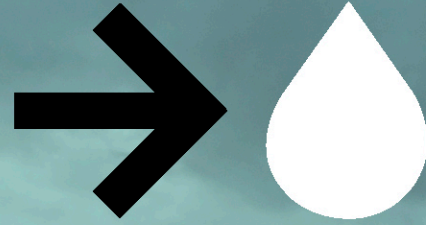


Miniseminar; EU-project Urban Agenda at Trondheim kommune, June 6th 2019
By Berit Time, Chief Scientist SINTEF/Centre Director Klima 2050



KLIMA 2050

RISK REDUCTION THROUGH CLIMATE ADAPTATION
OF BUILDINGS AND INFRASTRUCTURE

What is a Centre for Research-based Innovation (SFI) ?



Klima 2050 is a centre for research-based innovation (SFI) financed by the Research Council of Norway and the partners in the consortium

The SFI status shall enhance the capability of the business sector to innovate by focusing on long-term research based on forging close alliances between research-intensive enterprises and prominent research groups.

Main goal: SFI Klima 2050 will reduce the societal risks associated with climate changes and enhanced precipitation and flood water exposure within the built environment.



Climate exposure

Moisture-resilient buildings

Stormwater management

Water triggered landslides

Decisionmaking processe and impact



The building sector - a value chain of actors

- 58 000 companies
- 235 000 employees

Climate in Norway 2100

– a knowledge base for climate adaptation

NCCS report no. 1/2017



Photo: Anne Olsen Ryum, www.hasvikfoto.no



Lead authors

I. Hanssen-Bauer, E.J. Førland, I. Haddeland, H. Hisdal, S. Mayer, A. Nesje, J.E.Ø. Nilsen, S. Sandven, A.B. Sandø, A. Sorteberg og B. Adlandsvik



KLIMA 2050

CONSORTIUM

Private sector

SKANSKA **MESTERHUS**

Multiconsult  **Finans Norge**

 **SKJEFVELAND**
GRUPPEN  **NORGESHUS**

Leca  **Isola**  **powel**

Public sector



Stats vegvesen



Norges
vannkraft- og
energidirektorat



AVINOR



Jernbane-
direktoratet



STATSBYGG



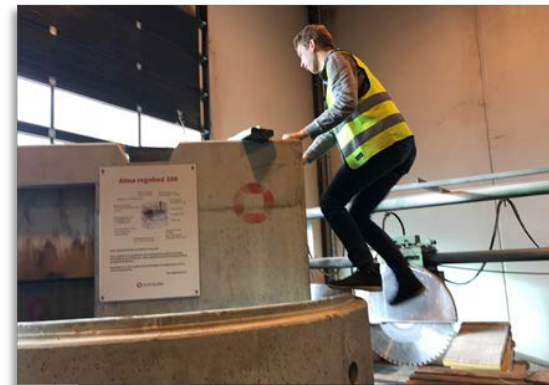
TRONDHEIM KOMMUNE

Research & education



Klima 2050 in figures

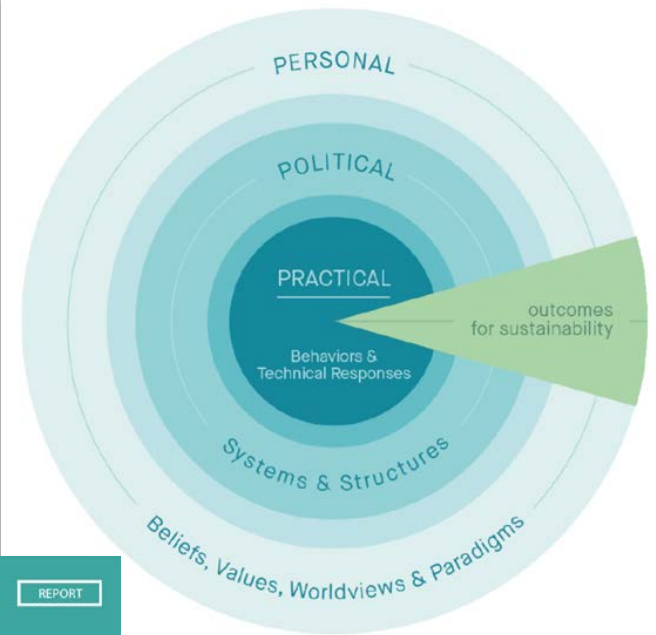
- Duration: 2015 - 2023
- Host: SINTEF
- 20 partners from private sector, public sector and research
- Budget: ~ 220 mill NOK (cash and in-kind)
 - Ca. 45 % from the Research Council of Norway
- 15 PhD student/Post.docs (at least 3 more will come)
- 56 Master Thesis submitted by now
- 86 scientific articles
- Approximately 25 active professors and researchers
- 15 + national spin-off and pilotprojects
- 5 international spin-off projects (EU)



Innovations for reduced societal risk lies in

- **Regulations**
- **Municipal plans and building processes**
- **Robust technology**
- **Nature-based solutions**
- **Incentives and business models**
- **Services**

Barriers and drivers for climate adaptation



The three spheres of transformation (O'Brien & Sygna, 2013) etter (Sharma, 2007).

Flyen, C, Hauge, Å.L, Almås, A-J & Godbolt, Å.L: **Municipal collaborative planning boosting climate resilience in the built environment.** *International Journal of Disaster Resilience in the Built Environment* 2018, Vol. 9(1), p. 58-69; doi.org/10.1108/IJDRBE-10-2016-0042, ISSN 1759-5908 (Published online 19 February 2018)

Hauge, Å.L, Flyen, C, Almås, A-J & Ebeltoft, M: **Klimatilpasning av bygninger og infrastruktur - samfunnsmessige barrierer og drivere.** Klima 2050 Report 4. Trondheim, 2017. ISBN 978-82-536-1532-5

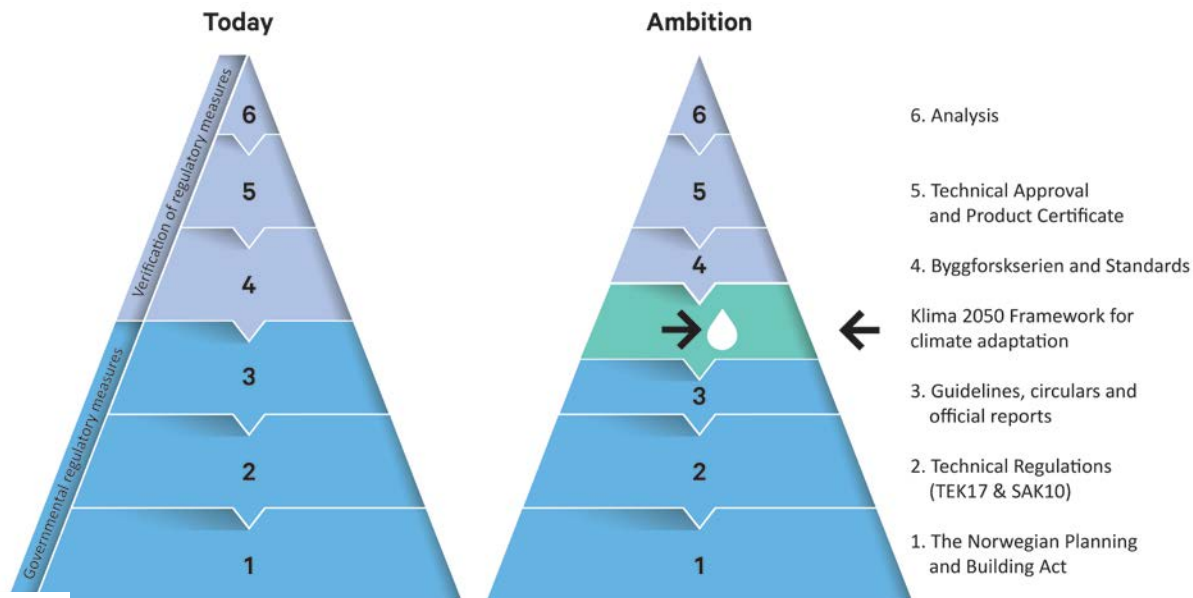
Kvålshaugen, R, Bygballe, L.H: **Practices in institutional projects as mobilizers of change: A case of adaptation to climate change.** *Academy of Management Proceedings*, Vol. 2018, No. 1. ISSN 2151-6561, (Published online July 9 2018)



Framework for climate adaptation of building

”The framework will make it easier to follow the building act and regulations because it shows how it can be done in specific terms. It is a good tool for the developers.”

Christine Molland Karlsen, Norwegian Building Authority

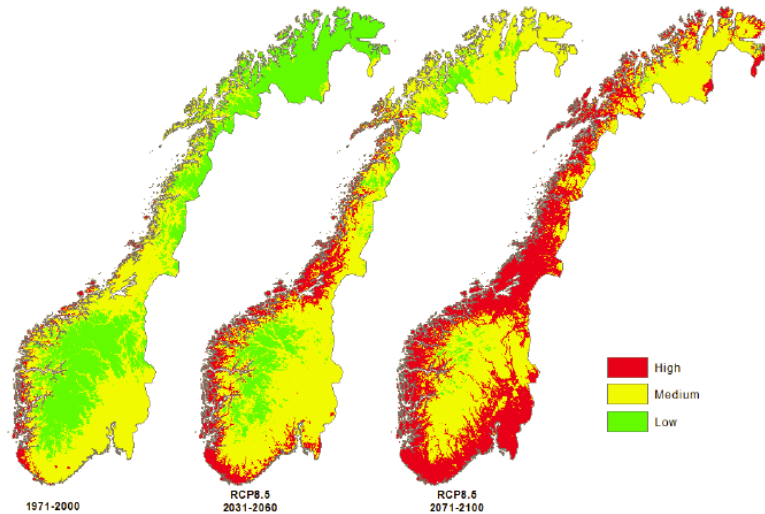


Lisø, K.R, Kvande, T & Time, B: *Climate adaptation framework for moisture-resilient buildings in Norway*. 11th Nordic Symposium on Building Physics. *Energy Procedia* 2017, Vol. 132, p. 628-633; doi.org/10.1016/j.egypro.2017.09.698, ISSN 1876-6102 (Available online 17 October 2017)

Danbolt, J.S: *Klimatilpassing av bygninger - Aktuelle hjelpemidler for prosjektering*. Master Thesis. NTNU, Trondheim 2018

An example of a new tool:

Potential risk of wood decay



Example of tools:

Performance of blue-green roofs



Example of tools:

New recommendations for increased rain resistance for masonry



Slapø, F, Kvande, T, Bakken, N, Haugen, M & Lohne, J: *Masonry's Resistance to Driving Rain: Mortar Water Content and Impregnation*. Buildings 2017, 7(3), 70



NYTT FRA NTNU

Bortkastet impregnering mot slagregn

Slått impregneringsmiddel bremset for å bedre egenskapene til regnvarsk, men effekten er så liten med tanke på pris og andre praktiske problemer. Forskningen i TEK10 er utvetydningssaker som vil legge på et underkastet impregneringskrav som skal være for å sikre seg.

Impregneringsmiddel
 Dette er et middel som impregnerer muren med vannrepulver og andre stoffer som gjør at vannet ikke trenger inn i muren. Dette er et middel som impregnerer muren med vannrepulver og andre stoffer som gjør at vannet ikke trenger inn i muren. Dette er et middel som impregnerer muren med vannrepulver og andre stoffer som gjør at vannet ikke trenger inn i muren.

09/09

NYTT FRA NTNU

Best med våt murmørtel

Reinert Slapø og Tone Kvande
 Murstenen med 1,5% luftvegg vil normalt inneholde vannet, vil mest kliner seg lettere til lagret og kan gi mer til på murverket. I tillegg kan for tett oppbygging av murverket gi vannvekkelse og vannet som murverket for muren kan sette seg.

Impregnering
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KLIMA2050

How to plan and build a climate-adapted building

What is important to consider when building a climate-adapted building? Klima 2050 has, in cooperation with the municipality of Trondheim, prepared a checklist of 21 points describing how to proceed in the different construction stages - from the concept to the completion.



Anne Grete Valstad
Project manager,
Trondheim kommune

Sivertsen, E, Elvebakk, K, Kvande, T & Time B: *Klimatilpasset bygning. Anvisning for anskaffelse i plan- og byggeprosessen*. Klima 2050 Report 12. Trondheim 2019 . ISBN 978-82-536-1610-0

Elvebakk, K, Time, B, Skjeldrum, P.M & Kvande, T: *Ombygging til blågrønne og blågrå tak. Problemstillinger og sjekklister*. Klima 2050 Report 10. Trondheim, 2018. ISBN 978-82-536-1588-0

Hauge, Å.H, Hanssen, G.S & Flyen, C: **Multilevel networks for climate change adaptation – what Works?** *International Journal of Climate Change Strategies and Management* 2018, ISSN 1756-8692 (Published online 7 August 2018)

Hauge, Å.L, Hanssen, G.S, Flyen, C & Strømø, E.B: *Nettverk for å lære klimatilpasning. Hvorfor og hvordan?* Klima 2050 Report 9. Trondheim, 2018. ISBN 978-82-536-1582-0

PKA arkitekt

ning
man-

bygning

BUILDING LARGE, CLIMATE ADAPTED WOODEN ROOFS

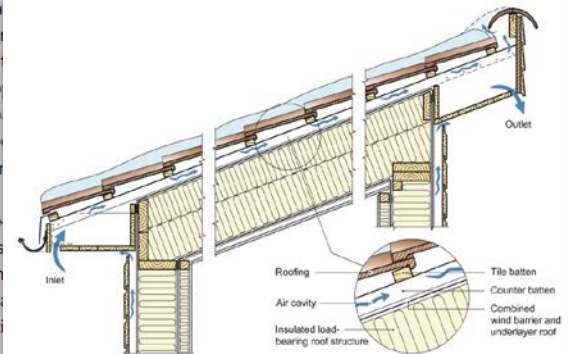
The use of wood as a climate-friendly material, is becoming more and more common, including in the construction of larger buildings. According to a new PhD thesis, the wooden roofs can be built both longer and with a lower slope than today's recommendations.

Damage to wooden roofs accounts to 20 per cent of all damage claims analysed by SINTEF Byggforsk. In his PhD Thesis Lars Gullbrekken has investigated what

– In compact
common causes
to damage in slo

The study is p
wooden roofs b
SINTEF «Byggfor

Wood is climate
Compared with s
more relevant m
and as an insulat



A ventilated gable roof structure with snow on the roof. The snow may reduce the air flow through the opening in the upper air cavity opening. The structure has the following build up from the cold face of the structure: roofing, ventilated air cavity, combined wind barrier and underlayer roof and an insulated load-bearing roof structure closed by the vapour barrier and the ceiling in the interior floor.

MORE LANDSLIDES - AND BETTER MEASURES FOR REDUCING RISK

More rainfall increases the risk of landslides and thus also the needs for effective landslide risk reduction measures. A new web-based platform recommends which mitigation measures are appropriate for different types of landslides.



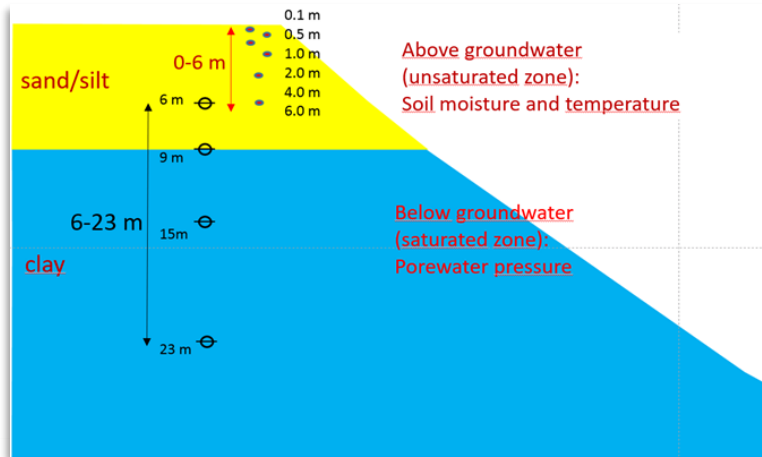
LARIMIT

An Expert-Based Landslide Mitigation Portal



Uzielli, M, Choi, J.C & Kalsnes, B: *A web-based landslide risk mitigation portal*. In M.Mikos et al. (eds): *Advancing culture of living with landslides, Volume 3 – Advances in landslide technology*, p. 431-438. Springer International Publishing AG 2017, DOI 10.1007/978-3-319-53487-9_50

Monitoring and early warning as a mitigation measure



Piciullo, L, Calvello, M & Cepeda, J.M: **Territorial early warning systems for rainfall-induced landslides.** *Earth-Science Reviews* 2018, Vol 179, p. 228-247;
 doi.org/10.1016/j.earscirev.2018.02.013 ISSN 0012-8252 (Published online 21 February 2018)

Heyerdal, H, Høydal, Ø.A, Kvistedal, Y, Gislås, K.G & Carotenuto, P: **Slope instrumentation and unsaturated stability evaluation for steep natural slope Close to Railway line.** UNSAT2018 - 7th International Conference on Unsaturated Soils. Hong Kong, 03-05.08.2018



Rainfall-triggered landslides in Almåskroken, 13.08.2013
 Photo: Ole Jergen Kjellmark taken from helicopter

Flood risk management in small catchments due climate and land use changes



PhD Candidate

Aynalem
Tasachew

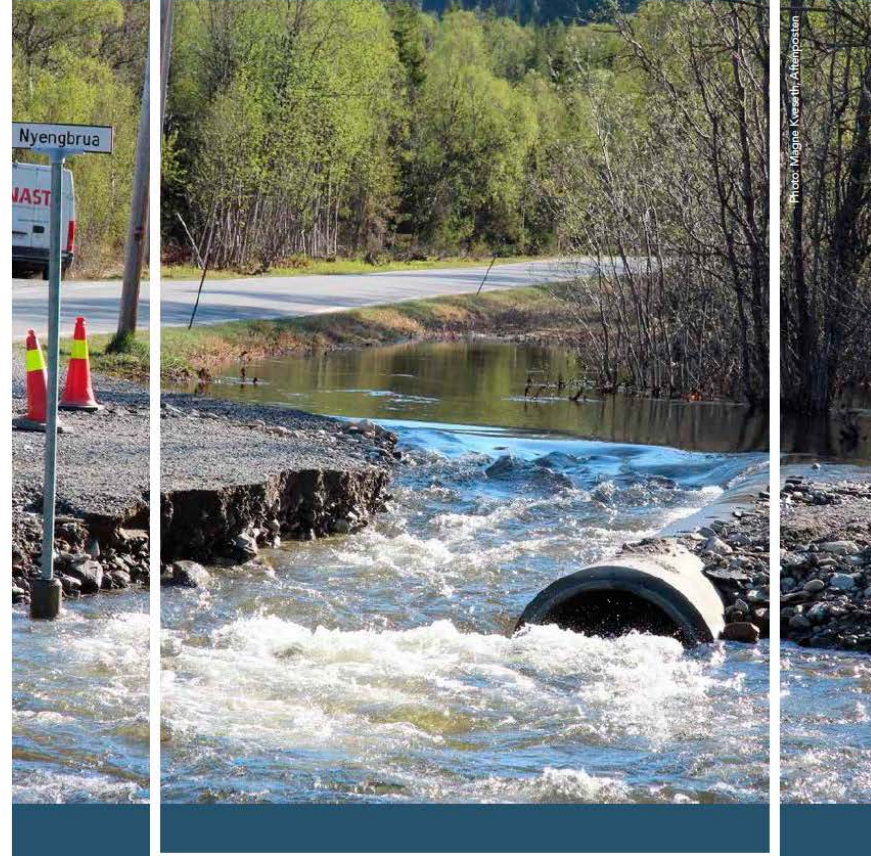
FLOODS ARE ONE OF THE MAJOR climate-related hazards and cause casualties and substantial damage on a global scale every year. Accurate and timely flood forecasting and design flood estimation for small catchments upstream of bridges and culverts are important to protect people and property. However, most of the small catchments are ungauged. The design flood, where the magnitude of the flood is associated with a return period, and hence a level of risk, is important in the planning, design and operation of hydraulic structures (e.g. bridges and culverts) and for protection.

CURRENTLY THE MOST used design flood estimation methods are based on stationarity assumption. However, there is a growing interest in continuous simulation method of flood estimation as an alternative to event-based and statistical frequency analysis methods. Climate and land use change could bring a change in the risk due to floods and stationarity assumption may be less valid when the flood potential at a location is changing along with the changing environment.

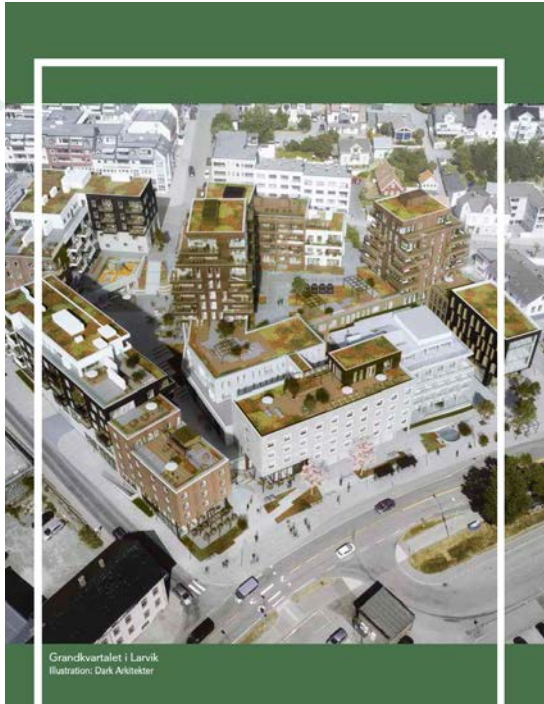
THE PHD RESEARCH work investigates and contributes an alternative method for design flood estimation for small (area < 50km²) ungauged rural catchments using continuous time rainfall-runoff modelling that could help in flood risk analysis and management. A

Tsegaw, A.T & Alfredsen, K: *Importance of dynamic river network in distance distribution dynamics hydrological model*. Proceedings to the XXX Nordic Hydrological Conference organised by the Norwegian Hydrological Council (NHR) and the Nordic Association for Hydrology (NHf), p. 114. Bergen, Norway 13.-15.08. ISBN: 978-82-410-1724-7

Municipal plans and building processes



Bluegreen and bluegrey infrastructure



Johannessen, B.G, Muthanna, T.M & Braskerud, B.C: **Detention and Retention Behavior of Four Extensive Green Roofs in Three Nordic Climate Zones.** *Water* 2018, Vol. 10(6), p. 671; doi: 10.3390/w10060671, ISSN 2073-4441 (Published online 23 May 2018)

Hamouz, V, Lohne, J, Wood, J.R & Muthanna, T.M: **Hydrological Performance of LECA-Based Roofs in Cold Climates.** *Water* 2018, Vol. 10(3), p. 263; doi:10.3390/w10030263, ISSN 2073-4441 (Published online 3 March 2018)

Andenæs, E, Kvande, T, Muthanna, T.M & Lohne, J: **Performance of Blue-Green Roofs in Cold Climates: A Scoping Review.** *Buildings* 2018, Vol. 8(4), p. 55; doi:10.3390/buildings8040055, ISSN 2075-5309 (Published online 10 April 2018)

Muthanna, T.M, Sivertsen, E, Kliewer, D & Jotta, L: **Coupling Field Observations and Geographical Information System (GIS)-Based Analysis for Improved Sustainable Urban Drainage Systems (SUDS) Performance.** *Sustainability* 2018, Vol. 10(12), p. 4683; doi.org/10.3390/su10124683, ISSN 2071-1050 (Published online 8 December 2018)

The insurance companies will share their loss data



Stormwater damages has increased from 18 000 in 2008 to

26 000 in 2016.

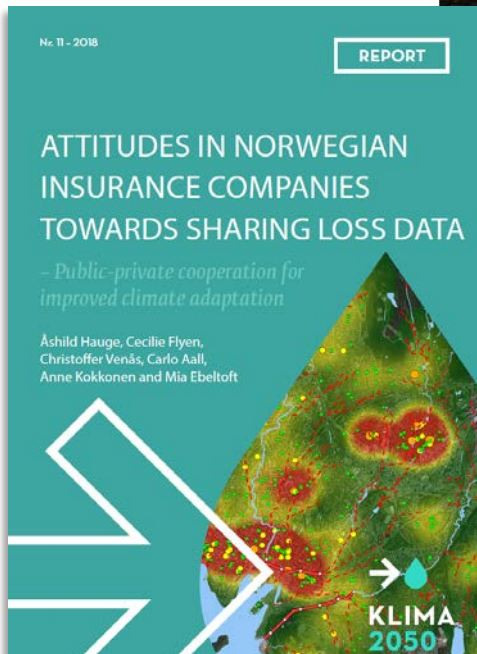


Idar Kreutzer
CEO of Finance
Norway



"It may be logical to think that the best solution would be to build a new database, but it would be too difficult because it requires everyone to change their way of working."

Nathalie Labonnote, SINTEF



No. 11 - 2018

REPORT

ATTITUDES IN NORWEGIAN INSURANCE COMPANIES TOWARDS SHARING LOSS DATA

Public-private cooperation for improved climate adaptation

Åshild Hauge, Cecilie Flyen,
Christoffer Venås, Carlo Aall,
Anne Kokkonen and Mia Ebeltoft

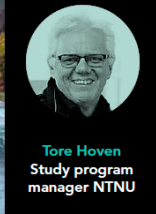
Gradeci, K, Labonnote, N, Sivertsen, E & Time, B: **The use of insurance data in the analysis of Surface Water Flood events – a systematic review**, *Journal of Hydrology* 2019, Vol 568, p. 194-206; doi:10.1016/j.jhydrol.2018.10.060, ISSN 1879-2707 (Published online 31 October 2018)

Labonnote, N, Hauge, Å.L & Sivertsen, E: **A climate services perspective on Norwegian stormwater-related databases**. *Climate Services* 2019, Vol. 13 p.33-41, doi.org/10.1016/j.cliser.2019.01.006 ISSN 2405-8807 (Published online 2 February 2019)



Photo: Shutterstock

Master thesis for Klima 2050



Tore Hoven
Study program
manager NTNU

The ambition was 50 students to write their master thesis in connection with Klima 2050 during the Centre's eight-year period. However, the goal has already been reached today.

– A win-win situation for both the students and Klima 2050, says Tore Hoven, study program manager at the NTNU program for Civil and Environmental Engineering, referring to the fact that so many postgraduate students want to write a master thesis within Klima 2050.

– The students get a great possibility to work on highly relevant issues and real research projects, while Klima 2050 gets relevant research of use for the Centre. They put a lot of work into it, continues Hoven.

Climate and particularly stormwater management very relevant

Hoven says that 90% of the students get offered a job even before they finish their studies. A thesis on climate has a high relevance in the job market today. This applies particularly to the many who choose to write about stormwater management, a topic that has become very popular among the master students.

– We have just hired someone who will work to ensure that postgraduate theses become more innovative. The experience they gain from developing innovative solutions in Klima 2050 is fully in line with our commitment, says Hoven.

Awarded master students:

2016

Mareike Anika Becker



awarded
Næringslivsringens award
for best master thesis in
building and environmental
technology.

2017

Fredrik Slapo

awarded
Næringslivsringens
award for
best master



thesis in building and
environmental technology.

2018

Thea Ingeborg Skrede

awarded the
RIF award
(Consulting
Engineers'
Association)



for this year's best master
thesis.



Master thesis reward to Thea Ingeborg Skrede, NTNU

The applicability of urban streets as floodways

Urban streets as floodways will require additional hydraulic performance and safety criteria. In her master thesis Thea identified and evaluated such criteria, and a method for evaluation of urban streets applicability as floodways is proposed. The method can be used to evaluate the applicability of multifunctional streets used as urban floodways and can be adapted by municipalities as a decision support tool for stormwater management.



Photo: Christian Sandstad