ANNUAL REPORT 2016

KLIMA 2050

ORGANIZATION

Grethe Bergly
Multiconsult

REFLECTIONS
FOR THE FUTURE

Klima 2050 will develop solutions for tomorrow in areas which will have great impact on society and the building, construction and transport industry.

The Centre Klima 2050 has an active and dedicated Board lead by Grethe Bergly, Multiconsult. She highlights the central role of the building and transportation sector in adapting the built environment and infrastructure to the future climate changes. Climate adaption requires that we actively search for new knowledge and skills in how society, technology, organizations and people interact to achieve the good solutions for the future.

– The success factor for climate adaptation and risk reduction may be found in the acknowledgement that tomorrow's solutions is not necessarily found in the present solutions and way of working, says Bergly.

CLIMATE CHANGES AFFECT US

Society therefore has to cope with future negative effects of climate change. Scenarios for climate change in Norway indicate an increased occurrence of extreme weather. Together with a warmer climate, intense precipitation over parts of Norway will also increase. We must prepare for increased precipitation with subsequent increased strain on drainage systems, more water damage to buildings, several landslides and more flooding.

Unfortunately, the built environment is particularly vulnerable to climate change. Changes in climate will enhance the need for maintenance and the renewal of robust key societal infrastructure. New knowledge, methods and tools for implementing solutions is of outmost importance for a safe, sustainable and cost-effective development of the Norwegian society.
Klima 2050 - Risk reduction through climate adaptation of buildings and infrastructure is a Centre for Research-based Innovation (SFI) financed by the Research Council of Norway and the consortium partners. The SFI status enables long-term research in close collaboration with private and public sector, as well as other research partners aiming to strengthen Norway's innovation ability and competitiveness within climate adaptation. The composition of the consortium is vital in order to being able to reduce the societal risks associated with climate change.

The Centre will strengthen companies' innovation capacity through a focus on long-term research. It is also a clear objective to facilitate close cooperation between R&D-performing companies and prominent research groups.

«The Intergovernmental Panel on Climate Change concluded that most of the global warming observed over the last 50 years is attributable to human activities, and that anthropogenic climate change is likely to persist for centuries to come»

Hanne Rønneberg, SINTEF

Photo: iStock

VISION

The Centre for Research-based Innovation Klima 2050 shall be synonymous with excellence within risk reduction through climate adaptation of buildings and infrastructure exposed to enhanced precipitation and flood water. Klima 2050 shall be an effective instrument for the development and implementation of adaptive innovations for the Centre partners and society.

MAIN GOAL

Klima 2050 will reduce the societal risks associated with climate changes and enhanced precipitation and flood water exposure within the built environment. Emphasis will be placed on development of moisture-resilient buildings, stormwater management, blue-green solutions, measures for prevention of water-triggered landslides, socio-economic incentives and decision-making processes. Both extreme weather and gradual changes in the climate will be addressed.

The Centre will be recognised for its research training within the field of climate adaptation of the built environment. Through education of graduate students, training of highly qualified research personnel through PhDs and training of professionals in the sector, the Centre will stimulate new solutions and further research and development in the building, construction and transportation (BCT) sector long after the term of the Centre's existence.

«Both extreme weather and gradual changes in the climate are addressed»

Berit Time, SINTEF

Photo: Ilja Hendel, Scanpix

THE RESEARCH IS DIVIDED INTO FOUR MAIN AREAS:

WP1 Climate exposure and moisture-resilient buildings
WP2 Stormwater management in small catchments
WP3 Landslides triggered by hydro-meteorological processes
WP4 Decision-making processes and impact

THE PARTNERS / CONSORTIUM

The user partners represent important parts of Norwegian building industry; consultants, entrepreneurs, property developers, producers of construction materials and authorities. Three partners joined the consortium in 2016, and the value chain within Klima 2050's fields of research is complete.

The host institution for SFI Klima 2050 is SINTEF, and the Centre is directed in cooperation with NTNU. BI Norwegian Business School, Norwegian Geotechnical Institute (NGI) and Norwegian Meteorological Institute (MET Norway) are research partners.

Photo: Johannes Jansson, norden.org

CONSORTIUM

Private sector

SKANSKA

MESTERHUS

Multiconsult

Finans Norge

SKJÆVELAND GRUPPEN

NORGESHUS

weber SAINT-GOBAIN

isola

powel

Public sector

Statens vegvesen

Noregs vassdrags- og energidirektorat

NVE

AVINOR

Jernbaneverket

STATSBYGG

TRONDHEIM KOMMUNE

Research & education

SINTEF

BI

NTNU

Meteorologisk institutt

NGI

THE ORGANIZATION

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CENTRE MANAGEMENT

Berit Time, chief scientist at SINTEF, Centre Director

Tore Kvande, professor at NTNU, Principal Investigator (WP1)

Edvard Sivertsen, senior research scientist SINTEF (WP2)

José Cepeda, senior advisor at NGI (WP3)

Bjørn Kalsnes, senior engineer at NGI (WP3)

Åshild L. Hauge, senior research scientist SINTEF (WP4)

Lena Bygballe, associate professor at BI Norwegian Business School (WP4, IA)

Anders-Johan Almås, senior research scientist SINTEF (IA)

Randi I. Henriksen, administrative coordinator at SINTEF (adm)

CENTRE BOARD

Grethe Bergly, Multiconsult (Chairwoman)

Anne Britt Leifseth, NVE

Håvard Zachariassen, Statsbygg

Marit Brandtsegg, Statens vegvesen

Dag Runar Båtvik, Norgeshus

Rune Stene, Skanska

Anders Solheim, NGI

Carl Thodesen, NTNU

Hanne Rønneberg, SINTEF

Svein Erik Moen, The Research Council of Norway (observer)

Chairman of General Assembly: **Kim Robert Lisø**, Skanska

THE ORGANIZATION

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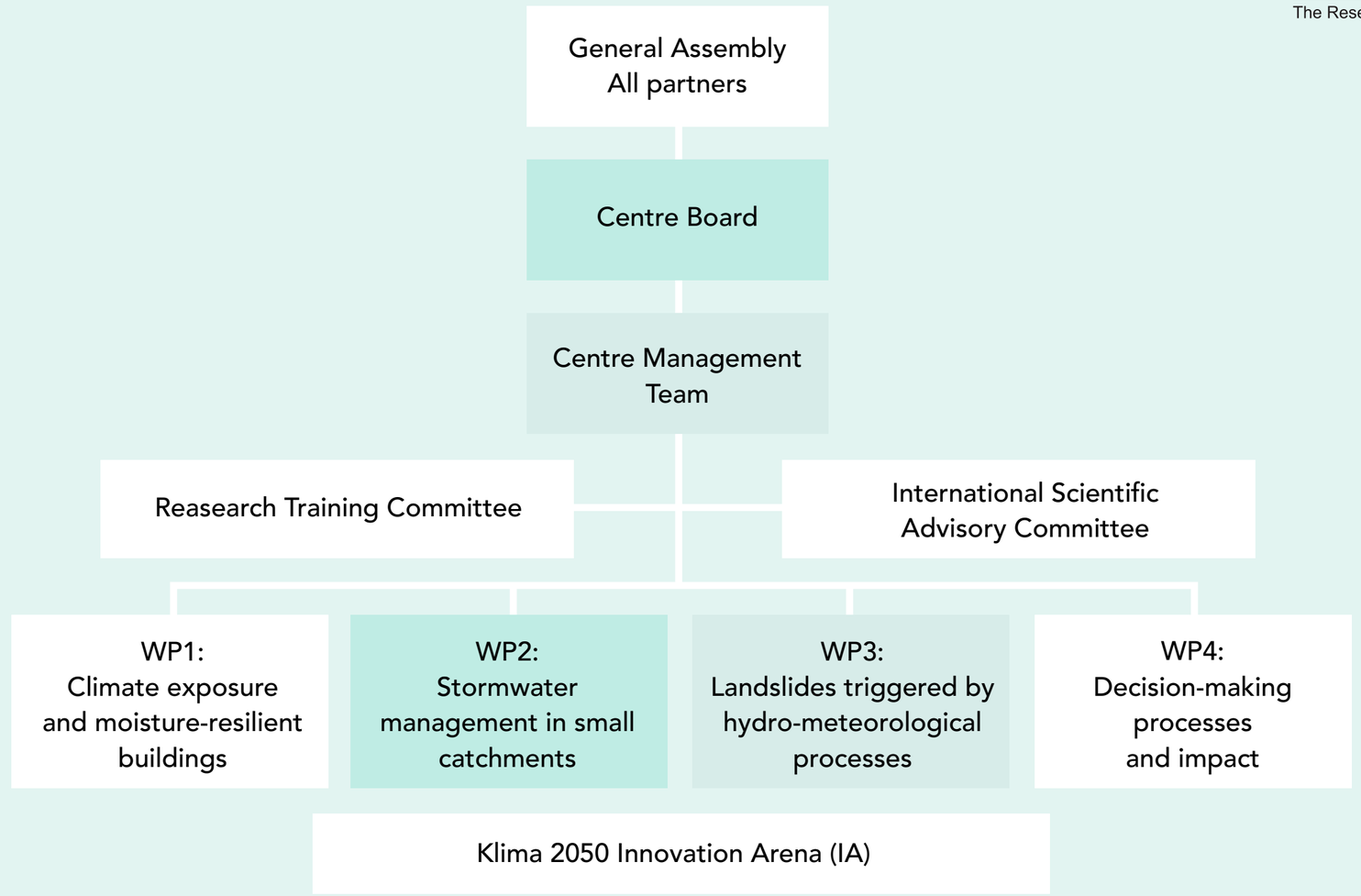
sfi Centre for Research-based Innovation
The Research Council of Norway



RESEARCHER TRAINING

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– A priority for Klima 2050 is the education and training of highly qualified research personnel, says Ragnhild Kvålshaugen, BI.

This will be accomplished through education of a number of Ph.D. candidates, improved and intensified graduate and undergraduate education at NTNU and BI, and the establishment of a new adjunct professorship, promoted by the industry, in climate adaptation of buildings and infrastructure at the Faculty of Engineering Science and Technology – NTNU. In addition, extensive competence enhancement will take place through the R&D activities, conferences, seminars and thematic meetings inside the Centre and in collaboration with external partners.

The activity concerning researcher training focus three main areas;
1. publication activity,
2. Ph.D.-gatherings, and
3. the ambition to include the industry and public partners of the Centre into the research activity through the work of the Ph.D.'s.

The fist Ph.D.-gathering took place in Stokkøya in October, 2016, and the team is established.

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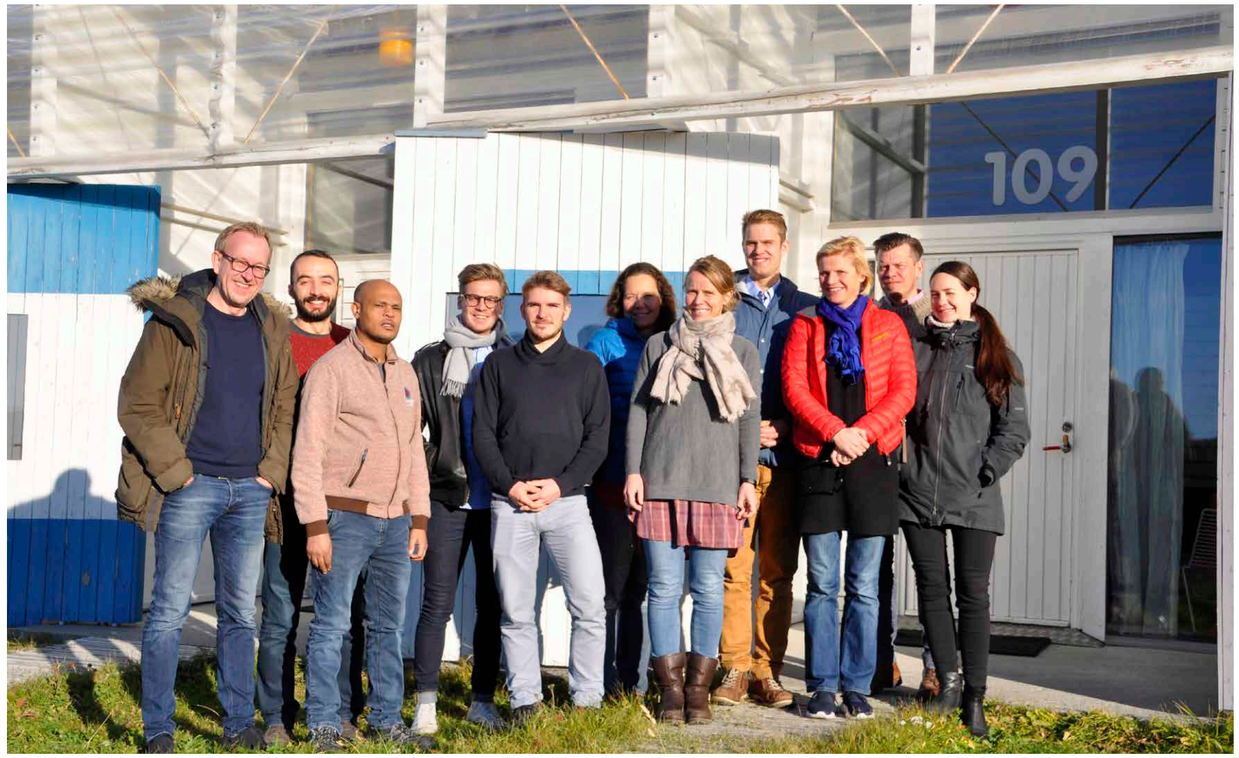

INTERNATIONAL COLLABORATORS

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International collaboration is one of the success criteria for SFI centres defined by the Research Council of Norway.

One example of Klima 2050s international cooperation is with Chalmers University of Technology on the project "Storm water flooding in urban areas: risk mitigation by utilizing roofs as storm water buffers". Another example is the contact with VTT in Finland: Mutual visits have led to cooperation on stormwater management and possible exchange of master students. Finally, two post.doc researchers from University of Rome and University of Salerno have stayed at NGI in 2016. The cooperation is linked to the work on an event based inventory for landslides triggered by water.

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The International Scientific Advisory Committee designated to give advices related to the research and the overall progress and achievement of the Centre. Photo (from the left) Kristina Mjörnell, Hallie Eakin, Rafaela Matos and Thomas Glade.

Klima 2050 has tested a new filter material and examined how effectively filter removes chemicals used at airports. Hopefully the filter can also clean the stormwater from roads. Key players in the development are Saint-Gobain Weber, Avinor and Statens vegvesen.

Reduction of landslide risk can be achieved using a wide range of mitigation measures that have to be technically suitable and socio-economically feasible. Klima 2050 is preparing a web portal as a tool for assisting NVE, Multiconsult and others in decision making.

A barrier to implement climate adaptation in local planning is lack of collaboration within the municipality and between municipalities. Trondheim municipality has taken a leading role in the region by assisting neighbouring municipalities, which do not participate in networks and centres like Klima 2050.

Together with Norgeshus and Isola we are developing a pilot project with the use of a smart vapour barrier to increase robustness in compact wooden roofs. The solution gives reduced material use and a more efficient construction process, which gives economic benefits.

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WHY KLIMA 2050 IS IMPORTANT

Photo: Scanpix

THE INSURANCE INDUSTRY LIVING WITH CLIMATE CHANGE

Director of insurance at Finans Norge, Geir Trulserud, hopes that Klima 2050 will come up with many good solutions to reduce the risk and damage to buldings caused by climate change.

– The insurance industry has been working with climate adaptation for a long time. We were, for instance, involved in Klima 2000 where the perspective was to see how climate changes affect existing buildings, says Geir Trulserud, director of insurance at Finans Norge.

The insurance industry is living with the consequences of climate change. According to Trulserud, after the torrential rain in Asker and Bærum in August 2016, the reconstruction bill for that alone came to more than half billion Norwegian kroner.

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Geir Trulserud
Director of insurance at Finans Norge

Photo: Ilja Hendel

Stormwater problems
According to the Natural Perils Insurance Act, all buildings and personal property insured against fire damage are also automatically insured against natural hazards. The growing problem of stormwater is usually covered by contents insurance and home insurance.

Although there is more damage to buildings now than before, until now no insurance premiums have increased.

– It's interesting for us that Klima 2050 looks at how existing building structures are affected and suggests solutions and possibilities for improvement, says Trulserud.

Health consequences
The insurance industry is concerned not only with the damaging effects of more extreme weather conditions on buildings. Rot, fungus and mould also affect health and, consequently, personal insurance.

– What do you see as important for reducing risks associated with climate change?

– Finding new methods of handling large amounts of precipitation, such as green roofs, is important for us. In the future, those who take measures to counter the effects of climate change when building and renovating could possibily be rewarded with a better insurance premium.

Meeting future challenges
– What does it mean for Finans Norge to be a partner in Klima 2050?

– We gain access to inside information, cooperate with highly skilled people and establish important networks. We also hope that we contribute positively with our knowledge to the research.

The hope is that Klima 2050 will produce these results:
– Provide useful knowledge which government, local authorities, businesses, the general public, and not least the insurance industry can use to meet future climatic challenges, says Geir Trulserud.

Gordana Petkovic
Statens vegvesen
Vegdirektoratet
(SVV)

Photo: Nathan Anderson

THE NEED FOR PRACTICAL KNOWLEDGE AND FLEXIBILITY

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– Without mutual support, no climate adaptation will be achieved. I hope that Klima 2050 will be a national effort, says Gordana Petkovic of Statens vegvesen Vegdirektoratet (SVV).

Statens vegvesen Vegdirektoratet (SVV) has just finished the draft of a strategy plan for civil security and climate adaptation. Gordana Petkovic, who has been working with climate adaptation in SVV since 2007, led a project which investigated the impact of climate change on Norwegian roads, such as more frequent landslides and flooding.

– In all new projects we take into account climate change and the need for adaptation. Our regulatory framework is constantly being updated with stricter requirements which also apply to suppliers.

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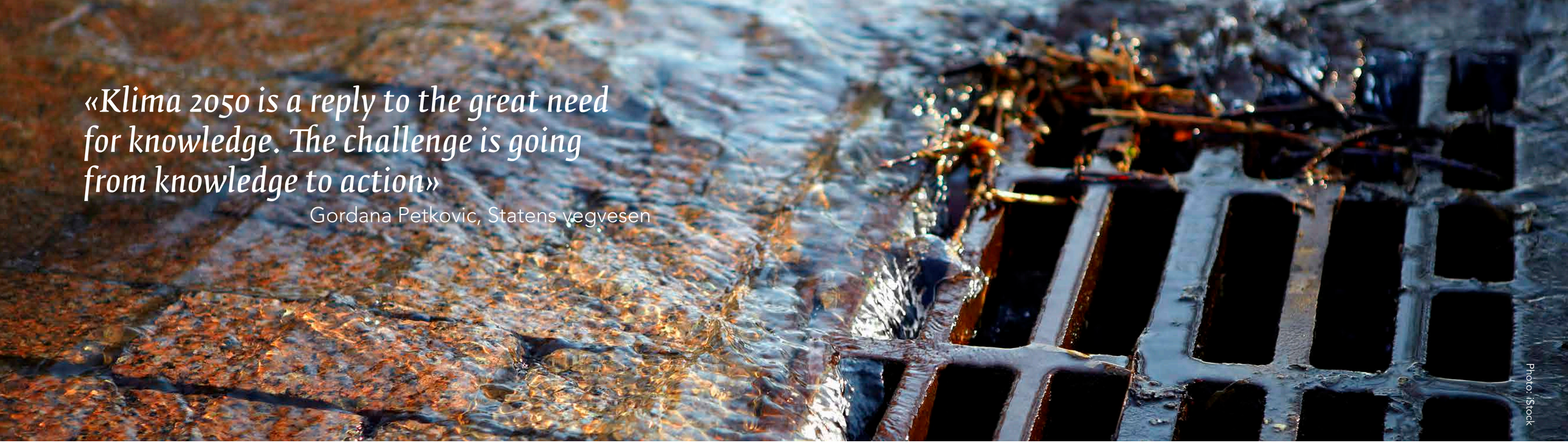

Shared concerns

– What opportunities do cooperation and partnership in Klima 2050 offer you?

– We have great expectations for the partnership. We hope that it will result in a framework for communication and collaboration which will benefit everyone, that we will function more like a unified family with common interests.

– The more we know about the climate adaptation tasks and challenges of other partners, the easier it will be to cooperate. We face, for instance, many of the same challenges as Jernbane-direktoratet and Avinor, continues Petkovic.

Better dialogue with scientists

Petkovic hopes that there will be opportunities in Klima 2050 for testing new solutions in pilot projects .

– Klima 2050 is a response to the urgent need for more knowledge. The challenge is to convert knowledge into action. When the research project is completed, our job is to implement the findings, for example by building a drainage solution in a new way. To manage this, good dialogue between research and users is absolutely essential.

Uncertainty and flexibility

– What challenges do you face when working with climate adaptation?

– Within strict timeframes and budgets, it's not easy to calculate in an economically responsible manner for the uncertainty of climate change and what it will mean for the future.

Petkovic also thinks that a task for SVV projects is to accept that there are no 'blueprint' models for future conditions and that this situation requires flexible contracts.

– Uncertainty must be met with flexibility, says Gordana Petkovic.

Kristin Fjellheim
Avinor

Photo: Avinor

LEARNING FROM THE CONSORTIUM PARTNERS

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Climate adaptation has aquired status as a strategically important topic in line with reduction of greenhouse gas emissions and environment issues at Avinor. Through Klima 2050, Avinor benefits from the experiences of other partners.

Avinor first worked with climate adaptation in connection with the National Transport Plan in 2001. Some years later, they started improving safety at seaside airports in response to more uncertain weather conditions, higher water levels and storm surge.

– For many years, we have be working on adapting runways, but more systematic work with climate adaptation and buildings is relatively new to us. We try now to embed standards for climate adaptation both when upgrading and building new constructions, says Kristin Fjellheim at Avinor.

Climate adaptation belongs to everyone

– What does participation in Klima 2050 mean for you?

– Through the partnership, it gives us a sense of how others are working, which is very useful. We need new knowledge and practical advices.

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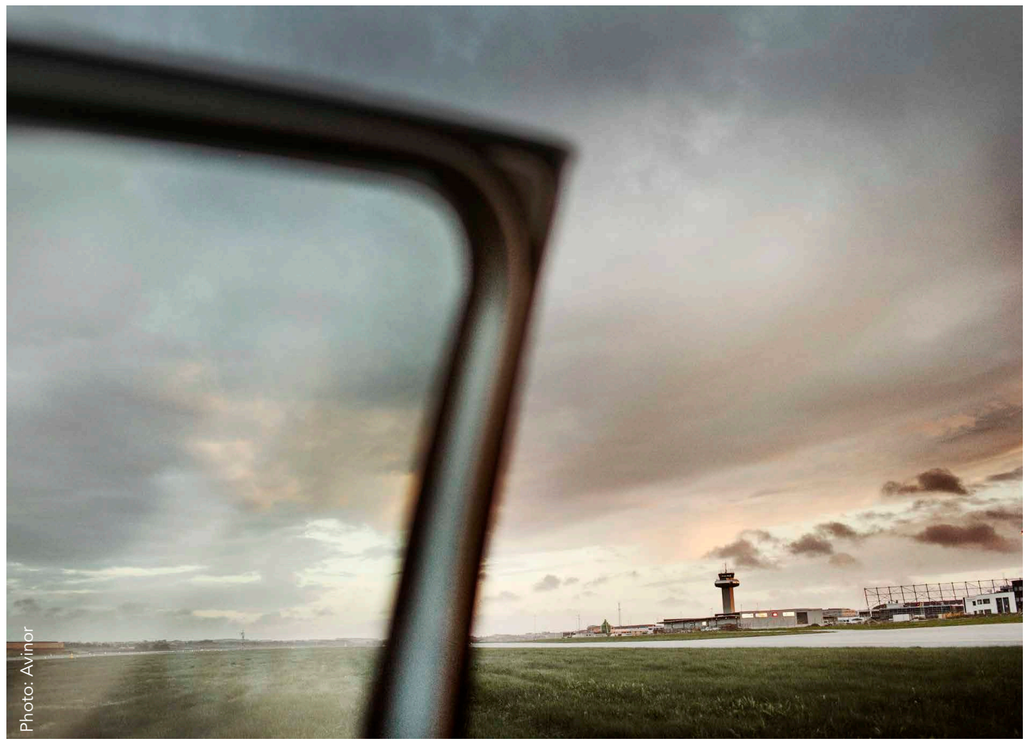
Photo: Avinor


Photo: Jørn Emil Gaarder

– Climate adaptation is a topic that does not really belong to one specific department, but to all of them in some way. It is useful for us to see how others deal with the organisational challenges, continues Fjellheim.

Testing new solutions

Avinor finds it useful to test new solutions and participates in a pilot project through Klima 2050. This project investigates how to meet the challenges created by increased runoff water from runways and how to clean this water. In another study dealing with climate adaptation in existing buildings, an Avinor building is one of the cases.

– How do you work to reduce risks resulting from climate change?

– We have carried out risk assessment for all airports based on the consequences of climate change. We have examined the major airports in detail and the smaller ones more generally.

The need for more expertise among employees

Fjellheim says that work with climate adaptation is well established and that the topic is now considered as strategically important as reduction of greenhouse gas emissions and environment issues. However, Avinor is a large organisation.

– We have 46 airports, and it can be difficult to involve the right people throughout the country because so far there has been a lack of knowledge. It's easier to work with more familiar topics like climate change and environmental issues. Managers and other employees need to become more aware of the need for climate adaptation and need to acquire expertise.

Ragnhild Wahl
Jernbanedirektoratet

Partner Jernbaneverket reorganised in 2016. Partner from 2017 is Jernbanedirektoratet.

Photo: iStock

A MORE ROBUST RAILWAY

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Natural disasters such as floods and landslides which affect the railways have immense consequences for society. Ragnhild Wahl believes that climate adaptation must be planned and managed collectively.

– Major floods and landslides which put the railroad out of operation get wide media coverage. When we rebuild after such events, we also make the railway more robust, says Ragnhild Wahl from the Jernbanedirektoratet.

No possible detour

Wahl emphasises how huge the consequences are for society when the railway is disrupted. And because the railway is single track and because there are no possible detours in the event of floods or landslides, the railway is particularly vulnerable to natural hazards. This is particularly challenging for goods traffic which is dependent on reliable solutions.

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Another challenge for the railway is that the infrastructure is old and was built with materials available from the surrounding areas, many of which were finer sediments which are easily washed out.

– A third challenge is that the lines were often built at the lowest point in the landscape, below later road and housing developments. Drainage was planned before all these new developments and water has now found new paths, says Wahl.

Adaptation through collaboration

– What opportunities do cooperation and partnership in Klima 2050 offer you?

– Adaptation needs to be addressed and planned jointly and Klima 2050 creates an arena where we can discuss both academic matters and practical measures. Collaboration is rewarding and it should contribute to good innovative solutions for the future. Everything is connected, says Wahl.

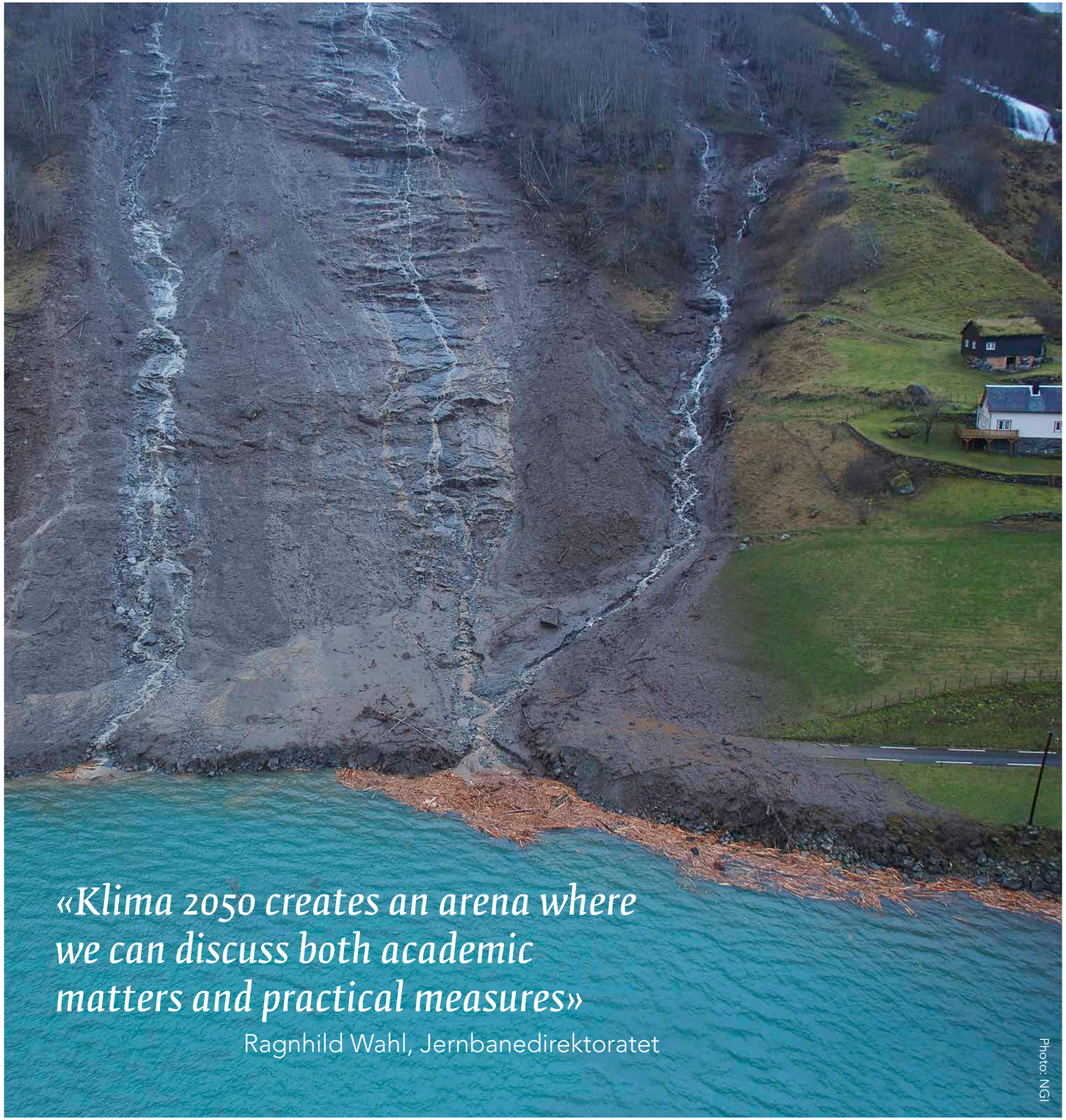
She also thinks it is important that NTNU and SINTEF, which are involved in education and research, develop greater understanding of the challenges faced by the Jernbanedirektoratet and other partners. It is they who will generate new knowledge and train future professionals in this field.

Need for smart solutions

– What does the job reducing risks involve for the Jernbaneverket?

– Natural disaster are both costly and time consuming. What we hope and believe is that Klima 2050 will provide us with knowledge and good solutions which will help to make the railway more reliable, says Ragnhild Wahl.

Wahl thinks it is a paradox that, because the infrastructure of roads with detour options is considered more reliable, climate change may lead to more goods being transported by road. To strengthen its credibility as a reliable way of transporting goods, the railway must be more robust.



Reidar Øye
Powel

Photo: Powel

MANAGING STORMWATER

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With more rainfall the need to find ways to manage stormwater also increases. Reidar Øye in Powel believes there is an urgent need for better digital solutions.

The drainage network is not designed to handle the large amounts of rainfall we experience today and which we know will increase even more in the future. Reidar Øye, business manager of Powel, wants to develop digital solutions for improving stormwater management.

Global solutions

Powel is well known for its Gemini VA mapping solution which monitors and documents water and sewage systems and which is currently being used by more than 250 municipalities. The company wants to continue improving these solutions for councils and, at the same time, to expand and offer the solutions to an international market.

– As a result of climate change, urbanisation and the increasing demands of society, finding robust, climate adapted solutions for coping with stormwater is a global challenge. The trend is towards internationalisation and we hope we can provide global solutions, says Øye.

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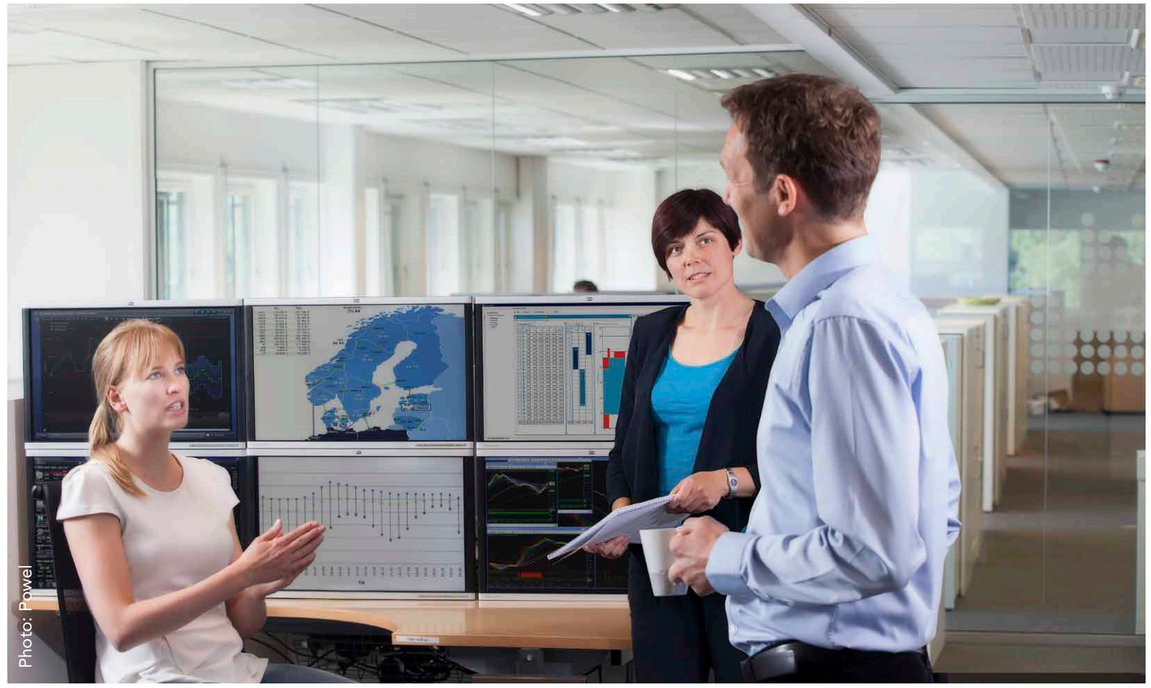
Photo: Powel


Photo: Powel

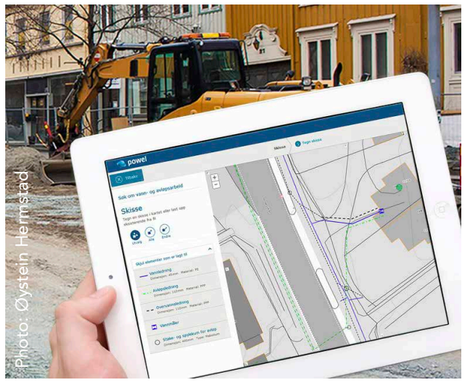

Photo: Øystein Hermstad

«Everyone knows that we must adapt to the future climate, but it must be prioritised in a busy everyday life»

Reidar Øye, Powel

Data model

Øye sees Klima 2050 as a meeting ground where partners can learn from each other and create together. Powel hopes to take part in joint pilot projects where various partners work together.

The company aims to develop a computer model which describes the different types of stormwater infrastructure which must be established in order to handle increased rainfall, ranging from streams, piping, rain gardens and green roofs.

– Currently, there is no software which describes stormwater structure and stormwater solutions in general. We hope Klima 2050 can contribute to developing such software for the international market.

Adaptation on hold

– What are the challenges of working with climate adaptation?

– When we talk to our customers, the municipalities, they do not always have clear requirements about how stormwater systems should be documented. Perhaps some local authorities are not yet well enough informed about handling future quantities of stormwater. Everyone knows that we must adapt to cope with future climate demands, but adaptation must be prioritised in busy everyday life, says Reidar Øye.

Rune Stene
Skanska Teknikk

Illustration: Skanska

INNOVATIVE SOLUTIONS

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Rune Stene from Skanska believes there is a need for public mechanisms to support climate adapted infrastructure. He hopes Klima 2050 will contribute to new innovative solutions.

– We are fighting a climate battle on two fronts. On the one hand, we must reduce greenhouse gas emissions. On the other, we have to deal with the fact that we have not managed to reduce emissions in time and, that as a result, we must actively work with climate adaptation, says Rune Stene, Chief of Skanska Technology and member of the board in Klima 2050.

– Much to learn from the partners

– It is useful for Skanska to be a partner in Klima 2050 since there is, for instance, much to learn from the experience of other partners, says Stene. Skanska uses Klima 2050 to verify that the internal standard building technique is as climate adapted as possible. He expects that Klima 2050 will contribute to good, innovative solutions.

– More rain creates the need for more robust drainage pipe networks. But it is both costly and resource intensive to just keep on adding larger dimensions and more material to the infrastructure.

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Illustration: Skanska

Skanska uses Klima 2050 to verify that the internal standard building technique is as climate adapted as possible.

What we need are new types of materials and innovative solutions and methods to deal with the pressure on infrastructure, says Stene. In fact, the solution can sometimes be to reduce the use of materials. Because the climate is getting warmer, in many places it may be possible to use less building insulation yet maintain thermal comfort.

Wetter in Eastern Norway

Stene points out that the climate maps which have been used in building plans in various parts of the country are changing.

– A wetter and warmer climate in Eastern Norway affects buildings, leading to problems such as rot and damp. There is much to be learned from Western Norway, where heavy precipitation is already a familiar problem.

More long-term thinking

– What are the challenges of working with climate adaptation?

– Financially, it's easier to be more proactive, for example, to get funding for climate-neutral buildings. It is more difficult, however, to reach an understanding that it can be an advantage to bear the extra costs of making a building more resilient to moisture. Getting to terms with the long-term effect of climate change also requires a change of mindset, says Stene.

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GLIMPSES FROM THE RESEARCH ACTIVITIES

Photo: John Towner

Durable buildings
With a lifetime of 40 to 100 years, buildings are exposed to climate variations over decades. Leader of the project Climate exposure and moisture resilient-buildings is Tore Kvande.

Photo: Remy Eik-Nikolaisen

BUILDING FOR THE CLIMATE OF THE FUTURE

Since construction and maintenance should last for several decades, it is important to have climate change and future climate in mind. But what exactly is a climate-adapted building?

In Norway today, it already rains 20 percent more than it did 100 years ago. Scenarios for climate change indicate that rainfall will continue to increase and that there will be more extreme weather such as storms and heavy rainfall. While 600,000 buildings are currently located in areas where there is a high risk of rot decay, this number will increase to 2.4 million between 2070 and 2100. Moisture is the cause of about 75 percent of damage to buildings.

There is no set definition of a climate-adapted building. In 2016, Klima 2050 partners began the process of specifying the meaning of the concept with the aim of agreeing on a definition.

Lack of definition
– There is a lot of talk about climate-adapted buildings, but it's not specific enough. And it's not easy to agree on a definition of what a climate adapted building is. One reason for this is that weather and climate vary considerably in Norway, so what's a good measure of

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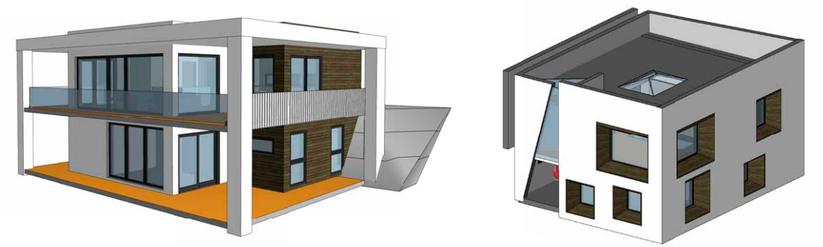
climate adaption for Western Norway may not be good for Northern Norway, says Tore Kvande, Professor of building materials at NTNU and principal investigator in SFI Klima 2050.

Kvande finds it interesting that while traditional Norwegian building culture was adapted to the local climate, nowadays we build more or less the same regardless of where we live. Regulations do not take into account differences between the climate in Oslo and Bergen.

Adapting houses to different climates

Elisabeth Bjaanes, Chief technology officer at Mesterhus, agrees with Kvande that "one size fits all" is not a good long term solution.

– Our goal is to be able to offer climate adapted homes at competitive prices,' says Bjaanes. The 150 members of the Mesterhus chain, she says, are very interested in being able to build safe and climate adapted buildings. Mesterhus has now begun the process of developing a model of a standard house which can be adapted locally to different climatic conditions in Norway.



Architect Tove Ovesen, Unikus

Currently, knowledge within the construction industry about the topic is limited, but Bjaanes maintains that Klima 2050 can change this.

– The attempt to define a climate adapted building is a good starting point. It entails looking at and discussing many issues, but it is difficult to agree on a final definition. For us, while taking into account climate change adaptation and protecting against moisture, it is important to retain good living qualities, such as daylight and attractive design.

Models from Unikus

Towards the end of 2016, Unikus, which is part of Mestergruppen with architects and engineers, developed models of a possible climate adapted building.

– To make things as easy as possible, we started with a model of a detached house, but much of what we learned can apply to other types of home, such as tower blocks. It is much easier to come up with specific content for 'climate adapted' when you work with a specific building, says Kvande.

Now several other Klima 2050 partners are in the process of developing prototypes for climate adapted buildings.

Stamp of quality

When standards for a climate adapted building are set, these will also make it be easier for firms to gain a competitive edge.
In her Master thesis on climate adaptation of buildings, Torun Krangsås Vikan found that economy was often an obstacle, that climate adaptation was considered to be expensive. This

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negative impression can be countered by demonstrating clearly for contractors, builders and advisors what adaptation has to offer and what the long term benefits are. Climate adaptation must be promoted as a market advantage.

The thesis concludes that adaptation must be user-friendly and that it may arouse more positive attention from the building industry by being identified as a stamp of quality.

Need for regulations

Bjaanes believes that it will be an advantage if demands for climate adaptation are regulated.

– If more specific requirements for adaptation become part of the technical regulations, that will be a step in the right direction. Perhaps some Klima 2050 results can provide a driving force for new regulatory requirements, says Bjaanes.

– And perhaps the ones that have a good climate adapted house can be rewarded with a lower insurance premium. Then it's crucial that we have clear criteria for what a good climate adapted building is, continues Bjaanes.

Market advantage

According to Kvande, it is only a matter of time before climate adapted housing becomes a well-known concept and being able to supply such houses constitutes a market advantage.

– In the beginning, no one knew what a Passive House was, so we advertised it as 'a house with extra insulation'. Today many label a climate adapted building as 'moisture robust', but in the future there may be a market advantage in calling it climate adapted. Should it take a long time to develop a definition, Kvande does not see that as a problem.

– ZEB, the research centre for zero emission buildings, worked for eight years on its definition. Similarly, work with our definition of climate adapted buildings can provide an impetus for constantly gaining knowledge and insight in the research and innovation.

Høvringen

Høvringen pilot project is owned by Trondheim kommune. The pilot is part of the project Stormwater management in small catchments lead by Edvard Sivertsen, SINTEF.

GREEN, BLUE AND GREY ROOFING SOLUTIONS

New solutions for delaying water runoff when it rains are being tested out on the roof of Høvringen sewage treatment plant in Trondheim. The new roofing solutions are green, grey and blue.

For a long time, the usual way of leading rainwater off a roof has been with gutters and downspouts to the ground. In 2016, in cooperation with companies in Klima 2050, researchers started focusing instead at how to delay runoff while at the same time converting the roof into an attractive terrace.

Traditional stormwater management faces two major challenges today. The first is more precipitation in general and more frequent short periods of torrential rain which result in large quantities of water overloading stormwater and sewage networks. The second is densification of urban areas and fewer natural areas for absorbing water.

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Photos from the mounting of the first test field at Høvringen.

«The traditional way of handling stormwater is simply by redirecting the water problems to a new location. We must rather find solutions which make it possible for people to handle rainfall on their own property»

Per Møller-Pedersen, Storm Aqua

– The traditional way of handling stormwater is simply by redirecting the water problems to a new location. We must rather find solutions which make it possible for people to handle rainfall on their own property, says CEO of Storm Aqua, Per Møller-Pedersen.

Three experimental roof plots

Storm Aqua (part of Skjæveland Group) and Leca Norway (part of Saint-Gobain Construction materials) are partners in the new pilot project which tests stormwater solutions on the roof of Høvringen sewage treatment plant in Trondheim. The project manager is Tone Muthanna, Associate Professor at the Department of Hydraulic and Environmental Engineering, NTNU. She is PhD adviser to Vladimir Hamouz, who is writing his thesis on the Høvringen project.
The roof at Høvringen is divided into three experimental fields, each measuring 90 square meters. Storm Aqua and Leca started work on the first field in the autumn of 2016.

They have created a roof consisting of a permeable cover which is made of paving stones with wide joints which allow water to penetrate and which is placed on top of a special Leca material.

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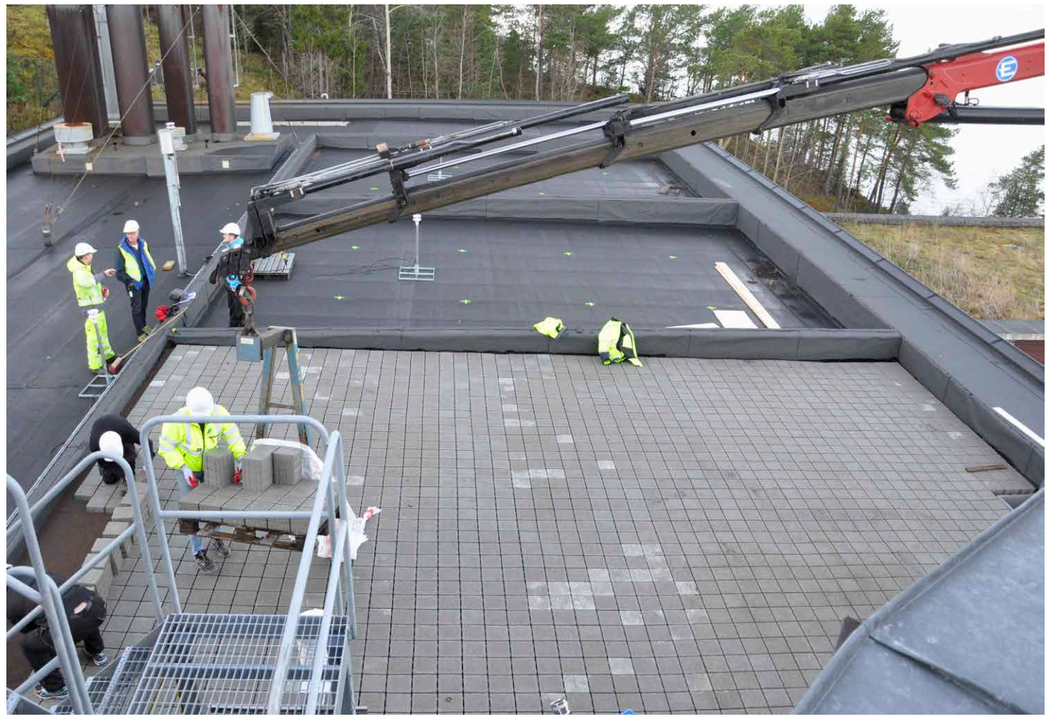

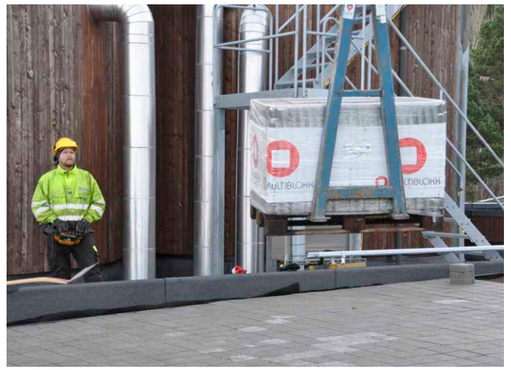

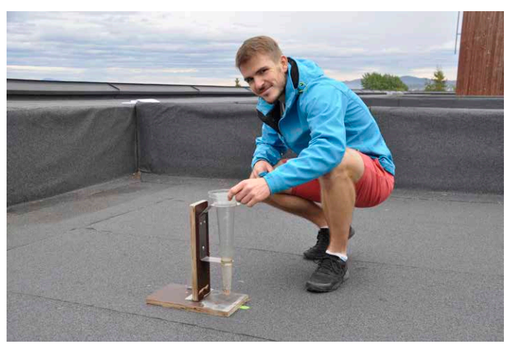

Leca is a building material made of burnt Norwegian clay transformed into small, porous beads with a hard surface.
The second field will be made with sedum which is widely used on green roofs. The third field is covered with black roofing membrane so as to make it possible to compare the traditional roofing solution with the new ones.

Weather station
The roof is equipped with a weather station which measures temperature, wind and rain. There are walls along the perimeter to facilitate control of water flow, so the roof itself is an isolated unit A sophisticated system measures the amount of water which flows into the drains of each of the three experimental plots. The system can measure the full range of precipitation from drizzle to torrential downpour.

– We have added a 20 cm layer of finely crushed Leca under paving stones with wide joints which are also filled with Leca so that water can filter through. Leca absorbs water temporarily and then releases it gradually. What we mostly want to control is water resulting from short, intense periods of rain, says Jaran Wood from Leca Norway.

He continues:

– Increased quantities of stormwater constitute a socioeconomic burden because they make it more expensive and less energy efficient to run sewage treatment plants. In addition, stormwater which is out of control can cause traffic and pollution problems as well as damage to property.

Leca cleanes stormwater
Wood also believes that the research findings can be used to

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develop stormwater solutions for more than just roofs. Leca, which is frost- resistant, can also be used under both parking lots and pavements. The advantage of using an area of roofing for the research is that the amount of rain which falls on the roof and the amount that goes out from it can be measured.

– Leca functions as a filter which can remove pollutants and is used in systems for cleaning tap water and in sewage treatment plants. Part of the project is to explore the possibility of cleaning different types of stormwater with Leca, says Wood.

Municipalities need stormwater solutions

Høvringen sewage treatment plant treats wastewater from two thirds of Trondheim local municipality.

– It will be exciting to see the results from the Høvringen project. Finding solutions for dealing with stormwater is important for us, says Håkon Pedersen, from Trondheim municipality technical department.

The municipality is aware that increasing rainfall is already causing problems and damage to infrastructure.

– Trondheim is part of a joint project on climate mitigation with other Nordic cities, which constantly strive to separate wastewater from cleaner stormwater. There are also several on-going projects aimed at re-opening old, closed streams. In addition to other environmental benefits, getting the water up to the surface increases capacity and improves flood security, continues Pedersen.

Developing solutions together

– The Høvringen project is a good example of how Klima 2050 cooperation makes it possible to develop solutions together. The idea of water retention on the roof surfaced at one of the thematic meetings during a conversation with Leca, explains Møller-Pedersen.

He sees great potential in utilising roofs. Høvringen shows that permeable cover, which is currently used in industry and parking spaces, can also be used on roofs. There has been a lot of focus on green roofs, but Møller-Pedersen thinks that a roofing solution where grey is combined with green and blue may provide an even better solution and possibly also result in new and attractive outdoor spaces in urban areas.

– It is interesting to observe the significant effect of water retention at Høvringen where the infrastructure is not designed to handle short bursts of heavy rainfall, says Møller-Pedersen.
For documentation of the quality and the characteristics of their materials, projects such as the one at Høvringen are important for both Skjæveland Group and Leca.

– After seeing the first results from Høvringen, Skjæveland Group has started trial production of a new type of paving stone which is lighter and better suited for rooftops, says Møller-Pedersen, adding that they have also started developing new fields of research in collaboration with Leca near Stavanger.

«The Høvringen project is a good example of how Klima 2050 cooperation makes it possible to develop solutions together. The idea of water retention on the roof surfaced at one of the thematic meetings during a conversation with Leca»

Per Møller-Pedersen, Storm Aqua

The river Veikleåa is able to transport masses of water in floodings. A combination of the water masses, mass movement and debris flows caused the river to flood and find new ways in 2011 and 2013.

Kvam
The flow events are part of the project on water induced landslides.
Project leader: José Cepeda, NGI.

Photo: Wiggo Houmb, NVE

IMPROVED SAFETY WITH LANDSLIDE INVENTORY

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During 2016, Klima 2050 has further developed the most complete event based database for landslides triggered by meteorological factors in Norway. It is based on two specific debris flow events in Kvam in 2011 and 2013.

– The idea of further developing an event based database for landslides stems from a Klima 2050 thematic meeting in January 2016. In the future, we must expect more frequent landslides, triggered primarily by extreme precipitation and snowmelt, says Jose Cepeda from the Norwegian Geotechnical Institute (NGI) and leader of this sub-project of Klima 2050. He considers Klima 2050 to be an important arena for finding practical solutions to the consequences of climate change.

A better understanding of what causes landslides and how the risks associated with them can be reduced are important topics within climate adaptation. Landslides can cause significant damage to infrastructure such as railways and roads as well as to buildings. As precipitation increases so also does the danger of landslides and the need for cost effective safety measures.

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Debris flows and floods in Kvam

In cooperation with Norges vassdrag og energidirektorat (NVE), NGI has been involved in implementing safety measures in Kvam following landslide incidents caused by heavy rainfall and floods in 2011 and 2013. The decision to start collection of data from these events was a result of both the scale of the damage and the extent of the landslides.

The village of Kvam in Gudbrandsdal is built on sediments produced by previous floods and landslides (alluvial fans). Loose sediments in the sides of the steep valley upstream from Kvam make the area especially hazard prone.

In 2011, large quantities of rainfall triggered landslides in Veikvedalen, upstream from Kvam. The landslide masses flowed along the river at the bottom of the valley and resulted in flooding which caused a large amount of damage. Although, on estimate, such events occur on average once in every hundred years, a similar event occurred only two years later in 2013.

Water triggered landslides cost most

A warmer climate and more extreme weather will lead to more water triggered landslides, particularly soil slides, which can be triggered by intense rainfall, long periods of lower intensity precipitation or by rapid snow melting and thawing of frozen soil.

In addition to NGI and NVE, the team lead by Cepada involved the University of Rome and also made use of scientific input from the Geological Survey of Norway (NGU). Starting with the work that had previously been carried out to register and evaluate the events in Kvam, the team set about developing the database.

– In order to understand the area and what actually happened in Kvam, we have done a lot of fieldwork. We have documented

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Safety measures in Kvam implemented by NVE to prevent damages caused by heavy rainfall and floods like in 2011 and 2013.

several additional, previously unmapped landslides and based on field observations, interpretations of results from remote sensing and geophysical surveys, we have calculated a model for bedrock depth. We have also separately identified both initiation and runout zones over the whole landslide footprint for each event, which has not been done before.

Responsibility for the landslide warnings

In Norway, NVE issues warnings for both floods and landslides. The warning system is based on conditions such as precipitation and snow melting.

In addition, NVE has a national landslide database comprising 60,000 registered events, very few of which, however, contain details about the landslide footprint. Many events come from Norwegian Public Roads Administration records of landslides which blocked roads.

– We want to improve landslide warning methodology for debris slides and debris flows. A complete database like the one developed here will be useful for that,' says Odd Are Jensen from NVE.

– The type of data gathered in Kvam is the kind we would like to see more of in the national landslide database, he adds, and mentions too that the structural mitigation measures in Kvam are scheduled for completion in spring 2017.

Local knowledge for landslide mapping

The damage caused by landslides and floods in Kvam shows how important it is to have complete mapping of the consequences of expected climate effects in an area, in order to adapt and secure infrastructure and buildings.

– Of course, no database will ever be complete but we have come a long way, says Cepeda. He believes that the Kvam database will provide an important basis for future predictions and for identifying necessary safety measures.

«In order to understand the area and what actually happened in Kvam, we have done a lot of fieldwork. - The type of data gathered in Kvam is the kind we would like to see more of in the national landslide database»

Odd Arne Jensen, NVE

– When mapping landslide hazards, one of the most fundamental things to investigate is landslides which have previously occurred in the area. It is useful to speak to local farmers who perhaps know about landslides which occurred in the 18th century or just three years ago. Nowadays, such local knowledge is about to vanish, so incorporating information about historical events in the database has become more and more important, says Jensen. He encourages people to register landslides on www.skredregistrering.no.

Predicting landslides at other locations

The Kvam database can be useful in risk analyses for landslide prone areas in other parts of the country which are similar to Kvam in terms of terrain and ground conditions. It should be possible to use analyses based on the data to predict landslides and recommend mitigation measures.

– More complete databases can help us to prepare for future landslide events and to optimise mitigation measures, says Cepeda.

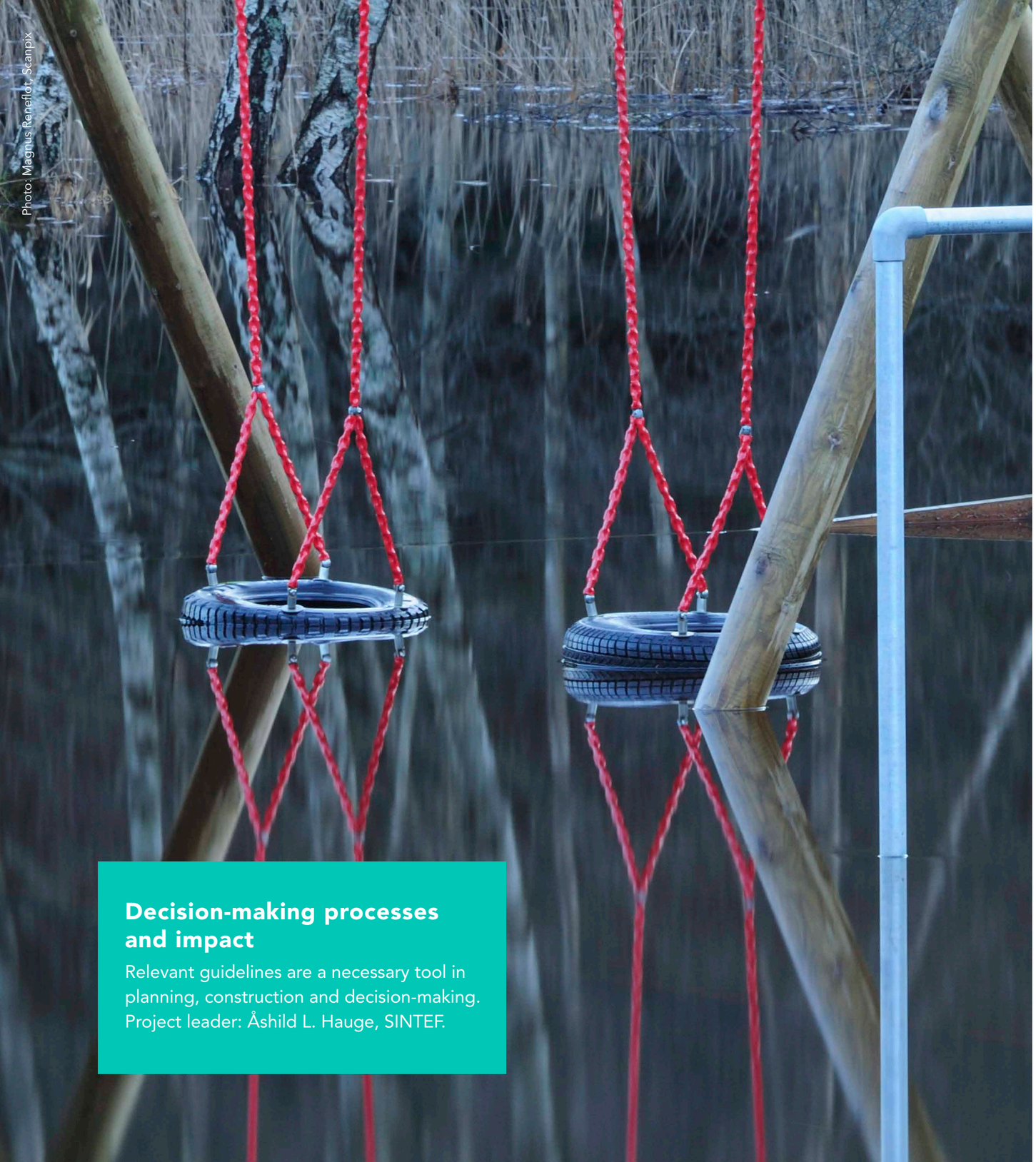

Photo: Magnus Reneflot, Scanpix

Decision-making processes and impact

Relevant guidelines are a necessary tool in planning, construction and decision-making. Project leader: Åshild L. Hauge, SINTEF.

GUIDELINES LACK PRACTICAL KNOWLEDGE

In general, many guidelines on climate adaptation are not practical enough and there is a lack of material on how to conduct decision making processes. These are among the conclusions of a project which has analysed 84 guidelines.

In 2016, Klima 2050 analysed 84 guidelines and web portals which offer an introduction and training in practical and organisational climate adaptation of buildings and infrastructure.

– Most of the material describes climate adaptation on a basic level and contains a lot of general background information about climate change, but offers little when it comes to practical implementation. There is a need for guidelines which explain practical measures in depth, says the leader of the project, Åshild Lappegard Hauge, researcher at SINTEF.

Local government lacks capacity

A third of the guidelines are aimed at local authority employees. According to the report, these employees often lack the time and

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84 guidelines and web portals have been analysed by Klima 2050 in 2016.

«There is a need for guidelines which explain practical measures in depth»

Åshild Lappegard Hauge, SINTEF

capacity to search for and read guidelines on climate adaptation. Hauge believes that employees in smaller municipalities who often lack specialist knowledge need material which describes practical measures.

None of the material describes decision-making process and collaboration in depth. There is a lack of guidance on how to plan for adaptation and how to coordinate sectors.

Defining the target audience

– Today, there is overload of information about everything and getting through to people can be difficult. It may be better to develop guidelines which target a specific group with very specific information, says Hauge.

Research on communication strategies shows that the more specific information is, the more likely it is to reach its target audience. In addition, guidelines should be adapted to fit the tools and working methods which users already possess.

On the other hand, some specific guidelines may also be relevant for others groups. A simple and reasonable form of dissemination of information would be to adapt existing guidelines for new target audiences and to spread them through appropriate channels.

Surprised about high quantity

Researchers were positively surprised at the vast number of guidelines, mostly from the last five years.

– Interviews confirm that the number of guidelines is overwhelming. The impression is that this can lead to confusion and uncertainty among users, which itself may be a barrier to achieving climate adaptation, says Hauge.

Need for practical examples

Senior Engineer at Statsbygg, Jonas Vevatne, agrees and thinks it is important that the guidelines should contain some basic knowledge about the consequences of climate change, such as the expected rise in sea levels and greater risk of floods.

– We have distanced ourselves from natural conditions and have

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been confident that we can build in conflict with the natural forces. The fact that there are so many guidelines around can be taken as a sign that this is a new field and that many want to contribute and explore possible solutions, even though climate adaptation, to a large extent, is about retrieving the knowledge of previous generations. In the past, building styles around the country were more adapted to local conditions, said Vevatne.

Good guidelines, in his opinion, should contain good practical examples of adaptation to make the topic more real and easier to work with.

– Climate adaptation involves finding specific local solutions to abstract global climate changes which have local impact. Measures must be assessed on the basis of actual local contexts.

Guidelines for private developers

The report concludes that networks and training play major roles in determining whether guidelines are applied.

– We must make sure that guidelines are not simply kept in a drawer. There must be a capacity for continued effort and a network for development. Responsibility cannot simply be placed on individuals, says Vevatne.

Another important point is that users must have a real need for the information offered in guidelines.

Hauge thinks there is a special need for guidelines directed at private developers, who are behind 80 % of the zoning proposals in Norwegian local municipalities.

What training is needed?

The study is intended to provide Klima 2050 with the basis for further case studies on guidelines in local authorities and businesses.

– Relevant issues to investigate further include looking at how guidelines on climate adaptation can be compiled to ensure rapid implementation of efficient measures for climate adaptation in both private and public sectors.

– We should also investigate the kind of training and networking needed to ensure that guidelines are used, says Hauge.

«We must make sure that guidelines are not simply kept in a drawer. There must be a capacity for continued effort and a network for development. Responsibility cannot simply be placed on individuals»

Jonas Vevatne, Statsbygg

2024 KEY FIGURES

Photo: iStock

Photo: iStock

COMMUNICATION AND VISIBILITY

Weather events throughout the year have shown the relevance of Klima 2050, and the general interest from media has been high.

The policy of the Centre is to publish at least one user-oriented/ public-oriented publication for each scientific publication. The counting by the end of 2016 shows following distribution of publications.

COMMUNICATION
AND VISIBILITY

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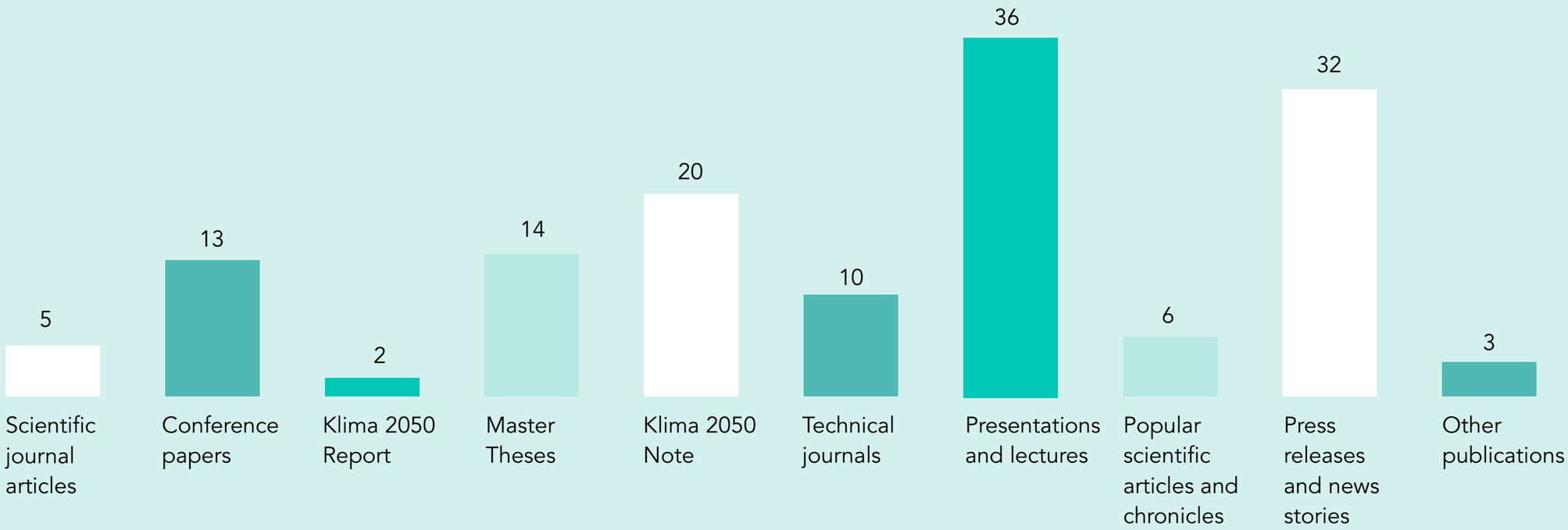
All publications in 2016 are listed on
www.klima2050.no

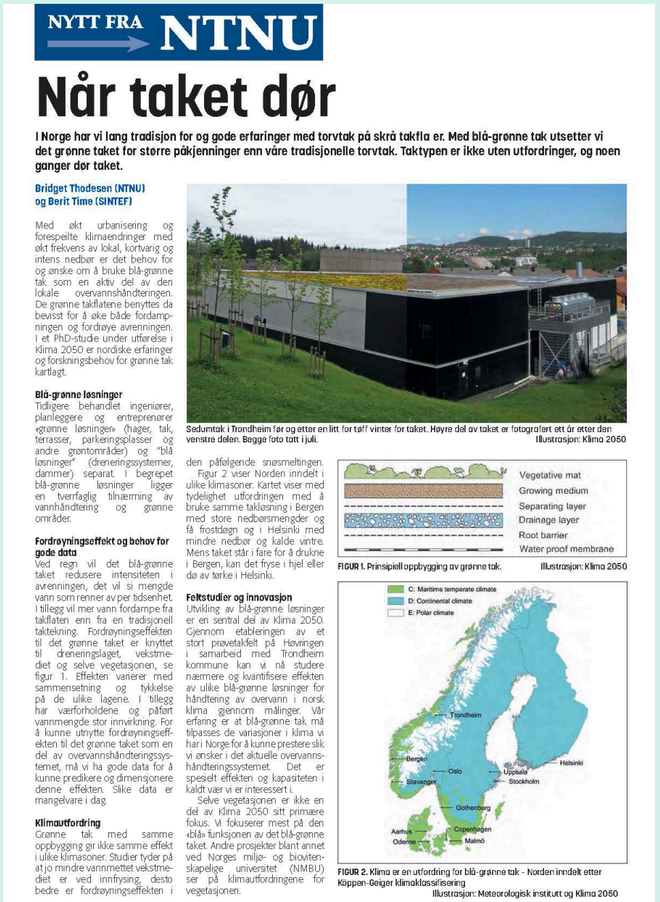
«Klima 2050 gives us an opportunity to be ahead in developing robust building technology that can prevent the consequences of more rain and an increase in temperature»

Jørgen Young, Isola and Snorre Bjørkum, Norgeshus



COMMUNICATION
AND VISIBILITY

Some examples from publications in 2016



NYTT FRA NTNU

Når taket dør

I Norge har vi lang tradisjon for og gode erfaringer med torvtak på skrå takflate er. Med blå-grønne tak utsetter vi det grønne taket for større påkjenninger enn våre tradisjonelle torvtak. Taktypen er ikke uten utfordringer, og noen ganger dør taket.

Bridget Thodesen (NTNU) og Berit Time (SINTEF)

Med økt urbanisering og forespeilte klimaendringer med økt frekvens av lokal, kortvarig og intens nedbør er det behov for og ønske om å bruke blå-grønne tak som en aktiv del av den lokale overvannshåndteringen. De grønne takflatene benyttes da bevisst for å øke både fordampningen og fordrøye avrenningen. I et PhD-studie under utførelse i Klima 2050 er nordiske erfaringer og forskningsbehov for grønne tak kartlagt.

Blå-grønne løsninger

Tidligere behandlet ingeniører, planleggere og entreprenører «grønne løsninger» (hager, tak, terrasser, parkeringsplasser og andre grøntområder) og "blå løsninger" (drenerингssystemer, dammer) separat. I begrepet blå-grønne løsninger ligger en tverrfaglig tilnærming av vannhåndtering og grønne områder.

Fordrøyningseffekt og behov for gode data

Ved regn vil det blå-grønne taket redusere intensiteten i avrenningen, det vil si mengde vann som renner av per tidsenhet. I tillegg vil mer vann fordampe fra takflaten enn fra en tradisjonell takteknikk. Fordrøyningseffekten til det grønne taket er knyttet til dreneringslaget, vekstmediet og selve vegetasjonen, se figur 1. Effekten varierer med sammensetning og tykkelse på de ulike lagene. I tillegg har værforholdene og påført vannmengde stor innvirkning. For å kunne utnytte fordrøyningseffekten til det grønne taket som en del av overvannshåndteringssystemet, må vi ha gode data for å kunne predikere og dimensjonere denne effekten. Slike data er mangelvare i dag.

Klimautfordring

Grønne tak med samme oppbygging gir ikke samme effekt i ulike klimasoner. Studier tyder på at jo mindre vannmettet vekstmediet er ved innfrysing, desto bedre er fordrøyningseffekten i den påfølgende snøsmeltingen.

Figur 2 viser Norden inndelt i ulike klimasoner. Kartet viser med tydelighet utfordringen med å bruke samme takløsning i Bergen med store nedbørsmengder og få frostdøgn og i Helsinki med mindre nedbør og kalde vintre. Mens taket står i fare for å drukne i Bergen, kan det fryse i hjel eller da av tørke i Helsinki.

Feltstudier og innovasjon

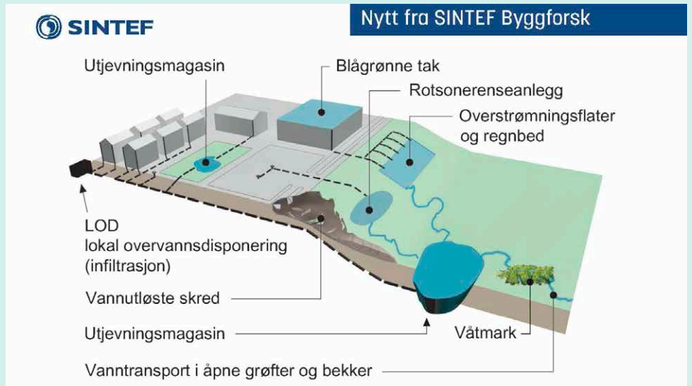
Utvikling av blå-grønne løsninger er en sentral del av Klima 2050. Gjennom etableringen av et stort prøvefelt på Hovringen i samarbeid med Trondheim kommune kan vi nå studere nærmere og kvantifisere effekten av ulike blå-grønne løsninger for håndtering av overvann i norsk klima gjennom målinger. Vår erfaring er at blå-grønne tak må tilpasses de variasjoner i klima vi har i Norge for å kunne prestere slik vi ønsker i det aktuelle overvannshåndteringssystemet. Det er spesielt effekten og kapasiteten i kaldt vær vi er interessert i.

Selve vegetasjonen er ikke en del av klima 2050 sitt primære fokus. Vi fokuserer mest på den «blå» funksjonen av det blå-grønne taket. Andre prosjekter blant annet ved Norges miljø- og biovitenskapelige universitet (NMBU) ser på klimautfordringene for vegetasjonen.

Sedumtak i Trondheim før og etter en litt for tøff vinter for taket. Høyre del av taket er fotografert ett år etter den venstre delen. Begge foto tatt i juli. Illustrasjon: Klima 2050

FIGUR 1. Prinsipiell oppbygging av grønne tak. Illustrasjon: Klima 2050

FIGUR 2. Klima er en utfordring for blå-grønne tak - Norden inndelt etter Köppen-Geiger klimaklassifisering
Illustrasjon: Meteorologisk institutt og Klima 2050



SINTEF

Nytt fra SINTEF Byggforsk

Eksempler på tiltak for overvannshåndtering i tettbygde strøk. Illustrasjon: SINTEF Byggforsk

Vi trenger nye løsninger for overvannshåndtering

SFI Klima 2050 skal utvikle fremtidens løsninger for håndtering av overvann i byer og tettsteder.

Kontaktpersoner
Edvard Sivertsen og Berit Time

Et varmere klima gir hyppigere og mer kraftig nedbør. Økt boligbygging og tetting av flater i byene gjør det utfordrende å håndtere belastningen i dagens overvannssystemer.

Må kartlegge lokale værkostnader

For å kunne drifte og vedlikeholde et lokalt overvannssystem på en sikker og god måte er det avgjørende å ha tilgang til beskrivelser av både topografi, bebyggelse og infrastruktur i området. I tillegg vil skadedata fra ulike aktører (f.eks. vegholder og forsikringsselskaper) gi et mer komplett bilde av kostnadene ved ekstremværhendelser, avdekke kritiske punkter og gi ulike samfunnsaktører, som boligbyggere, jernbaneverk og vegvesen, mulighet til å lære av hverandres erfaringer. Vi kartlegger nå hvilken type informasjon som er tilgjengelig og hvordan informasjonen kan settes sammen for å gi et mer helhetlig bilde av skadeomfanget og -potensialet innenfor et avgrenset område.

Overvann bør renses lokalt - vi tester rensefilter

Overvann kan være forurenset og må noen ganger renses før det kan slippes ut i nærliggende elver og innsjøer. Mer nedbør og tettere overflater vil gi større mengder vann som må behandles og lokale rensetiltak vil være å foretrekke. Vi vil teste og utvikle innovative rensemetoder for lokal rensing av overvann, og har startet med å teste filtreringsegenskapene til et utvalg filtermaterialer. Arbeidet utføres i samarbeid med NTNU, og flere masterstudenter bistår med forsøkene.

Blågrønne tiltak er en del av løsningen

Blågrønne overvannstiltak, det vil si bed/parkanlegg med innslag av vann, vil være viktige for å håndtere overvann i fremtiden. I tillegg til å forebygge flomskader, bidrar de blågrønne tiltakene til økt vegetasjon, naturmangfold og trivsel for befolkningen. Både her til lands og kanskje spesielt på et europeisk nivå er blågrønne løsninger antatt å være en del av løsningen for å forsinke avrenning gjennom infiltrasjon og fordrøyning, samt gi en trygg avledning av overvann til elver og innsjøer. Vi jobber med å dokumentere effekten av ulike blågrønne tiltak, både av enkelttiltak og kombinasjon av flere tiltak (se figur for eksempler). Videre jobber vi med et verktøy som skal hjelpe planleggere, utbyggere og kommuner med å velge riktige løsninger til gitte utfordringer. Tre PhD-studenter ved NTNU deltar også i dette arbeidet.

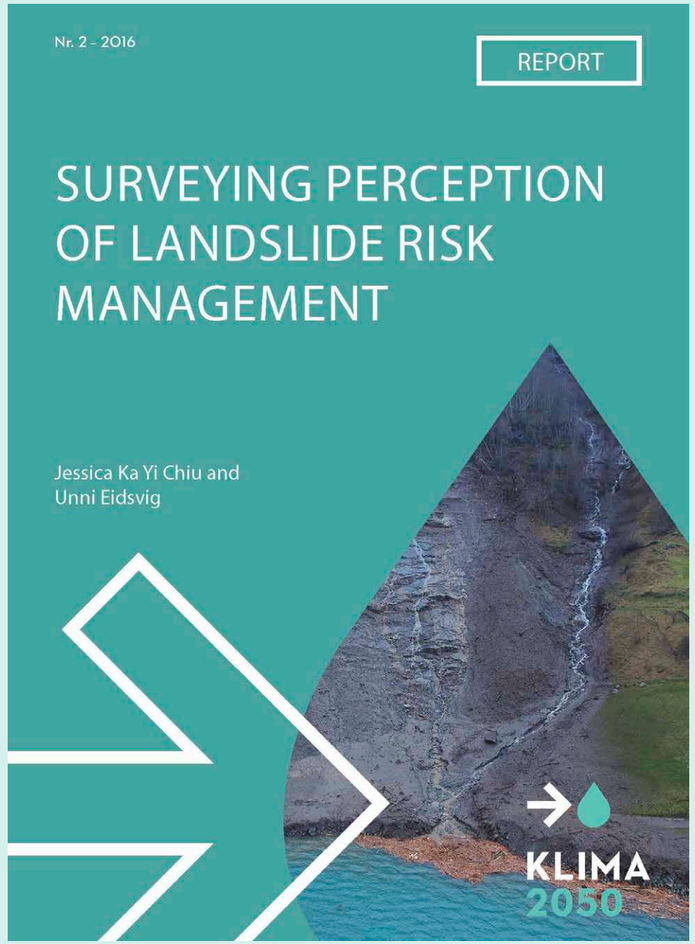
Bedre evaluering av risiko for oversvømmelse

For å redusere risikoen for oversvømmelse, trengs det metoder og modeller for å evaluere denne risikoen. En forbedret metode for risikoevaluering som kan benyttes i avgrensede områder og urbane strøk, vil gi bedre grunnlag for å planlegge og velge riktige løsninger for overvannshåndtering og risikoreduserende tiltak. Vi jobber nå med å kartlegge hvilke metoder som benyttes for å evaluere risiko og vil foreslå forbedringer tilpasset de lokale utfordringene. I tillegg startet det nylig en PhD-student ved NTNU som skal jobbe med denne problematikken.

Om Klima 2050

Klima 2050 (www.klima2050.no) er et senter for forskningsdrevet innovasjon (SFI) finansiert av Norges forskningsråd og de 20 partnerne som er med i senteret. Klima 2050 har som hovedmålsetning å redusere effekten av klimaendringer og økt nedbør på infrastruktur og det bygde miljø. Senteret ledes av SINTEF Byggforsk.

Les mer om overvann NOU2015:16 Overvann i byer og tettsteder



Nr. 2 - 2016

REPORT

SURVEYING PERCEPTION OF LANDSLIDE RISK MANAGEMENT

Jessica Ka Yi Chiu and
Unni Eidsvig

KLIMA 2050

RECRUITMENT

Klima 2050's PhD candidates financed by the Centre in 2016:
Petter Fornes, NTNU
Lars Gullbrekken, NTNU
Vladimir Hamouz, NTNU
Aynalem Tasachew, NTNU
Bridget O'Brien Thodesen, NTNU
Ola Eggen Thorseth, BI

Associated PhD candidates in 2016:
Manuel Franco Torres, NTNU/ Multiconsult
Birgitte Gisvold Johannessen,
Trondheim kommune / NTNU
Kaj Pettersson, Chalmers University
of Technology

Post.docs 2016:
Åshild Lappegard Hauge, SINTEF
Jardar Lohne, NTNU
Luca Piciullo, University of Salerno
Luca Schiliro, University of Rome

14 master students were associated with the Centre in 2016.

ANNUAL ACCOUNT
2016

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FUNDING		COST	
The Research Council	13 430		
SINTEF (host institution)	2 317	SINTEF (host institution)	13 542
Research partners	2 676	Research partners	11 493
Private partners	10 042	Private partners	8 342
Public partners	5 299	Public partners	349
Transfer to coming years	-38		
Sum	**33 726**	**Sum**	**33 726**

All figures in 1000 NOK

KLIMA 2050

For more information about Klima 2050 go to our webpage:
www.klima2050.no

Klima 2050 Report No 5

Annual Report 2016

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