# Klima 2050 – Utvikling mot bærekraftig og robust overvannsinfrastruktur

Norsk Vann fagtreff, Gardermoen, 6. februar 2019

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(edvard.sivertsen@sintef.no)

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## CONSORTIUM

*Private sector*

SKANSKA
MESTERHUS
Multiconsult
Finans Norge
SKJÆVELAND GRUPPEN
NORGESHUS
Leca
isola
powel

*Public sector*

Statens vegvesen
Norges vassdrags- og energidirektorat NVE
AVINOR
Jernbane-direktoratet
STATSBYGG
TRONDHEIM KOMMUNE

*Research & education*

SINTEF
BI
NTNU
Meteorologisk institutt
NGI

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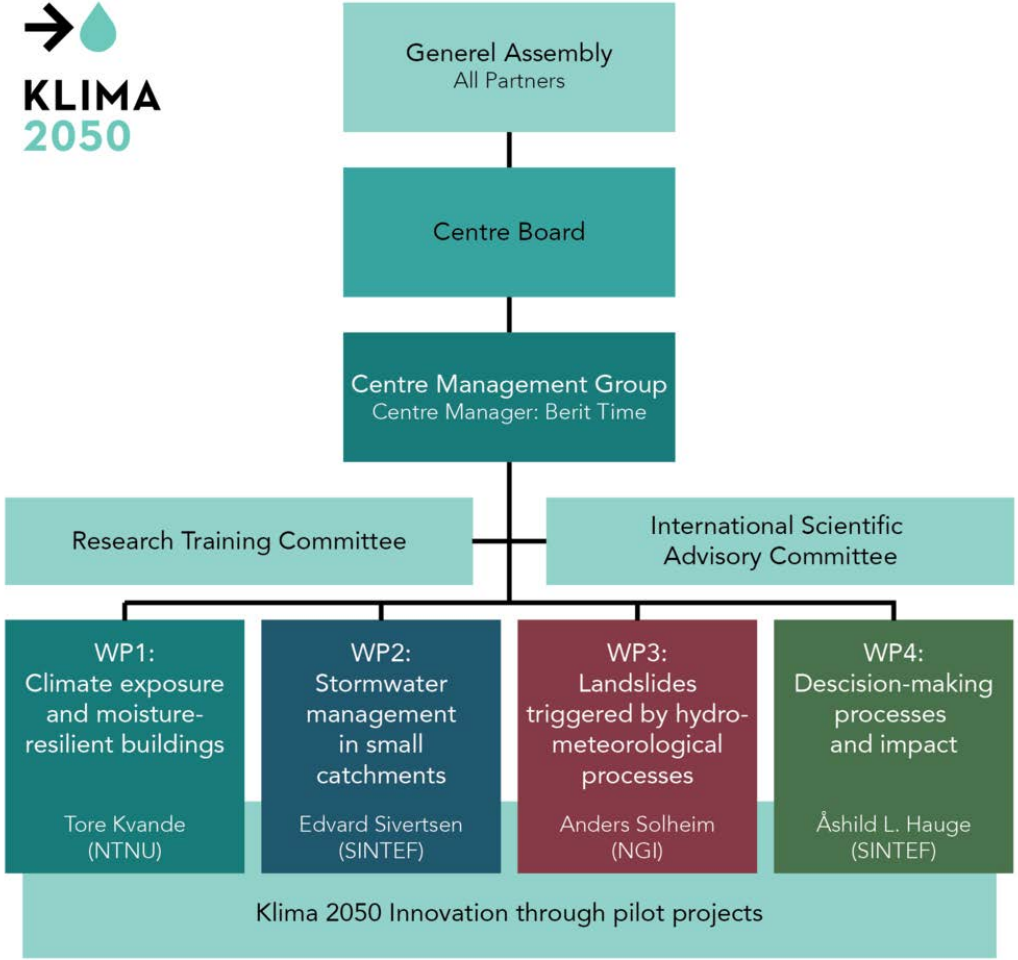


sfi = Senter for forskningsdrevet innovasjon
Norges forskningsråd

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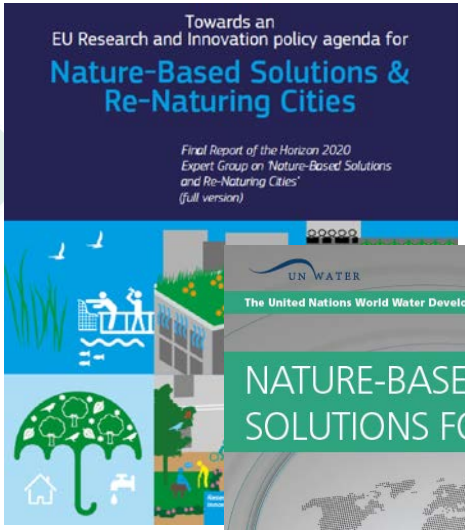
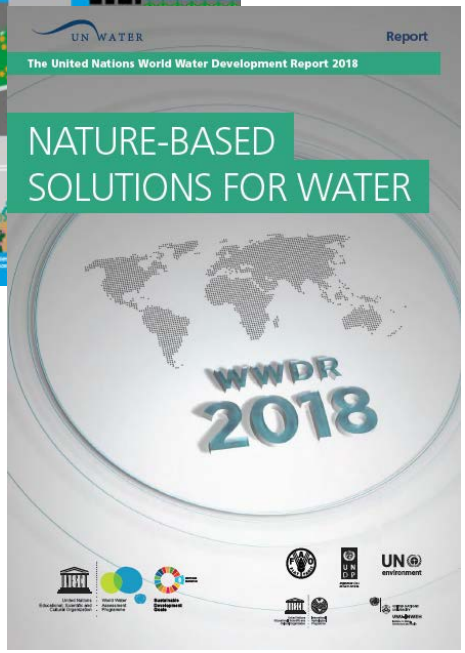

Towards an
EU Research and Innovation policy agenda for
Nature-Based Solutions &
Re-Naturing Cities
Final Report of the Horizon 2020
Expert Group on 'Nature-Based Solutions
and Re-Naturing Cities'
(full version)


UN WATER
Report
The United Nations World Water Development Report 2018
NATURE-BASED
SOLUTIONS FOR WATER
WWDR
2018
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environment


Norsk Vann
Rapport
162 | 2008
Veiledning i klimatilpasset
overvannshåndtering
NOU
Norges offentlige utredninger 2015: 16
Overvann i byer og
tettsteder
Som problem og ressurs
MENON ECONOMICS
NINA
Norsk institutt for naturforskning
SWECO
RAPPORT
NATURBASERTE LØSNINGER FOR
KLIMATILPASNING
MENON-PUBLIKASJON NR. 61/2017
M-830|2017

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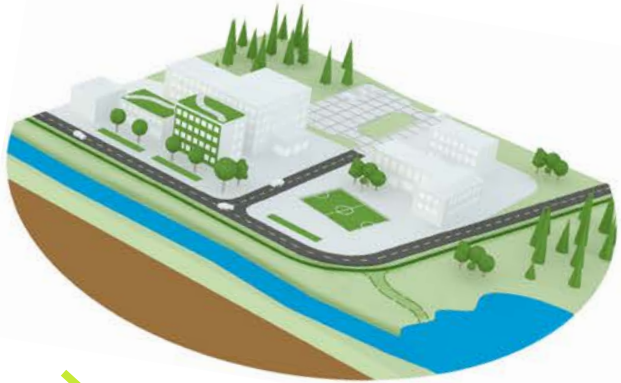
# Statlige planretningslinjer for klima- og energiplanlegging og klimatilpasning (Vedtatt 28.09.2018)

Arealer som vurderes tatt i bruk til utbyggingsformål i kommune- og reguleringsplaner kan være utsatt for farer, som for eksempel flom og skred. Utbygging kan også øke påkjenningen for nedenforliggende arealer. For å kunne forebygge tap av liv, helse, kritisk infrastruktur og andre materielle verdier er det nødvendig at det, gjennom risiko- og sårbarhetsanalyser tidlig i planprosessen, vurderes om klimaendringer gir et endret risiko- og sårbarhetsbilde.

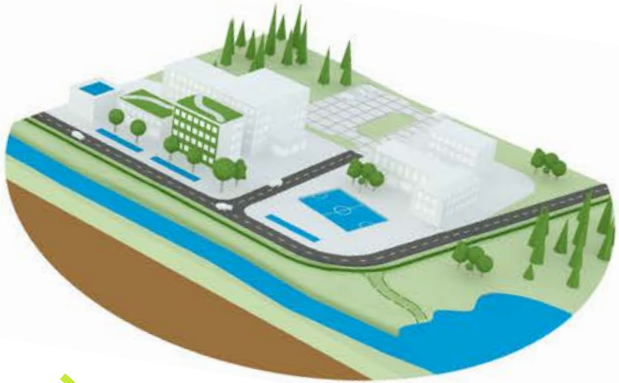
Ved planlegging av nye områder for utbygging, fortetting eller transformasjon, skal det vurderes hvordan hensynet til et endret klima kan ivaretas. Det bør legges vekt på gode helhetlige løsninger og ivaretakelse av økosystemer og arealbruk med betydning for klimatilpasning, som også kan bidra til økt kvalitet i uteområder. Planer skal ta hensyn til behovet for åpne vannveier, overordnede blågrønne strukturer, og forsvarlig overvannshåndtering.

Bevaring, restaurering eller etablering av naturbaserte løsninger (slik som eksisterende våtmarker og naturlige bekker eller nye grønne tak og vegger, kunstige bekker og basseng mv.) bør vurderes. Dersom andre løsninger velges, skal det begrunnes hvorfor naturbaserte løsninger er valgt bort.

# Treleddsstrategien



Infiltrere



Fordrøye

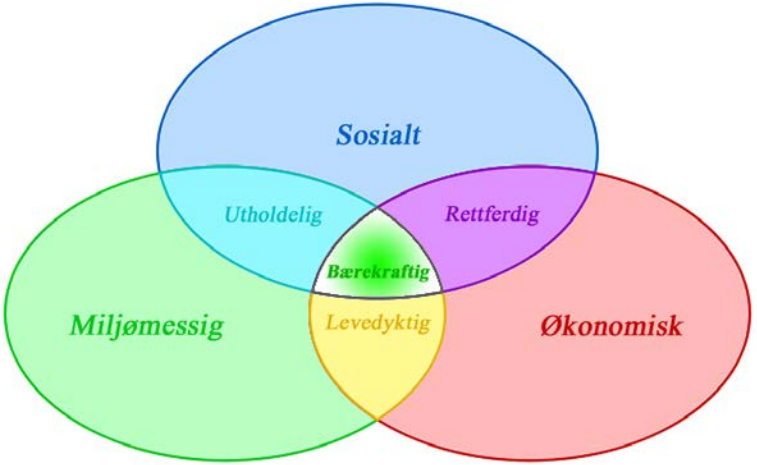
Sikker flomveg

# Helhetlig vurdering av bærekraft

- Mange faktorer som påvirker
  - Generelle som befolkningsvekst, klimaendringer, økonomiske utsikter
  - Områdespesifikke
  - Institusjonelle forhold
- Valg av tiltak bør baseres på en helhetlig vurdering
- Flere dimensjoner og kriterier:
  - Et tiltak skal være sosialt, økonomisk og miljømessig bærekraftig
  - Iht. TRUST (EU-prosjekt) skal også infrastruktur og styring med i vurderingen
  - Måles ved hjelp av indikatorer

Helness et al. (2018)

# Bærekraft og ulike dimensjoner



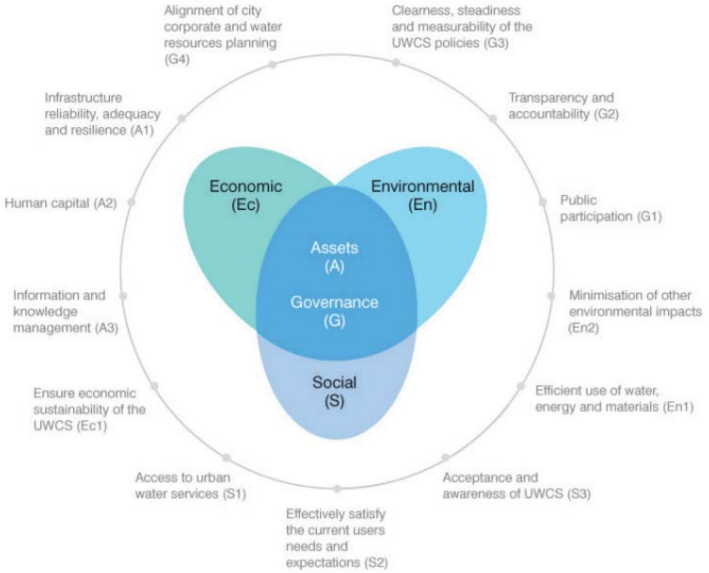




*Figure 1 – TRUST approach to sustainability assessment*

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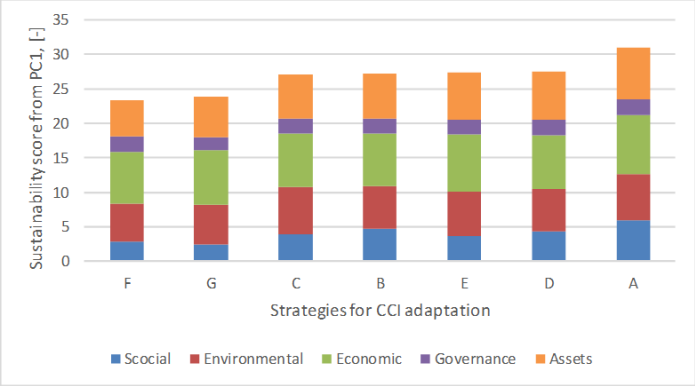
SINTEF-utviklet metodikk for helhetlig vurdering av bærekraft

Klima 2050-utviklede løsninger vil bli brukt som case i nytt JPI Water prosjekt koordinert av SINTEF (EviBAN)




**Efficient 2019,** Manila 16. januar 2019

**Principal Component Analysis for Decision Support in Integrated Water Management**

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**Keywords:** PCA; Integrated Water Management; Sustainability

**Introduction**

The purpose of the work presented here was to develop a general methodology for holistic sustainability assessment in integrated water management, suitable in a range of cases from assessments at the strategic level to detailed assessment of technological solutions.

Aquatic ecosystems worldwide are subjected to multiple pressures from agricultural intensification, pollution from industry and transport, and urban development. These pressures cause hydro-morphological, chemical and biological changes resulting in non-compliance with the objectives set out in *e.g.* the EU Water Framework Directive (WFD). In water-scarce areas this is aggravated when flow is reduced below the required ecological flow. Anthropogenic pollution, expansion of urban areas and poor farming practices cause degrading soil quality and increased water stress in many of the world's important food producing areas. The resulting decrease in the availability of arable land requires intensified agricultural production to feed a growing global population (Alexandratos *et al.*, 2012). Climate change will exacerbate these pressures by changing rainfall patterns and temperature regimes (IPCC, 2014). In urban areas, intense precipitation will create more run-off volumes exceeding the capacities of urban sewerage systems, which may cause water quality problems in receiving water bodies. Overexploitation of aquifers could also be accentuated because of changing precipitation patterns, especially in already water scarce areas. These multiple pressures, threatening achievement of the United Nation Sustainable Development Goals (SDGs) (UN, 2016) will in addition be affected by political and cultural changes. Increasing knowledge of the magnitude and complex interaction between these multiple pressures has created a call for integrated approaches in water management (UN Water, 2016). To ensure progress towards SDGs, however, a methodology for holistic evaluation of the sustainability of alternative mitigation and adaptation measures is needed.

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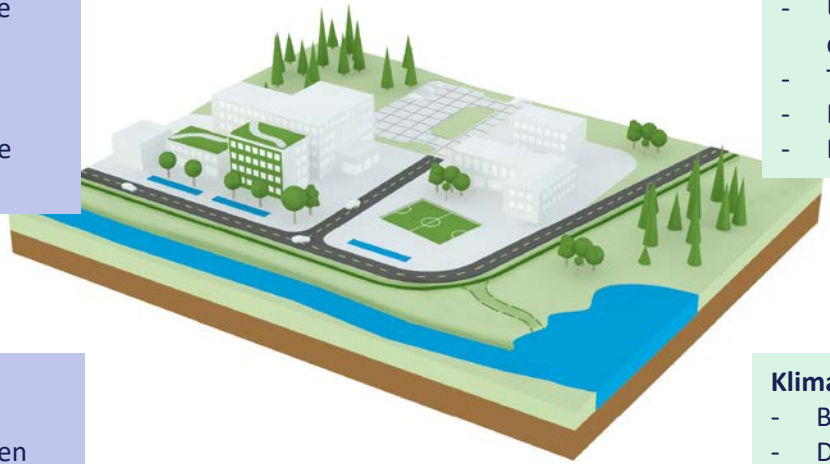
# Blågrønne og blågrå løsninger for overvannshåndtering

**Teknisk funksjonalitet**:
- Dokumentere funksjon under reelle forhold
- Forstå og modellere transportmekanismer
- Forstå og modeller effekten av flere løsninger satt sammen



**Praktisk implementering:**
- Utvikle design- og dimensjoneringskriterier
- Ta nye løsninger i bruk
- Drift og vedlikehold
- Informasjon og kunnskapsspredning

**Klima 2050**:
- Phd-prosjekt Vladimir Hamouz
- Phd-prosjekt Birgitte G. Johannessen
- Phd-prosjekt Erlend Andenæs (risiko)
- Phd-prosjekt ny utlysning er ute nå
- Tilknyttede masteroppgaver

**Klima 2050**:
- Praktiske designkriterier og modeller for dimensjonering og prosjektering
- Drift og vedlikeholdsanbefalinger

**Klima 2050**:
- Beslutningsstøtteverktøy v1.0
- Datastruktur og drift/vedlikehold for NBS
- Praktisk uttesting under reelle forhold – innovasjon gjennom pilotprosjekter
- Ovase.no

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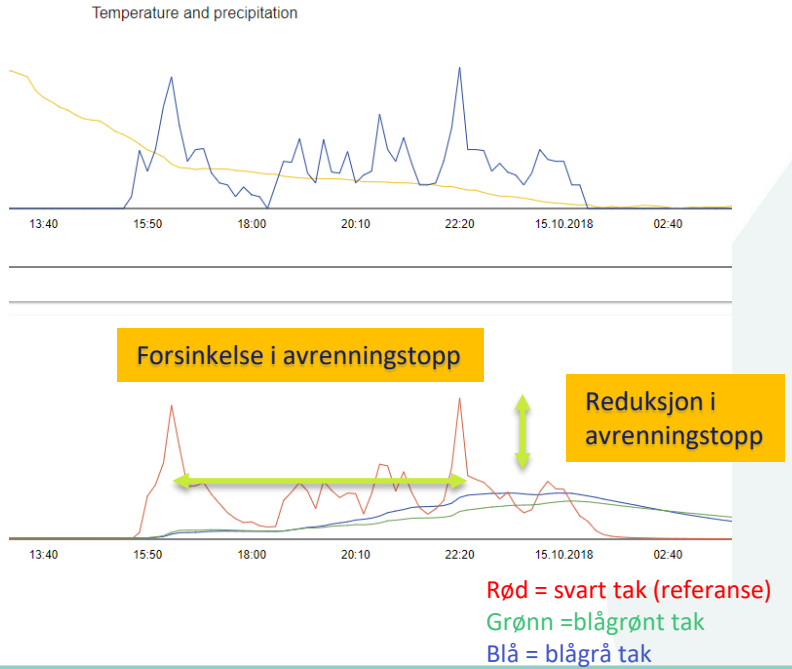
# Blågrønne og blågrå tak – Høvringen testfelt




Rød = svart tak (referanse)
Grønn =blågrønt tak
Blå = blågrå tak

Foto: Klima 2050

http://www.klima2050.no/hovringen-data

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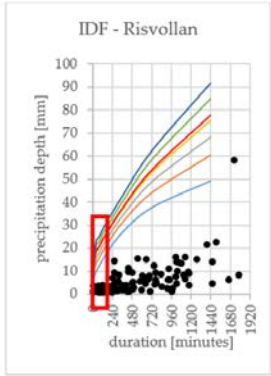
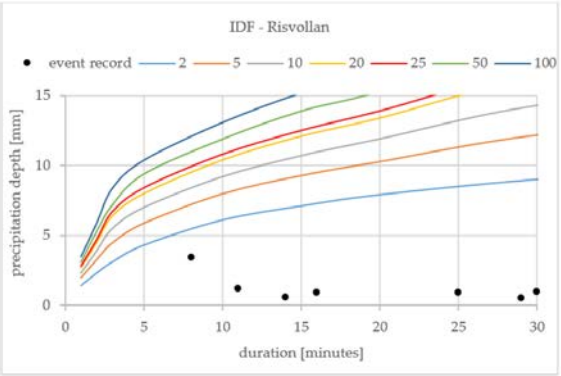
# Blågrønne og blågrå tak – Høvringen testfelt

Foto: Vladimir Hamouz




Hamouz et al. (2018)

Sprinkleranlegg muliggjør testing av ekstremvær

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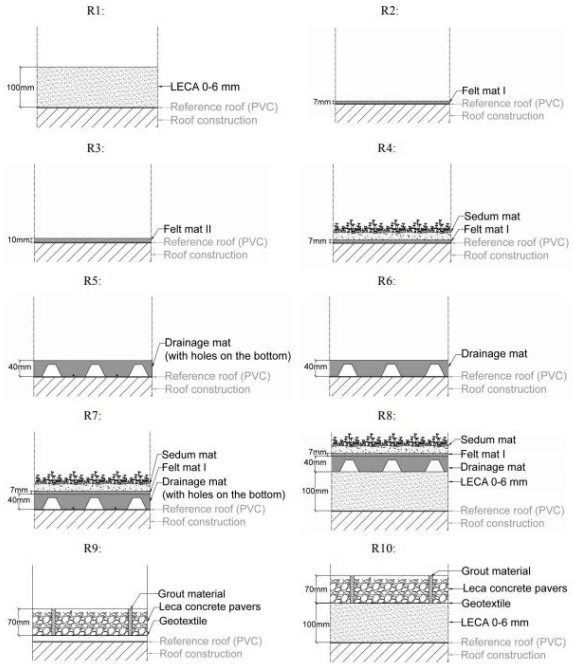
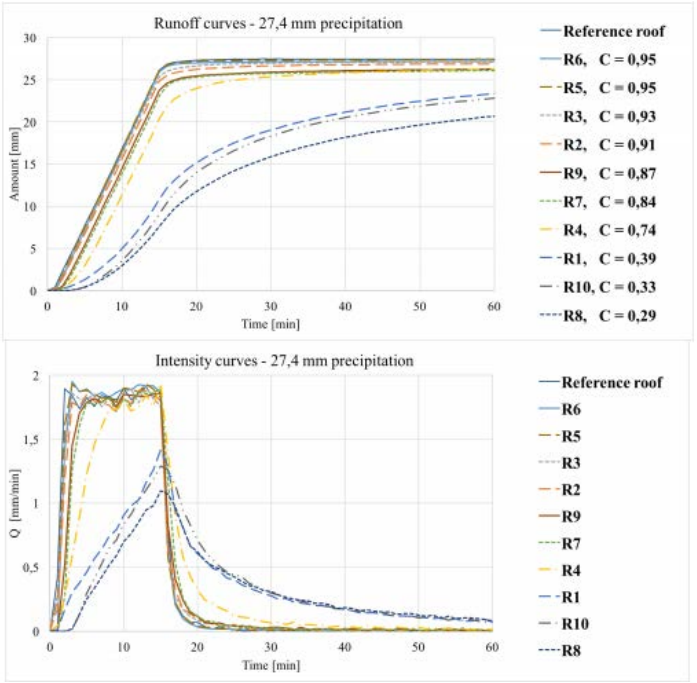
# Blågrønne og blågrå tak – bidrag fra enkeltkomponenter




Testes i standardiserte laboratorietester

Schärer (2018)

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water

MDPI

*Article*

## Detention and Retention Behavior of Four Extensive Green Roofs in Three Nordic Climate Zones

**Birgitte Gisvold Johannessen [1,*], Tone Merete Muthanna [1] and Bent Christen Braskerud [2]**

[1] Department of Civil and Environmental Engineering, Norwegian University of Science and Technology (NTNU), N-7491 Trondheim, Norway; tone.muthanna@ntnu.no
[2] Department of Water and Wastewater, The City of Oslo, N-0506 Oslo, Norway; bent.braskerud@vav.oslo.kommune.no
* Correspondence: birgitt

Received: 26 April 2018; Acc

**Abstract:** Climate change both for retrofitting and while managing stormw detention performance ba typical cold and wet Nord Accumulated retention w The performance was four material storage capacities than 5 mm are given and compared to the precipita The event-based approach the precipitation in the stu on the observed time series green roofs and to be usef

water

MDPI

*Article*

## Hydrological Performance of LECA-Based Roofs in Cold Climates

**Vladimír Hamouz [1,*], Jardar Lohne [1], Jaran R. Wood [2] and Tone M. Muthanna [1]**

[1] Department of Civil and Environmental Engineering, Norwegian University of Science and Technology, 7491 Trondheim, Norway; jardar.lohne@ntnu.no (J.L.); tone.muthanna@ntnu.no (T.M.M.)
[2] Leca International, Årnesvegen 1, 2009 Nordby, Norway; Jaran.Wood@Leca.no
* Correspondence: vladimir.hamouz@ntnu.no; Tel.: +47-410-70-318

Received: 15 December 2017; Accepted: 28 February 2018; Published: 3 March 2018

**Abstract:** Rooftops represent a considerable part of the impervious fractions of urban environments. Detaining and retaining runoff from vegetated rooftops can be a significant contribution to reducing the effects of urbanization, with respect to increased runoff peaks and volumes from precipitation events. However, in climates with limited evapotranspiration, a non-vegetated system is a convenient option for stormwater management. A LECA (lightweight expanded clay aggregate)-based roof system was established in the coastal area of Trondheim, Norway in 2016. The roof structure consists of a 200 mm-thick layer of LECA® lightweight aggregate, covered by a concrete pavement. The retention in the LECA-based roof was estimated at 9%, which would be equivalent to 0.27 mm/day for the entire period. The LECA-based configuration provided a detention performance for a peak runoff reduction of 95% (median) and for a peak delay of 1 h and 15 min (median), respectively. The relatively high moisture levels in the LECA-based roof did not affect the detention performance. Rooftop retrofitting as a form of source control may contribute to a change in runoff characteristics from conventional roofs. This study of the LECA-based roof configuration presents data and performance indicators for stormwater urban planners with regard to water detention capability.


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Tester blågrønne tak i full skala

Norges største prosjekt for overvannshåndtering

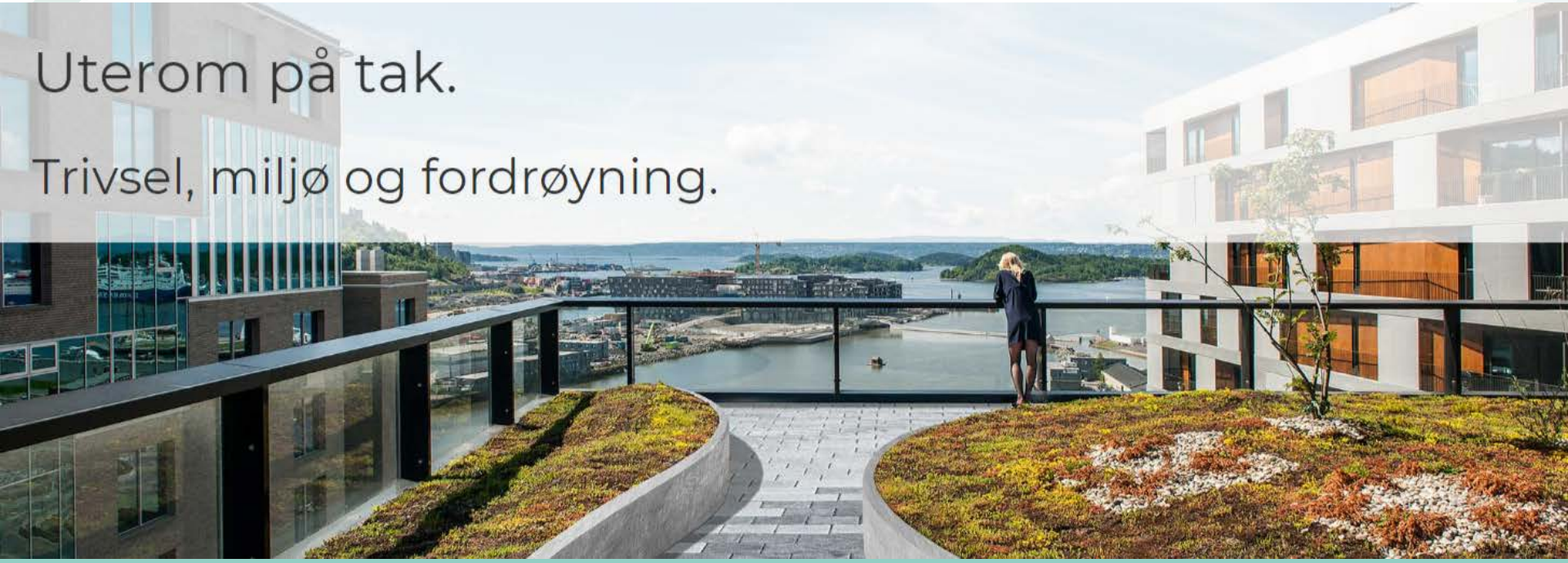
NTNU
Norwegian University of Science and Technology

Comparing experimentally measured runoff coefficients with field observations for detention-based roofs

Lotte Askeland Schärer

KLIMA2050

# www.urbaneuterom.no

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# Beslutningsstøtteverktøy for naturbaserte løsninger

## Slik finner man de beste stedene for infiltrasjon av overvann

*Regnbed, grønne grøfter og permeable dekker er viktige elementer i overvannshåndteringen i byer, men de må plasseres på steder med tilstrekkelig infiltrasjonskapasitet. Forskere ved SINTEF og NTNU foreslår en ny metode for å velge riktig plassering.*

**Kontaktpersoner: Edvard Sivertsen** (SINTEF), **Tone Muthanna** (NTNU)

*sustainability*

MDPI

*Article*

## Coupling Field Observations and Geographical Information System (GIS)-Based Analysis for Improved Sustainable Urban Drainage Systems (SUDS) Performance

**Tone M. Muthanna [1,*], Edvard Sivertsen [2], Dennis Kliewer [2] and Lensa Jotta [1]**

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[2] SINTEF Building and Infrastructure, 7465 Trondheim, Norway; edvard.sivertsen@sintef.no (E.S.); d.kliewer@fh-muenster.de (D.K.)

* Correspondence: tone.muthanna@ntnu.no; Tel.: +47-9518-6817

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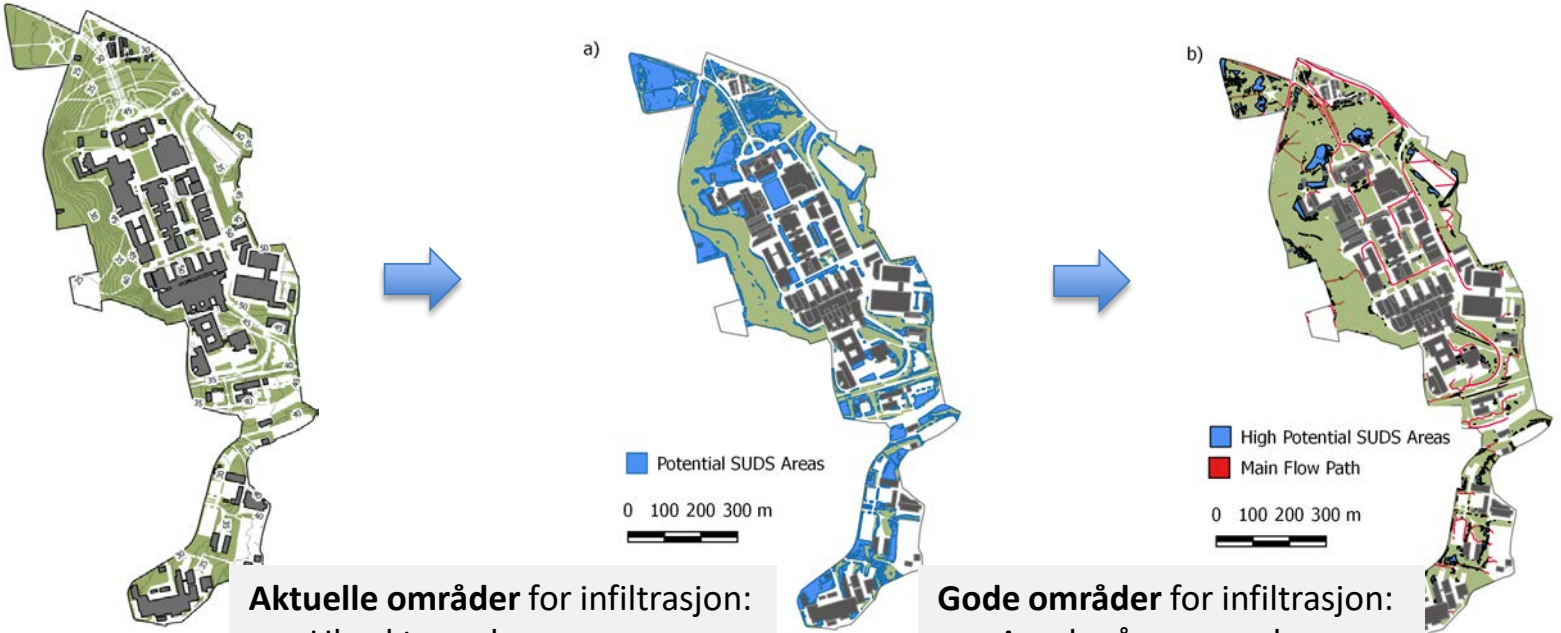
check for updates

**Abstract:** Urbanization and increased precipitation volumes and intensities due to climate change add pressure to the urban drainage system, resulting in increased flooding frequencies of urban areas and deteriorating water quality in receiving waters. Infiltration practices and the use of blue green infrastructure, also called Sustainable Urban Drainage Systems (SUDS), can limit, and, in some cases, reverse the effects of urbanization. However, adequate infiltration capacity is an essential parameter for the successful implementation. In this paper, a Geographical Information System (GIS)-based hydrology analysis for SUDS placements is coupled with field measurements using Modified Phillip Dunne infiltrometer tests. The case study area is the expansion of the campus at the Norwegian University of Science and Technology (NTNU) over the next decade. Infiltration in urban soils can be highly heterogenous over short distances. When comparing measured infiltration rates with physical characteristics of the soils showed that the physical characteristics are not a good indication

# Beslutningsstøtteverktøy for naturbaserte løsninger II

1. Detect NBS Areas
2. Identify Soil Conditions
3. Apply Construction Conditions
4. Select Possible NBS Solutions
5. Determine Possible Impact Reduction
6. Give Decision Support for NBS

# Beslutningsstøtteverktøy for naturbaserte løsninger III

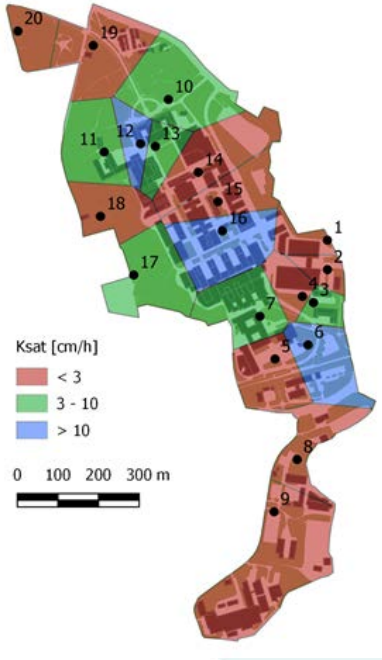



**Aktuelle områder** for infiltrasjon:
- Ubrukt areal
- Helning < 10 %

**Gode områder** for infiltrasjon:
- Areal må være ved og lavere enn vannvei

# Beslutningsstøtteverktøy for naturbaserte løsninger IV

Feltundersøkelser:
- Infiltrasjonspotensial (Ksat-verdier)
- Karakterisering av jordsmonn



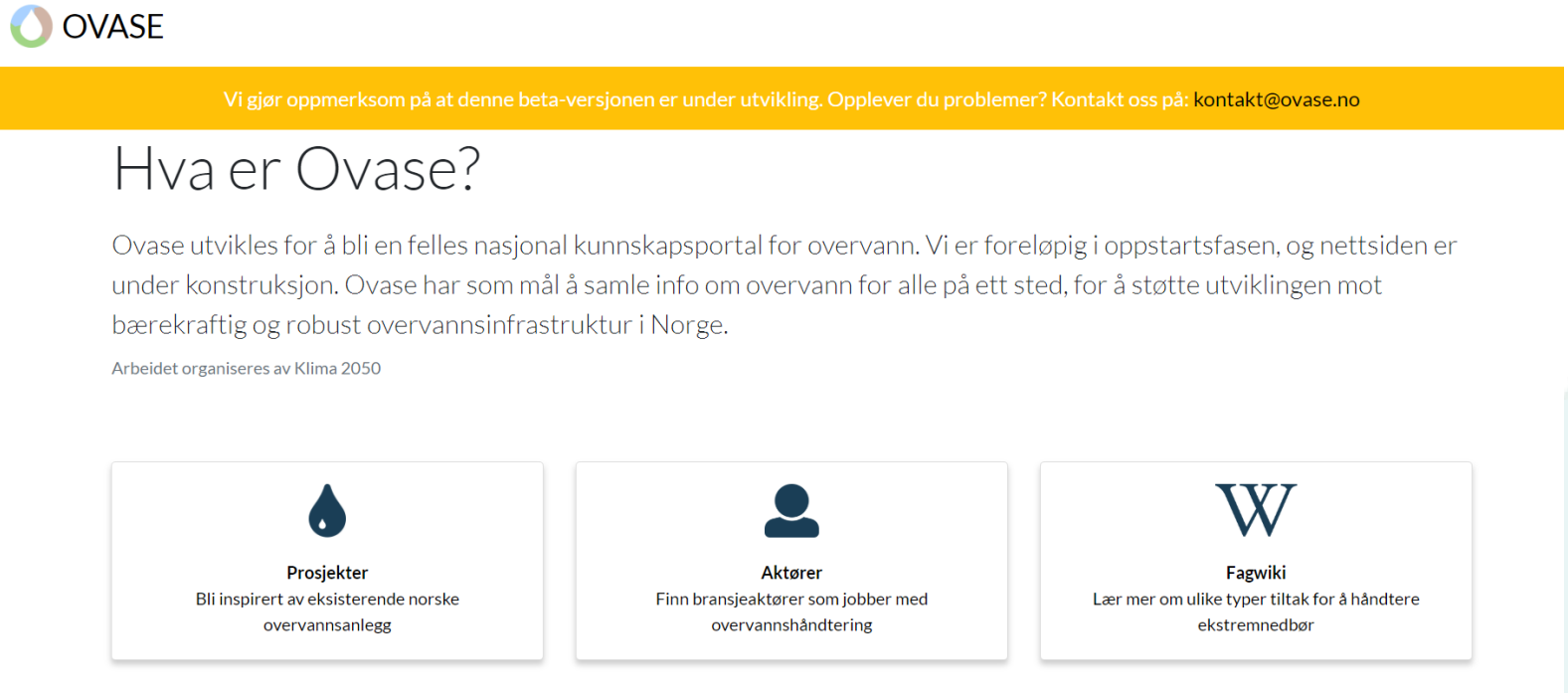
# Pilotprosjekt


Foto: Per Møller-Pedersen

# Pilotprosjekt


Illustrasjon: Agraff AS/ Visualis

# Pilotprosjekt

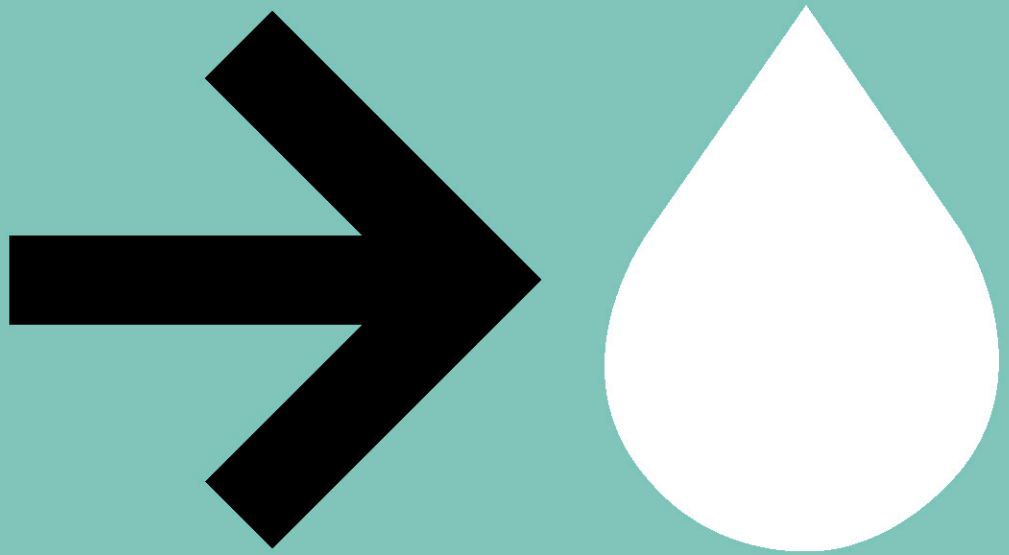


# Frost i grunne overvannsystemer

Masteroppgave våren 2019

Ønsker kontakt med personer som har erfaring med grunne overvannssystemer og frost

Foto: Asbjørn Rafdal



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