Climate adaption between mountains and fjords

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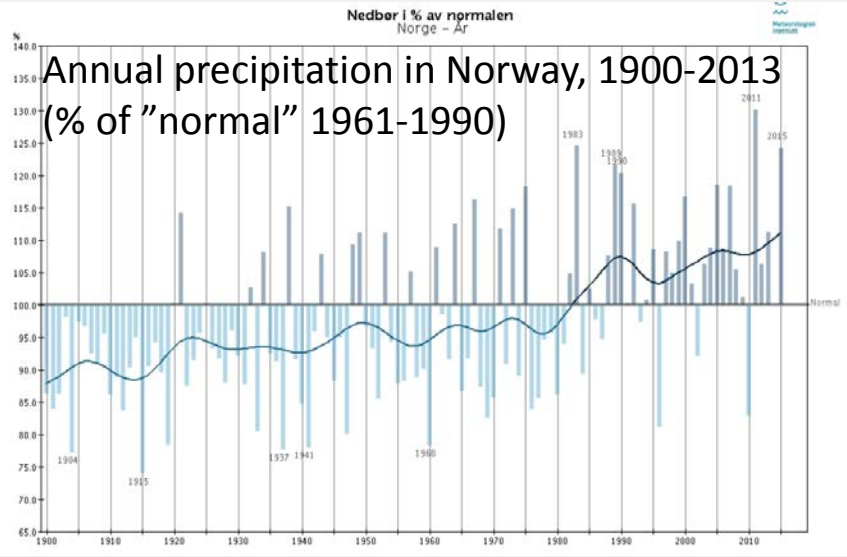
Natural Hazards NGI

Mountains amplify risks

- Expected increase in intensity and frequency of extreme weather events
- Extreme weather events trigger rapid-moving mass gravity flows in mountainous regions that pose a significant risk to local population, infrastructure and ecosystems
- Rural mountainous regions do not receive same attention as urban areas and coastal regions



The Norwegian Water Resources and Energy Directorate

Mud and debris flows – major threat to the built environment

- Most often triggered by prolonged and/or intense precipitation, or snow melt
- Often assisted by human activity

..as well as to the transport infrastructure

Flash flood and blocked culvert, Notodden, July 2011

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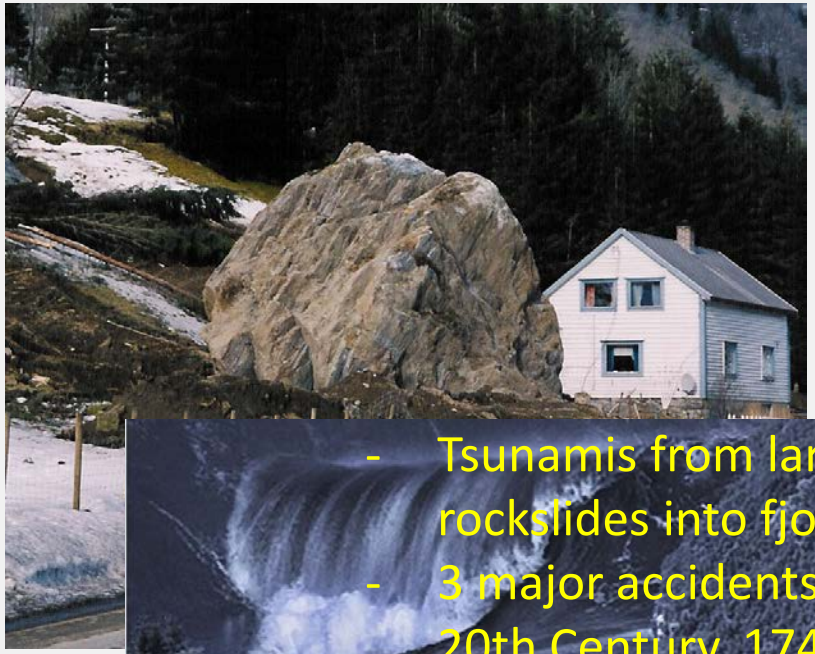
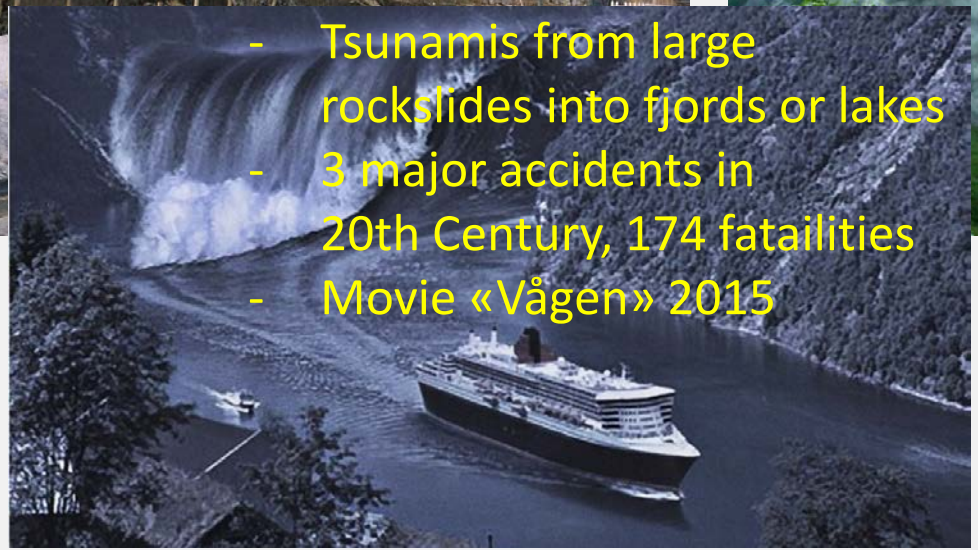
Rock fall to large rock slides – huge consequences





- Tsunamis from large rockslides into fjords or lakes
- 3 major accidents in 20th Century, 174 fatalities
- Movie «Vågen» 2015

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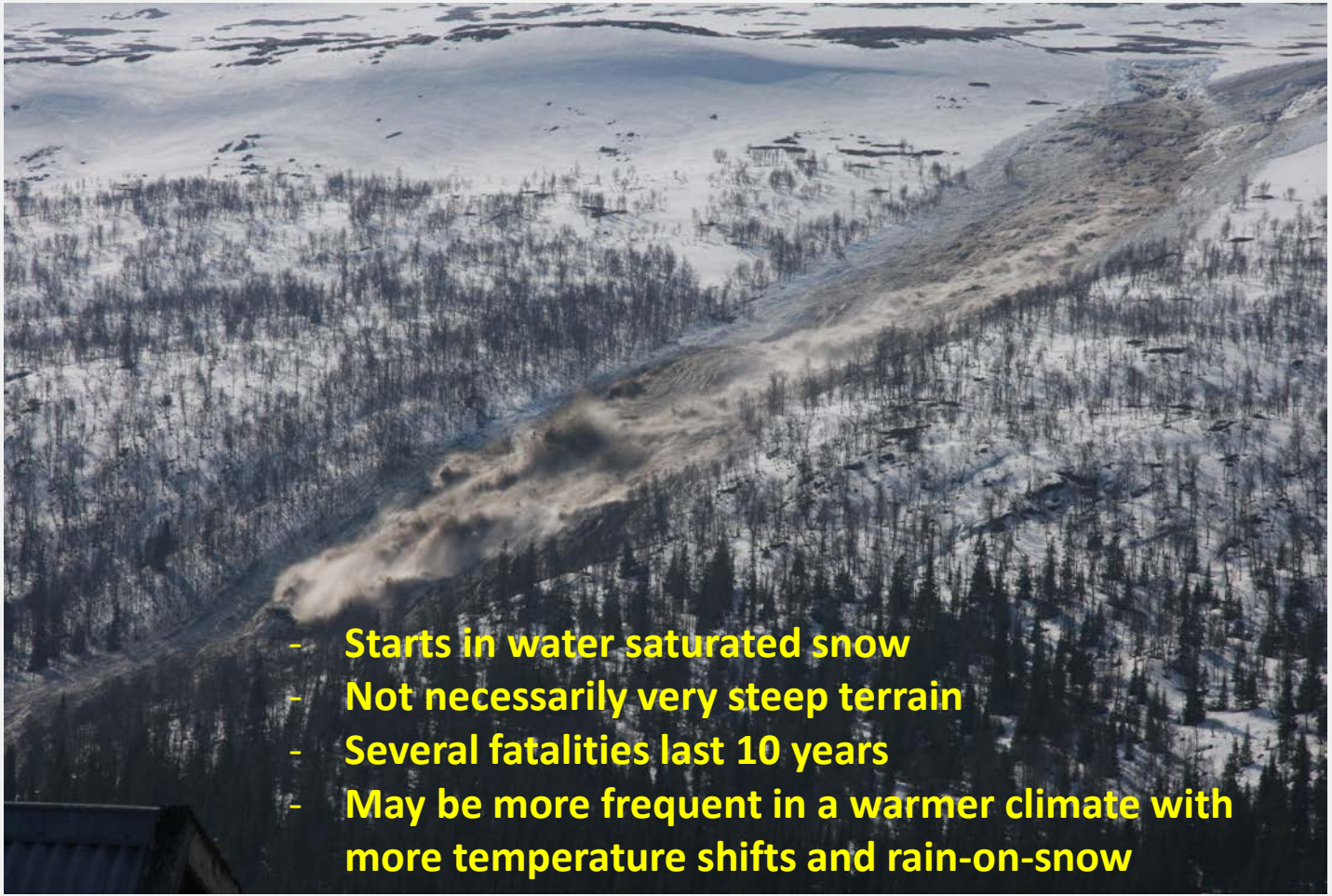
Snow avalanches – major problem for railroads and roads

Slush flows – high speed and high energy



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Flooding and torrents in narrow valleys – Village Kvam, 2011 and 2013

- Rebuilt after 2011
- Hit again in 2013!
- Homes built on flood and debris flow fans are common in Norway

Flooding in large rivers

Situations we may see more often and not only during spring and fall

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Expected effects of climate changes in Norway

Debris slides / flows

- Most of Norway will experience more days with strong / extreme precipitation → increased frequency of landslides

Flooding

- Frequency of floods will increase and be distributed more evenly through the year
  → not only the typical spring and autumn floods
- More frequent and more intense extreme weather situations combined with sea level rise
  → increased storm surge hazard

Landslides in sensitive clay (quick clay slides)

- Most quick clay slides in recent 50-60 years are triggered by human activity
- Increased erosion from flooding in rivers and streams
  → Increased probability of naturally triggered quick clay slides

Rock fall, rock slides, and tsunamis

- More days with strong precipitation, more frequent freeze – thaw episodes
  → increased rock fall/rock slide/tsunami hazard

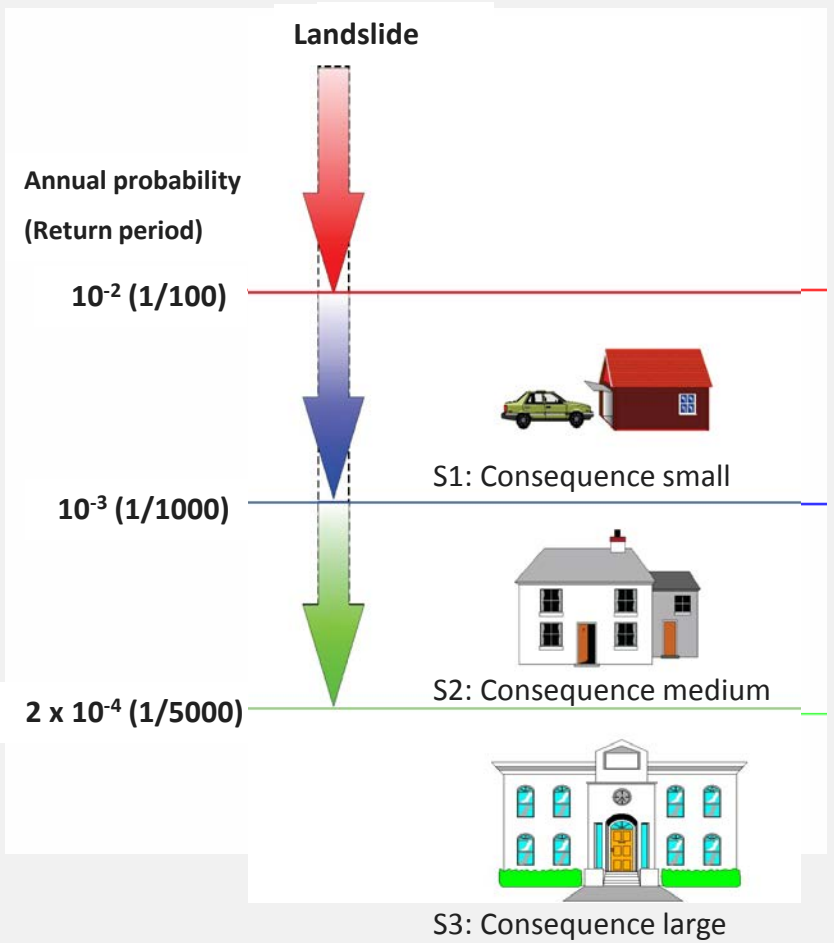
Snow avalanches:

- More precipitation, indications of more days with strong wind → increased snow avalanche hazard
- But! Increased temperatures → higher snow line and also higher tree line → decreased hazard for built infrastructure

The Norwegian Planning and Building Act (PBA)

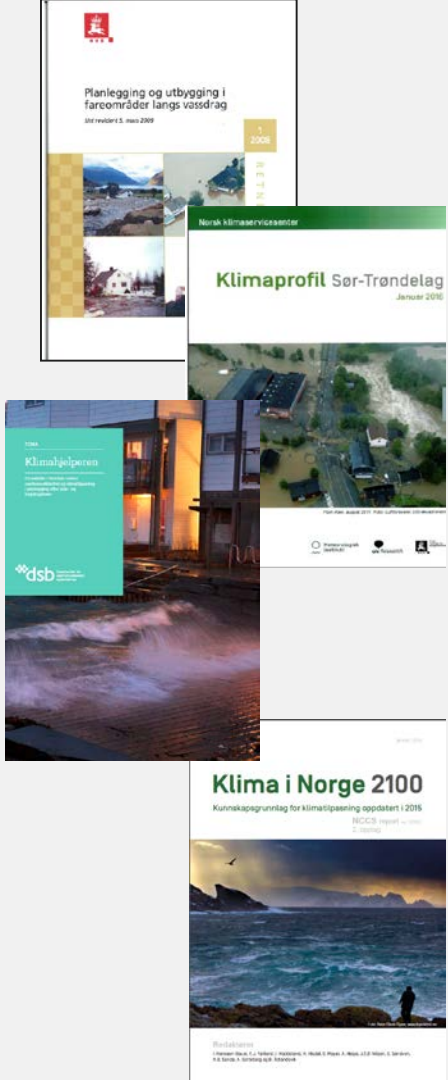
- Based on annual probability (recurrence interval) of impact
  - some countries use intensity (loads)
- Gives acceptable hazard for various kinds of buildings
- Equivalent for flood hazard, but
  - Higher probabilities accepted
  - Flux and flow depth rather than impact (“wet”)
- Not for older buildings (PBA from 1985)
  - Older buildings cannot be expanded/rebuilt after fire, etc

- **The PBA is a good tool – when followed**



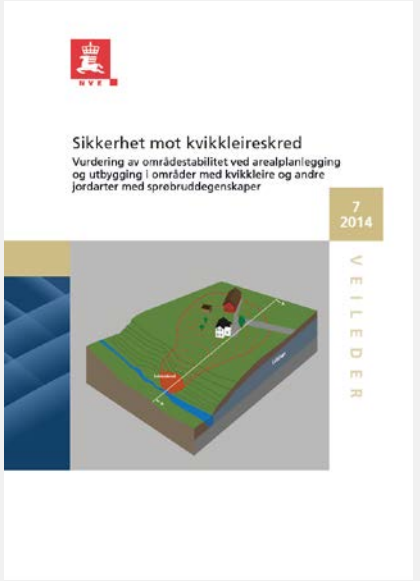
Laws and Regulations for CA

- What does the Planning and Building Act say?
  - Probability of impact → Indirectly one should take CC into account
  - A weakness that climate is not mentioned explicitly
  - PBA → Regulations (Teknisk Forskrift TEK17) that briefly mention CC
    «Effect of CC will influence on locations and loads…»
    «PBA and Regulations are meant to contribute to CA»
  - Links to Guidelines (Retningslinjer) and «Klimaprofiler» for each county (by Norsk Klimaservicesenter) with recommended climate add-on values
  - «Klimahjelperen» (by DSB) provides guidance on CA according to PBA!
- Act on climate «Klimaloven» from 1.1.2018
  - Mainly about emission
  - «Government must annually report … how Norway adapts to CC»
  - Weak from a natual hazards perspective
- 2010: Act on mandatory municipality preparedness expanded
  - CC to be included in the overall risk and vulnerability analyses of each municipality
- 2015: “Klima i Norge 2100” ordered by the Norwegian Environment Agency
  - Responsibility of the municipalities emphasized



If we do not follow laws and regulations?

- Guidances (Veiledere) open for other dimensioning
  - documentation needed
- Not much happens until there is an incident → and then the trials (more will follow)
- Who pays the damage?
  - Twofold compensation scheme
  - Norsk Naturskadepool (Norwegian Natural Perils Pool): Fire insurance also includes damage caused by natural hazards
  - Statens Naturskadeordning (Norwegian National Fund for Natural Damage Assistance) compensates damages to objects one cannot normally insure against damage by natural perils by means of ordinary insurance schemes
  - There should be more focus on mitigation (rather than repair)
  - Less will to compensate than before. More trials.
- How far has the local municipalities come with CA? Do they have firm plans?
  - Most have not come very far
  - Limited resources (knowledge, funding, capacity)
  - Confusion, uncertainty: «Can we please have only ONE net page to guide us?»

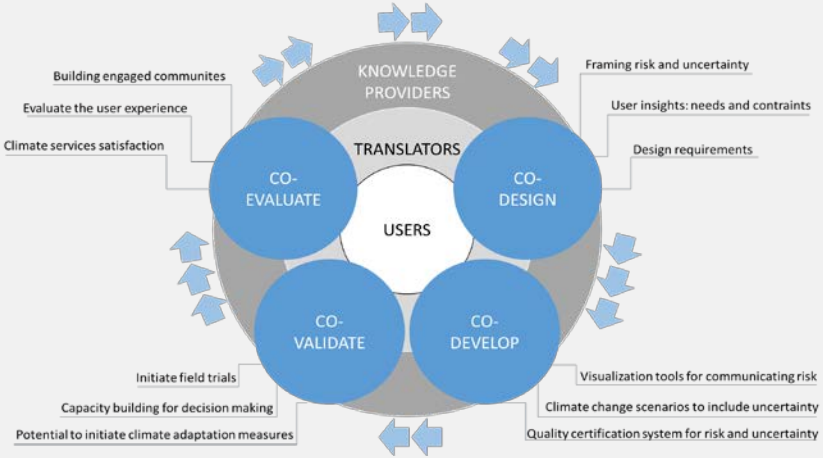


Physical measures in a steep country

- Need for innovative, more space- and cost effecient, as well as environmentally friendly solutions
- Presently a great focus on green, nature based solutions NBS, also in major calls from EU-H2020 and the RCN
- NGI co-ordinator for 10 mill. €
  EU H2020 project PHUSICOS on NBS
  https://phusicos.eu/

EVOKED: Enhancing the value of climate data – translating risk and uncertainty utilizing a Living Labs approach

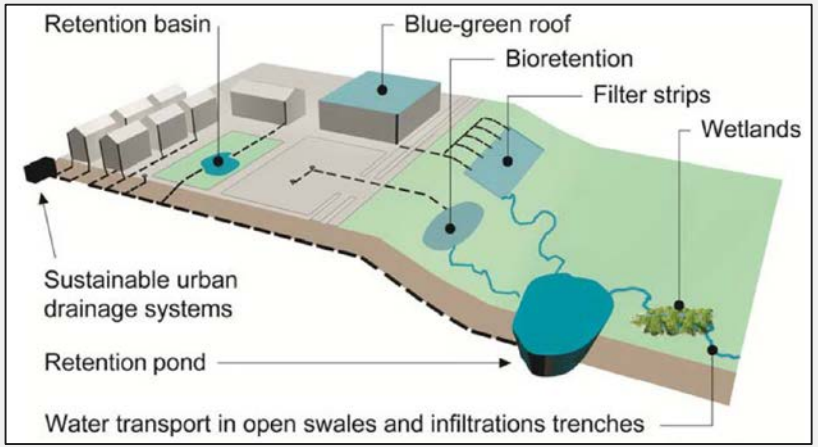
- EVOKED (2017 – 2020)
  - EU ERA4CS (European Research Area for Climate Services)
  - JPI Climate (Joint Programming Initiative "Connecting Climate Knowledge for Europe")
- *Objective: To re-frame the risk and uncertainty associated with climate data into knowledge products more understandable and useful for end-users concerned with risk mitigation and adaptation*
- The end-users' knowledge needs are vital for response to climate change impacts
- To overcome the barriers of climate adaptation at the global scale, EVOKED will be initiated at local and regional case study sites in Norway, Sweden, Germany and the Netherlands
- Swedish partner: SGI with end-user Värmland County
- http://www.jpi-climate.eu/nl/25223447-EVOKED.html
- https://www.ngi.no/eng/Projects/EVOKED



RCN: Center for Research Based Innovation (SFI): ‘KLIMA2050’

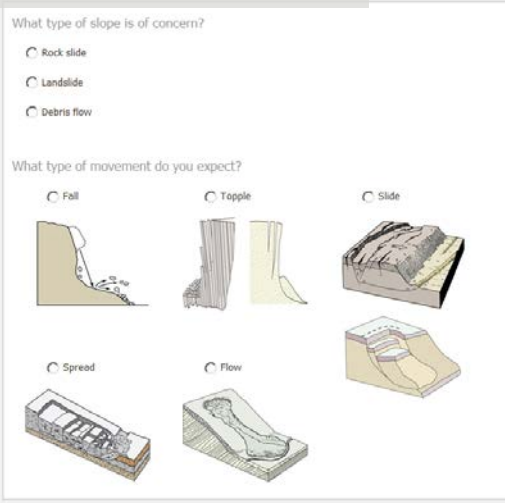
- *Risk reduction through climate adaptation of buildings and infrastructure*
- 20 Partners
  - from research, public sector, industry
- 8 years; 2015-2023
- Total budget NOK 221 mill. (24 mill. EURO)

WP 1: Climate adaptation of buildings
WP2: Urban flooding
WP3: Water induced landslides (NGI)
WP4: Management and decision processes



NGI www.klima2050.no

KLIMA2050 toolbox https://www.larimit.com/



- Further development of toolbox from EU FP7 Project SAFELAND (2009 – 2012) https://www.ngi.no/eng/Projects/SafeLand

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CA Consulting:
Impact and mitigation of natural hazards in a changing climate – a pilot project for Larvik and Lardal municipalities, Norway


Stavernkrysset, 29.6.2012
(Østlandsposten, foto: Kari Goverud)


Numedalslågen,
juli 2007


Stormflo Indre Havn, Larvik, 1987
(Foto: Terje Antonsen)


Ved Hedrumveien i Larvik, 24.12.2013
(Østlands-Posten, foto Knut Utklev)

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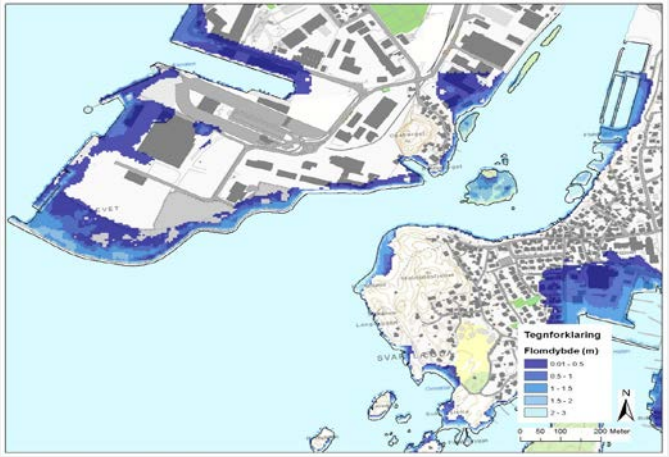
Design of local climate scenarios

- In close collaboration with the client
- Climate predictions depend on selected emission scenario
  - Assumed radiative forcing?
  - RCP 8.5 is «business as usual»
- How far ahead?
  → 50 years → 2065
  - In agreement with the planning perspectives of Larvik/Lardal
- How extreme events?
  → Return period: 200 years (in 50 years!)
  - Not «too extreme»
- Give applicable examples rather than identify high risk
  - Various hazards: extreme precipitation – landslides – flood – storm surge and sea level rise
  - 5-6 scenarios for each hazard: Geographical spread, various sceneries

Past and future 'total radiative forcing' [W/m^2] relative to pre-industrial time. Scenarios from previous IPCC reports together with 'Representative Concentration Pathways' (RCP

Applications of the results

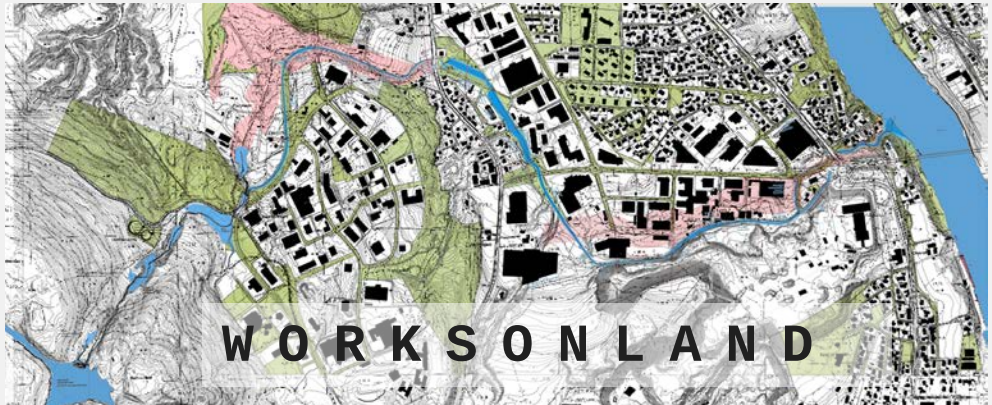
- Results to be used for
  - Further mandatory risk and vulnerability analyses with CC
  - Area and land-use planning
  - Planning of mitigation measures
- Larvik municipality as partner or end-user in R&D projects
  - EVOKED
- 428 Norwegian municipalities are supposed to do CA
  - 279 coastal municipalities



CC and contaminated ground: Kjørbekk, Skien, eastern Norway – From pipeline under waste disposal to open creek

SKIEN KOMMUNE

- Today: Water in pipeline under two waste disposals
- Pipe capacity too small with increased precipitation (CC) → Distribution of contaminants
- Repair and increase cacapicty of pipes will be too expensive
- Move deposits to approved waste disposal site is too expensive
- → Immobilise and locally replace contaminated deposits
- → Blue-green infrastructure / Nature Based Solution with retention pond and open creek for CA
- NGI's role:
  Based on example study Kjørbekk
  → develop general guidelines for regaining of disposal sites



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Some take-home messages

- Norway is a steep country, with lots of weather, and natural hazards will always be present
- Climate change leads to more frequent landslides and floods
- Risk can be reduced, but not eliminated!
- Best adaptation measure is proper land use planning and building techniques, with ‘climate effect added’ on most dimensions
- If current rules, regulations, guidelines are followed, we have come quite far
- Research is crucial, with active stakeholder involvement as a very important factor
- Mitigation is needed – now more than ever!

#påsikkergrunn

NORGES GEOTEKNISKE INSTITUTT
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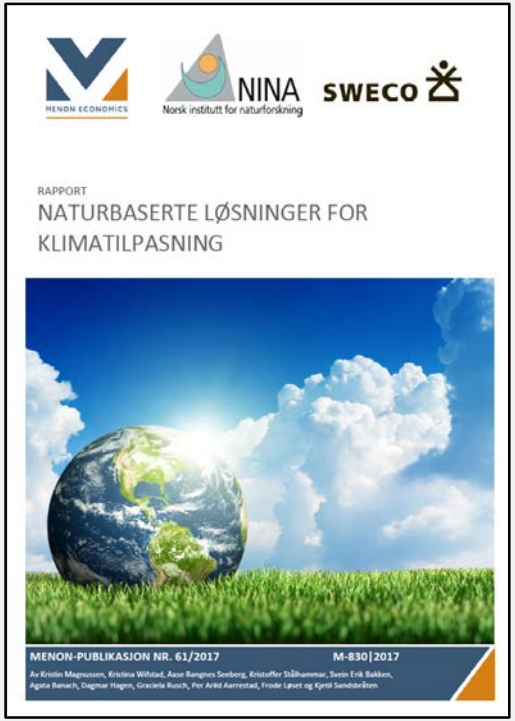
Outline

- Climate related natural hazards in Norway
- Norwegian regulations related to climate adaptation
- Laws and regulations
  - National services for climate adaptation
- Adaptation – mapping and mitigation
- Important research - example projects

NBSs for climate change adaptation

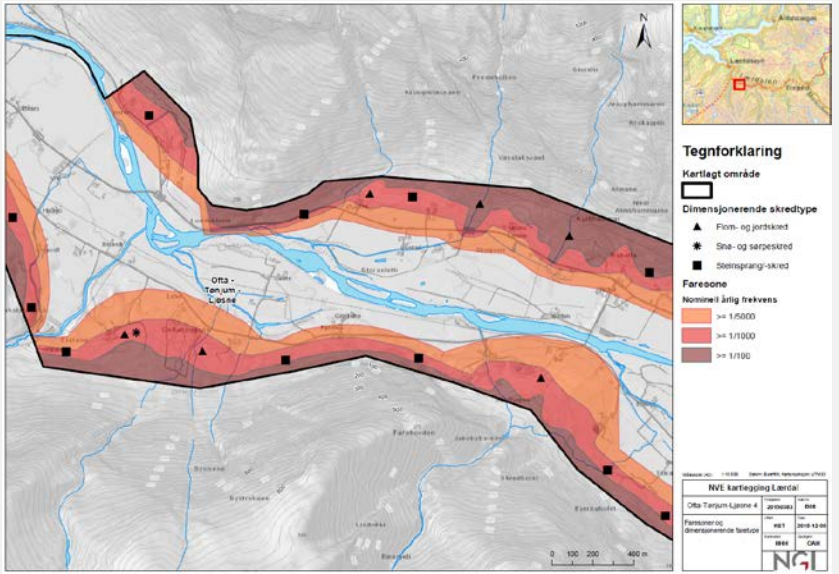
- Challenges addressed in the report prepared for the Norwegian Environment Agency:
  - Flood
  - Storm water management
  - Sea-level rise and storm surge
  - Landslides
  - Precipitation (linked to erosion)
  - Temperature (urban heat islands)
  - Drought
  - Wind
  - Ocean acidification



Is the hazard zoning completed all over Norway?

- Susceptibility maps completed
  - Automated exercise
  - Much disputed
- Hazard maps made step by step
  - Proritized and contracted by the government
  - Should be revised for CC?
- More detailed maps produced for municipalities etc.

- Soft measures:
  - mapping and landuse planning (PBA)
  - warning systems
  - closure and reduced speed
  - evacuation and rescue plans



Mapping of landslide and snow avalanche hazard, Lærdal, Norway

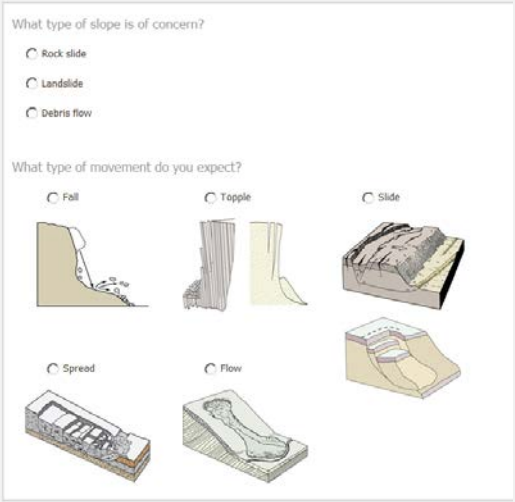
Sources of funding for research on natural hazards and climate change impact

NGI internal research funding

EU FP7 Project SAFELAND (2009 – 2012)

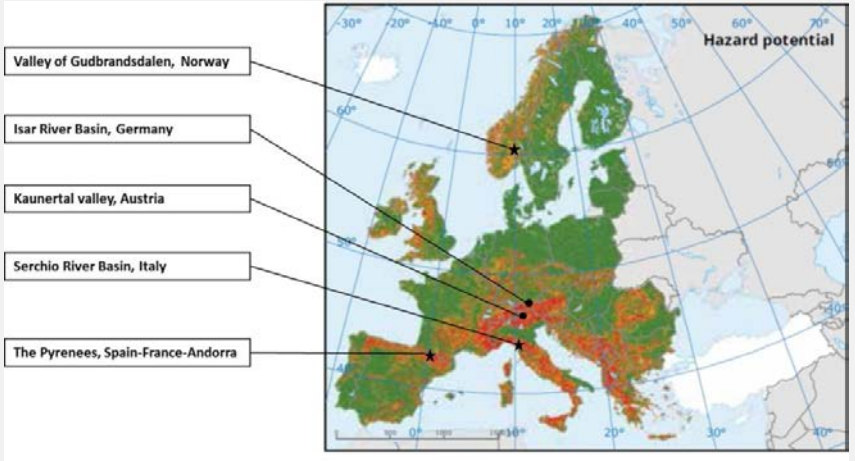
- *Living with landslide risk in Europe: Assessment, effects of global change, and risk management strategies*
- http://esdac.jrc.ec.europa.eu/projects/safeland
- https://www.ngi.no/eng/Projects/SafeLand
- 27 partners, 25 end-users
- Coordinated by NGI

- Web based toolbox of mitigation measures



EU H2020 Project PHUSICOS (2018 – 2022)

- ‘According to nature’ (Greek)
- How will nature-based solutions provide robust, sustainable and cost-effective measures for reducing the risk of extreme weather events in rural mountain landscapes?
- 15 partners, 5 demonstrator sites
- A total budget of 10 mill. €
  - the largest research project managed by NGI to date
- https://phusicos.eu/



Phusicos demonstrator site
Valley of Gudbrandsdalen, Norway

Photos: from Heidi Eriksen and Turid Knutsen-Løvik at Oppland County