



KLIMA 2050



KLIMA 2050

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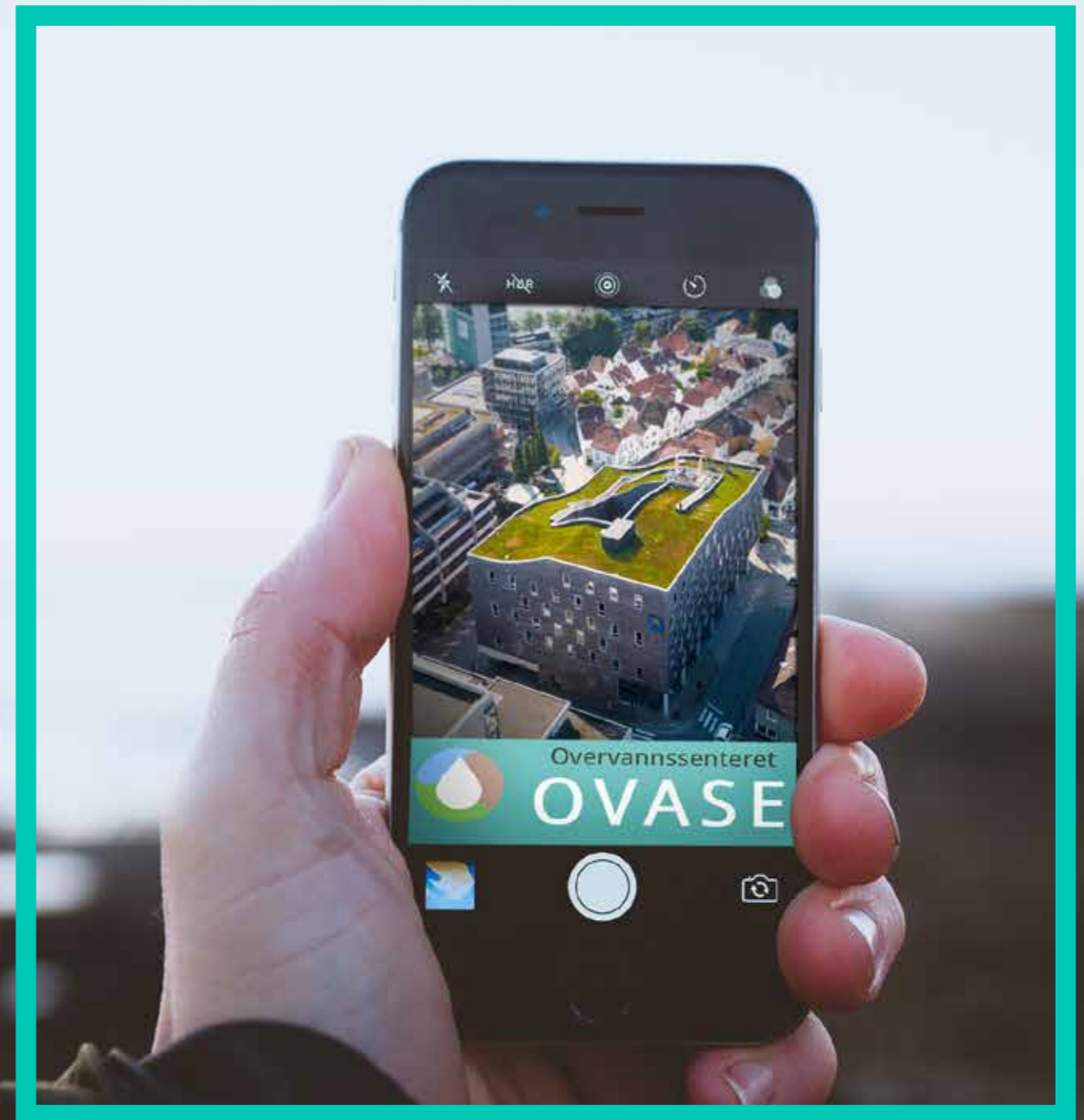
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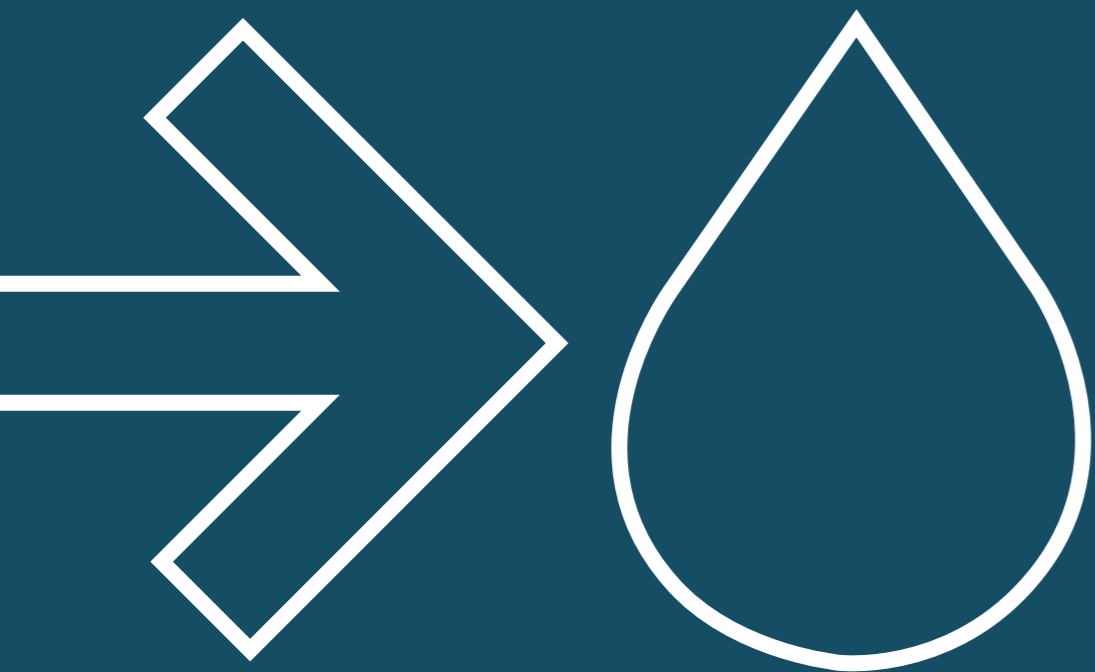
ORGANIZATION



VISION AND MAIN GOAL

"Klima 2050 has set ambitious goals. Progress and deliverables from the Centre is on track. The foundation created in Klima 2050 will set new standards for the industry and the society in years to come and together researchers and partners are creating new innovative solutions for a challenging future"

Grethe Bergly, Klima 2050 Chairwoman, Multiconsult



ACHIEVING GOALS



Grethe Bergly
Multiconsult

— The Klima 2050 Research Centre has set an ambitious goal; this is to reduce the societal risks associated with climate changes and enhanced precipitation and flood water exposure within the built environment. Research alone cannot achieve this goal. In addition to the research organisations, the Klima 2050 consortium also consists of 15 meritable partners, all of whom have key roles in actions to reduce societal risk in the built environment. The Centre's public sector partners are dealing, on a day-to-day basis, with key challenges. Klima 2050 is, along with the private sector partners, developing risk-reducing measures. The Centre's partner group is diverse, to ensure a breadth of knowledge and expertise, and to make maximum use of opportunities for innovation.

The Centres for Research-based Innovation (SFI) intends to strengthen innovation and develop expertise at a high international scientific level. This requires up-to-date relevant professional expertise. Relevance is ensured through close collaboration with Klima 2050's partners.

Klima 2050 has established structures to ensure successful societal engagement, and to facilitate innovation;

- *The annual Klima 2050 day* brings all the partners together and highlights the breadth of the Centres activities. The focus is on presenting results, partner needs and innovation opportunities.

- A number of thematic meetings covering various topics are held throughout the year to ensure knowledge exchange, secure cooperation between partners and facilitate innovation.
- User partners are responsible for the pilot projects, which function as innovation arenas for product and process development, as well as for the testing of results. Collaboration and dissemination are further facilitated through these activities.
- PhD and master students play a role in all activities. Close engagement with the user partners leads to recruitment opportunities, which will in the long run, provide the skills required by society.
- The Centre emphasizes collaborating on international projects and in other forums. This contributes to the acquisition and sharing of knowledge, ensuring the scientific quality of the research.
- Last but not least, career development for researchers is now systematised through the *Klima 2050 Researcher Training* initiative.

This holistic and multidisciplinary thematic approach will enable Klima 2050 to be an effective instrument for the development and implementation of adaptive innovations for the Centre partners and society.

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.

”Klima 2050 create, by bringing together key actors from the public sector, innovative private enterprises and prominent research groups, a meeting place with unique atmosphere for innovations.”

Hanne Rønneberg, SINTEF

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. The value chain within Klima 2050's fields of research is complete. Private partners in the consortium in 2017: Finans Norge, Isola AS, Multiconsult AS, Mesterhus/Unikus, Norgeshus AS, Powel, Saint-Gobain Byggevarer AS, Skanska Norway and Skjæveland Gruppen. Public partners : Avinor AS, Jernbanedirektoratet, NVE (the Norwegian Water Resources and Energy Directorate), Statens vegvesen, Statsbygg, and the municipality Trondheim kommune.

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.

CONSORTIUM

Private sector



Public sector



Research & education



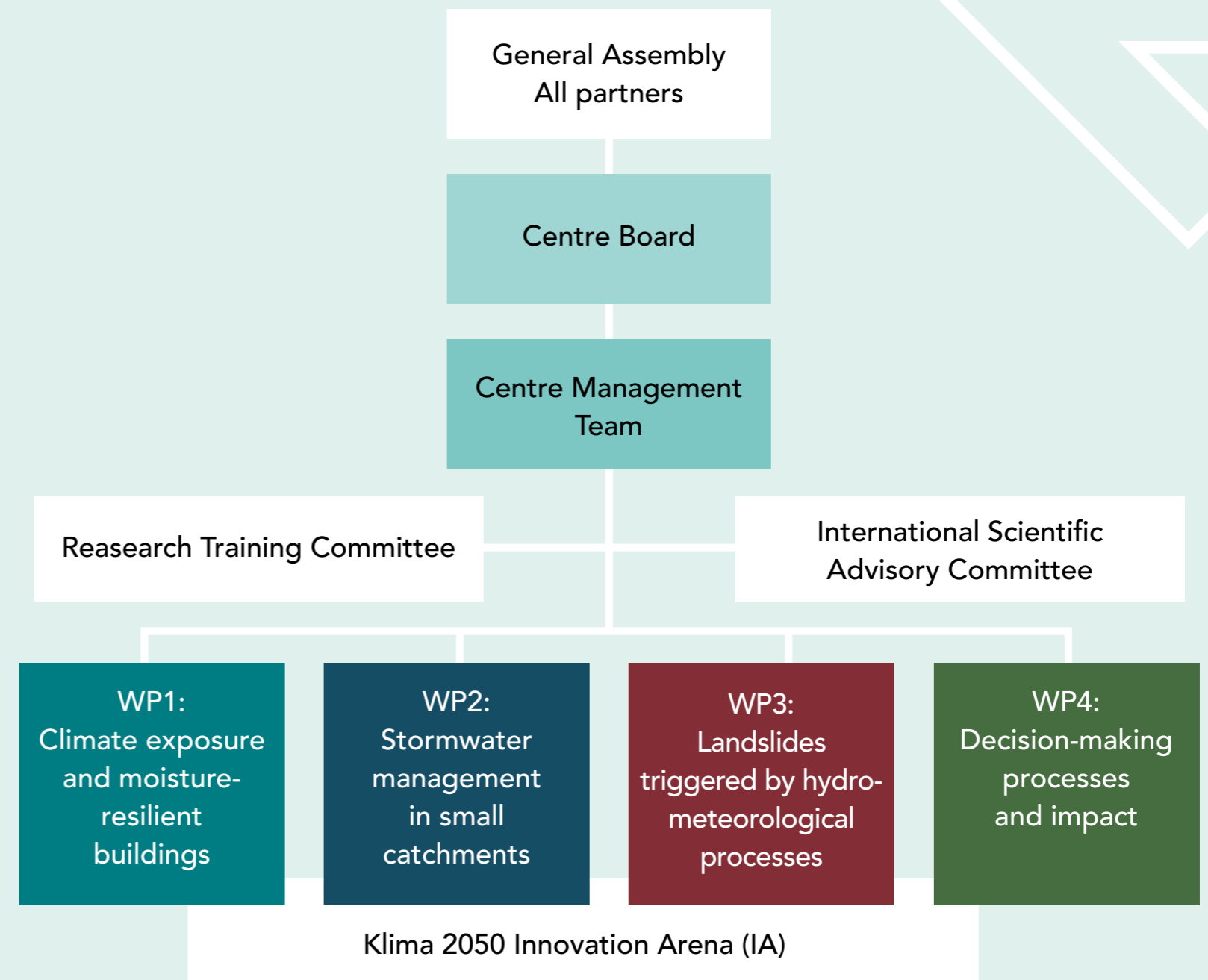
THE ORGANIZATION

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) until June
 Randi I. Henriksen, administrative coordinator at SINTEF (adm) until July
 Brynhild Garberg Olsø, administrative coordinator at SINTEF (adm) from August

CENTRE BOARD

Grethe Bergly, Multiconsult (Chairwoman)
 Anne Britt Leifseth, NVE
 Håvard Zachariassen, Statsbygg
 Marit Brandtsegg, Statens vegvesen
 Dag Runar Båtvik, Norgeshus
 Rune Stene, Skanska Norge
 Anders Solheim, NGI
 Carl Thodesen, NTNU
 Hanne Rønneberg, SINTEF
 Svein Erik Moen, The Research Council of Norway (observer)
 Chairman of General Assembly: Jørgen Young, Isola



RESEARCHER TRAINING

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Klima 2050 aims to attend effectively to education of researchers and is actively engaged also in education at the masters level.

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.

On a practical level, the ambition of the Centre is to enable the involved Ph.D. Candidates/researchers in assembling productive creative clusters with industry and public partners for research and publication purposes. So-called "writing lab's" – basically creating a room for sitting together whilst writing out the insights gained through experience and research – permit the inclusion on a non-committal level of involvement of industry and public partners with researchers at different levels. Active engagement of the industry and public partners in these processes is of the essence for producing the research required.

The Ph.D.-gathering of 2017 took place in Rypetoppen, Meråker in May, focusing on excellence in publishing and climate understanding.

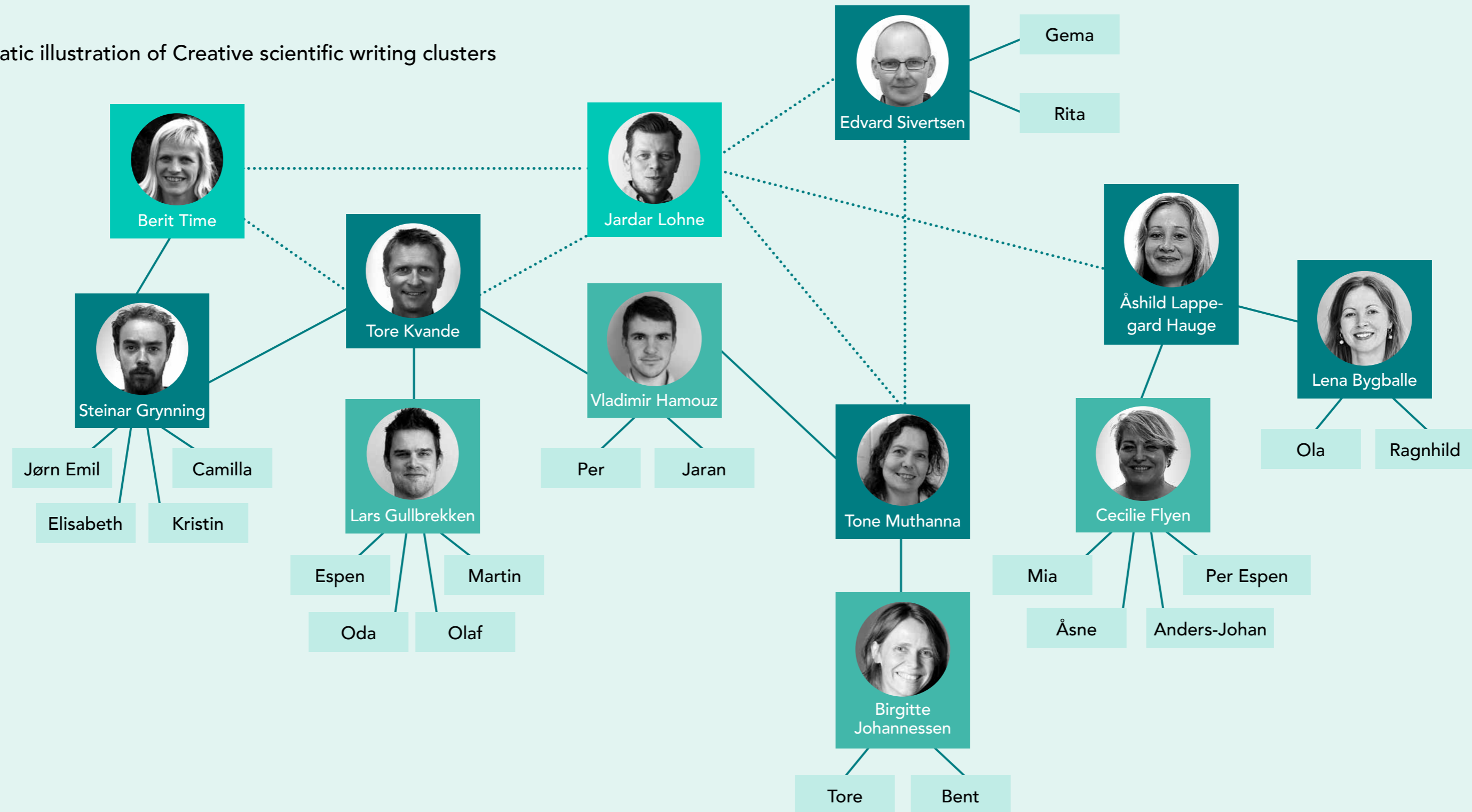
«The establishing of creative scientific writing clusters are seen as a promising measure for realizing an added value that lies within Klima 2050»

Carl Thodesen, NTNU



RESEARCHER TRAINING

Schematic illustration of Creative scientific writing clusters





INTERNATIONAL COLLABORATORS

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The awarded SFI status expand our international network with other universities and promote the formation of new collaborations in benefit for our partners from private and public sector.

— The Centre had a prominent role in the arrangement of the 11th Nordic Symposium on Building Physics in Trondheim in June. Climate adaptation of buildings were awarded a session, and moisture resilience was a core topic at the conference. An International Scientific Committee ensured high quality papers. 220 researchers and practitioners from 26 countries were participating.

The collaboration between VTT and SINTEF is evolving and a plan for a common seminar on Nordic nature based solutions for stormwater management was the outcome of the closing seminar of the VTT Stormfilter project.

The international project *The Minnesota - Norway Collaboration for excellence in education and research on adaptation to climate change* was granted through the Research Council of Norway's INTPART-program.

NGI (coordinator) was successful in the Horizon 2020 Innovation Action SC5-08-2017, with the application *Phusicos*. The project is about nature based solutions for rural climate related events.

➔
From the Nordic Building Physics Conference
1. Partners at conference dinner
2. Arrangement Committee at the welcome reception
3. Dinner at the Archbishop Hall in Trondheim
4. Discussions at the Conference

Photo: Mir foto, Anastasia B.

WP4:
Effective climate adaptation requires the involvement of many actors, who need to create a common understanding of what constitutes appropriate solutions to the challenges incurred. Collaborative programs, projects, and networks are important arenas in this respect. Klima 2050 is one such arena, and several of the partners in the centre participate on other arenas as well, such as Naturfareforum.

WP3:
The open source code REEF3D for computational fluid dynamics has been improved by implementing a new material model (rheological model) that is suitable for runout assessment of precipitation-induced landslides. Simulations using this code and rheological model can be useful for the design of mitigation measures by our partners Multiconsult, SVV and NVE.

WP2:
Estimating discharge in small ungauged catchments is a challenge, and in Klima 2050 we have regionalised the DDD hydrological model as a tool to compute runoff where no discharge measurement exists. This can be used to provide reliable data for planning of water use and design of infrastructure for partners NVE, Statens Vegvesen, Jernbanedirektoratet and others.

WP1:
We see a large interest in rebuilding to bluegreen and bluegrey roofs. This might be a challenge from a building physical perspective. Klima 2050 has developed a method to show how to proceed and what has to be thought of at the different stages in a rebuilding process. This will be a valuable tool for partners Multiconsult, Skanska, Statsbygg, Isola, Skjævelandgruppen and Weber Saint-Gobain (Leca).



INNOVATIONS

INNOVATIONS

OVASE.NO SPREADS KNOWLEDGE ABOUT STORMWATER

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Ovase.no will provide both information and inspiration to those who work with stormwater management. Multiconsult believes there is a great need for a web-based information portal.

— The web-based information portal *ovase.no* has its origin in a student group that studied technology management at NTNU in 2015. Tone Merethe Muthanna, associate professor at the Department of Civil and Environmental Engineering is the project manager of *ovase.no*.

– We have conducted a user survey that shows there is a great need for knowledge. There are a number of international information sites about sustainable solutions for stormwater, but none in Norwegian, says Muthanna.

Ovase wants more information

A beta version of *ovase.no* has been launched, and Klima 2050 is hosting and developing the platform. It will include a wiki, a toolbox and a sector presenting different projects and contributors in the field of stormwater management.

Ovase.no will address different user groups in need of advice about stormwater management, ranging from individuals to professionals in municipalities,

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Tone Merethe
Muthanna
Project manager
Ovase.no

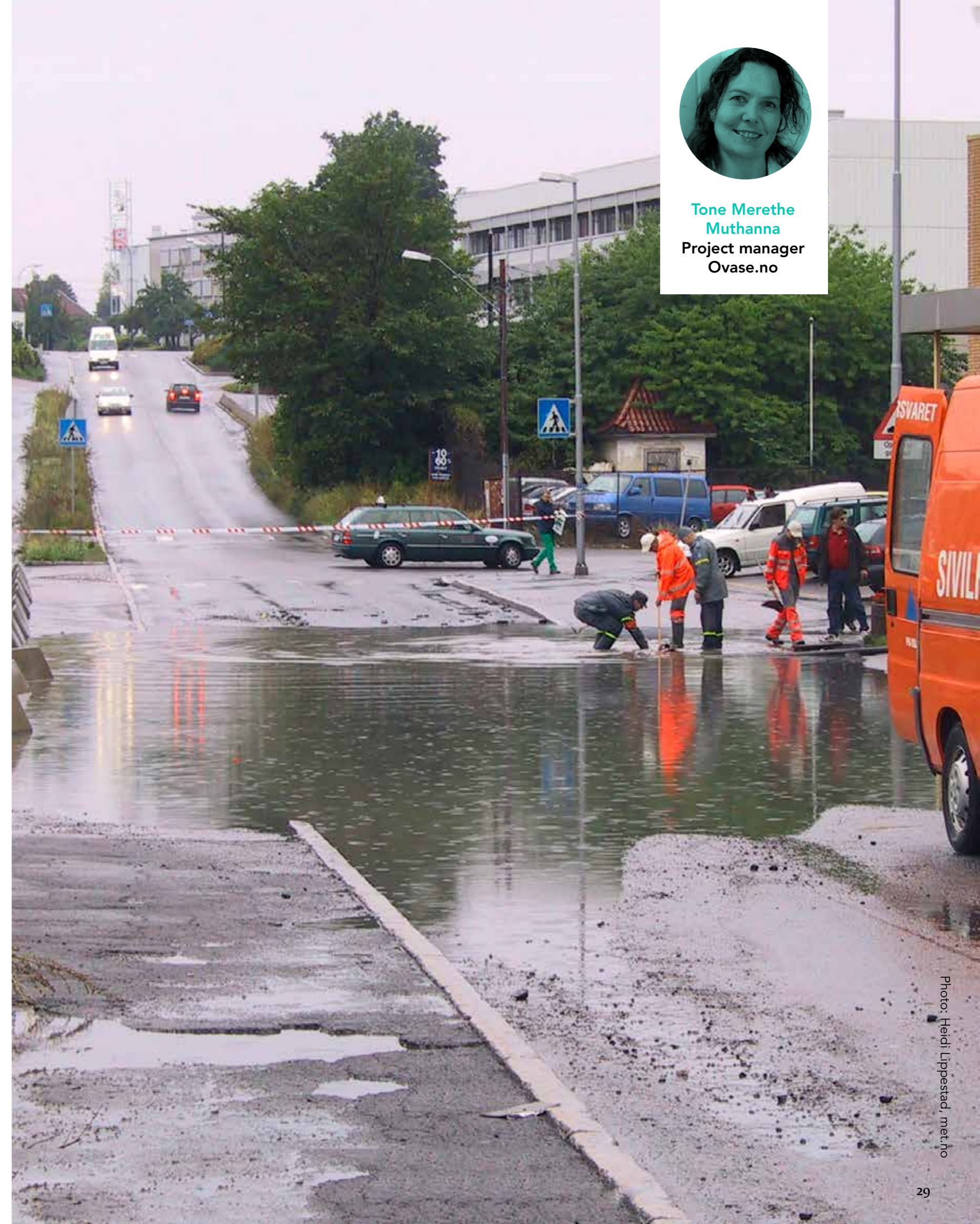


Photo: Heidi Lippestad, met.no



Photo: NVE

developers and suppliers of technology and products. The portal is free and accessible to everyone.

– The value of *ovase.no* is the sum of all the knowledge we all manage to put into it. We hope to create enough enthusiasm, and ask for descriptions about good solutions on stormwater management, says Muthanna.

Multiconsult sees the need

Lisa E. Hoven is working on climate adaptation in Multiconsult and believes *ovase.no* is a useful tool. She also hopes that as many people as possible will share their information to *ovase.no*.

– In Multiconsult, we miss feedback on projects, if we build a stormwater solution for a municipality we do not know if they are satisfied afterwards. A portal like *ovase.no* could contribute with such knowledge.

She is also looking forward to read about and get inspired by other projects and solutions.

Better choices - reduced social risk

Multiconsult is a partner in Klima 2050, Hoven sees great benefits in the partnership.

– Klima 2050 is a forum where we get insight about new solutions that we can propose to our customers.

Muthanna concludes by emphasizing that *ovase.no* can reduce social risk.

– Increased precipitation creates major challenges for the infrastructure. More and better knowledge about stormwater solutions leads to better choices, thus reducing social risk.

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Photo: Scanstockphoto

WILL MONITOR THE USE OF DE-ICING CHEMICALS



Ingvald Erga
Environmental
manager at
Stavanger Airport,
Sola

— The use of de-icing chemicals increases at Stavanger Airport, Sola and other airports in Norway. A pilot project looks at how the use can be monitored and do less harm.

— A more unstable, wetter and warmer climate with increased night frost generate more use of de-icing chemicals than before. This applies not only to Sola, but for most airports, says Ingvald Erga, environmental manager at Stavanger Airport, Sola.

The chemicals run out with the stormwater to Hafrsfjord, which is a fjord with a threshold and limited exchange of water. The de-icing chemicals are harmless organic compounds that break down biologically, but the process requires a lot of oxygen.

— Increased amount of chemicals can be an issue for Hafrsfjord where the oxygen conditions are poor, so we work to find a solution through Klima 2050, says Erga.

Microorganisms break down the chemicals

The pilot project aims to find a method for real-time detection measuring the concentration of de-icing chemicals in the stormwater, and to develop

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solutions that treat the stormwater locally. The aim is also to document the treatment effect, operation and maintenance of the solutions implemented.

Storm Aqua, part of the Skjæveland Group, has developed a drainage system that leads the stormwater to the ground, avoiding that everything ends up in Hafrsfjord. The de-icing chemicals that mainly consist of glycol and formate will then be broken down by microorganisms in the ground.

Great need for a solution

Both Per Møller-Pedersen, general manager of Storm Aqua AS, and Erga, believe there is a great potential for innovation.

– This solution is not yet available, and we know that many are struggling

with similar issues related to stormwater and climate change. It may also be of international interest, says Møller-Pedersen.

Innovation happens by meeting people

The drainage system must be developed according to emission permits, and Møller-Pedersen emphasizes collaboration with the research community and laboratory tests as important in product development. He believes Klima 2050 is an important arena for innovation.

– Many believe that innovation takes place in a formal way. But most of the time it happens by meeting someone face to face and exchanging ideas and thoughts. The idea of the project arose because Avinor and Storm Aqua are partners in Klima 2050, and I cannot emphasize enough how important such a meeting place is.

”The idea of the project arose because Avinor and Storm Aqua are partners in Klima 2050, and I cannot emphasize enough how important such a meeting place is.”

Per Møller-Pedersen, Storm Aqua





Photo: Bergknapp

GREY-GREEN OUTDOOR SPACE ON THE ROOFTOP



Rune Egeland
General Manger
at Multiblokk

Birdsong, a garden with breath-taking views, fresh air - and a good way to deal with extreme rainfall. «Urbane uterom» has developed a light weight and attractive roofing solution.

The annual report from 2016 describes the blue-green/grey roof pilot project at Høvringen sewage treatment plant owned by Trondheim kommune and the collaboration between Skjæveland Gruppen and Leca Norway on building a roof that delayed the runoff. This inspired Skjæveland Gruppen and Leca Norway to start the innovation project Urbaneuterom.no, where Bergknapp is the third partner.

– Experience from Høvringen showed that the combination of the permeable Leca material and paving stones delayed the runoff by one to two hours, and that it provided a good insulating effect. Leca and Skjæveland Group created Urbaneuterom.no because we want to work together to find good solutions for the future, says Rune Egeland, General Manager at Multiblokk, one of three companies in the Skjæveland Group.





Nature on an urban rooftop

The rooftops from Urbaneuterom.no are both grey and green. The green area which is covered by sedum, a plant that provides an important nourishment for insects and birds, and the grey area which is used to create an outdoor space for people.

Egeland explains how the roof is constructed: First here is a membrane covered with crushed Leca. The crushed Leca is then covered either with concrete stone, or with sedum. Leca absorbs rainwater and releases it slowly into the drainage network.

– The concrete stone is a newly developed product from Multiblokk and Leca, with Leca at the bottom and concrete on the top. It is 70 to 80 percent lighter

than normal paving stones and therefore suitable for rooftops, says Egeland.

Attractive and modern

In addition to the fact that the residents get a roof garden and that the runoff is delayed so they can avoid flooding, the roofing solution for Urbaneuterom.no also has other advantages, Egeland list:

- The insulation effect make heating and cooling more energy efficient
- An outdoor space on the roof provides better use of the area
- Higher rental and sales prices
- Because stormwater is handled on the roof it can compensate for other investments in stormwater management

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Photo: Bergknapp

– There is a lot of interest, we have several ongoing pilot projects. Developers are always reluctant and don't want to be the guinea pig. But we think it will become popular, the solution is light and provides the opportunity to shape exciting surfaces, says Egeland.

“Experience from Høvringen showed that the combination of the permeable Leca material and paving stones delayed the runoff by one to two hours, and that it provided a good insulating effect.”

Rune Egeland, Multiblokk

“Klima 2050 and the establishment at Høvringen have been important for urbaneuterom.no, that is where the partners started working together.”

Oddvar Hyrve, Saint-Gobain Weber





Photo: Geir Mogen



Fredrik Slapø
SINTEF

STATSBYGG GETS FIRST-HAND KNOWLEDGE FROM KLIMA 2050

—

A new master thesis from NTNU has found that fresh wet masonry mortar gives the best quality for brickwork. Statsbygg wants to be a driving force so such new knowledge will be put into practice.

— In 2017, Fredrik Slapø received «Næringslivsringens» award for best Master thesis at the Department of Civil and Environmental Engineering at NTNU. It is the second year in a row the prize goes to a student affiliated with Klima 2050.

Slapø, who has worked for seven years as a bricklayer, noticed that it's up to each bricklayer on how much water to add when mixing mortar, and that the amount of water varies greatly from construction site to construction site. The aim of his master degree was to determine whether the variation in water added to the mortar affects the quality of finished tempered brickwork.

Wet mortar works best

Slapø found that building with mortar with high water content (wet mortar) gives the best protection against rain and tensile strength, and thus more solid brick masonry.

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” If you look at life cycle costs, brick facades works out very well. They have a long duration, don’t need that much maintenance, are robust and withstand a lot.”

Håkon Einstadbland, Statsbygg

– If you look at life cycle costs, brick facades works out very well. They have a long duration, don’t need that much maintenance, are robust and withstand a lot. But this is the first time it has been proven that wet mortar gives the best glue effect between brick and mortar. This is very important knowledge that the construction industry should put into practice says Håkon Einstadbland, senior engineer in Statsbygg.

Wishes better quality

Although concrete and steel have become the most common material in large constructions, brickwork remains the dominant facade material in commercial and institutional buildings.

– Statsbygg is both the constructor and the responsible for managing and operating of our buildings. Therefore, we are interested in quality at all stages for the buildings to last. The cooperation in SFI Klima 2050 means that we get first-hand information of new knowledge that can improve the quality, says Einstadbland.

The construction industry needs impartial knowledge

He says it is a challenge that they themselves become a bit dependent on the suppliers to know the effect and quality of products. Therefore, it is important to do research on new solutions and materials to provide impartial knowledge to the construction industry.

– Klima 2050 has also done research on various types of water-repellent impregnation of brickwork where they have found that not all impregnation products work in stopping rain penetration. For us, such knowledge can be useful to save unnecessary costs, says Einstadbland.



Photo: Statsbygg



**GLIMPSES FROM
THE RESEARCH
ACTIVITIES**



BEST TO LEARN ABOUT CLIMATE ADAPTATION IN A NETWORK

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Technical solutions are not enough when working with climate change adaptation. Klima 2050 will publish a report with the recipe for how to best organize a climate adaptation network.

— How should climate adaptation networks be organized so that those involved can learn as much as possible and take the knowledge back to the workplace where it gets turned into action? Åshild Lappegard Hauge, senior researcher at SINTEF in Environmental Psychology, has tried to find the answer by studying two climate networks. She has particularly looked at the role of the municipalities. The research has been done in collaboration with Norwegian Institute for Urban and Regional Research (NIBR) and the project GOVRISK by Gro Sandkjær Hanssen.

Relationships of practical, political and personal nature can make driving forces or barriers to climate adaptation.

– More cooperation across municipalities and sectors is one of the most important measures for new climate adaptation solutions being implemented, says Hauge.

Feeling alone with the knowledge

The networks, which aim have been to learn and get a deeper understanding

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Photo: Roar Seljesæter



of climate adaptation, have consisted of representatives from both municipalities and county councils. They have met for one day events with lectures and workshops where they have discussed opportunities and challenges with climate adaptation work.

The municipalities have the main responsibility, and decide how and to what degree measures for climate adaptation are to be carried out. A common experience in the municipalities is that the climate adaptation work is pushed aside, because the employees already have enough work, and there is a lack of resources and expertise.

Which other challenges has Hauge seen?

– There is a danger that the knowledge about climate adaptation stays with the one or ones participating in the network. We see that many people have

trouble engaging the others in the municipality and they feel they are alone with their knowledge. Then it becomes difficult carrying out the work.

Learning from others

Social psychology shows that what other people do, especially those we associate with, is a strong driving force in influencing our attitudes. The best way to learn about climate adaptation is by attaining a network and not by sitting alone in the office reading a report. Or to put it simply: When we see what others are doing, we learn from it.

– Learning about climate adaptation is also about changing attitudes, ambitions and values. Some social mechanisms make this happen better when we are together with others in a network, says Hauge.

Management must be engaged

Hauge comes with some recommendations to avoid that the knowledge will just stay with the people in the network, but will be spread to others in the municipality or organization. An important point is political anchoring at a high level in the organization.

– When a municipality is invited to join a network, it is important to involve the management. There are examples of mayors who are not aware that the municipality is part of a network.

It is also recommended that at least two representatives from the municipality should participate and that those in the network are handpicked.

– Occasionally, the municipality sends the person who happens to have time on the day the network meets. Perhaps it is a government official who is fully busy with case proceedings and who is not exempted from work duties in order to work with the network. Then the opportunity to do something and spread the knowledge to the others in the municipality is minimal.

Hauge also says it's beneficial if the members of the network may decide on the program and the topics that are addressed. It makes it more relevant and engaging.

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“Learning about climate adaptation is also about changing attitudes, ambitions and values.”

Åshild Lappegard Hauge, SINTEF

“Network Recipe” will be tested

The two networks that Hauge and Sandkjær Hanssen have studied have now been completed. Klima 2050 has started a new network sponsored by the Norwegian Environment Agency.

– In this network we will test what we have experienced works well, says Hauge.

The final recipe with recommendations on how to start and organize a climate network does not come until spring, after the evaluation of the new network is done. These will be published in a Norwegian report.

The network Climate adaptation Trøndelag

In March 2017, the climate adaptation network Nettverk klimatilpasning Trøndelag was started. It is organized as a project for the period 2017 until 2025 with the county governor, county council and Trondheim municipality as initiators. 13 partners from state, regional authorities, research community and industry are involved. The network will create motivation for the work on climate adaptation and it will contribute with its expertise.

– The goal is that by 2030, Trøndelag will be climate-resistant, which mean the region should be well prepared and adapted to future climate change, said Ellen-Birgitte Strømø, coordinator for climate adaptation in Trondheim municipality and one of the initiators of the network.

The municipality of Trondheim has gained good expertise and experience in working with climate adaptation. But Strømø sees that many of the small municipalities do not have the necessary resources. For these it will be particularly beneficial joining the network.

All municipalities receive support

– We have started the first part of the job, consisting of the workgroup for the network visiting the municipalities in groups of 3-5 municipalities. Usually 4 people participate from each municipality, and we emphasize that at least one has a management position and that subjects such as planning, property, engineering, agriculture and the environment are covered. We think such smaller gatherings provide a good start. They feel comfortable and we get a picture of their expectations and future needs, says Strømø.

The municipalities will eventually organize themselves in groups where they work on topics that are important to them, such as sea level rise, landslide danger, cultural heritage or conservation of biodiversity. And the partners in the network will provide guidance to the municipalities on the topics where they have special knowledge.

A new way of thinking

The network will also support the municipalities in the work on risk and vulnerability assessments (ROS), mapping their own vulnerable areas, organize interdisciplinary work and create a plan for climate adaptation. The goal is that the Trøndelag municipalities should have this in place by 2022.

– In order to create a climate-resistant Trøndelag, those of us who work in the municipalities must find new ways of working. Through collaboration with the research communities we gain more expertise, and we must learn to share knowledge and experience. I think we are the first ones in the country that establish a network in such a way. Eventually we can share our experiences with other regions in Norway, says Strømø.

“The goal is that by 2030, Trøndelag will be climate-resistant, which mean the region should be well prepared and adapted to future climate change.”

Ellen-Birgitte Strømø, Trondheim kommune

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.

— The Norwegian Water Resources and Energy Directorate (NVE) has a warning system that announces when there is a risk of flood and landslides. Due to increased precipitation and climate changes, and the temperature changing rapidly between below and above zero, the number of landslide and flood alerts has increased lately.

A better understanding of how landslides are triggered and how the risk of landslides can be reduced is important in mitigation of climate related risks.

– The market offers many different risk reduction measures, but it takes a lot of work to understand what they provide and not everyone is equally suitable. Therefore, in Klima 2050, we have made a prototype of a web-based platform, which recommends what kind of measures are appropriate to take place in a particular vulnerable area, says Bjørn Kalsnes, Technical Lead of Risk and Climate Change at Norwegian Geotechnical Institute (NGI).

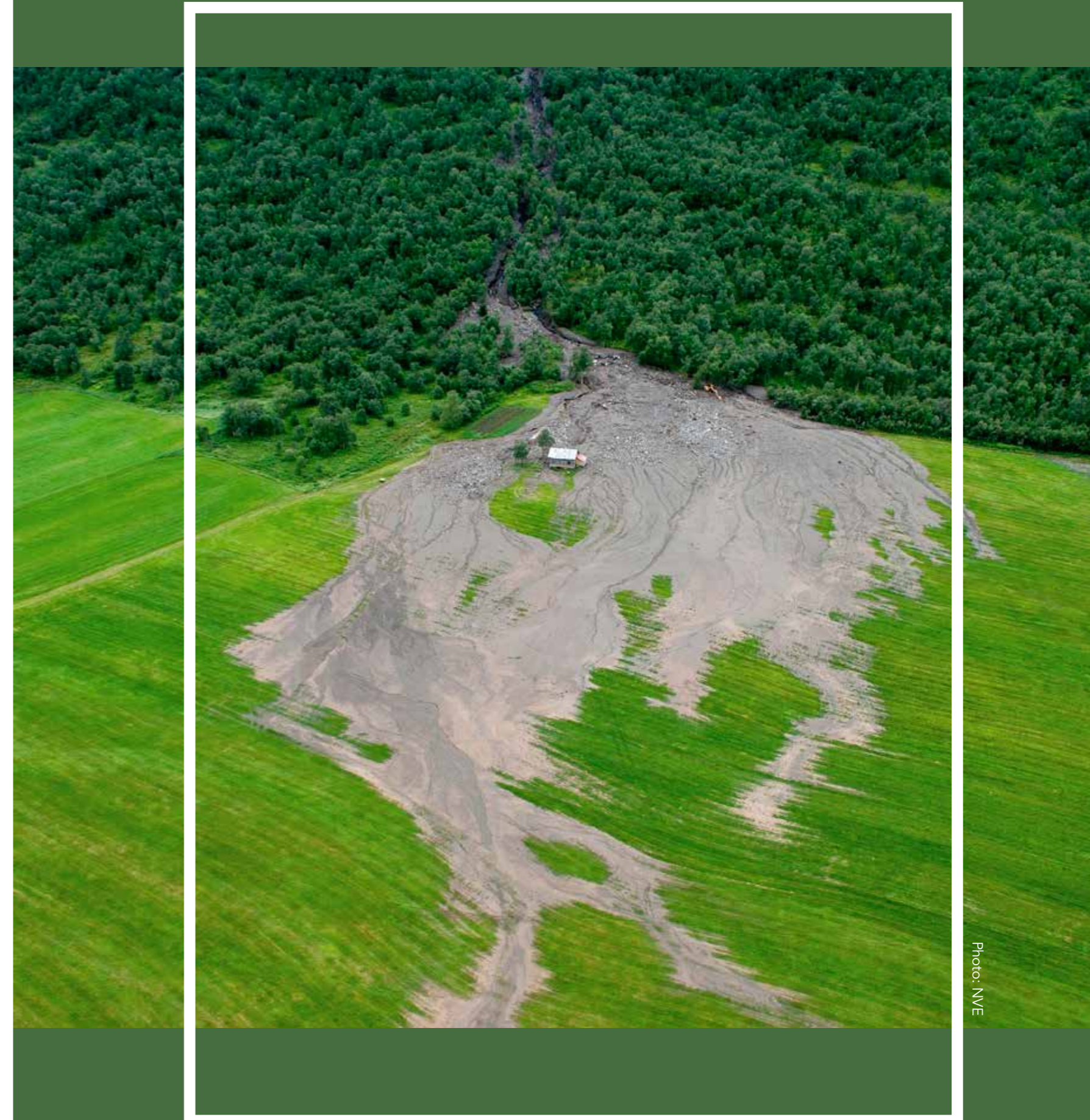


Photo: NVE



Difficult to choose the right measures

The selection of the most appropriate mitigation measures is a complex process which depends on both the characteristics of the expected landslide event and the potential impacts on the physical, financial, environmental, cultural and social values.

The measures for reducing risk can be divided into two main groups. The first is measures made in the landscape that prevents the landslide from being triggered. The second is measures near infrastructure and buildings to ensure that they are not affected if a landslide should occur.

The platform currently contains the description and overview of more than 60 existing mitigation measures. The descriptions come from an EU project on landslide that NGI previously coordinated. Ultimately the ambition is to include more measures, including new ones developed in Klima 2050.

Ask the platform - it gives you advice

But how should we act to get a list of recommended measures on how to, for instance secure an area? Kalsnes explains with an example: – Let's say that in a specific area in a municipality they frequently experience small debris floods along a stream. Local authorities want to secure buildings because in the case of an extreme rainfall, a much larger debris flood can occur. In this case, it could be helpful for a municipal engineer to get guidance from the platform.

The engineer must be able to provide some data about the possible event such as type of landslide, expected speed, volume, etc.

Also, economic and environmental limitations must be added into the system, for instance whether costly solutions are acceptable. Then the landslide platform will come up with a list of proposals of suitable security measures for this particular case.

The goal is to get a solid overview of the measures that can be taken in a quick and easy manner.

– Does it require a lot of expertise to use the platform?



”The market offers many different risk reduction measures, but it takes a lot of work to understand what they provide and not everyone is equally suitable.”

Bjørn Kalsnes, NGI

– It requires some knowledge about the area to be secured, but you do not need to be an expert yourself. We imagine that the typical user will be a municipal engineer who will do some planning activities in connection with a new housing project or the building of a new road.

Bane Nor finds it useful

The preliminary version of the platform has been tested by a group from Bane Nor on the behalf of Jernbanedirektoratet. They used information about landslide events they were familiar with to see how the tool responded after plotting in the information.

– We find that this tool may be useful after a landslide event or when planning for new development, to get an idea about what measures can be taken. But in order to assure the quality of the proposals we will need professionals, said Maria Hetland Olsen, who has tested the tool.

Kalsnes emphasizes that the information provided by the platform is not meant to be so specific that it is suitable for carrying out the measures themselves, but that it is useful in a research phase.

Hetland Olsen’s experience was that the tool was easy to use, and that it was relatively quick to enter the information.

– Some of the recommendations we received were typical measures that we knew and might have thought of ourselves while others were new and more innovative. We thought the recommendations that came up were reasonable.

Needs clearer definitions

Kalsnes hopes to get the platform ready for summer 2018. The preliminary

version will be tested by other users, and improved according to the suggestions. Among the feedback from Bane Nor was that the definitions of terms should be more precise, so that users can be completely confident that they enter the correct information when answering the questions, and that they also understand the different measures correctly.

– Definitions of terms and values should be easily available. It would be useful if definitions came up when you click on the different terms, says Hetland Olsen. They also want it to be clear what is emphasized in the various measures as they get different scores according to their suitability.

Suitable for both state institutions and municipalities

Hetland Olsen believes that state institutions like Bane Nor, Jernbanedirektoratet and the Norwegian Public Roads Administration, as well as municipalities, can benefit from the tool. She emphasizes the importance that the right professionals in each municipality or organization know that the platform is available for free use.

– It is possible to extend the program gradually. Currently, it does not include snow slides, or quick clay slides, but it would be useful to include that as well. Ultimately we also think that the platform for landslide risk reduction measures can be linked to hazard or susceptibility maps or directly to landslide events, says Kalsnes.



FLOODING AND STORM-WATER INJURIES ARE THE MOST EXPENSIVE

—

The waste water system is struggling to handle heavy rainfall, and from 2008 to 2016 the number of stormwater injuries increased from 18,000 to 26,000. Better access to data is needed to reduce the damage.

— Already today it rains 20 percent more in Norway than 100 years ago. Research in climate change indicate that extreme rainfall will be the most serious problem for Norway until the year 2100.

– Stormwater events are the most expensive, more than flooding or earthquakes or any other natural disasters. Perhaps the reason why the problem has not yet received much attention is that it is not dangerous, no one will be killed due to it, says Nathalie Labonnote, Senior Scientist at SINTEF.

Klima 2050 wants to discover how the use of data can be a good measure to reduce the social risks of climate change. Labonnote has mapped existing data on stormwater damage and handling, and published the findings in the report; Stormwater-related Databases - Review and Recommendations.

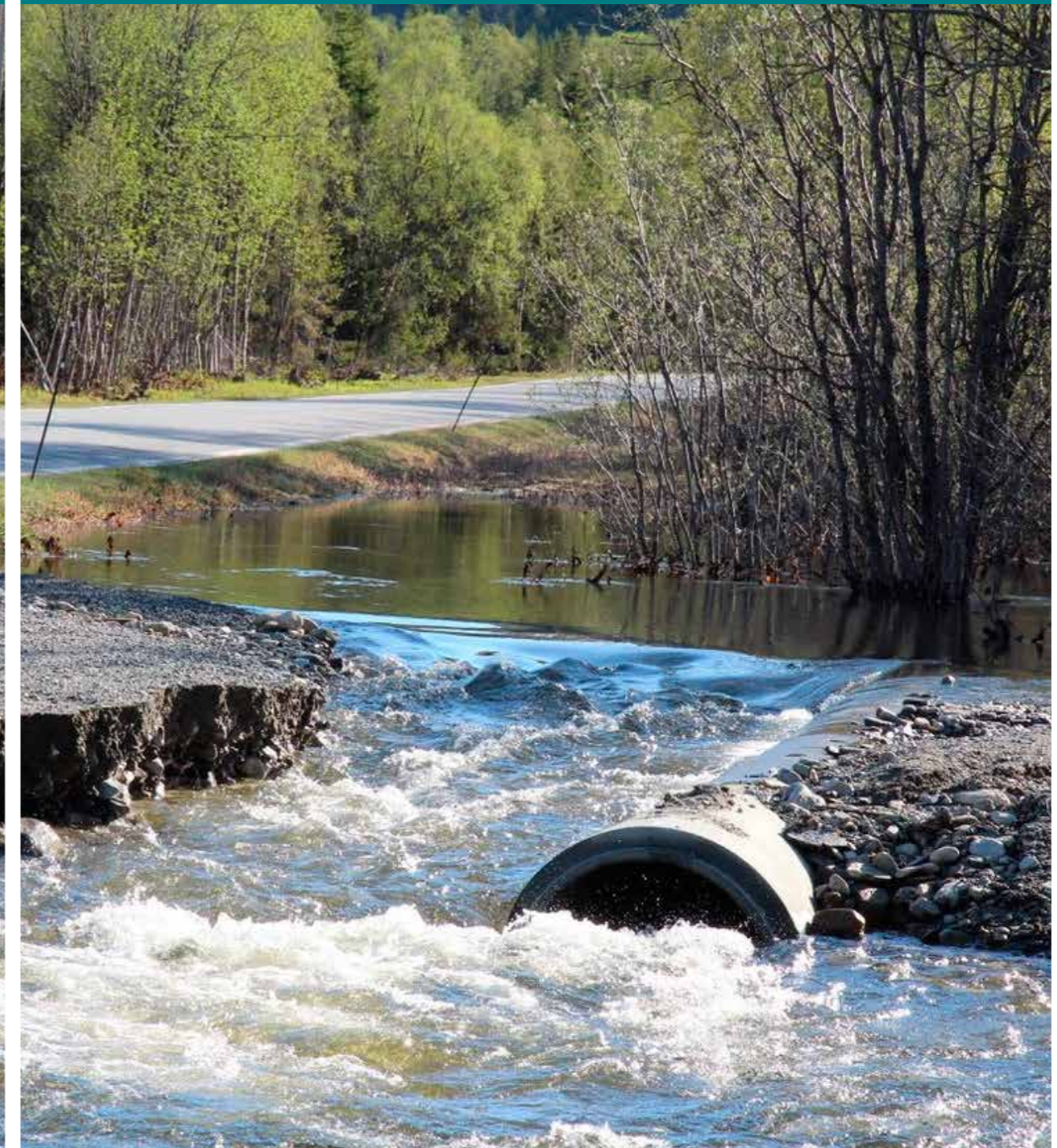


Photo: Magne Kveseth, Ataposten

20%

Today it rains 20% more in Norway than 100 years ago.

Fewer green areas and more rainfall

The traditional method of stormwater management is facing two major challenges today: More precipitation in general and more torrential rain with large quantities of water in a short period of time that overloads the waste water network. The second challenge is densification in urban areas and fewer natural areas that absorb water.

Statistics from Finance Norway show a sharp increase in injuries since 2008. The number of reported injuries related to stormwater was 18 000 in 2008, while the figure for the same type of injuries was 28,000 in 2016. The compensation for these injuries increased from 700 million Norwegian krone in 2008 to 1.3 billion Norwegian krone in 2016.

– There is a lot of data about stormwater incidents, but the information is fragmented and spread across different databases. Most of the data is exclusively for internal use. Our idea is that this information may be useful for others, says Edvard Sivertsen, Senior Scientist at SINTEF. He leads Klima 2050s work on stormwater management, which is one of four main areas.

Difficult to use for others

This project has mapped databases for stormwater events from Bane Nor, the Norwegian Public Roads Administration (SVV), The Norwegian Water Resources and Energy Directorate (NVE), Trondheim Municipality and Finance Norway.

Sivertsen thinks the biggest challenge with the information in these databases is that it is not collected for the purpose of being used by others. Everyone has their way of mapping and register data, even their own language, which makes it difficult to use for others.

– Some calls it flooded basement, some calls it stormwater, and others just call it water intrusion. Because there is no specific standard, the data is difficult to use for others, says Sivertsen.

Twice the work and lack of cost overview

This way of working and using data is not efficient, says Labonnote, and illus-



Photo: Morten Aakre

trates with an example: If Bane Nor is to carry out a risk assessment related to a construction project, they do not cooperate with the Norwegian Public Roads Administration, which already may have information about previous events in the specific area. This can lead to unnecessary double work.

– We need to find a solution to increase the knowledge about stormwater in the society. The challenge is to get all the sectors to talk together.

Another challenge Labonnote sees is that the data primarily contains a registry of events, they are not designed to be used for landslide prevention. If Bane Nor has to repair a damaged train track, their data is not linked to the Meteorological Institute, which may have information whether there was a flood when the damage occurred.

– Because the data is not analysed, we do not know the cause of the stormwater events. This makes it difficult to make the right decision to prevent the damage from being repeated in future. The lack of good information about the costs is also a problem which makes it difficult to plan the mitigation measures.

Smart system provides information

Based on the knowledge they have gathered, Labonnote has a proposal on how to make data more accessible and relevant so they can be used to reduce societal risks.

– 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. Instead, we want to develop a system that can retrieve data from different databases. The plan is to create a demonstration model and then develop it further.

In this system, one can enter a specific question such as which stormwater events have occurred at a particular location in Trondheim municipality. The system will search for information from different bases, such as from Norwegian Public Roads Administration, Trondheim municipality and from insurance companies. Based on this, the system creates a report for the user.

An important conclusion from the mapping is that before moving on to develop the system they need to know better what the needs of the users are. Labonnote has talked to people who use data on a daily basis, stating that the internal data are not user-friendly and does not cover their needs.

Sivertsen points out that they must first clarify the legal rights of the data and who should have access to such a system.

Insurance companies have the best data

Insurance companies are the ones that have the most complete data. Insurance damage data contains information about where, what and how much should be invested in prevention to reduce societal risk. The data can make it easier for both authorities and private companies to prevent and insure themselves against damage.

1,3 bill.

The compensation for storm-water related injuries increased from 700 million NOK in 2008 to 1.3 billion NOK in 2016.



“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

Mia Ebeltoft, Head of Insurance in Finance Norway, is trying to get insurance companies to understand the benefits of sharing their data.

– Better planning and prevention requires knowledge of vulnerable areas, known as “hot spots”.

There is a greater understanding in the insurance companies of how important these data are when reconstructing after damage to prevent it from happening again, such as after the flood in Asker and Bærum in the summer of 2016.

Collaboration between research, private and public sector

Ebeltoft sees the collaboration between research, private and public sector as the most important aspect of Klima 2050.

– This kind of collaboration is really essential for climate adaptation and has been in short supply. For us it is valuable that the research institutes learn how insurance handles injury, risk and use of damage data, and that this is utilized in new research, says Ebeltoft.

She emphasizes that the increase in damage is not only due to climate change, but also poor planning of buildings in exposed areas and lack of maintenance in the sewage system. She believes the value of prevention should be understood better.

– According to the UN and the World Bank, 1 dollar in prevention will mean 5-7 dollars saved in damages. If this also applies to Norway, it should be interesting for the Norwegian authorities, says Mia Ebeltoft.

BUILDING LARGE, CLIMATE ADAPTED WOODEN ROOFS

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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 is required to build climate adapted wooden roofs.

– In compact roofs and roof terraces, rainfall and leakages are the most common causes to damage, while air leaks are an equally contributing factor to damage in sloped roofs, says Gullbrekken.

The study is part of a major process in developing guidelines for sloped wooden roofs beyond the limitations of today's recommendations in the SINTEF «Byggforskserien» (SINTEF Building Research Design Guidelines).

Wood is climate-friendly

Compared with steel and concrete, wood is a more climate-friendly building material due to much lower CO₂-emissions. And wood becomes a more and more relevant material for large buildings, including load-bearing structures and as an insulation material.



Illustration: Norgeshus

– Stricter requirements for reducing CO₂-emissions and for energy reduction make it more important to find climate-friendly materials. There is a lot of development in the usages of wood in modern constructions; today wood is used in building constructions up to 10 floors. Tree grows naturally, it's easy to harvest and to utilize, says Gullbrekken.

He emphasizes the importance of testing new solutions to establish new guidelines.

Sloped wooden roofs need air

Sloped wooden roofs are built with a gap between the roofing and the underlayer roof. There are two main reasons why the roof needs ventilation: One is to prevent the rise in temperature which can cause snow melting and icing in gutters and drains, while the other reason is to ensure ventilation of humidity from the roof structure.

20% Damage to wooden roofs accounts to 20 per cent of all damage claims.

Gullbrekken explains that large icicles hanging down from the gutter can indicate insufficient insulation of the roof structure, or lacking ventilation of the roofing.

The Norwegian guidelines given in Byggforskserien include wooden roofs with a total area up to approximately 15m x 15m. The minimum roof pitch is set to 10° or 18° depending on the underlayer roof construction and air cavity design. When the recommendations were made, the experience was that there was difficulties in ventilating longer roofs.

– Based on measurements and calculations, we have found that it's possible to build both longer and more flat roofs than previously recommended, says Gullbrekken.

New way of roof venting

The roof is usually ventilated through openings at the eaves and at the ridge



“Today, the solar panel is installed on the top of the roofing. The best solution would be to develop a system where the solar panel itself could function as a roofing.”

Lars Gullbrekken, NTNU

of the roof. One of Gullbrekken's findings is that ventilation by air passing through the whole roof, from eaves to eaves can be sufficient.

– Ventilation opening at the roof ridge is not always practical neither aesthetically desirable. One problem may be that water and snow can enter through this opening more easily. Our measurements show that ventilating from eaves to eaves is efficient, even for steep wooden roofs, says Gullbrekken.

What is the recommended size of the air gap depend on the size and build of the roof.

– Today we use more insulation than before. The air gap can be reduced compared to the current guidelines because increased insulation thickness lowers the heat transportation into the ventilated air gap. Because of this you can build longer roofs and perhaps also reduce the air gap.

Solar panel as roof deck

Gullbrekken believes the next step must be to be able to use the solar panel as a roofing. So far, he has just briefly touched upon this in his PhD thesis.

– Today, the solar panel is installed on the top of the roofing. The best solution would be to develop a system where the solar panel itself could function as a roofing, in this way we would save materials and money. There are currently no well documented solutions available so there is a great opportunity for innovation! For example, we need to figure out a solution adapted to Norwegian winters.

Climate change requires better materials

A more unstable climate like we have experienced this winter with rain one

>>

day, and sub-zero temperatures and snow the next day, demands a lot from roof constructions. Not least in terms of ventilation, says Jørgen Young in Isola. Isola is a supplier of products used in roof constructions and has been a partner in this project. They experience a much greater interest in using wood in larger constructions.

– We think being a part of Klima 2050 is a win-win situation for all the partners. We want to be ahead, and by participating in research, we see which products need to be developed. Since we have contact with our customers, I believe we can become the epitome for research about what’s going on out there, says Young.

He sees there is a need to develop new and more detailed solutions that can be part of the SINTEFs Byggforskserien to build climate-friendly and robust, and thus avoid damage.

”Our hope is to use Lars’ research findings preferably in combination with new, modern architecture.”

Ole Mangor-Jensen, Skanska

Need to verify new solutions

Ole Mangor-Jensen from Skanska also believes there is a great need to verify new solutions and test how one can build differently today than before.

– Earlier we used 25 cm of insulation in the roof, according to the regulations from 1997, and thought that was a lot. Whereas today it’s not uncommon to use 40 cm.

More insulation makes it possible to build roofs with less need for ventilation, lower roof angles, and other roof shapes, but before Lars finished his PhD thesis we didn’t have any evidence that it was possible.

A challenge for Skanska when they want to test new solutions is that most contractors want the design to be done quickly and efficiently according to pre-adapted solutions. Getting the necessary approval to testing out new solutions is not always easy, so it is useful to participate in pilot projects under the auspices of a research program.

Wanting innovation in the construction industry

– Our main motivation for being part of Klima 2050 is that we want to contribute to research leading to development and innovation in the construction industry. It is a conservative industry. It is important to have a good research environment and a leading institute such as SINTEF to develop the industry says Mangor-Jensen, and adds:

– Our hope is to use Lars’ research findings preferably in combination with new, modern architecture.

At the same time, Mangor-Jensen says that a challenge in a project like Klima 2050 is to find a balance between theory and practice and how to involve partners and contributors.

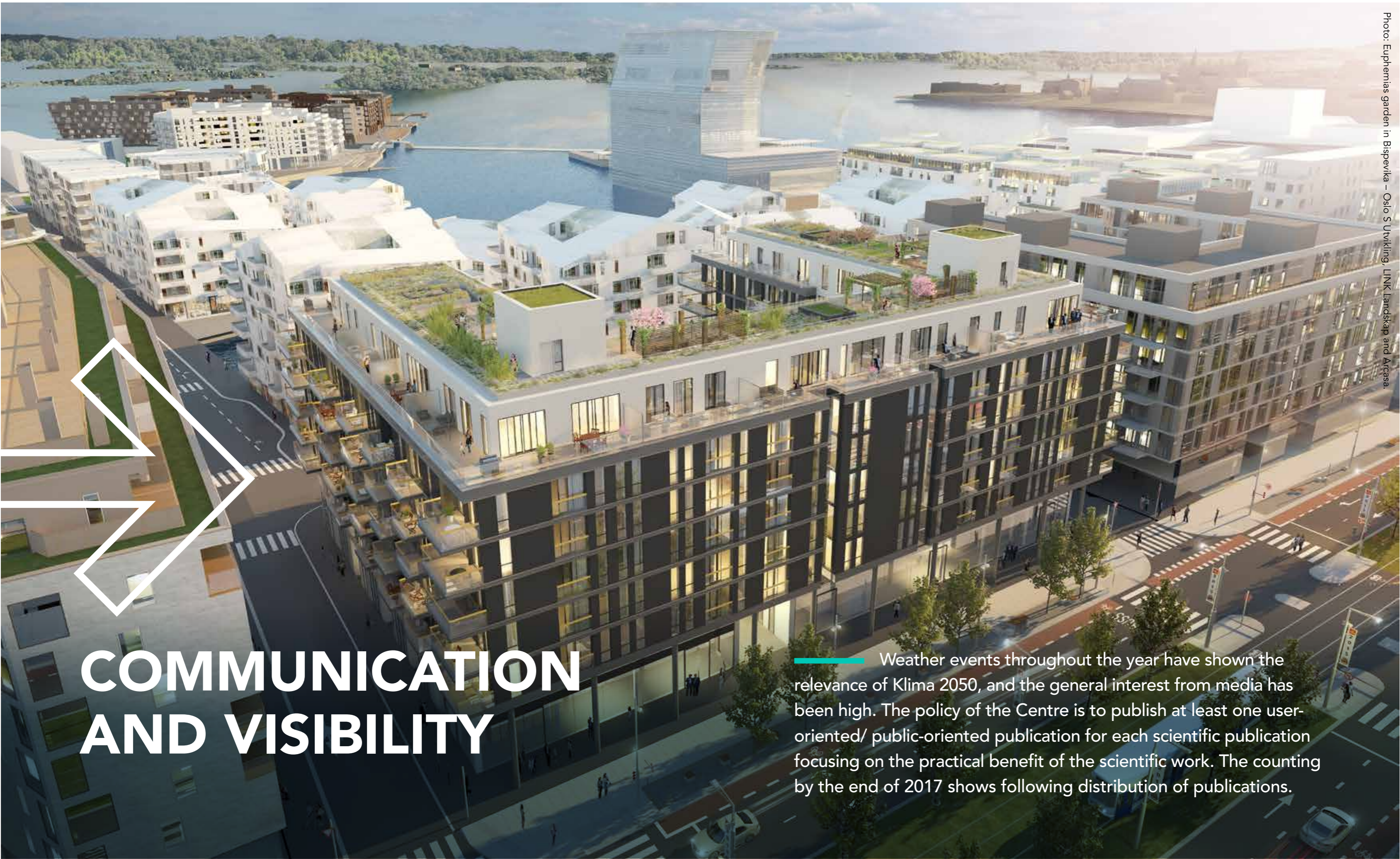
– There has been too little research in this field for the last 20 years; we need a better foundation to show that innovative solutions are durable. It is also important that material manufacturers such as Isola and others in the field of research and product development are joining in. The more documented solutions, the greater the possibilities when designing our projects.





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KEY FIGURES




COMMUNICATION AND VISIBILITY

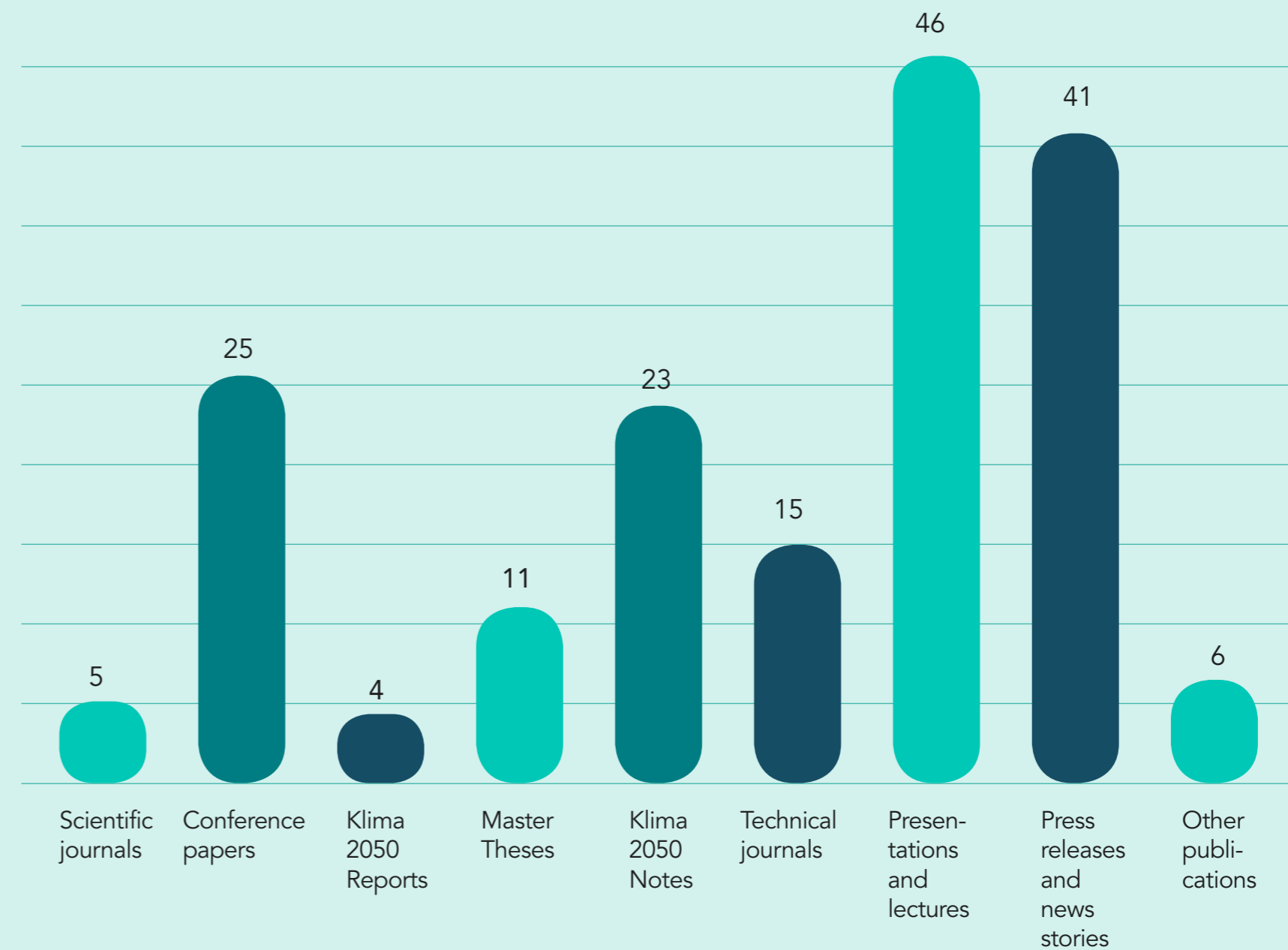
Weather events throughout the year have shown the relevance of Klima 2050, and the general interest from media has been high. The policy of the Centre is to publish at least one user-oriented/ public-oriented publication for each scientific publication focusing on the practical benefit of the scientific work. The counting by the end of 2017 shows following distribution of publications.

COMMUNICATION AND VISIBILITY

All publications in 2017 are listed on www.klima2050.no

 **Design and climate adaptation**

Klima 2050 were awarded a session on Design and Climate adaptation in **Forum Wood Building Nordic** in Trondheim in September. Researcher **Helga Therese Tilley Tajet, Meteorologisk Institutt** gave insight into climate change and perspectives on potential risk of wood decay. 500 participants visited the conference which was hosted by partner Trondheim kommune.



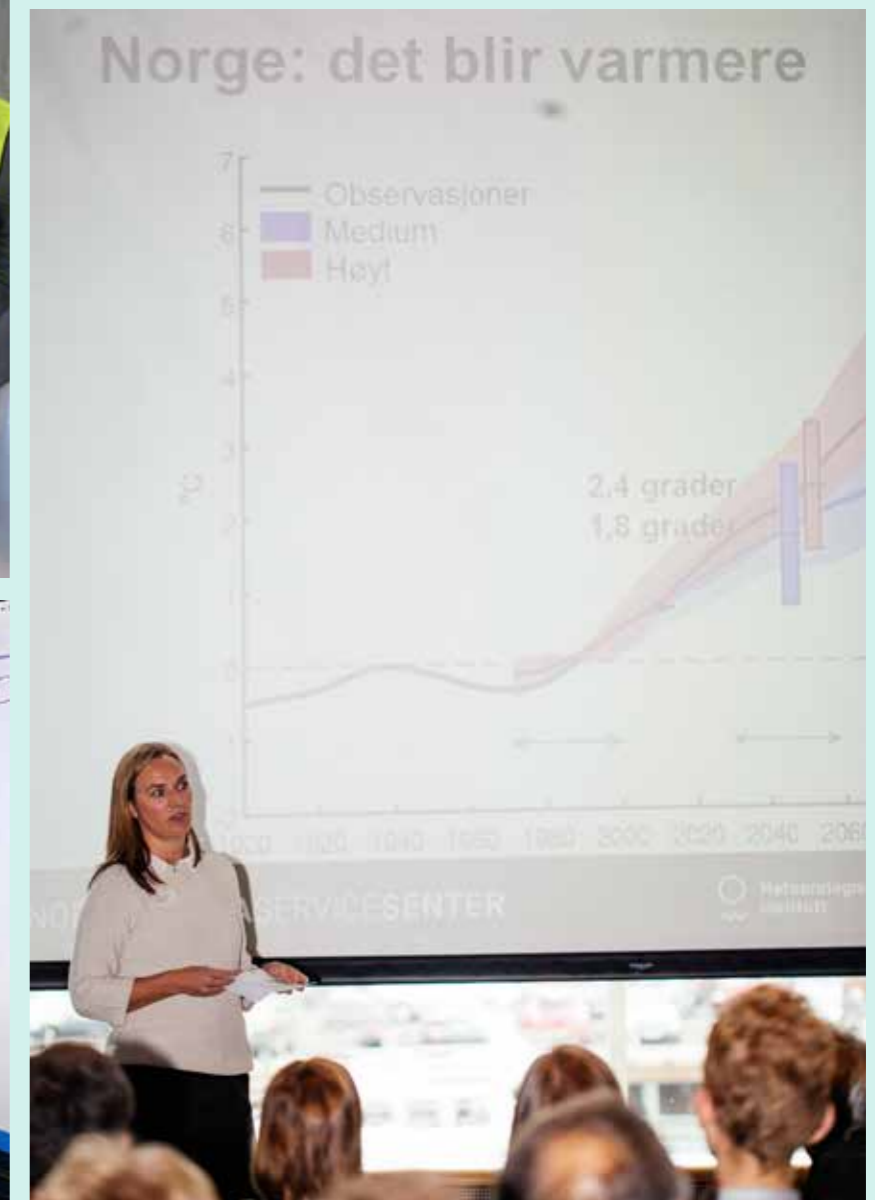
THEMATIC MEETINGS

Thematic Meetings

- gatherings organized including all or part of the consortium with the purpose of contributing to the dissemination of knowledge, experience exchange, research exchange and innovation.
- a meeting point for the partnership.

The gatherings, collecting between 10 and 50 people are important in view of knowledge exchange, the researchers receive direct input to the research work and areas of closer collaboration are pointed out.

- *Klima 2050 Innovation Arena*, SINTEF/NTNU, Trondheim 5. April
- *Modelling hydro-meteorologically induced landslides in Norwegian conditions*, NGI, Oslo 6. April
- *Master theses in stormwater management spring 2017*, Klima 2050 HUB, Trondheim 2. May
- *Research Plan for Høvringen 2017 – 2020*, Klima 2050 HUB, Trondheim 1. June
- *Ovase.no design sprint*, Klima 2050 HUB, Trondheim 19. June
- *Structures towards the ground – how can we improve moisture robustness?*, Isola, Porsgrunn 28. August
- *Green roofs meeting the ground*, Skanska, Oslo 13. November
- *Information needs and data for cost-effective risk management*, NGI/SINTEF, Oslo 10. November



Snapshots from Thematic Meetings

RECRUITMENT

Klima 2050's PhD candidates financed by the Centre in 2017:

Silje Asphaug, NTNU
Erlend Andenæs, NTNU
Erin Lindsay, NTNU
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 2017:

Manuel Franco Torres, NTNU/Multiconsult
Birgitte Gisvold Johannessen, NTNU/Trondheim kommune
Kaj Pettersson, Chalmers University of Technology

Post.docs 2017:

Åshild Lappegard Hauge, SINTEF
Jardar Lohne, NTNU

Fredrik Slapø was awarded «Næringslivsringens Pris» for the best Master Thesis in 2017.

Partnerinteraction at Klima 2050-dagen

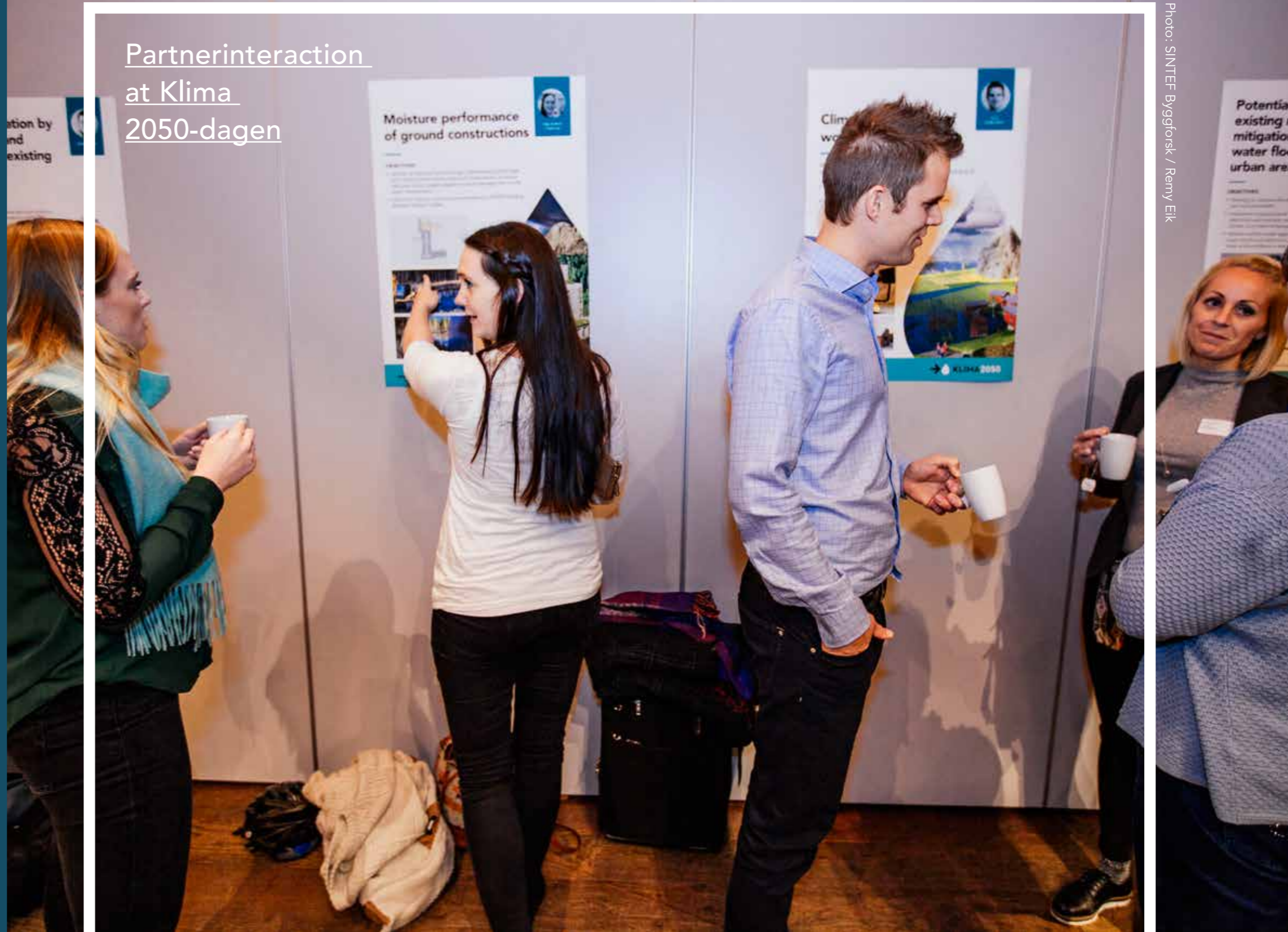


Photo: SINTEF Byggeforsk / Remy Elk

ANNUAL ACCOUNT

2017

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FUNDING

The Research Council	12 600
SINTEF (host institution)	2 622
Research partners	2 247
Private partners	8 782
Public partners	5 887

Sum	32 138
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COSTS

SINTEF (host institution)	12 052
Research partners	12 480
Private partners	7 282
Public partners	324

Sum	32 138
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All figures in 1000 NOK



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

Klima 2050 Report No 8

Annual Report 2017

Berit Time (editor)

Keywords: Klimatilpasning, bygninger, overvann, skred,
beslutningsprosesser

ISBN: 978-82-536-1570-7

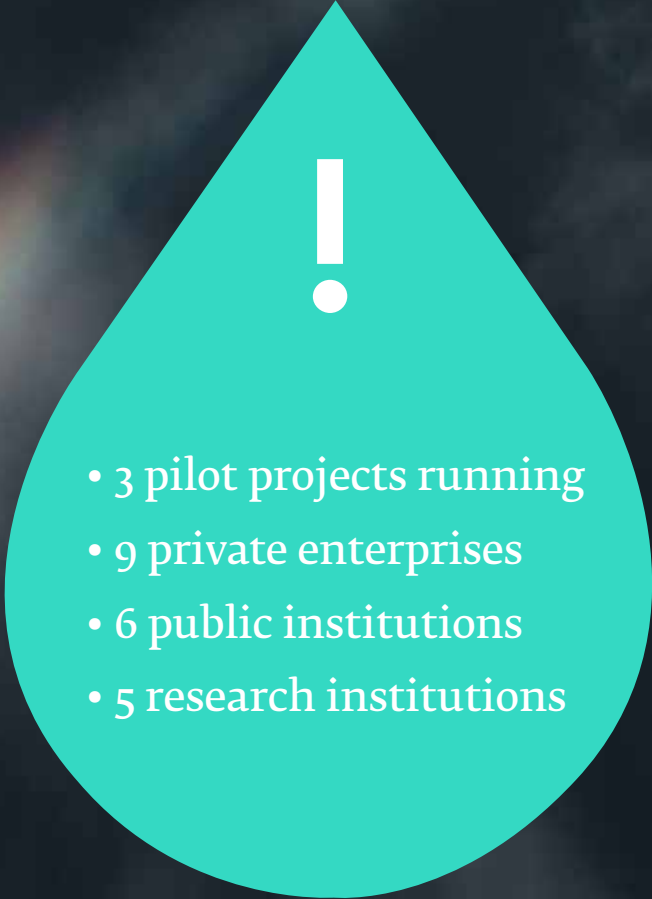
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- 3 pilot projects running
 - 9 private enterprises
 - 6 public institutions
 - 5 research institutions