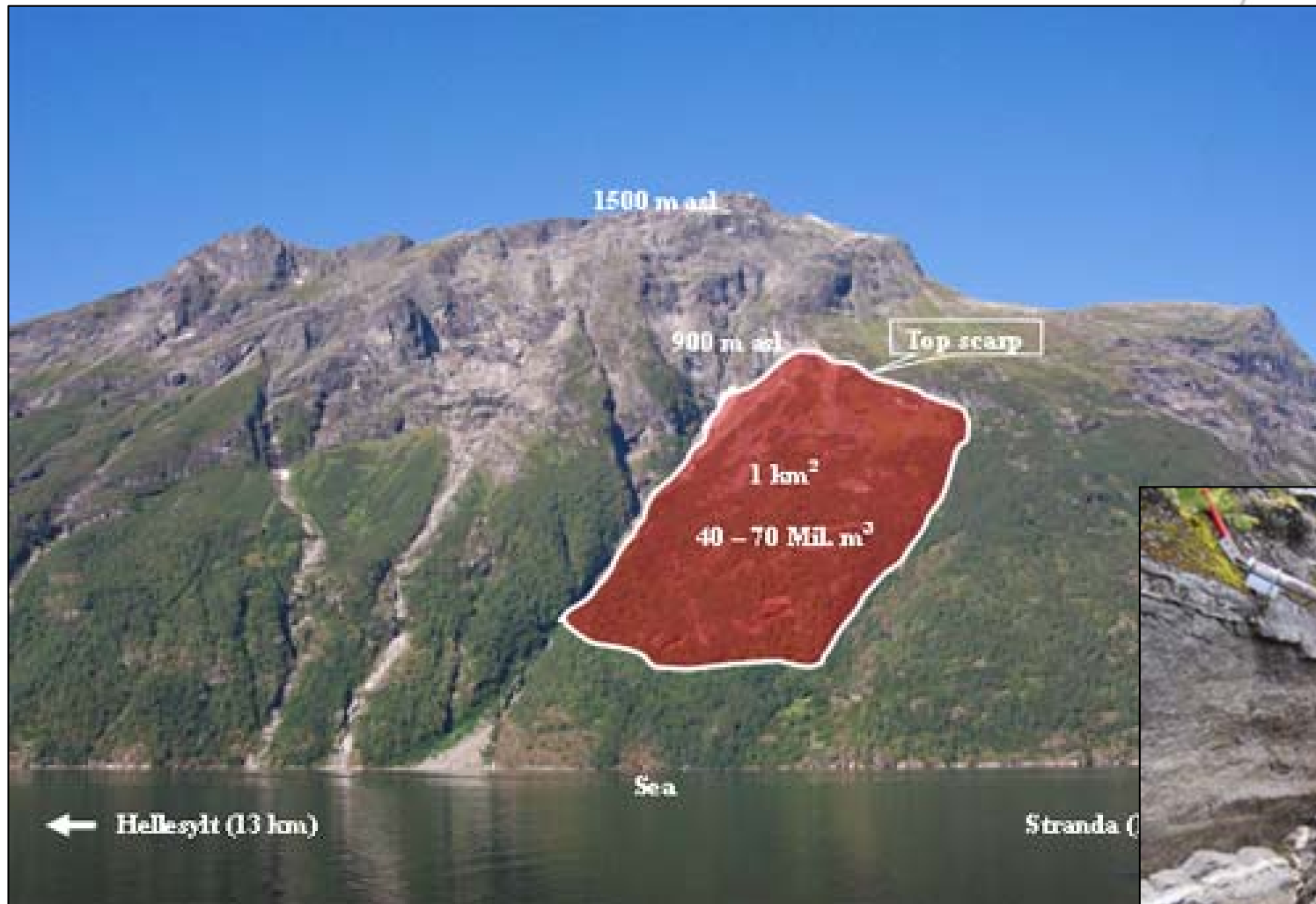


Photo: www.norsar.no

Aaknes (danger of 40-70 million m³ rockslide and tsunami)





Photo: Erik Olsen, NGU archives

Where the ground failed in the 1893 Verdal valley quick clay slide and the valley after the slide (65 million m³ quick clay slide → dam → flood)



Photo: Erik Olsen, NTNU archives



Quick clay slide in Reina, Nord-Trøndelag, 2007. 1 million m³ moving 1,3 km downstream.



Photo: Lars Erik Skjærseth/NRK

Approach

Apply approach of Cutter and associates (Cutter et al. 2003; Borden et al. 2007), that utilises the hazards-of-place-model of vulnerability (Cutter 1996; Cutter et al. 2000) to build vulnerability indices.

Two versions:

- Replica
- Adapted

Method

1. Select statistical indicators of social vulnerability on the basis of empirical knowledge
2. Reduce complexity of data using factor analysis
3. Compile index from factor scores in an additive process



Do results make sense?

Because we run the analysis twice; we also study two major sets of data variables:

1. Data that replicate the variables included in the Cutter et al. (2003) SoVI model
2. Data where concepts and metrics have been reconsidered and adapted to the Norwegian setting

Example: Original considerations of vulnerability concept *gender*

Cutter et al (2003) consider:

- Due to gender inequalities, women's role in care giving, lack of mobility, and limited access to resources, gender is regarded as a significant, explanatory variable in disaster and vulnerability research (Fothergill 1996).
- Disadvantaged women suffer disproportionately in a disaster (Hewitt 1997).
- Many women in low skill service occupations – employment that is more likely to be affected by disasters (Morrow 1999).
- High proportion of females in population increases vulnerability (Cutter et al. 2003)
- High proportion of females participating in the work force increases vulnerability (Cutter et al. 2003).

Therefore, in the American context, the proportion of women in population and in workforce is considered to increase vulnerability.

Example: Reconsideration to the Norwegian setting

We reconsider:

- Nordic countries have high levels of gender equality (Plantenga et al. 2009; Hausmann et al. 2007), which reduces the significance of gender as a major contributor to vulnerability.
- Female participation in the labour force reduces women's economic dependency, and female participation in the labour force contributes positively to women's health (Rostad et al. 2009).
- Many women are employed in sheltered sectors health care and primary and secondary education.
- High proportion of women in population signifies vital community

Therefore, in the Norwegian context, we consider gender equality to moderate vulnerability.

Table 1. Cutter et al. (2003) vulnerability concepts and metrics vs. Norway adapted SeVI and BEVI.

Vulnerability concept	Increases (+) or decreases (-) social vulnerability	
	SoVI (Cutter et al. 2003)	SeVI and BEVI
Socioeconomic status	High Status (+/-) Low income or status (+)	High status (-), Low income or status (+) Good public finances (-), Civic involvement (-)
Gender	Gender (+)	Gender equality (-)
Immigration and ethnicity	Nonwhite (+) Non-Anglo (+)	Immigrants of non-western origin (+) Western immigrants (-)
Age	Elderly (+), Children (+)	Elderly (+), Children (+)
Commercial and industrial development	High density (+) High value (+)	High density (+)
Employment loss	Employment loss (+)	Employment loss (+)
Rural / urban	Rural (+), Urban (+)	Rural (+), Urban (+)
Residential property	Mobile homes (+)	House value (-), Old houses (+)
Infrastructure and lifelines	Extensive infrastructure (+)	Extensive infrastructure (+) Old infrastructure (+), Exit routes (-)
Renters	Renters (+)	Renters (+)
Occupation	Professional or managerial (-) Clerical or laborer (+), Service sector (+)	Low-skilled service sector (+), Primary sector (+), Labour force participation (-)
Family structure	High birth rates (+), Large families (+) Single-parent households (+)	Single parent households (+)
Education	Little education (+), Highly educated (-)	Little education (+), Highly educated (-)
Population growth	Rapid growth (+)	Out-migration (+)
Medical services	Higher density of medical (-)	Higher density of medical (-) Distance to medical services (+)
Social dependence	High dependence (+), Low dependence (-)	High dependence (+), Low dependence (-)
Special needs populations	Large special needs populations (+)	Large special needs populations (+)

Table 2. Factors, factor labels, factor loadings, and factor sign adjustment for the SOVINOR model.

Factor Label	Variable (main loading)	Loading	Sign
1. Population structure	% population 67 years or older	-0.89	
	% population 5 years or younger	0.79	
	% households with income less than 150 000 NOK	-0.76	
	% population change	0.69	
	% population living in nursing homes (old & disabled)	-0.67	
	Birth rate (number of births per 1,000 population)	0.66	
	Average number of household members	0.53	
2. Gender	% females in labour force	0.77	
	% employed in service sector	0.74	
	% females	0.67	+
	% employed in primary extractive industries	-0.69	
	Distance to nearest hospital	-0.47	
	% electorate voting in municipal election	-0.45	
3. Income	# commercial establishments per km ²	0.78	
	Average income	0.75	
	% households earning more than 500000 NOK	0.69	
	% first or second generation non-western immigrants	0.64	-
	Value of housing units	0.56	
	% urban population	0.53	
4. Socioeconomic status	% unemployed	0.83	
	% receiving invalidity pension	0.65	
	% with only lower secondary education	0.63	+
	% participating in the labour force	-0.61	
	% single-parent households	0.53	
	% agricultural land	-0.53	
5. Renters	# physician labour years in primary health care per 10000 inhabitants	0.56	+
	% renters	0.88	

NOTE: Table shows the results from Principal Components Factoring (PCF) analysis with Varimax rotation and Horst normalization. Analysis is based on 431 Norwegian municipalities and 27 variables. 5 factors were extracted. For the method, variables, and definitions, see the text. Sign adjustment: absolute (||), negative (-), or positive (+).

Table 2. Factors, factor labels, factor loadings, and factor sign adjustment for the SeVI model.

Factor Label	Variable (main loading)	Loading	Sign
1. Population structure and socioeconomic status	% households with income less than 150 000 NOK	-0.79	
	% population 67 years or older	-0.77	
	% population living in nursing homes (old & disabled)	-0.67	
	% receiving invalidity pension	-0.64	
	% households earning more than 500 000 NOK	0.76	-
	Median income	0.71	
	% participating in the labour force	0.66	
	% population 5 years or younger	0.76	
	% Labour force employed in health care and social services	-0.68	
2. High-skilled, equal, and multiethnic vs. low-skilled	% with only lower secondary education	-0.67	
	% employed in primary sector (farming, fishing, forestry)	-0.59	
	% first or second generation non-western immigrants	0.59	
	% Western immigrants	0.51	-
	% employed in low skill services	0.41	
	% with 4 years or more of tertiary education	0.79	
	Gender equality	0.66	
3. Municipal viability	Average value of housing units	0.65	
	% municipality's net debt of gross revenue	-0.65	
	% municipality's expenditure on debt service of total income	-0.49	
	Municipality's disposable income per inhabitant	0.73	-
4. Declining periphery	% electorate voting in municipal election	0.63	
	% unemployed	0.75	
	% out-migration	0.64	
	% single-parent households	0.54	+
	Median per capita capital assets	-0.55	

NOTE: Table shows the results from Principal Components Factoring (PCF) analysis with Varimax rotation and Horst normalization. Analysis is based on 431 Norwegian municipalities and 25 variables. 4 factors were extracted. For the method, variables, and definitions, see the text. Sign adjustment: negative (-) or positive (+).

Table 2. Factors, factor labels, factor loadings, and factor sign adjustment for the BEVI model.

Factor Label	Variable (main loading)	Loading	Sign
1. Lifelines	Length of municipal roads (km per capita)	0.7721	
	# exit routes per 1000 inhabitants	0.6964	
	Distance to nearest hospital	0.8045	
2. Settlement pattern	Population density	0.8651	+
	Number of housing construction sites	0.8534	
3. Aging infrastructure	Average age of water pipelines	0.68	+
	Average age of sewer pipes	0.7404	
	% residential building stock built after 1980	-0.7204	

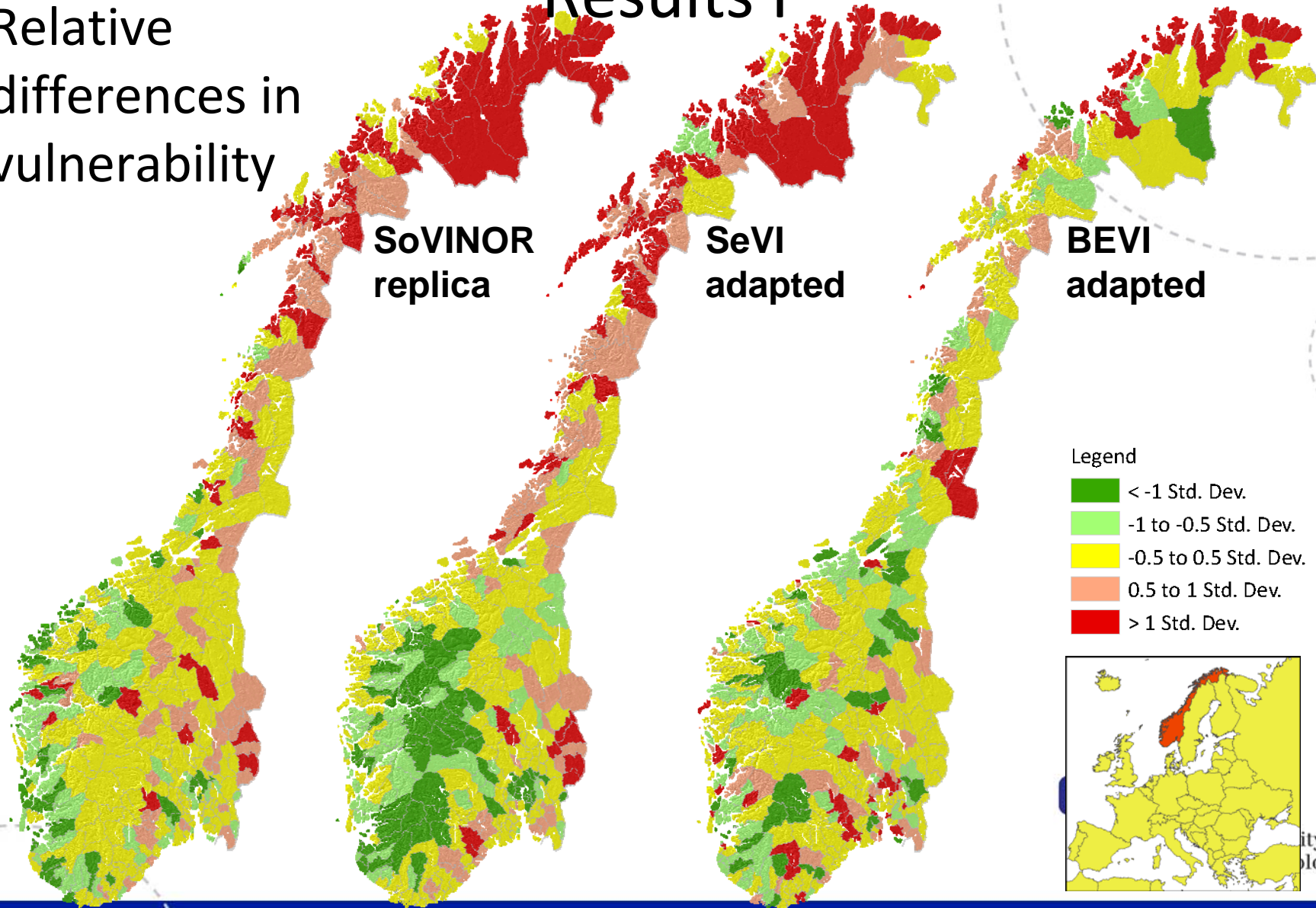
NOTE: Table shows the results from Principal Components Factoring (PCF) analysis with Varimax rotation and Horst normalization. Analysis is based on 431 Norwegian municipalities and 8 variables. 3 factors were extracted. For the method, variables, and definitions, see the text. Sign adjustment: absolute ||, negative (-), or positive (+).

Where is the GIS in this?

- Create variables (density measures, distance to nearest hospital, exit routes)
- Inspection of results impossible without maps
- Communicate relative differences in vulnerability

Results I

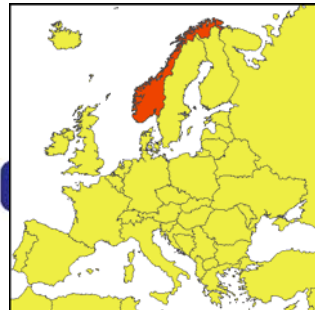
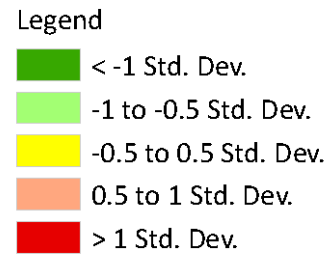
Relative differences in vulnerability



**SoVINOR
replica**

**SeVI
adapted**

**BEVI
adapted**



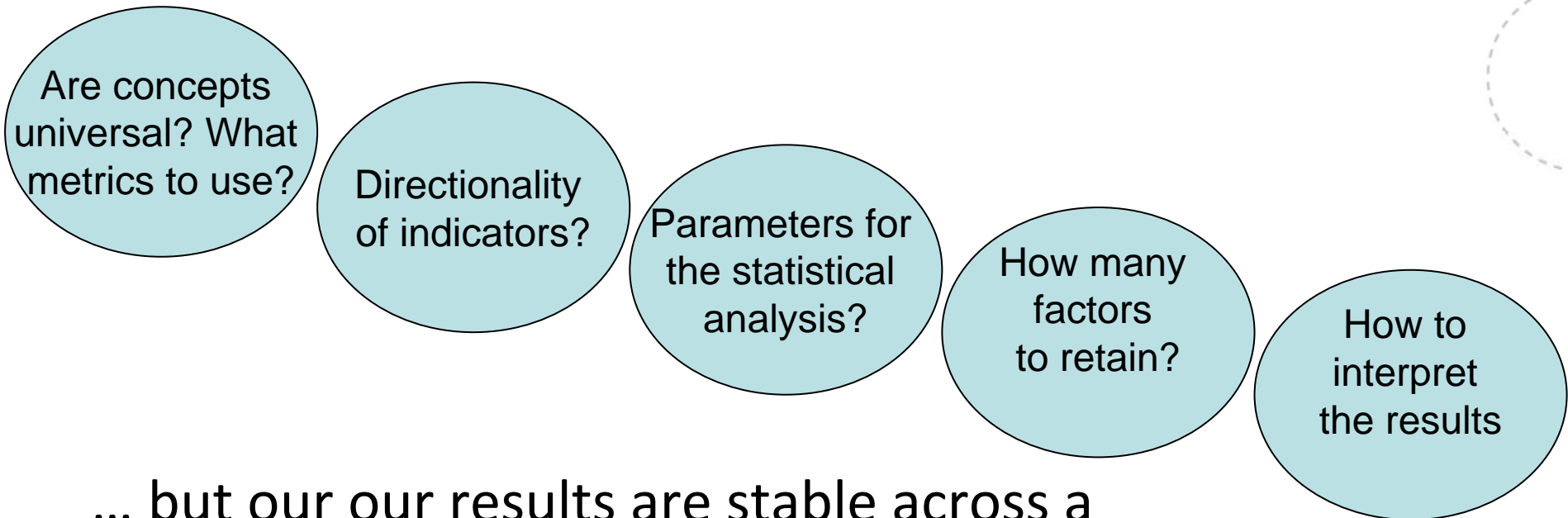
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Results II

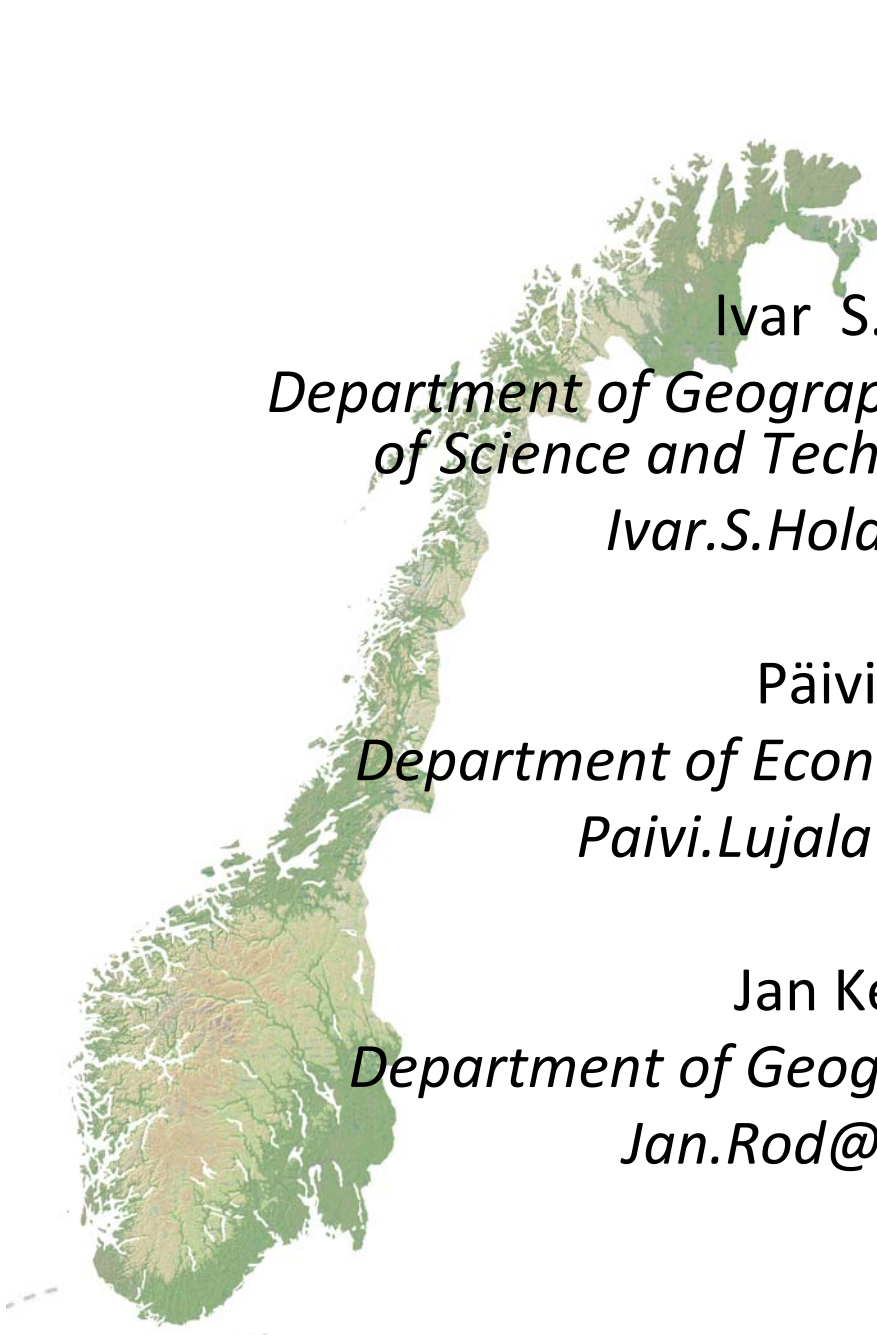
- Social vulnerability index framework applicable also outside the USA
- Because the social order of societies varies, it is important to adjust models to local context

Results III

- The building of indices such as the Social Vulnerability Index using factor analysis is a subjective process...



... but our our results are stable across a number of model specifications.

A topographic map of Norway, showing the coastline and inland terrain in shades of green and brown. The map is positioned on the left side of the slide, with the text of the speakers' names and affiliations overlaid on it.

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