



Oslo

Klimaetaten

Climate Change Vulnerability Analysis for Oslo

Short version

«Our climate change
adaptation efforts
should be one step ahead
of climate change»



Oslo will become a climate-resilient city

Oslo's climate is becoming warmer and wetter, while its population is steadily growing. This combination makes Oslo increasingly vulnerable to climate change unless decisive steps are taken to prevent the adverse impacts of current and future climate change. Our climate change adaptation efforts should therefore be one step ahead of climate change.

In 2015 the City of Oslo set the goal of making Oslo a climate-resilient city. The aim of the Climate Strategy for Oslo towards 2030 is to strengthen the city's capacity to withstand climate change between now and 2030 and to develop the city to prepare it for the changes projected by 2100. A climate-resilient city can prevent the impacts of higher temperatures and more torrential rain so that it can absorb most climate-related hazards without incurring major interruptions or damage.

Climate resilience

Climate resilience entails building resilience to negative impacts of climate change. The concept embraces two components:

1. society should absorb external stresses imposed upon it by climate change, and
2. society should have the ability to adapt and develop new solutions that strengthen sustainability and prevent future impacts of climate change.



Climate change and climate-related hazards in Oslo

The Earth's climate is changing. The weather changes naturally from day to day and year to year, but by climate change is meant an average change over a longer period. Weather observations have established that the climate has become warmer over the past century and, according to the Intergovernmental Panel on Climate Change (IPCC), the global average temperature will continue to rise between 1.5 and 4 degrees Celsius towards 2100, depending on how much greenhouse gases are emitted into the atmosphere. In line with the precautionary principle, which applies to the work done on climate change adaptation in Norway (Meld. St. 33 (2012–2013) Report to the Storting (white paper) Climate change adaptation in Norway), we must expect that anthropogenic emissions will continue as before and that climate changes will occur as a result.

Although climate change is occurring globally, local conditions vary widely. The main trend indicates more extreme weather such as torrential rain and heatwaves. Extreme weather in this context is defined as extreme deviations from normal weather, and not necessarily catastrophic weather phenomena. Over the past century, the climate in Oslo has become 1.5 degrees warmer and 15 per cent wetter, and extreme events have occurred more frequently. These changes became more prevalent in the late 1900s and early 2000s, and will continue throughout this century. Unless we reduce greenhouse gas emissions globally, the average temperature will increase by between 3 and 6 degrees Celsius and precipitation levels by between 5 and 30 per cent by 2100. By that time the climate in Oslo will have changed dramatically, particularly in the winter months. Temperature rise is projected to be highest in the polar regions and lowest in the equatorial regions. Temperature rise is therefore projected to be higher in Norway than the global average.

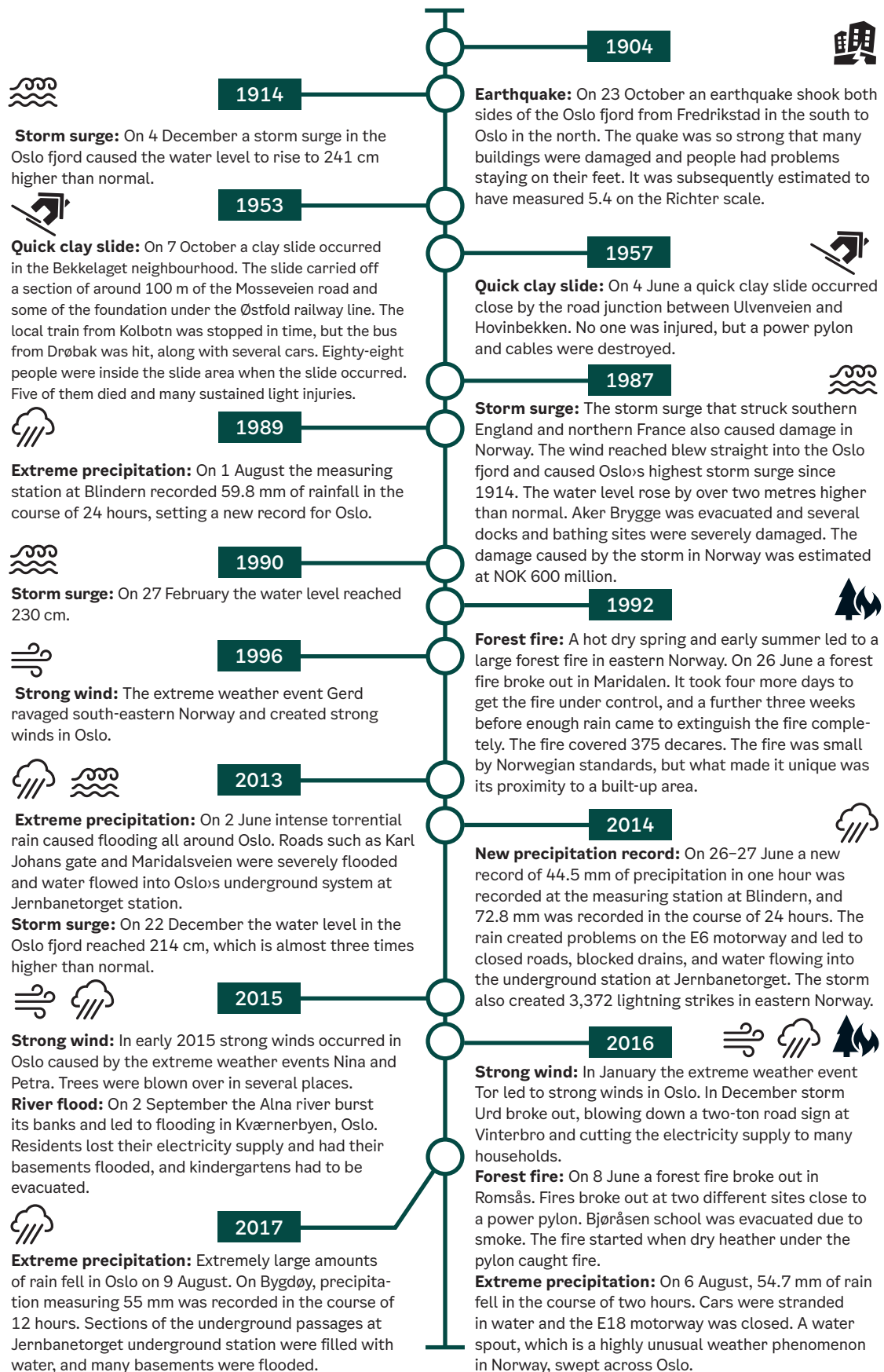
About the Climate Change Vulnerability Analysis

This is a short version of the Climate Change Vulnerability Analysis for Oslo, which is the first comprehensive analysis of the status of Oslo's preparedness for climate change. Climate change vulnerability is the result of how exposed society is to climate change and of its capacity to adapt to and prevent the impacts of climate change. The aim of the Climate Change Vulnerability Analysis is to strengthen the knowledge base for a more climate-adapted city, where considerations of climate change are assessed and climate adaptation solutions are integrated.

The assessments of climate-related hazards in this analysis are research-based, while the climate-related impacts and adaptive capacity have been identified by the City of Oslo's own agencies. They know what impacts the various climate-related hazards will have on our city and how we are equipped to address them.

A subsidiary report has also been prepared on climate changes and climate-related hazards for Oslo, which is an extract taken from the chapter with the same title in the Climate Change Vulnerability Analysis. The Climate Change Vulnerability Analysis for Oslo and the subsidiary reports can be downloaded from klimaoslo.no.

Summary of selected extreme natural events in Oslo from 1900 up to today.



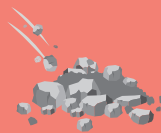
INCREASED PROBABILITY



The number of episodes of heavy precipitation is expected to increase significantly in terms of intensity and frequency. These will also lead to more stormwater and urban floods.



More frequent and heavier floods are expected, and floodwater flows in streams and rivers must be expected to increase.



Increased risk of landslides and flood-related debris flows resulting from increased precipitation.



Higher storm surge levels are expected as a result of sea level rise.

POTENTIALLY INCREASED PROBABILITY



Minor changes are expected in summer precipitation, and higher temperatures and increased evaporation may therefore increase the risk of drought during the summer.



Increased erosion caused by heavy precipitation and increased flooding of rivers and stream may trigger more quick clay slides.

UNCHANGED OR LESS PROBABILITY



Snowmelt floods will occur increasingly earlier in the year and become smaller in scale towards the end of the century.



Shorter ice cover season and reduced ice drift. Coastal rivers will have little ice cover.

UNCERTAIN



It is uncertain whether the incidence and intensity of **strong winds** will change.



- More frequent episodes of heavy precipitation may increase the frequency of rockfalls and rock slides, though mainly smaller **rockfall events**.

Probability for some of the climate related hazards in Oslo towards 2100.
Source: Klimaprofil for Oslo og Akershus (Norsk klimaservicesenter 2017)



These climate changes will create more frequent and more severe climate-related hazards due to more extreme weather and to changes in normal weather. While some of the capital's future climate-related hazards will be acute, others will emerge more gradually. The most acute hazards will be associated with more extreme precipitation. The increases in precipitation that have occurred and that will continue to occur in Oslo will materialise in the form of heavy and intense rainfall. As a consequence, today's extreme precipitation may become the new normal. This would increase the likelihood of:

- ♦ Stormwater and urban floods. We must reduce the extent of impermeable surfaces in the city, manage stormwater locally, and use it as a resource in the urban landscape.
- ♦ River floods. It will be increasingly important to control where water runs when rivers flood, and to secure flood zones along rivers and streams that take a changed climate into account.
- ♦ Landslides and avalanches. Soil deposits and terrain types usually determine where landslides and avalanches occur, and potential slide zones will remain mostly the same, but because they are often triggered by extreme precipitation, future landslides and avalanches in Oslo may become more frequent and cause more damage. This will apply particularly to minor landslides and flood-related debris flows, but also to quick clay slides.



Photo: NTB Scanpix / Torstein Bøe

- Rising average temperatures and a gradual change in normal climate in Oslo will also lead to climate-related hazards that are important to prevent in the long term:
- Heatwaves may pose a challenge if we do not prepare for longer, more intense periods of higher temperatures than what have been normal in Oslo.
- Despite a wetter climate, dry periods may pose a greater hazard in future as a result of high temperatures and stable weather systems.
- Sea level rise may pose a hazard when it becomes higher than the land uplift following the last glacial period, which until now has prevented a higher sea level in the Oslo fjord. By 2100, however, the water level could be 47 cm higher than today, which will significantly increase hazards such as storm surges, flooding and wave damage along the fjord.
- A warmer and wetter climate will increase hazards related to humidity and decay, and in Oslo the risk of decay will shift from moderate to high in the course of the century, which could particularly affect the city's wooden buildings.
- It will be increasingly important to take account of local climate in the city, because densification and infill resulting from a wish to build a more compact and climate-friendly city may trap polluted air and create wind tunnels, heat islands and other hazards.

How will climate change affect Oslo?

Climate change and climate-related hazards will result in impacts on nature and society which in this analysis are referred to as climate-related impacts. Climate change threatens many assets which we as a society value, and some assets will be lost. The adverse impacts of climate change create a need for nature and society to adapt.

Oslo is particularly vulnerable to climate change due to its concentrated population and built environment. This creates a broader range of climate-related impacts than in less populated areas.

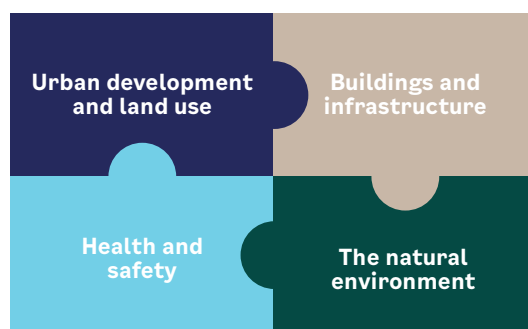
We have already experienced some impacts of climate change, such as stormwater hazards, for several years now. Oslo already had problems dealing with stormwater before the climate began to change, but now precipitation events are becoming more intense than ever and the hazards greater, while the city is growing larger and denser.

We know less about some impacts of climate change that have not yet occurred, especially regarding the impacts of higher temperatures, and this work has therefore been less methodical. Experiences of more abnormal weather events are increasing our awareness of what could happen as a result of climate change and of what is needed to prevent negative impacts.

The analysis has assessed the impacts of climate-related hazards in four areas of society: urban development and land use; buildings and infrastructure; the natural

environment; and health and safety. All areas of society are affected by climate change, though in different ways. Buildings and infrastructure are most directly affected, while health and emergency preparedness are most indirectly affected. The challenge for the natural environment is twofold: climate change affects nature's inherent ability to adapt, which in turn affects the ecosystems that make the city climate-resilient. The solutions and adaptive capacity lie to a large extent in the areas of land use, buildings and infrastructure, which prevents climate-related impacts in other areas of society as well.

Each climate-related hazard can generate multiple climate-related impacts in multiple areas of society. For example, extreme precipitation and stormwater affect the city's infrastructure but may also contaminate water sources and cause personal injuries as well impose substantial costs on society and create planning challenges..





Is Oslo climate-resilient?

Oslo is on the way to achieving its goal of becoming a climate-resilient city, especially with regard to stormwater management, but more measures are still needed to achieve this goal. There are other hazards related to extreme precipitation and higher temperatures where more knowledge and better preparation are needed, such as river floods, landslides, storm surges, heat islands and drought.

Small socioeconomic inequalities, a high level of education, good local government finances and a well-functioning political system and bureaucracy strengthen the capacity to plan and prevent adverse impacts of climate change and to opt for climate-adapted solutions in Oslo.

The forest areas in the City of Oslo and its neighbouring municipalities (Marka) account for almost two-thirds of the municipality's land area. Oslo also has large stretches of green areas inside and outside the building zone. Oslo's blue-green structures provide central ecosystem services, such as water retention and temperature control, which contribute to making Oslo climate-resilient.

Oslo's location and topography are decisive factors in the city's vulnerability to climate change. Located deep inside a fjord, Oslo is quite well protected against harsh weather conditions, but its topography of steep hills surrounding the city centre makes heavy precipitation runoff a hazard. The city's basin-shaped topography and compact city centre may also result in temperatures that are higher than in the surrounding areas.

How is the city organised for taking climate change considerations into account?

Because the effects of climate-related hazards are wide-ranging and the solutions can be found in many places, coordination of knowledge and efforts is particularly important in climate change adaptation. As the specialist agency responsible for initiating climate-related policies, the Agency for Climate coordinates the city's overarching climate change adaptation activities. The Agency for Planning and Building Services has responsibility for coordinating and implementing the action plan for stormwater management. Several agencies have appointed climate change coordinators to ensure good integration internally and to coordinate dialogue between the respective agencies. Nonetheless, there is still a need to strengthen coordination and cooperation on climate change adaptation activities within the municipality and with other actors. Moreover, it is important to clearly define roles and responsibilities; among other things, responsibility for water courses that follows from the Water Resources Act should lie more clearly within the municipality.

Oslo's municipal master plan of 2018 states that climate change adaptation must be a natural part of all aspects of urban planning. This is a key prerequisite for achieving the goal of a climate-resilient city. To achieve it, however, there is a need to further develop how a changing climate is taken into consideration in planning processes, decision-making bases, regulations, requirements and performance monitoring. Standards developed by the Agency for Planning and Building Services for blue-green factors and climate change criteria are examples of measures that address this need. The requirement to take a changing climate into consideration in municipal processes is creating a growing need for competence building in every stage.

Adaptive capacity

Adaptive capacity depends on how activities are organised, what resources and knowledge are available, and on how much priority is given



The precautionary principle, which is established in the white paper on climate adaptation (Meld. St. 33 (2012–2013)), entails planning for the higher end of the range of scenarios for national climate projections. This means that municipal planning should start at the higher end of the range of scenarios for global greenhouse gas emissions (Norwegian Centre for Climate Services).

If we are to adapt to the climate, we must plan well and use land in smart ways. How we build buildings and housing constitutes a key factor in achieving the goal of becoming climate-resilient. The location of buildings can obstruct the natural course of a water flow from Oslo's forest areas down to the fjord, increase the risk of landslides, create heat islands or exacerbate local wind conditions. Ten large rivers run through Oslo, in addition to a number of streams. The risk of river floods increases with climate change, and it will therefore be increasingly important to maintain building-free zones along the city's river courses. Impermeable surfaces and fewer green structures render us vulnerable not only to the impacts of extreme precipitation, but also to the impacts of higher temperatures. That is why we need to give more consideration to climate changes in area planning and to the tools we use in this process. The Agency for Planning and Building Services has begun implementing the action plan for stormwater management which includes amongst others

a mapping of the routes of the urban flood channels, with a view to developing a comprehensive network of urban flood channels.

One of Oslo's most important tools for managing the impacts of climate change is the city's forest boundary (Markagrensen). The forest areas in the City of Oslo and its neighbouring municipalities serve many purposes for the city, one of them being to act as a sponge by filtering and purifying water. Various types of peatland represent a key type of natural habitat in this connection. Many peatlands have been drained over the years, and the Agency for Urban Environment is already well under way with restoring them. Restoring the peatlands will enhance capacity for water filtration and purification.

Establishing a sound ecosystem-based management of Oslo's natural resources in its forest areas and building zone not only improves nature's capacity to adapt to climate change; it also protects the ecosystem services nature provides. For example, prolonged dry periods create problems for the natural environment, but an ecosystem that is in good condition will be able to recover from such periods.

Until recently, the city's emission reduction and climate change adaptation efforts were not coordinated. Climate considerations related both to reduction of greenhouse gas



Photo: NTB Scanpix / Helge Mikalsen

emissions and to climate change adaptation must be regarded jointly and follow the process from municipal plan through zoning plans and area plans to the processing of building plans. Viewing these considerations together will ensure more effective work processes and prevent differences in priorities from arising. The new climate strategy for Oslo ensures that future work on climate change adaptation and emission reductions is coordinated.

What resources are available to the city for addressing climate change?

Climate change adaptation pays off. It pays to integrate climate change considerations with new investments and with maintenance activities. Oslo is not adequately adapted to today's climate, so its investment should be increased in order to cover current needs and to meet new challenges. The more climate-resilient our buildings and infrastructure, the less need they will have for maintenance, repair and restoration.

If we use climate-adapted solutions, operation and maintenance are among the city's key activities for securing a more climate-resilient city. Furthermore, long-term investments in the city will prove more sustainable if consideration is given to the future climate. Having the right expertise and local knowledge is important for being able to integrate climate-related considerations with various planning and

decision-making processes as well as with operation and maintenance activities in the city.

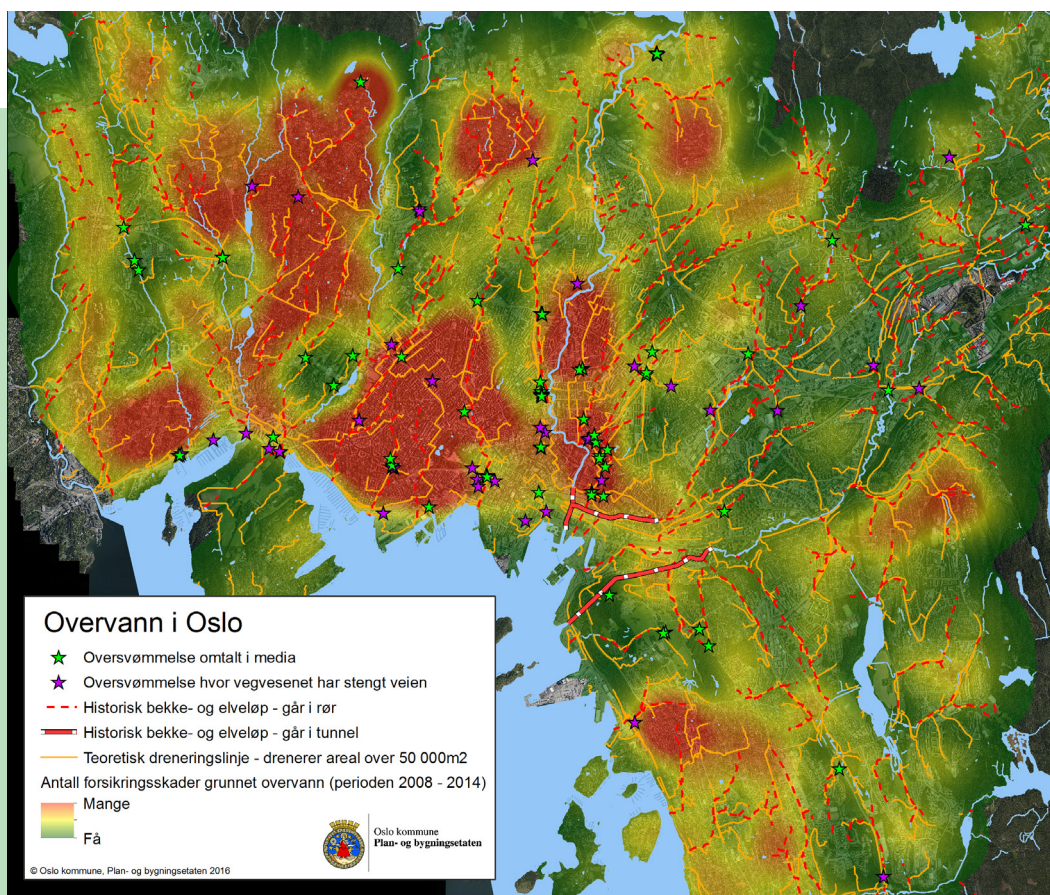
New climate-related hazards call for new solutions. We can no longer build or operate as before; we need to find new climate-adapted solutions. Taking a changing climate into account will increase the need for new technology in the form of planning tools and practical solutions. Nature-based solutions also entail technical solutions that draw on nature for inspiration. This is a relatively new field, and the technology and the market are continually developing. The City of Oslo has begun installing green roofs and rain gardens as nature-based solutions, and needs to upscale its investments in this type of solution to achieve its goal of becoming a climate-resilient city.

The blue-green structure contributes to ecosystem services that represent an important resource for enhancing the city's climate resilience. This resource should be taken into account when planning for operation and maintenance activities as well as for new investments.

What knowledge does the city have about climate change?

The knowledge base on how the climate in Oslo and Norway will change has grown considerably in recent years. The

Registered damages
in Oslo due to
stormwater in the
perioden 2008-2014.



Norwegian Centre for Climate Services website and Climate Profile for Oslo and Akershus provide a lot of important information. Nevertheless, knowing how the climate will change is not enough; if we are to identify necessary and concrete measures, we also need to know what impacts it will have on society and where society is vulnerable. There is a need to further develop knowledge about the impacts of climate change in light of urban development.

A solid knowledge base is needed in order to integrate climate considerations with municipal plans and to increase resources for climate change adaptation in new investments as well as in operation and maintenance activities. The decision-making basis includes map data, mapping and monitoring, and new knowledge about local climate changes. These form the basis for various decision-making tools such as cost-benefit analyses and local climate analyses.

Stormwater is the climate-related hazard that is most researched in Norway and in Oslo. A broad knowledge base was developed in connection with preparing the action plan. Less research and mapping of relevance to the city has been conducted on other climate-related hazards, especially concerning higher temperatures. Experiences from the summer of 2018 show that we are not prepared for prolonged periods of high temperatures or drought, nor for

the impacts they would have on water consumption, public health or on managing and maintaining infrastructure in areas at risk of forest fire. Monitoring nature and the effects of climate change on natural environments in Oslo will be essential to our ability to implement measures that mitigate or avoid the negative effects of climate change.

Consideration of climate changes will place new requirements on the precision and thematic content of map data. There is still a need for better data material on stormwater and floods. This particularly applies to runoff and water flow data as well as to terrain data on rivers and streams on the banks along them. The small water courses react fastest to heavy precipitation and are most vulnerable to climate change, yet these are the ones on which we have the least data. The only map that has been developed for Oslo's future climate is the one showing storm surges, and shows storm surge events up to 2100. Based on new knowledge about these topics, the new land-use part of the municipal master plan will include a revision to the zones requiring special consideration, so these will be of the best possible quality.

Since climate change will continue in the future, much uncertainty is attached to how it will manifest itself, and there will be a constant need for updated knowledge about climate change and its impacts. Adaptation is an ongoing process that

Climate risk

«Climate change is one of the biggest challenges we face today. Measures to adapt to the change and measures to reduce greenhouse gas emissions contribute to reducing the risks associated with climate change. Climate change adaptation goes hand in hand with reduced emissions for preventing severe impacts of climate change.»

Source: klimatilpasning.no, 25 February 2016

Innovative stormwater management
in Deichmansgate.

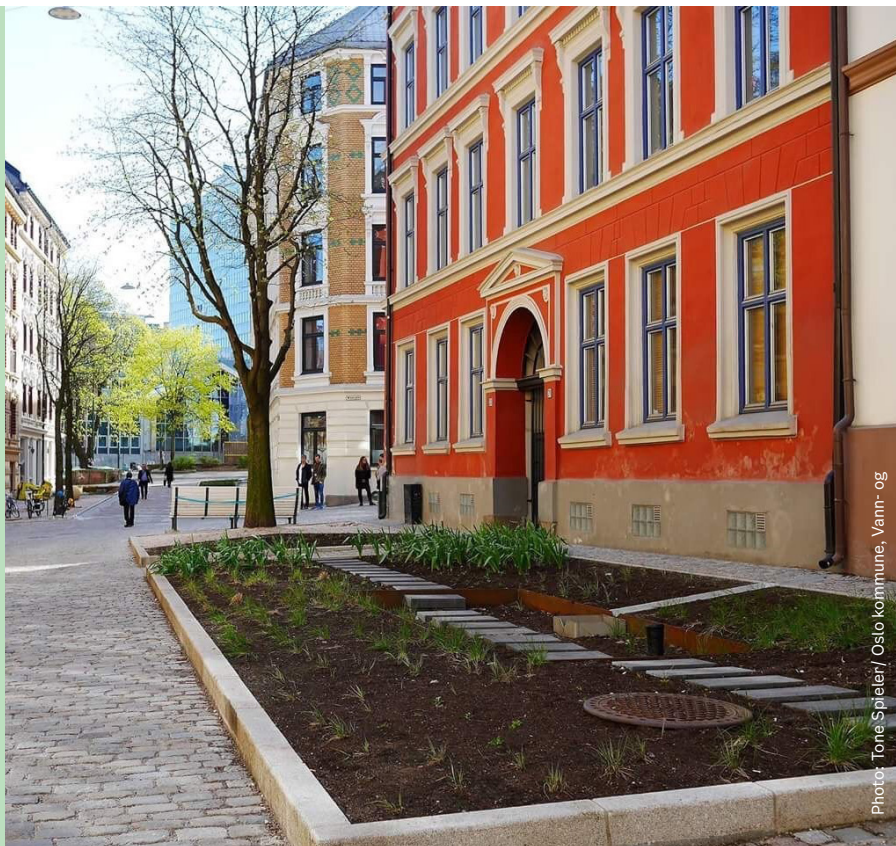


Photo: Tone Spieler/ Oslo kommune, Vann-og

requires engagement and flexibility to acquire and respond to new knowledge as it gradually emerges from science and research.

How is climate change adaptation prioritised?

Our climate change adaptation efforts should be one step ahead of actual climate change by pursuing the precautionary principle.

Stormwater is – and will continue to be – the climate-related hazard that will affect Oslo the most, and is the one for which most preventive measures have been taken. Now it is urgent to implement the action plan for stormwater management, in particular to develop an urban flood channel network that secures urban flood channels through the city by using open streams and planned water courses during extreme precipitation events. However, there are other hazards related to extreme precipitation and higher temperatures for which better preventive measures are needed, such as river flood, landslides and avalanches, storm surges, heat islands and drought.

To become a climate-resilient city, Oslo should adopt an approach to climate change adaptation that is based on transformation. This means acknowledging that new

hazards call for new knowledge, solutions and technology. Furthermore, all of Oslo, including its population and business community, must contribute to developing a climate-resilient city. The climate survey carried out on Oslo's population and business community reveals the need for more knowledge about hazards and solutions. KlimaOslo, a website on climate-related issues for the population of Oslo, and Næring for Oslo, a climate network for businesses coordinated by the City of Oslo, are central channels that offer the potential to share ownership of hazards and solutions. The City of Oslo is currently developing a solution for handling complaints, support schemes and a guidance service for the population regarding stormwater.

The key step towards achieving a climate-resilient society is to address the cause of climate change, which is greenhouse gas emissions. Reducing anthropogenic greenhouse gas emissions is therefore the most crucial measure for climate change adaptation. Climate change adaptation measures and emission reductions both contribute to reducing the risks associated with climate change.



What is climate change adaptation?

The concept of climate change adaptation derives from the natural science that describes today's biodiversity as a result of species' adapting to their habitats and climate conditions. The current and future challenge is that the climate will change even faster than the natural environment and society can adapt if we fail to react.

Climate change adaptation is about preventing the negative impacts of current and future climate change and to have good preparedness in place when events actually occur. Climate change adaptation is measured in negative terms in the sense that nothing happens in an extreme weather event when something is climate-adapted.

According to the national planning provision for climate and energy planning and climate change adaptation, climate change adaptation is about taking the current and future climate into account. This means that climate change adaptation is about how we build and develop society. Because climate change creates economic, social and environmental challenges, climate change adaptation is a prerequisite for sustainable development. Because climate change creates cross-sectoral challenges that must be resolved in multiple sectors, overarching goals are set for climate change adaptation.

Climate change adaptation pays off. It costs less to invest in preventing climate change than to repair and

Climate change adaptation

Climate change adaptation is about taking the current and future climate into account. Climate change will have short- and long-term effects on nature and on society. Taking the climate and the changes in the climate into account, along with other changes in society, is decisive for ensuring sustainable development. A vital and diverse natural environment is less vulnerable to change and can play a part in society's adaptation. Consideration of climate change adaptation works together with other overarching and cross-sectoral goals towards societal and land development.

Source: Statlige planretningslinjer for klima- og energiplanlegging og klimatilpasning [national planning provision for climate and energy planning and climate change adaptation], 2018

restore after an event occurs (Finance Norway 2018). In many cases, climate change adaptation measures will not cost more; it may only be a matter of doing things a little differently. In other cases, heavy investments will be needed, but will reduce the long-term costs. Investment in climate change adaptation is a form of insurance against future risks associated with climate change.

**“Oslo is on the way
to achieving its goal
of becoming a
climate-resilient city”**

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