Norway's first adaptation communication

03.05.2021 Ministry og Climate and Environment

With reference to The Paris Agreement Article 7, paragraph 10 and 11 and the decision 9/CMA.1, the enclosed document serves as Norway's first adaptation communication under the Paris Agreement.

The document is a copy of Chapter 6 of Norway's 7th National Communication, submitted to the UNFCCC April 2018. It provides information on Climate change impact on Norwegian mainland and the Arctic, vulnerability assessment, climate change impacts and adaptation measures planned and implemented. Since this information was prepared for the 7th National Communication, it reflects the activities undertaken up to the year 2017.

Norway intends to submit its second adaptation communication in conjunction with its 8th National Communication in 2022.

1 Vulnerability assessment, climate change impacts and adaptation measures

1.1 Introduction

The Norwegian economy, environment and society are vulnerable to climate change. The Government has conducted several actions, in compliance with the requirements of UNFCCC, in order to prepare for climate change. In 2010, an Official Norwegian Report[1] NOU 2010:10 *Adapting to a changing climate* was published. In this report, a committee appointed by the Government assessed Norway's vulnerability to the effects of climate change and the need to adapt. The NOU incorporates many of the aspects described in the Intergovernmental Panel on Climate Change (IPCC) Technical Guidelines for Assessing Climate Change Impacts and Adaptations and the United Nations Environment Programme (UNEP) Handbook on Methods for Climate Change Impacts Assessment and Adaptation Strategies. Following publication of the Official Norwegian Report, a white paper on climate change adaptation, Meld.St. 33 (2012-2013) *Climate change adaptation in Norway* was prepared and adopted by the Norwegian Parliament. The White Paper outlines actions to be taken at various governmental levels and within sectors in order to adapt to a changing climate.

Since the release of Norway's Sixth National Communication in 2014, Norway has passed several milestones in its work related to climate change adaptation, and important progress has been made on local to national administrative levels and across different sectors. Projections of climate change for Norway have been updated, an Official Norwegian Report (NOU) concerning urban storm water management has been published, and the development of guidelines on how to integrate climate change adaptation into municipal planning activities is under way. Capacity building has been strengthened through networks, cooperation and other activities related to climate change adaptation. Climate change adaptation is also integrated into strategies and action plans within and across relevant sectors, such as in the recently adopted White Paper *Risk in a Safe and Secure Society* (Meld.St. 10 (2016-2017)), where climate change is considered one of the major threats to the Norwegian society.

In 2017, the Norwegian Parliament adopted a Climate Change Act which includes reporting requirements related to adaptation to climate change.

This chapter provides an overview of observed and projected climate change in Norway, the expected impacts of these changes and related risks and vulnerabilities. Furthermore, the framework for climate change adaptation work is described, including the legal framework, policies and strategies. Adaptation actions are presented in the final part of the chapter. Norway's climate change related support to developing countries is described in chapter 7.

1.2 Climate Change on the Norwegian mainland

Norway is a sub-Arctic country with a long and convoluted coastline combined with a long mountain chain facing a relatively warm ocean surface to the west. This results in large geographical contrasts in the present climatic conditions as well as in the projections of future climate change. These contrasts are found both from coast to inland and mountainous regions, from north to south and not least from the Norwegian mainland to the Arctic islands (Spitsbergen, Bear Island and Jan Mayen).

[1] Official Norwegian Reports (NOU). The government or a ministry may appoint committee and work groups to report on different aspects of society. A report may either be published as a Norwegian Official Report, or as a regular report.

Climate change at the high Arctic islands is described in section 6.5.1 *Climate change in the Norwegian Arctic*.

In Norway, comprehensive studies of regional climate development in a scenario of global warming were initiated in 1997 through the RegClim project, and from 2007 to 2011, continued in the NorClim project. In later years, several research projects have contributed to continuing these activities, and from it was established in 2013, the Norwegian Centre for Climate Services (NCCS) has taken on a responsibility for regular assessments of available regional climate projections.

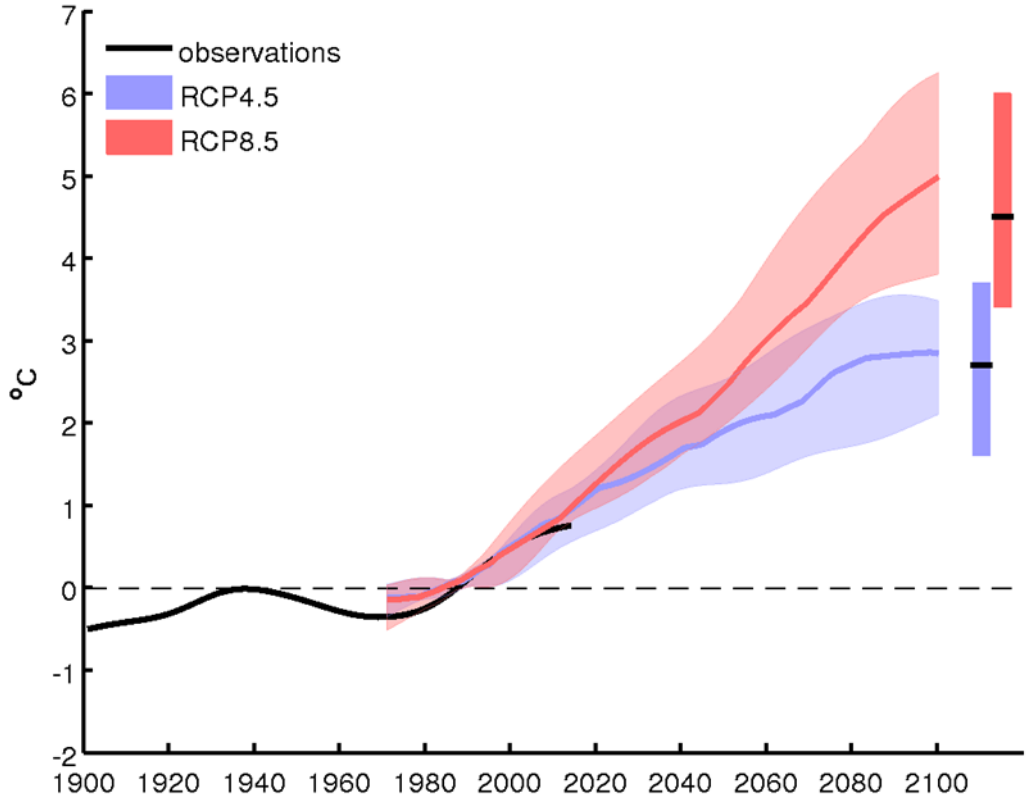
In 2015, the NCCS published an updated report describing projections of climate change for Norway from the present climate (1971-2000) and up to two scenario periods (2031-2061 and 2071-2100)[2]. The projections are based on statistical and dynamic downscaling of global climate model results from IPCCs fifth Assessment report (2013). Due to national guidelines relevant to climate change adaptation stating that assessment of climate change impact is to be based on a precautionary approach the results related to the emission scenario RCP8.5 are presented below. Graphics however, show projections for two different emission scenarios, namely RCP4.5 and RCP8.5. However, if future global greenhouse gas emissions are reduced significantly (e.g. following RCP4.5 or RCP2.6) projections show that the expected changes in climate parameters will be significantly less.

Temperature

The projections indicate warming in all parts of Norway and during all seasons. The annual mean temperature for Norway (Figure 6.1) is estimated to increase by 4.5 (3.3-6.4) °C towards the end of this century. For the Norwegian mainland, the greatest change in annual mean temperature is estimated for the northern parts of Norway, where the warming is approximately 6 °C by the end of the century. For Western Norway the estimated warming is considerably lower with a median value close to the global average estimate of 3,7 °C. A general trend is that the projected warming is greater for winter (DJF) than for summer (JJA) season. This trend is more pronounced inland than along the coast; more pronounced in the north than in the south, and more pronounced for RCP8.5 than RCP4.5.

Figure 6.1 *Annual temperature for Norway as deviation (in °C) from the mean for the reference period 1971-2000. Black curve shows observations (1900-2014), red and blue curve show median value for the ensemble of ten RCM simulations for emission scenarios RCP4.5 and RCP8.5. All curves are smoothed by low-pass filtering. Shading indicates spread between low and high climate simulation (10th and 90th-percentile). The box plots on the right show values for 2071-2100 for both scenarios.*

[2]NCCS report no. 2/2015. A condensed English version of NCCS report no. 2/2015 was published in 2017 as NCCS report no. 1/2017



Growing season

The growing season, defined as the number of days with an average temperature above 5° C, is expected to become considerably longer over the course of this century. Calculations show a one to two-month increase in large parts of the inland areas, and a two to three months increase in in coastal areas and in a zone between the coast and the inland. The total area (not only area used for agricultural purposes) with a growing season longer than six months, is projected to increase from about 37,000 km^2 in the period (1971-2000) to 165.000 km^2 by the end of the century (2071-2100).

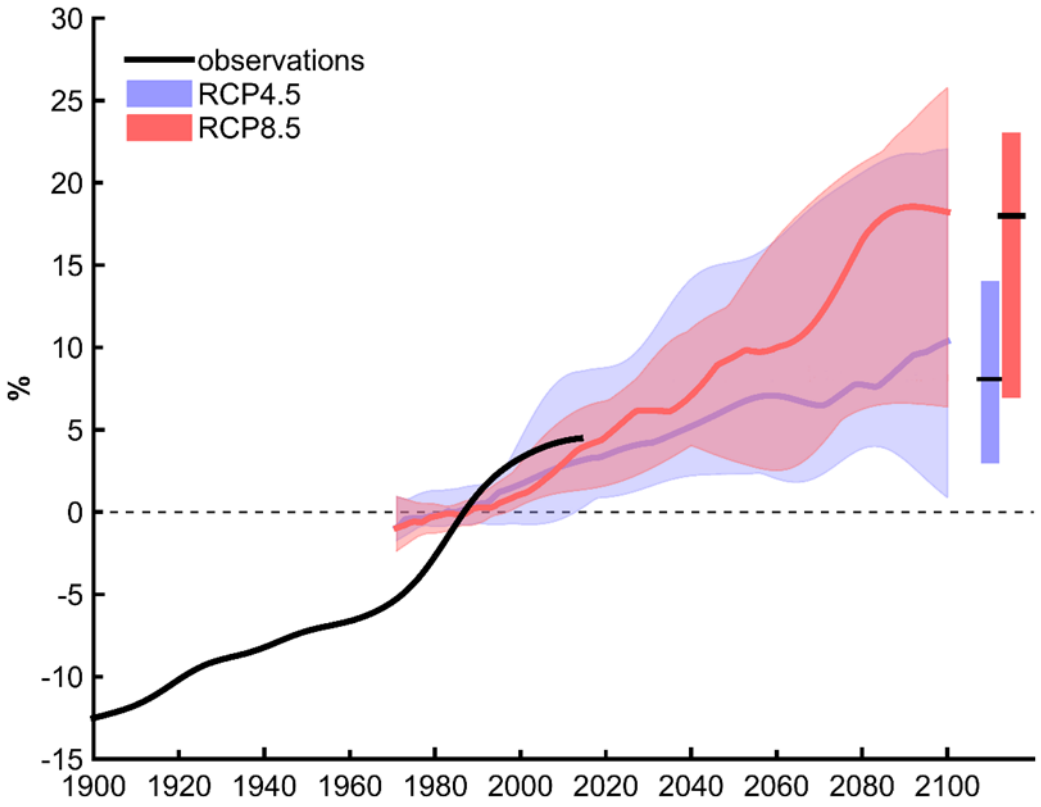
Precipitation

Amounts of annual precipitation averaged over the Norwegian mainland is projected to increase by 18 per cent towards the end of this century (Figure 6.2). The projections indicate increases for all seasons.

Heavy rainfall is defined as the 99.5th percentile for 24-hour precipitation, i.e. the amount of rainfall that is expected to be exceeded approximately twice a year on annual basis. The projections indicate an increase of days with heavy rainfall for all season and all regions. For the Norwegian mainland an 89 per cent increase is projected by the end of this century, with the largest increase in the winter season. However, due to the large range in the projections it cannot be ruled out that the number of days with heavy rainfall will more than double by the end of the century. In addition, it is expected that the actual amount of rainfall on such days will increase with between approximately 10 and 20 per cent. This also applies to all seasons and for all regions.

In general, such increases, for both amount and frequency, are even higher when analysing high-intensity rainfall during a few hours (3-hours).

Figure 6.2 *Annual precipitation over Norway as deviation (per cent) from the period 1971-2000. Black curve represents observations (1900-2014), red and blue curved lines show median values for the ensemble of ten RCM simulations for emission scenarios RCP8.5 and RCP4.5. All curves are smoothed. Shading indicates the spread between low and high climate simulation (10th and 90th-percentile). The box plot on the right shows projections up to 2071-2100 for both scenarios.*



Wind speed

The projections from climate models indicate small changes in average, as well for high, wind speeds throughout Norway towards the end of this century. However, some model results indicate that adverse wind conditions may become more frequent.

Hydrology, floods and droughts

The annual runoff from the Norwegian mainland is estimated to increase, but less than annual precipitation since evapotranspiration also will increase. The largest relative changes are expected in the winter (large increase due to increased precipitation that falls as rain) and in the summer (large decrease caused by earlier snowmelt in mountainous regions and higher evapotranspiration losses).

In general, a trend towards a later snow accumulation and earlier snowmelt has already been observed. These observed changes are expected to continue in the future. For the high emission scenario, the snow season can become one to more than six months shorter.

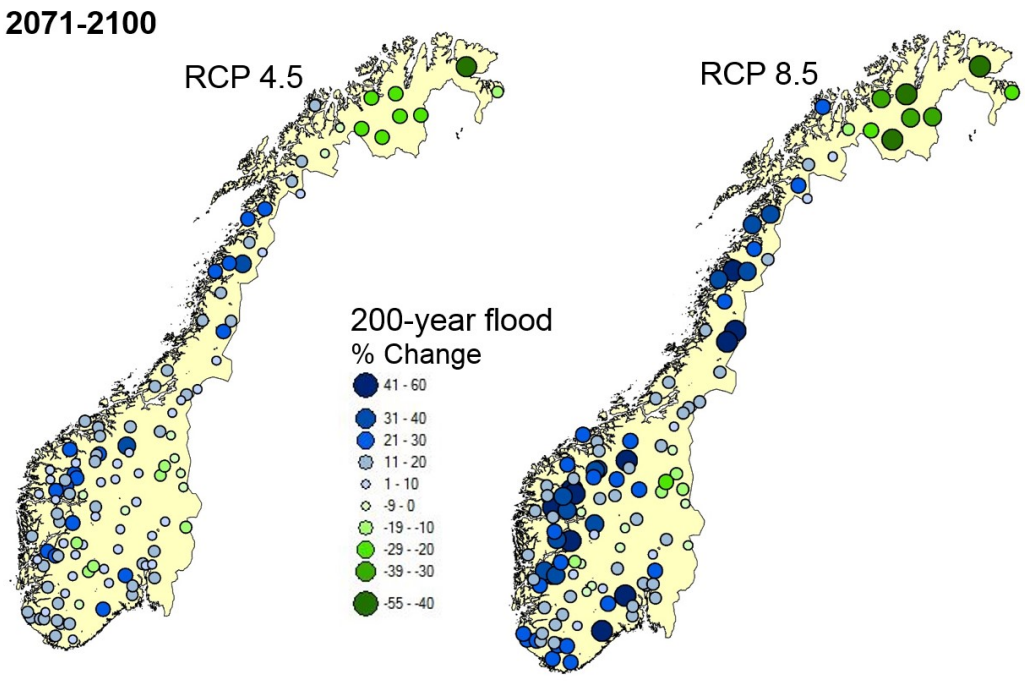
Future changes in flood magnitudes have been analysed for 115 rivers in Norway (Lawrence, 2016). The results show that the magnitude of change strongly depends on the emission scenario, but the direction of change is the same. We can expect rain flood magnitudes to increase and snowmelt flood magnitudes to decrease. In many areas, this is also associated with a change in seasonality.

More frequent and intense rainfall events may in the future give special challenges in small steep rivers and urban areas all over the country.

Higher temperatures causing earlier snowmelt and higher evaporation losses during the summer season may lead to reduced river flow, more severe soil moisture deficits and lower groundwater levels even in regions where summer precipitation is expected to increase. This will result in more severe summer droughts.

Expected climate change under the high emission scenario will have a large impact on the area and volume of glaciers in Norway towards the end of the century. For larger glaciers, a reduction of up to 2/3 of the area and volume they have today is expected, such that remaining glaciers will be significantly smaller and will only be found at higher altitudes. The smaller glaciers will disappear (completely melt).

Figure 6.3 *Percentage change in the 200-year flood for medium (RCP4.5) and high (RCP8.5) emissions. Green indicates a reduction and blue an increase in flood magnitude.*



Landslides and avalanches

Landslides are separated into earth slides (including flood slides), rockslides and quick clay slides. Avalanches are – depending on the water content in the snow – separated into dry and wet snow avalanches and slush slides. Landslides and avalanches mostly occur in steep terrain (except quick clay slides) but the weather is one of the main triggering factors, and hence, climate change will affect their frequency. In particular, we can expect more wet snow avalanches and earth, flood and slush slides.

Ocean temperature and acidification

Downscaled projections covering oceans along the Norwegian coast from different CMIP5 models have been performed during the last years. These show that the sea surface temperature in the

Barents Sea will increase by around 1 °C in wintertime 50 years from now, and somewhat more in the North Eastern parts which is reflected in the reduced sea ice cover in this region (Islantsonen, 2017; Klima i Norge 2100, 2015; Sandø et al., 2014[3]). In general, this warming is somewhat less during summers. The warming of the surface layer increases southwards along the coast during winter, and the greatest wintertime warming is seen in Skagerrak and Oslofjorden, where it reaches 3-4 °C. Also here, the warming is somewhat less during summer, and in Skagerrak and Oslofjorden, the model results indicate a summertime decrease in temperature of about 1 °C. It should be emphasized that natural variability on decadal timescale is relatively large compared to the average increase during this period, and that the choice of the relative short reference periods (2010-19 and 2060-69) might affect the results.

The ocean acidification is mainly a direct result of anthropogenic CO_2 absorption by the sea. There is considerable uncertainty associated with future CO_2 emissions, but ocean acidification is expected to accelerate over the course of this century. It is estimated in Skogen et al. (2014)[4] that the pH value will decrease by between 0,1 and 0,25 in the Nordic Sea, and between 0,25 and 0,35 in Arctic oceans, by the year 2065.

Sea-level rise and storm surges

The relative sea-level off the Norwegian coast is calculated in Simpson et al. 2015 to have increased on average by 1.9 mm per year in the period 1960-2010. During the more recent period 1993-2014, the average increase was about 3.8 mm per year. Thermal expansion of the ocean and melting of the world's glaciers and ice caps are the main reasons for this. Projections of regional sea-level change show that, for all emission scenarios, the majority of Norway will experience a sea-level rise over this century (Figure 6.4). For a high emission scenario, projections show that relative sea-level rise increases with between 10 and 60 cm towards 2100, and that the rate of sea-level rise may exceed 1 cm per year in the end of the century. The local differences in projected sea-level change largely reflect differences in land uplift. This effect on sea-level change is of particular importance for Norway where the Earth is rebounding following the last glacial.

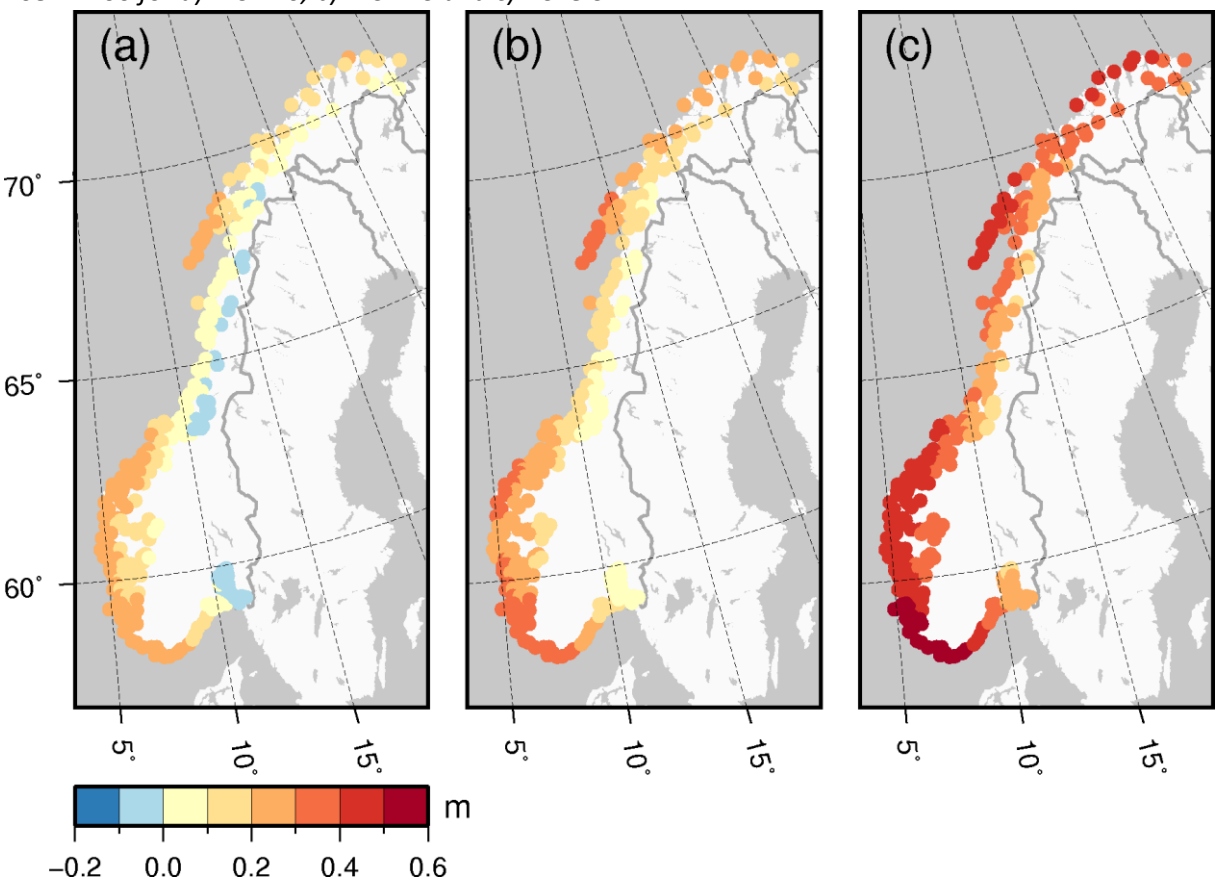
Future sea-level rise will cause an increase in the height of extreme sea-level episodes (e.g. storm surges). Owing to this, coastal areas already exposed to storm surges will experience a large increase in the frequency of inundation (Simpson et al., 2015). Climate change can also cause changes to the nature of storm surges themselves, for example, due to changes in storminess and/or waves.

Projections of storm surge changes are in general of low confidence. But projections available suggest a weak increase in future storm surge heights along the Norwegian coast.

[3] Iskantsonen, report from Norwegian Polar Institute 2017; Klima i Norge 2100, report from Norwegian Climate Service Center, 2015; Sandø, A. B., A. Melsom and W. P. Budgell (2014), Downscaling IPCC control run and future scenario with focus on the Barents Sea, Ocean Dynamics, doi:10.1007/s10236-014-0731-8

[4] Skogen, M.D., A. Olsen, K. Y. Børsheim, A.B. Sandø, and I. Skjelvan. 2014. Modelling ocean acidification in the Nordic and Barents Seas in present and future climate. Journal of Marine Systems 131:10-20.

Figure 6.4 *Projections (model average) of changes in relative sea level in Norway from 1986-2005 to 2081-2100 for a). RCP2.6, b). RCP4.5 and c) RCP8.5.*



Source: Simpson et al. (2015).

1.3 Vulnerability to climate change and expected impacts on society and nature

1.3.1 Introduction

According to the committee that conducted the vulnerability assessment in the Official Norwegian Report 2010:10 *Adapting to a changing climate*, Norway is in a good position to adapt to climate change. Future vulnerability, however, will depend on the extent to which climate change considerations are incorporated into planning and decision-making processes in all areas and all levels of society. The committee considered that the degree of vulnerability varies between different areas of society. Climate affects all areas of society, but in different ways, to different extents and at different timescales. In the committee's assessment of the various areas of society, vulnerability has been considered on the basis of how exposed the area is and its adaptive capacity.

Exposure to climate change was assessed on the basis of climate projections, other research results and contributions from people involved in the sectors. Adaptive capacity was evaluated in the light of the sector's organisational structure, resources, knowledge base and priorities. The interaction between these factors was also an important part of the assessment. The review showed that vulnerability is not just dependent on the exposure to climate change; it is also very closely linked to the adaptive capacities in various areas.

The committee concluded that the natural environment, infrastructure and buildings, in particular water and sewage, are especially vulnerable to climate change in Norway. The impact of the climate varies between regions and types of terrain. The nature of the exposure varies between the coast and the interior, between Northern Norway and Southern Norway, and between steep, mountainous areas and low-lying, flat areas.

The committee considered the north, particularly from Finnmark County and northwards, and alpine areas to be especially vulnerable to climate change. Part of the Sámi population in the north derives its livelihood from natural resources, and Sámi culture is therefore vulnerable to the impact of climate change on nature.

Climate change may intensify existing problems and create new ones. On the other hand, opportunities for business development and advantages for local communities may also emerge.

Climate change is expected to have a major impact on ecosystems and increase the overall strain on the environment. The environment is affected in various ways by human activities through land and resource utilization, transport and pollution. These activities and climate change affect ecosystems separately and in combination, and in some cases they are mutually reinforcing. The vulnerability of an ecosystem is a result of the integral impact of the numerous stress factors.

Ecosystems adapt continuously to climate variability. This takes place among others through changes in the distribution of species and through natural selection over generations. One challenge of a changing climate is the fact that changes may manifest themselves faster than ecosystems and species are able to adapt. Adaptation through natural selection is particularly challenging for species with small populations and low genetic variation. In addition, fragmentation and changes in land use may create barriers that prevent species from migrating to new areas.

Certain local communities that are not currently at risk for landslides, avalanches and floods, may face these risks in the future, but in general, climate change may enhance existing challenges. To some extent, these recurring themes take on different guises in different sectors, but they challenge adaptive capacity across sector boundaries.

The municipalities are Norway's local administrative level, and have the overall responsibility for development planning and provision of services within their geographical catchment areas. Many municipal responsibilities will be affected by climate change, and plans and decisions adopted by municipalities today will have consequences for many decades.

1.3.2 Nature and ecosystems

1.3.2.1 Terrestrial ecosystems

Effects of climate change on terrestrial ecosystems in Norway have already been observed. Earlier arrival of migrating birds, earlier sexual maturation in some animals, higher production and reproduction in both plants and animals, and earlier budding and pollen production are some of the changes observed. There are also some signs of plant species having expanded northwards or to higher altitudes. Satellite-based mapping indicate that the growing season has increased since the 1980's by up to 2-4 weeks in parts of Norway. Melting of palsa mires (type of mires that contain permafrost) has been observed in recent years.

Alpine and tundra ecosystems are regarded as particularly vulnerable to climate change. Climate change causes the tree line and vegetation zones to creep upwards, which in turn affects species in the mountains. For alpine species, there is a risk that there will no longer be any suitable natural habitats to migrate to and that some species will become extinct. This applies for example to the arctic fox, wild reindeer and alpine plants. Competition from new species will also pose a threat, such as the red fox which migrates to alpine areas and competes with the arctic fox. The tree line moving ever higher reduces the number of continuous alpine areas, something that will particularly affect those alpine species that are dependent on large, continuous alpine areas - such as wild reindeer. This will happen at the same time as pressure increases in alpine areas owing to land use and other human activity. Red listed species that are threatened in Norway because they are at their northerly distribution limits, may, however, become less threatened.

The growing season is expected to become longer and warmer. For *forest ecosystems* this will result in faster growth and primary production, a rise in the proportion of trees that prefer a warmer climate and perhaps changes in the species composition of forests with broadleaf species replacing pine and spruce in the south. Rising temperatures may also result in the northward and upward spread of forest. In the short term, climate change may result in increased damage by factors such as storms, pest outbreaks, drought, and forest fires. Such factors can pose serious threats to forest health, vitality and productivity. Some *cultural landscape systems,* such as species-rich hay meadows and grazed grasslands, are vulnerable to increased production. Many cultural landscapes are already threatened by re-growth due to abandonment, and increased growth will accelerate this process.

In Norway, *wetlands*, especially bogs, have also been exposed to major human encroachment, such as drainage for agricultural purposes, forestry, harvesting of firewood and peat moss, as well as other developments. Climate change represents a new factor that is threatening wetlands, in addition to other threats. This applies in particular to Southern and Eastern Norway where one expects higher temperature and less precipitation in summer and to certain types of wetlands, such as palsa mires which may melt in a warmer climate. Increased precipitation in other parts of the country may lead to an increase in wetland areas.

Conditions for invasive *alien* species also change with climate change. At present, many invasive alien species are not able to survive cold winter conditions in large parts of Norway. With the milder winters expected in the future, more of the harmful species will be able to survive and spread.

1.3.2.2 **Fresh water ecosystems**

The effects of climate change on the freshwater ecosystem are many and complex, and they will have impact on production, biomass, life cycles and the species composition. Together with an increase in extreme precipitation events and flooding, this will result in more runoff, transport of particulate matter and leaching of nutrients and other pollutants. Higher erosion rates along river banks and runoff of particulate matter and nutrients from farmland may become a greater problem, and such tendencies have already been registered in smaller rivers in Eastern Norway. Particulate matter and pollutants are transported downstream to coastal waters, adding to the overall environmental pressure on marine ecosystems.

The ice-free season will be longer, the water temperature will increase, and the thermal vertical stratification in the lakes will increase. In parts of Norway, prolonged periods of summer drought and low stream flow are expected. For vulnerable fish species such as salmon, trout and Arctic char and grayling, temperatures exceeding 20º-25 º C could be critical. Regulated rivers with low residual flows may be particularly exposed.

1.3.2.3 **Marine ecosystems**

In *marine waters*, climate change will result in higher temperatures, and a higher CO_2 content in sea water will lead to ocean acidification. This in turn may cause serious impacts on marine ecosystems. A large proportion of CO_2 of anthropogenic origin is absorbed by the oceans, where it reacts with water to form carbonic acid. Ocean acidification will result in changes in the seas' ability to precipitate calcium carbonate, on which calciferous organisms depend. This problem increases at great depths with high pressure and low temperatures. It implies that Norwegian waters and especially the Polar Regions are particularly exposed and will be impacted before more temperate regions. Calciferous organisms include coralline algae, phytoplankton, zooplankton, crustaceans, molluscs and corals. There are many cold-water coral reefs in Norwegian waters, including the world's largest known cold-water coral reef complex. Coral reefs are among the most species-rich ecosystems, and are a vital habitat for many types of fish. Ocean acidification has negative impacts on these ecosystems, and by the end of this century, up to 70 per cent of the calciferous organisms related to coral reefs in Norwegian waters are expected to show signs of erosion. Phytoplankton, such as calciferous flagellates, form the basis of marine ecosystems, and the zooplankton that graze on them are essential food for many fish species. As plankton species with calcareous skeletons may not survive in more acidic seawater, the acidification can have major impacts on many trophic levels.

Higher temperatures result in northwards migration of a number of species. Owing to its great depths, the Norwegian Sea is a key area for the production of copepods (zooplankton). They represent an important food source for fish larvae and fry for the large boreal fish stocks, such as herring and mackerel. In the North Sea, quantities of the common copepod *Calanus finmarchicus* have dropped considerably as the sea temperature has risen; at the same time, the quantities of a plankton species that prefers higher temperatures have increased. However, this species is less nutritious. A decline in *C. finmarchicus* and an increase in plankton species that spawn later in the season may result in a mismatch between spring-spawning fish and their prey, and also between seabirds and marine mammals and the herring. Detailed consequences to the ecosystems and particular species are however yet to be well known.

Along with a northwards migration of copepods, it is expected that the southern boundary for boreal fish species will move northwards. Species such as cod, haddock, herring and mackerel may have their migration patterns disturbed. However, it is expected that, in the 21st century, several temperate and subtropical fish species, such as sardine, anchovy, European bass and tuna, may

become common in the North Sea. In the Arctic, fish species such as Arctic char and polar cod may disappear from parts of the Barents Sea, since they primarily feed on the arctic zooplankton whose natural habitat is along the ice edge.

Overall, it is very uncertain how the changes will affect species composition, fish stocks and total production in marine ecosystems.

Seabirds along the coast are subject to a range of different pressures, many of which are caused by intended or unintended human activity – oil pollution, competition with fisheries, climate change (increasing sea temperatures), marine litter, persistent organic pollutants, introduced predators, habitat degradation and disturbance by people. Many seabird populations have shown a dramatic decline in recent years. Moreover, a number of seabirds are specialised feeders, which makes them particularly sensitive to climate change and changes in the availability of prey species such as sandeels, herring and capelin.

1.3.3 Human life and health

1.3.3.1 Civil protection and emergency planning

AThe exact scope, severity and pace of future climate change impacts are difficult to predict, still it is clear that climate change will affect societal safety. Specific examples include:

- Increasing frequency and severity of extreme weather events such as storms, floods and droughts will threaten human lives and health, material assets and vital societal functions.
- Both changed extreme weather events and a gradual change in the average climate will increase the vulnerability of critical infrastructure.
- Global effects of climate change can have an indirect impact on societal safety in Norway. For example, intensifying droughts or floods can result in food insecurity, economic collapse and human suffering, which in turn may lead to cross-border migration and the spread of harmful organisms.[5]

Climate change will thus challenge society's ordinary emergency management capacity.

From 2006 to 2009, The Norwegian Directorate for Civil protection (DSB) prepared a National Risk and Vulnerability Report (NSBR) as a basis for follow-up of cross-sectoral social security work. In 2012, DSB further developed methodology that enabled analyses of different types of events across sectors and areas of responsibility. From 2012 to 2014, the report was called National Risk Picture (NRB), and included a selection of likely worst case scenarios that could affect Norwegian society and that the authorities should be prepared to demand extraordinary government efforts. From 2017, the National Risk Picture has changed its name to "Crisis Scenarios" - analyses of serious events that may hit Norway.

The "Crisis Scenarios" has concluded that extreme weather and landslides are among the hazards most likely to affect Norway, with potentially severe consequences for our citizens.

Large forest fires can lead to great economic loss and damage to forestry, and may represent danger for life and health, housing and critical infrastructure. Norwegian Centre for Climate Services concludes that in particular the Southern and Eastern parts of Norway will have an increase in forest

[5] Ibid.

fire risk in the coming century.[6] In Eastern Norway, changes in climate could lead to doubling of the number of days with forest fire risk by 2050.[7]

1.3.4 Business and other industry

1.3.4.1 Introduction

Climate change in Norway will have a direct impact on industries that base their activities on natural resources, such as agriculture and forestry, fishing and aquaculture. Other businesses and industries may be indirectly affected by vulnerabilities in other sectors, such as interrupted power supply. Utilising the opportunities that may emerge will also require adaptive measures to enable these opportunities to be realised.

1.3.4.2 Agriculture and forestry

In areas where lower summer precipitation does not produce a soil moisture deficit, the combination of a longer growing season and higher CO_2 content in the air will allow the forest to grow more quickly. In addition the productive forests will expand both to higher altitudes and northwards throughout the country. There will be significant regional differences, with forests in Southern and Eastern Norway potentially facing drought stress and during a transition period, it appears that the growing season in the interior of Finnmark and Troms may become somewhat shorter.

The largest threat to the continued health and vitality of Norwegian forests will be increasing attacks by native pests, as well as non-native organisms that may be able to establish viable populations in Norway as a result of climate change.

Without ground frost for much of the year and with less snow cover, operating conditions will become more difficult using existing technology.

The main pattern in climate projections for Norwegian agriculture is higher temperatures and precipitation. Increases in rainfall may cause problems to field operations, like thinning and harvesting. Increase in evapotranspiration as a result of higher summer temperatures may, however, also cause drought in certain periods. In addition to such changes in abiotic factors, new pests and diseases may arise that reduce productivity in plant production as well as animal husbandry.

Climate change may also result in more damage caused by freeze–thaw cycles, changes in wind patterns, heightened fire risk due to drought and increased erosion as a result of more precipitation, with a risk of nutrients being washed out of the soil, causing environmental stresses. Climate change also has impact on the conditions for reindeer husbandry, see section 6.5.3.

1.3.4.3 Fisheries and aquaculture

The Norwegian fisheries and aquaculture generate significant export revenues, and Norway is one of the world's leading exporters of fish and seafood products. There is uncertainty linked to various aspects of climate change and the potential consequences for the marine environment. The fishing fleet has very high adaptive capacity since the ocean-going fishing fleet has an extensive range. The

[6] Hanssen-Bauer et al. (2015) Klima i Norge 2100 – kunnskapsgrunnlag for klimatilpasning oppdatert i 2015 NCCS-rapport 2/2015

[7] Tveito, O.E. 2014. Klimaendringer og betydning for skogbruket, MET Report 25/2014

traditional coastal fleet on the other hand may be more exposed to climate change owing to its more limited range or potential change of target species.

Climate change along the Norwegian coastline will reflect the changes that are expected to occur in the open sea. Coastal areas and the continental shelf are important spawning grounds for many fish stocks on which climate change may have an impact. Several of the coastal cod stocks have declined significantly over the past decades. A number of factors are probably involved in this, one of which may be climate change. A plan for rebuilding coastal cod stocks has already been adopted. It has been suggested that a combination of higher water temperature, eutrophication and sediment deposition explains the loss of sugar kelp forests (important as a nursery area for coastal cod and other species) from many areas along the Skagerrak coast and the south-western coast of Norway. Climate change will have a number of impacts on wild stocks of anadromous salmonids at different stages of their life cycle. A higher water temperature may result in changes in the numbers and distribution of important preyspecies for anadromous salmonids in coastal waters and the open sea, and of disease organisms and parasites such as sea lice. On the other hand, higher precipitation will increase water flow in rivers and the freshwater content in the coastal zone. This may improve conditions for juvenile salmonids in rivers and reduce the impacts of salmon lice. It is important to maintain the genetic diversity in the wild salmon populations, among other ways by reducing the genetic interaction between farmed salmon and wild salmon, as this makes the species and the various populations more robust for changes in the living environment brought about by climate change. Higher precipitation will also result in more runoff from land, which may lead to sediment deposition and pollution and subsequently to more frequent algal blooms, sometimes of toxic algae.

Higher sea temperatures may cause a shift in the distribution of marine organisms, with populations making a general migration northwards. The overall productivity of the boreal species of fish is expected to increase in the northernmost fishing areas, while the productivity of the Arctic species is expected to decline in the same areas.

Overall, climate change over the remainder of the 21st century may increase fish resources in Norwegian waters. There are however two factors that may counteract these predictions. One of them is associated with natural climate variability, which may dominate over anthropogenic climate change and result in a somewhat colder marine climate. The other major uncertainty factor is ocean acidification, a process taking place simultaneously with, and to some extent independently of, climate change. Acidification creates a more hostile environment for calcifying organisms.

Temperature is of vital importance to the aquaculture industry, as it affects factors such as growth rates, algal blooming and disease. In the long term, an increase in sea temperature therefore has the potential to result in significant structural changes in terms of the species farmed, the best production areas and siting structure, and occurrence of diseases. Emerging technology opens up for more off-shore aquaculture.

The nature of the risk from marine infectious agents (pathogens) will change. The extent to which this will lead to larger problems, as opposed to different problems, remains unclear.

1.3.4.4 Petroleum production

Oil and gas production on the Norwegian continental shelf is significantly affected by the weather and climate. The technology used in Norway for both production and support functions is therefore designed to withstand significant weather-related impact.

Higher sea temperatures may reduce the capacity of gas pipelines and reduce the efficiency of LNG plants (facilities that produce liquefied natural gas). Higher sea temperatures may also alter the

fauna and flora in the vicinity of the facilities, which may in turn result in fouling. If the temperature of the sea water used as cooling water increases, existing cooling water intakes may become too small in the future.

At some facilities, increased sea levels may change the evacuation criteria ahead of storms, and at others they may entail the introduction of procedures for evacuation in the event of high wave forecasts. Increased sea levels may also cause damage to facilities.

For onshore facilities, sea level rises and storm surges may make it necessary to construct facilities on high ground or to limit use of facilities.

1.3.4.5 Insurance

Climate change will affect the use of insurance policies and the market for insurance services.

More frequent weather-related and natural damage will both change the risk pattern and stimulate demand for insurance. Climate change will result in a greater need for various insurance policies, among other things related to health, primary industries, buildings and equipment.

1.4 Adaptation measures

1.4.1 Domestic adaptation policies and strategies

Climate change adaptation is a complex and interdisciplinary issue which demands a cross sectoral approach. In 2007, an inter-ministerial working group was appointed to promote coordination and dialogue in the national climate adaptation work. The working group was led by the Ministry of Climate and Environment and in 2008 the Government presented a five-year platform to enhance society's resilience to climate change, to reduce vulnerability and strengthen Norway's ability to adapt. The inter-ministerial working group was supported by a programme-secretariat that was established in the Directorate for Civil Protection (DSB). A committee consisting of experts from government agencies, research institutes and civil society published an Official Norwegian Report (NOU) on Norway's vulnerability and adaptive needs in 2010[8]. The objective of the report was to facilitate sustainable development through increased knowledge of the significance of climate change for Norway and to provide advice regarding how the authorities and other parties best can proceed to prevent negative impacts from these changes on people, society and the environment. In cases where climate change also represents a potential for increased economic growth, this should be made clear, and advice should be given on how society best can utilise this potential. The report addresses both challenges and opportunities caused by a changing climate, and provides guidance on priorities and specific measures to reduce vulnerabilities.

1.4.1.1 The national climate change adaptation strategy

Following the NOU, the Norwegian Parliament adopted the first white paper on climate change adaptation in 2013 (Meld.St 33 (2012-2013) – Climate change adaptation in Norway), outlining national policies and guidance for adaptation in Norway. The paper provides an overview of the implications of climate change for Norway and sets out a framework to facilitate the development of adaptation strategies and identification of effective adaptation measures across sectors and administrative levels. The white paper upholds that everyone – individuals, business and industry and

[8] NOU 2010:10. Adapting to a changing climate: Norway's vulnerability and the need to adapt to the impacts of climate change URL:http://www.regjeringen.no/en/dep/md/documents-and-publications/Official-Norwegian-Reports/2010/nou-2010-10-2.html?id=668985

the authorities – is responsible for assessing and addressing the impacts of climate change on their areas of competence. In line with the principle of responsibility, all ministries have responsibility to safeguard consideration for climate change within their sector.

Several actions are presented in the white paper;

- ensure that the knowledge base for climate change adaptation is strengthened through closer monitoring of climate change, continued expansion of climate change research and the development of a national centre for climate services.

- plans for pregular updates of knowledge about the impacts of climate change and vulnerability, and of assessments of adaptation needs in Norway. Updates will be considered when substantial new knowledge is available, particularly related to the assessment reports of the Intergovernmental Panel on Climate Change (IPCC).

- as a precautionary approach, assessments of the impacts of climate change to be based on figures from the high end of the range of national climate projections. However, when decisions are made in individual cases, climate change considerations and underlying assumptions about the degree of climate change must be weighed against other considerations of the public interest, the lifetime of the development in question and its importance to society.

Moreover, the white paper emphasises the role of the municipalities related to climate change, and describes that;

- appoint a committee to evaluate the current legislation and as appropriate make proposals for amendments to provide a better framework for the municipalities, which will have to deal with increasing volumes of stormwater as a result of climate change, will be appointed.

- draw up central government planning guidelines describing how the municipalities and counties should integrate climate change adaptation into their land-use and general planning processes. The new guidelines on adaptation will be incorporated into the existing guidelines for climate change mitigation and energy planning.

1.4.1.2 Climate change adaptation in other policy documents

In accordance with the principle of responsibility, the issue of climate change adaptation is addressed in several sectoral policy documents published recently. Among these are:

- The White paper Nature for life – Norway's national biodiversity action plan (Meld.St. 14 (2015-2016)).

- The White paper Risk in a Safe and Secure Society – on public security (Meld.St. 10 (2016-2017), executive summary in English)

- The White paper Friluftsliv – natur som kilde til helse og livskvalitet (Meld.St 18 (2015-2016) *Outdoor recreation – nature as a source of improved health and life quality*, in Norwegian only)

- The White paper Hvordan leve med farene, om flom og skred (Meld.St 15 (2011-2012) *How to live with the hazards – floods and landslides*, in Norwegian only)

- The White paper Verdier i vekst – konkurransedyktig skog- og trenæring (Meld.St 6 (2016-2017 *Values in growth – a competitive forestry and timber industry*, in Norwegian only)

- The White paper Endring og utvikling – en fremtidsrettet jordbruksproduksjon (Meld. St 11 (2016-2017) *Change and development – a future-oriented agricultural production*, in Norwegian only)

- The White paper Reindrift. Lang tradisjon, unike muligheter (Meld. St 32 (2016-2017) *Reindeer husbandry. Old tradition – unique opportunities*, in Norwegian only).

- The White paper National transport plan 2018-2029 (Meld. St 33 2016-2017, English summary)

Several agencies have prepared strategies and action plans addressing climate change adaptation. See further descriptions of concrete actions under 6.4.4 *Implementations and actions*.

1.4.1.3 Legislation relevant to climate change adaptation

Climate change adaptation concerns basic social structures, and a number of laws are therefore relevant, including rules on land use planning, contingency legislation, waterway legislation, legislation regulating various types of infrastructure, natural property legislation etc.

Planning is a core tool in the work to meet the challenges related to consequences of climate change. The Planning and Building act provides the framework for planning in Norway. This framework includes tools and requirements for local, regional and national planning. One such tool is the Central Government Planning Guidelines, which define certain areas of interest to be implemented in local and regional planning. Another tool is the national expectations regarding regional and municipal planning, issued every 4th year by the ministry. The Planning and building act is based on the principle of sustainable development.

The Environmental Impact Assessment framework and various guidelines and policies is revised as of 2017 and ensures that vulnerability due to climate change is included in environmental impact assessments

Pursuant to the Act of 25 June 2010 No. 45 relating to the Municipal Preparedness Duty, Civil Protection Measures and the Norwegian Civil Defence (Civil Protection Act), municipalities have a duty to identify the adverse events that could occur in their municipality, assess the likelihood of these events occurring, and assess how they could affect their municipality. The results of this work must also be assessed and compared in a comprehensive risk and vulnerability analysis. Municipalities must draw up contingency plans based on this analysis, have a municipal crisis team, and carry out exercises and other skills enhancing measures to ensure they are able to handle adverse events.

In June 2017, the Norwegian Parliament adopted a Climate Change Act (Lov om klimamål) which establishes by law Norway's emission reduction target for 2030 and 2050. The act will have an overarching function in addition to existing environmental legislation. According to the act the government shall submit to the Parliament updated information on how Norway prepares for and adapts to climate change.

Within the different sectors, several laws are relevant – though to varying extents – to the climate change adaptation work. Relevant legislation include, inter alia:

- The Harbour and Fairway Act

- The Pilotage Act
- The Pollution Act
- Svalbard Environmental Act
- The Public Health Act
- Water resources Act
- The Natural damage insurance act
- The Natural damage compensation act
- The Land Act
- The Forestry Act
- Nature Diversity Act
- Marine Resources Act
- Aquaculture Act
- Act relating to the Control of Communicable diseases
- Act relating to food production and food services
- Act relating to municipal health and care services
- Act on health and social preparedness

1.4.2 Monitoring, reporting and evaluation

The Norwegian Climate and Environment Ministry is responsible for the overall reporting of the climate change policy in Norway, including reporting on adaptation progress. The national Climate Act commits the government to providing annual reports to the parliament on the status regarding adaptation. A national system for monitoring, reporting and evaluation (MRE) for climate change adaptation has not yet been implemented, but is under way.

The member states of the United Nations adopted in 2015 the Sendai Framework for Disaster Risk Reduction 2015- 2030. According to the Sendai framework, climate change adaptation is a central part of UN Member States' commitments to reduce risk and vulnerability. Norway is among the countries that have joined the framework and committed to implement. The UN General Assembly adopted in February 2017 a resolution (A/71/L.54) for the indicators and terminology relating to disaster risk reduction based on the work and a report by an open-ended intergovernmental expert working group. These indicators (38) are based on the seven targets of the Sendai framework for disaster risk reduction. The national reporting on these indicators will start in 2018.

1.4.3 Roles and responsibilities

A key principle in Norway's adaptation policy is that all sectors – private and public – are responsible for assessing and addressing the impacts of climate change on their areas of competence.

1.4.3.1 National level

All government agencies and local and regional authorities carry a responsibility for climate change adaptation within their field. The Norwegian Environment Agency supports the Ministry of Climate and Environment in the work on climate change adaptation, and is the coordinating agency. The Environment Agency assists the Ministry in the follow-up of the White Paper on climate change adaptation (Meld.St 33 (2012-2013)) and in policymaking. Furthermore, it contributes to ensure that the Government's climate change adaptation work is being implemented in the public administration as well as in society in general, and supports the Ministry in its international climate change adaptation work.

In its role as coordinating agency for climate change adaptation, the Environment Agency works to ensure that actors on local, regional and national level are taking account of and adapting to climate change. As part of the coordination tasks, the Environment Agency also gives guidelines and guidance to the county governors in their climate change adaptation work.

As part of the role as coordinator, the Environment Agency works to strengthen climate adaptation efforts in Norway, among others things by increasing the knowledge base for climate adaptation. The Agency has a particular responsibility for disseminating and sharing knowledge and experience, contribute to competence and capacity building, and facilitate cooperation between different public administration levels, sectors and actors in the field.

Climate change has implications for natural hazards, and several actors have responsibilities in this regard. The Directorate for Civil Protection (DSB) supports the Ministry of Justice and Public security in coordinating civil protection and emergency planning efforts in Norway, in order to prevent and limit consequences of natural hazards. The interdisciplinary approach of civil protection ensures that climate change is managed as part of a comprehensive risk approach, emphasizing the interdependencies between different sectors, different types of infrastructures, and different levels of planning.

The Ministry of Petroleum and Energy has the responsibility for floods, landslides and avalanches at the national level, with the Norwegian Water Resources and Energy Directorate (NVE) as an executive authority. As a support to the municipalities, NVE performs mapping programmes, warnings (flood, soil landslides and avalanches), gives advice in the spatial planning processes and offers technical and financial support in the planning and construction of structural protection measures.

A number of other sectoral agencies also carry a sector responsibility for climate change adaptation, see further descriptions of actions under 6.4.4 *Implementations and actions*.

1.4.3.2 Regional level

The county governor is important in following up the government's policy on regional and local level. It plays an important role in supporting and guiding the municipalities in their work on adaptation, particularly related to risk and vulnerability analysis and land use planning. They also coordinate and cooperate the civil protection efforts, both prevention and preparedness, on the regional level. The county governors have to ensure that climate change has been taken into consideration and followed up, both in planning and risk and vulnerability assessments.

The county municipalities also play an important role regarding guidance and coordination in relation to municipal and regional plans.

1.4.3.3 Local level

Climate change will affect a number of municipal tasks and areas of responsibility. Therefore, the municipalities are required to use relevant knowledge about current and future climate change as a basis in their planning activities and exercise of authority, for example in their application of legislation relating to civil protection and nature management, where they have vital responsibilities. The local authorities must also take climate change into account when applying the rules on the construction of housing, roads and other infrastructure. Climate change will also affect a number of other municipal services, such as provision of drinking water and waste water and waste management. Climate change considerations are particularly important in long-term planning for the development of municipal services and associated infrastructure.

1.4.4 Implementations and actions

Since Norway's 6th National Communication, important progress have been made in the climate change adaptation work, within and across a range of sectors.

Climate change create a need for a service that provides information on the current and future climate and play a part in translating climate science into practical adaptation work. The Norwegian Centre for Climate Services (NCCS) was officially established in 2013. The development of a national centre for climate services involves the Norwegian Meteorological Institute, the Norwegian Water Resources and Energy Directorate and the Bjerknes Centre for Climate Research including Uni Research. The Meteorological Institute has overall responsibility for the centre.

One important reason for establishing a centre for climate services was to provide a basis for climate change adaptation to be implemented in the municipalities and by sectoral authorities. In 2015, the centre issued a synthesis report “Climate in Norway 2100 – a knowledge base for climate adaptation", based on the 5th Assessment Report of the IPCC.[9] The information for individual counties has later been published as so-called “county climate profiles”. The climate and hydrological projections for Norway are available at the NCCS's web site and can also be downloaded for use in further research on the effects of climate change[10]. The centre also participates in a number of research projects involving various user groups to increase the dialogue with decision makers to develop targeted products for use in climate change adaptation.

Furthermore, in the wake of the white paper on climate change adaptation, the Government appointed a committee to evaluate the current legislation and as appropriate make proposals for amendments to provide a better framework for the municipalities responsible for managing storm water, to deal with the increasing challenges associated with urban floods as a result of climate change. The committee launched their report with proposals for amendments in December 2015 (NOU 2015 -16) *Overvann i byer og tettsteder – som problem og ressurs* (Storm water runoff in towns and cities - As problem and a resource, in Norwegian only). The official report on urban storm water is further described in the section *Urban storm water management.*

In the white paper on climate change adaptation, the need to better integrate adaptation to climate change into the municipal responsibilities in order to enable the municipalities to ensure resilient and sustainable communities also in the future, is emphasised. New guidelines describing how the

[9] For further information about the report, see chapter 6.2 *Climate change on the Norwegian mainland*

[10] For more information, see chapter 6.2 *Climate change on the Norwegian mainland*

municipalities and counties can incorporate climate change adaptation work into their planning activities is currently being developed.

In addition, a circular published by The Ministry of Climate and the Environment in 2016 provides guidelines for the use of objections in climate and environment related issues (T-2/16 *Nasjonale og vesentlige regionale interesser på miljøområdet – klargjøring av miljøforvaltningens innsigelsespraksis*, in Norwegian only). The circular includes requirements regarding climate change adaptation.

Research

The Ministry of Climate and Environment has identified Norway's research needs related to environment and climate, also addressing specific research needs related to climate change adaptation. The Ministry's priorities are presented in the document *Priority research needs of the Ministry of Climate and Environment* (2016-2021). Furthermore, improving understanding of climate change and good practices for adaptation is also highlighted in the current government's Long-term plan for research and higher education (2015-2024).

The Norwegian Research Council supports several research projects related to climate change and adaptation. KLIMAFORSK, a 10-year programme for climate research (2014-2023) is aimed at providing new, future-oriented knowledge of national and international significance, including enhanced knowledge about how society can and should adapt to climate change.

Another major activity addressing climate change adaptation supported by the by the Research Council of Norway, is *Klima 2050*. *Klima 2050* is a Centre for Research-based Innovation (SFI).The SFI status enables long-term research in close collaboration with trade and industry, as well as other research partners aiming to strengthen Norway's innovation ability and competitiveness within climate adaptation. The center is addressing societal risks associated with climate change and enhanced precipitation, storm water runoff and water induced landslides within the built environment. The program started in 2015 and will last until 2022.

During the period 2012-2015 the Norwegian Water Resources and Energy Directorate, the Norwegian Public Roads Administration and the Norwegian National Rail Administration joined forces in the research and development project NIFS: "Natural hazards, infrastructure, flood and landslides" (www.naturfare.no). Several other agencies and other actors participated in the project.

For further information about research related to climate change, see chapter 8 *Research and systematic observation*.

BOX 17: R & D programme Natural Hazards – infrastructure, floods and slides (NIFS)

The overall goal of the programme was to contribute to a safer society with more robust infrastructure, safer homes, safer transport and reliable avalanche/landslide and flood warnings. Important objectives were to generate new knowledge and develop good, effective and forward-looking solutions for handling different natural hazards through collaboration across agencies and areas of responsibility. The programme was divided into 7 technical sub-projects, and climate change adaptation and coordination with flanking projects was important for all the sub-projects. The project had a total budget of 42 million Norwegian kroner, and approximately 120 specialist reports were produced.

Information, capacity building and education

Several pilot projects concerning climate change adaptation and related issues have been conducted. In 2014, a guide on how to integrate climate change adaptation efforts in social and spatial planning related to disaster risk management for municipalities was prepared by the Troms County Governor, the Directorate for Civil Protection, the Norwegian Water Resources and Energy Directorate, the Norwegian meteorological institute, the Troms county authority and the municipalities Lyngen, Balsfjord, Målselv and Tromsø. As a follow up, three County Governors and The Environment Agency are currently developing a guide on how to address climate change adaptation related to the nature and environment sector in municipal planning activities.

Furthermore, The County Governor of Vestfold has developed an introductory course on climate change adaptation for municipalities. The course has later been implemented in several other counties.

In 2008, the web based information portal *klimatilpasning.no* was established. The portal intends to support the Norwegian society in preparing for the consequences of climate change. Local level practitioners being the main target group, the website provides tools, case studies and information on climate change adaptation. It also comprises information and tools relevant for the building sector and agriculture. The Norwegian Environment Agency develops and maintains the website, on behalf of the sectoral authorities.

The information campaign *Sjekk huset* (website sjekkhuset.no), commissioned by The Norwegian Environment Agency and The Norwegian Building Authority and conducted in 2016, offered information to private house owners on recommended measures to prevent damage on houses and cottages due to changing climate conditions. Climate adaptation measures suitable for gardens were also included.

Starting in 2017, The Western Norway University of Applied Sciences (HVL) offers an interdisciplinary master programme on climate change management, where climate adaptation in general, and particularly related to land use planning, is a core topic. For further information about education, see chapter 9 *Education, training and public awareness*.

Financial support to county councils and municipalities

A grant scheme to support regional and local authorities in their climate change adaptation work was established in 2015 by the Ministry of Climate and Environment and is administered by the Norwegian Environment Agency. Support is given to projects designed to strengthen the knowledge base on which municipalities build their climate change adaptation measures. Between 2015 and 2017, a total of approximately 15 million Norwegian kroner were distributed among about 50 different projects.

Networks and cooperation

The Cities of the Future (2008-2014) was a collaborative effort between the Government and the 13 largest cities in Norway to reduce greenhouse gas emissions and adapt to a changing climate. The network *Cities of the Future* was an important driving force for the climate change adaptation work in Norway. 11 of the participating cities are continuing the collaboration through *The front runner network*, established in 2015. This network focuses on developing new knowledge on climate change adaptation on local level and sharing competence among the participating cities through joint projects (see example below).

BOX 18: Cost-benefit analysis "Consequences of increased precipitation, sea level rise, storm surge wave and current conditions"

One of the major future climate challenges in Norway is flooding from extreme rainfall and storm surges. A pilot study analyzing two cities, Stavanger and Tromsø, indicates that the cities can achieve economic net profit by taking preventive measures against the consequences of climate change.

The cost benefit analysis estimates damage with and without preventive measures on existing buildings and infrastructure, and disruption of social functions due to flooding from the sea or due to extreme precipitation. The analysis does not cover damage to life and health, loss of natural diversity or cultural values. Even if the study applies a relatively simple methodology, it still gives an initial indication on the economic costs of climate change, and the potential value of adaptation measures. Among other things, there is a risk chart that identifies areas where it will be relevant, from an economic point of view, to implement climate adaptation measures in each of the two cities.

The study was conducted by the consultancy company COWI Denmark, commisioned by the two cities Stavanger and Tromsø.

An improved cross-sectoral cooperation has been established related to natural hazards, including climate change. In 2016 the network “Naturfareforum” – Natural Hazards Forum was established. The aim is to improve cooperation between national, regional and local actors in managing natural hazards, including the impact of climate change. The Natural Hazards Forum will identify gaps and the potential for improvement related to the society’s management of risk related to natural hazards, and initiate projects or working groups on cross-sectoral issues. The network is organised with a secretariat consisting of The Norwegian Directorate for Civil protection, The Norwegian Water Resources and Energy Directorate and The Norwegian Public Roads Administration, and a steering committee where a number of directorates and other national level actors, as well as The Norwegian Association of Local and Regional Authorities (KS) and the Environment Agency, are represented. The Natural Hazards Forum acts as the national platform for the global Sendai Framework for Disaster Risk Reduction.

In addition to the public authorities, organisations in both the private and voluntary sector make important contributions to the climate change adaptation work. The Norwegian Association of Local and Regional Authorities support municipalities and county authorities in their work and carry out various capacity building and support activities related to climate change adaptation, including networks.

1.4.4.1 Risk reduction and natural hazard management

1.4.4.1.1 Introduction

Norway is a stable democratic society with low conflict levels, and one of the safest countries in the world to live in. However, we are experiencing serious events that may have disastrous consequences for individuals and major consequences for society. Dangers and threats with severe consequences may originate from a variety of causal factors both nationally and internationally.

Some of the most important trends are related to climate change, political, economic, technological and demographic factors. The risk picture society faces is wide and complex and changes over time.

Climate change adaptation is often considered through a sectoral lens. To gain an overall picture of responsibilities for dealing with climate change, it is important to use a different starting point: the types of phenomena and events on which climate change is expected to have an influence. In Norway's case, the main problems are expected to be water-related – in particular flooding, landslides and avalanches, stormwater, sea level rise and storm surges.

1.4.4.1.2 Civil protection and emergency planning

In Meld.St. 10 (2016-2017) *Risk in a Safe and Secure Society*, climate change is considered one of the major threats. Challenges related to natural hazards will probably increase in years to come, and good preventive work and active adaptation to a changing climate is crucial in order to handle these challenges. The white paper states that the Government will:

- support municipalities' work with societal safety and security in societal- and area-planning, maintaining its high quality to reduce the consequences of serious natural events, among other things through completing a national digital height and terrain model.
- improve society's ability to cope with flooding, landslide and avalanche risk.
- enhance municipalities' ability to include social security and climate change in its long term planning, by providing guidance and scientific-based knowledge.
- extend the natural insurance scheme to include property/land costs.
- actively contribute to the EU's and UN's work on societal safety and security, and follow up the UN adopted Sendai Framework for Disaster Risk Reduction 2015-2030

The Norwegian strategy for disaster risk reduction focuses on four priorities for reducing vulnerability and strengthening resilience. These priorities may also represent different stages in planning for disaster risk management (DRM):

- **Knowledge**: Assess risk and vulnerability at national, regional and local level. All relevant sectors and stakeholders should take responsibility for assessing their vulnerability, including both existing and future hazards (changes due to climate change, urbanisation, demographical/social changes, technological/economic development, etc.). Local knowledge of past and present experiences should be combined with available sciences and social science research as well as information available in databases etc. – they are supplementary elements of the knowledge base needed.
- **Prevention**: Avoid new risk and vulnerability by ensuring that development does not take place in hazard-prone areas, or by promoting protection measures in cases where such development cannot be avoided. Land-use planning; development of robust infrastructure, ecosystem based DRR; innovative urban design (e.g. creation of 'blue-green' structures); building restrictions etc. are key instruments to ensure development of resilient local communities.
- **Prevention**: Reduce existing risk and vulnerability through preventive measures in already developed areas, including technical (protective) installations; building enforcement; improvement of infrastructure; sustainable management of agriculture and ecosystems in order to enhance resilience; etc.

- **Preparedness and response**: Manage remaining risks by strengthening disaster preparedness and response at all levels, including monitoring and (early) warning systems; preparedness plans; information to the public; reconstruction programs ('build back better'), etc.

The report *Vital Functions in Society* (DSB 2017) identifies 14 vital societal functions. The designated vital societal functions are: Governance and Crisis Management, Defence, Law and Order, Health and Care, Emergency Services, ICT security, Nature and the Environment, Security of Supply (Food and fuel), Water and Sanitation, Financial Services, Power Supply, Electronic Communication, Transport and Satellite-based Services. Climate change will affect most of these vital societal functions. The Norwegian government has established a system of status assessments for these functions. Over a four-year period, the ministries will report to Parliament on status for the vital functions for which they are responsible. The status reports will largely be based on a risk and vulnerability assessment.

The National Mapping Authority (NMA) is currently working on developing a digital height and terrain model. The model will be largely based on new laser scanning data from survey aircraft. The program started in 2016 and is scheduled to finish in 2022. This model will help in many aspects of improving understanding of climate change impacts, for example in applications related to flooding, landslides, avalanches, and inundation from storm surges and sea-level rise. The NMA has now started work on inundation mapping using this new digital terrain model (where laser data is currently available in the coastal zone).

1.4.4.1.3 Urban storm water management

Several different authorities administer the legislation and determine the framework for municipal stormwater management in urban areas. Examples of the most important legislations are the Planning and Building Act, and the Pollution Control Act.

With growing cities and increasing precipitation, Norway has experienced an increase in frequency and cost of flooding events in urban areas due to uncontrolled storm water runoff. Today the annual total cost of storm water damage ranges from 1,6 to 3,6 billon Norwegian kroner. Recognizing the need for better storm water management, the Norwegian government established a committee in 2014 to assess the legal framework for urban storm water management. The committee published an official report in December 2015 (NOU 2015: 16) with recommendations on how to strengthen the capacity to implement urban storm water management plans. The recommendations consist of informative, legal and economic policy instruments that integrates with existing Norwegian legislation and governance. The committee proposed that property owners should be responsible for handling runoff from their respective premises, whereas local, regional and national authorities should be responsible for appropriate management frameworks and overall guidance. The committee suggests that early planning provisions for storm water management should be mandatory for both area planning and building authorities. Management plans should be catchment area wide and subject to stakeholder collaboration and joint action.

The committee emphasizes that the need for local measures should be subject to risk- and vulnerability assessments, cost- benefit analysis and continuous evaluation. Green infrastructure providing local infiltration, local retention and safe transport to a watercourse, can replace costly pipeworks, reduce storm water damage costs and offer environmental benefits. Hence, there is a potential to find solutions that will, in due time, be paid back by reduced storm water damage costs.

The relevant Ministries have welcomed the report and are looking into ways of implementing some of the recommended policy instruments.

1.4.4.1.4 Floods, landslides and avalanches

Climate change will increase the frequency of natural hazards and this entails a need for continuous climate change adaptation in order to prevent unwanted incidents that may endanger human life and affect key infrastructure and societal functions. The Norwegian Water Resources and Energy Directorate (NVE) has developed its second strategy for climate change adaptation (NVE's strategy for climate change adaptation 2015-2019 – summary in English)[11] that covers NVE's areas of responsibility. This includes how to use instruments such as flood and landslide hazard mapping, land use planning and protection measures as tools in climate change adaptation.

The general awareness regarding climate challenges has increased. The climate change effect on floods (Lawrence, 2016) is now included in flood hazard maps. Relevant knowledge has been incorporated in guidelines. For example, how to take climate change into consideration in design flood estimates, is included in the Dam Safety Guidelines. Particularly sensitive dams have been identified, and protection against flood and landslide hazards is included in the guideline "Flaum og skredfare i arealplanar" (Floods and landslides in land use plans, NVE, 2014). In a newly developed cost/benefit tool to assess and prioritize between protective flood and landslide measures, climate change effects are included.

The observed and projected climate development in particular calls for measures to protect against floods, erosion and landslides in small, steep, mass-transporting rivers with a large potential for damage. A particular guideline for floods in small rivers has been issued (NVE, 2015) as well as guidelines and reports on landslide and avalanche mapping and protection (Øydvin, 2011; Fischer, 2014; Schanche, 2014; Schanche and Haugen, 2014).

NVE, as the national hydrological institution, will continue to monitor the effect of climate change on hydrology. A high level of R&D activity on the effect of climate change on hydrology and natural disasters is ongoing and will be maintained. There is a general need to reduce the uncertainty of climate and hydrological projections and to develop methods to quantify the uncertainty, communicate these results, and make decisions under increased uncertainty.

1.4.4.1.5 Sea level rise

The Norwegian Mapping Authority (NMA) is responsible for the operation and maintenance of Norway's sea level observing system. The system provides data on tides, sea level extremes (storm surges), reference levels for use in planning, and observed changes in sea level. This information, as well as sea-level projections, and guidance on how to use these numbers in planning are available on the website www.kartverket.no/sehavniva. Users can also access this information through an interface that allows them to integrate the data into their own applications.

In December 2017 the NMAlaunched a new web tool, which allowes users to map and visualize storm surges and future sea-level rise at a very detailed level. Users will also have the option of mapping infrastructure at risk and downloading data. The tool will be designed to give communities, planners and policy makers the information they need to understand and respond to the risks of sea-level rise and coastal flooding.

In addition to this, the NMA has two pilot projects aimed at improving datasets in the coastal zone that are important for vulnerability assessments and climate change adaptation planning. The first of these will focus on the connection between the height system used on land and vertical reference

[11] https://www.nve.no/Media/3051/rapport2015_80.pdf

levels used at sea. The second project aims to map nearshore areas of the seafloor using water penetrating green laser from survey aircraft. .

1.4.4.2 Environment, nature and ecosystems

The white paper on climate change adaptation in Norway (Meld. St. 33 (2012 – 2013) – described above, constitutes the national strategy for adaptation measures, including for the natural environment. The white paper on biodiversity (Nature for life. Meld. St. 14 (2015-2016)) constitutes Norway's national biodiversity action plan. In both white papers the Government acknowledges that climate change will alter Norway's natural environment and entail a growing risk of losing characteristic species and habitats. Hence, climate change adaptation must be designed to support the capacity of species and ecosystems in order to adapt to rising temperatures, and to avoid any increase in the vulnerability of the environment. The white papers point to the importance of the principles that decisions affecting the environment should be based on scientific knowledge of the impacts of environmental pressures and on assessments of the cumulative environmental effects on ecosystems. These principles are stated in the Norwegian Nature Diversity Act (Act no. 100 of 19 June 2009) and must be followed when making any decisions affecting nature. The white papers also focuses on that the natural environment`s function as a buffer against many negative impacts of climate change. For example, wetlands may serve as effective buffers against flooding and forests may reduce the risk of erosion and avalanches.

A primary objective involves protecting the structure and function of the ecosystems. A major tool for this is ecosystem based management systems (developed on the basis of the Malawi Principles, laid down in the Convention on Biological Diversity). Integrated marine management plans are in place for all Norwegian marine areas (i.e. The Barents Sea and Lofoten, the Norwegian Sea and The North Sea and Skagerrak) and the management plans for the Barents Sea and Lofoten and for the Norwegian Sea has been updated in 2010 and 2017. The management plans are based on the ecosystem approach. They facilitate coexistence and coordination between different commercial activities such as offshore oil and gas extraction, maritime transport, fisheries, and other emerging activities such as off-shore renewable energy production. Management plans provide a framework for both existing and future commercial activities, while sustaining the structure, function and productivity of the ecosystems.

The Norwegian Environment Agency is developing a new strategy for the sectoral work on climate adaptation. The strategy aims to reduce the negative effects of climate change on nature and the environment. A changing climate will influence the use of, the distribution of, the levels and the effects of harmful substances. It also affects nature and ecosystems, and may influence outdoor recreation, an activity which is very important to many people in Norway. The Agency will therefore ensure that it has sufficient knowledge of how a changing climate influences its areas of responsibilities. The agency is responsible for an extensive number of monitoring programs, and possible effects of climate changes have been integrated in relevant programs. The Agency will also work to ensure that the effect of climate change have been assessed when developing new/revised regulations and that it is included in relevant risk-assessments before permissions to pollute are issued.

Norwegian Environment Agency coordinates the work of establishing a cohesive, ecosystem-based water management in Norway. The agency has undertaken a preliminary study with the aim to develop guidance of how to implement relevant adaptation actions in water management.

A workshop on climate adaptation in nature management was arranged in September 2016 (cf. workshop report: M-report 674/2016[12]) in which various types of adaptations or measures were discussed, among others planning work, administrative decisions, physical measures, amendments to statutes and regulations, information and advice, sectoral cooperation, monitoring and research and development (R&D). Following the strategy there will still be a need to develop action plans based on results from a.o. the workshop.

Securing a representative network of land areas through national parks, nature reserves etc is important for plants and animals that need to migrate as a consequence of climate change. In the existing work on expansion and adjustment of protected areas in Norway, such considerations are being included. Mountainous and Arctic areas are regarded as particularly vulnerable to climate change. In Norway approximately 33 per cent of the mountain areas is protected[13].

With regard to the cultural landscapes threatened by climate change due to increased growth and regrowth, a number of national and regional environmental programs and measures, which are aimed at securing cultural landscapes are in place.

Wetlands are particularly important with regard to climate change. Ecosystems along rivers are known as an important forms of insurance against flooding and erosion, and securing and restoring wetlands are regarded as win-win measures, which reduce climate vulnerability, store carbon and secure the habitat of many species. A number of wetlands are protected, and a national plan for restoration of wetlands for the period 2016-2020 has been developed by the Norwegian Environmental Agency and the Norwegian Agriculture Agency. The plan aims to meet the governmental goals connected to both climate change mitigation, biodiversity and climate adaptation.

A major contribution to the ecosystem based management of freshwater, is the comprehensive and cross-sectoral planning under the Water Regulations, which implement the EU Water Framework Directive in Norway. The regulations state that water must be managed as a whole, from mountain to fjord. Surface water, groundwater and coastal waters must be viewed in context. River basin management plans have been developed for all river basin districts, and include monitoring programs and measures to reach the environmental goals. A common European guide[14] has been prepared that provides guidelines for the management of catchment areas in a changing climate.

Many invasive alien species will have improved conditions for survival and reproduction owing to climate change in Norway. The Nature Diversity Act has a separate chapter on the importation and introduction into the environment of invasive alien species. In addition several regulations are in place which together provide Norway with a comprehensive and coordinated regulatory framework for better control of the invasive alien species. A cross-sectoral strategy has also been developed by 10 of the Ministries, which includes measures to be carried out by the different sectors, and measures that they must cooperate on accomplishing.

---

[12] Miljødirektoratet 2016. Klimatilpasning i naturforvaltningen. Rapport fra workshop 7.-8. september 2016. (*Climate adaptation in nature management. Workshop report 7.-8. September 2016.*) M-Report 674.

[13] Miljødirektoratet 2015 Miljøstatus.no: *(Norwegian Environmental Status*)

[14] European Commission (2009) River basin management in a changing climate. Common implementation strategy for the water framework directive (2000/60/EC). Technical Report 2009–040. Guidance document No. 24

Through various international agreements, Norway has committed to a number of goals and strategies related to management of the natural environment. At the 13th Conference of the Parties to the Convention on Biological Diversity in 2016 a decision on biodiversity and climate change was adopted by the conference of the parties, focusing among others on nature based solutions to climate change. Nature based solutions for climate change adaptation have been getting increasing attention over the last years in Norway. In autumn 2017, an assessment of possible and existing nature based solutions to climate challenges such as flooding, avalanches, runoff water and sea-level rise in Norway, was published[15]. The report included an evaluation of their effectiveness and brief analyses of cost-benefits, and concluded among others that nature-based solutions generally are cheaper particularly in the implementing phase and may have positive co-benefits. However, they are often not as effective as technical solutions with regard to meeting specific climate challenges. Hence, both nature-based and traditional solutions are needed.

The OSPAR Convention (Oslo/Paris Convention for the Protection of the Marine Environment of the north-east Atlantic) regulates the marine environment in the north-east Atlantic, especially with regard to pollution of the sea and protected marine areas. Marine fish resources are also managed at an international level, by e.g. quota negotiations with other countries and by regional fisheries organisations. The International Council for the Exploration of the Sea (ICES) plays an important role here.

Guidance about climate change adaptation and nature management towards local and regional level has been developed during the last years and is collated in the two web-portals: www.miljokommune.no and www.klimatilpasning.no. County Governors and The environment Agency are currently developing a guide on how to address climate change adaptation related to nature and environment sector in municipal planning activities.

1.4.4.3 **Human life and health**

1.4.4.3.1 Human health

The Norwegian Public Health Act is intended to induce societal changes that promote public health. Regional and local authorities shall have an overview of their respective states of public health and the factors that may have an effect on them. Regional and local authorities shall undertake the actions necessary to meet their respective public health challenges. Such action may be undertaken in anticipation of emergencies having public health implications.

Scope of the Norwegian Public Health Act includes the mitigation of likely threats to public health from climatic conditions, potential floods and the seasonal incidence of high pollen concentration in the air etc. Pre-emptive action is required to meet health threats from the deficiencies in the maintenance of water works. These actions are to be undertaken in accordance with the Norwegian Planning and Building Act, etc.

[15] Magnussen, K, Wifstad K Seeberg AR, Stålhammer K, Bakken SE, Banach A, Hagen D, Rusch G, Aarrestad PA, Løset F og Sandsbråten K. 2017. *Naturbaserte løsninger for klimatilpasning*. Menon-Publikasjoner 61/2017.

The Norwegian Public Health Act has also assigned to various government institutions certain responsibilities concerning health in general, the level of competence in social medicine in local authorities, emergency preparedness, internal quality assurance and supervision.

The annual white paper of the Norwegian Ministry of Health and Care Services defines the range and scope of the public health activities at national, regional and local levels. Norwegian Directorate of Health provides detailed guidelines on those activities as well as the public health issues related to the environment. In 2017, a survey was undertaken in order to determine the competence of local authorities to manage major accidents and crises.

1.4.4.3.2 Outdoor recreation

The Norwegian authorities have stated a goal that everyone shall have the opportunity on a daily basis to take part in outdoor recreation. A white paper on outdoor recreation, *Friluftsliv – natur som kilde til helse og livskvalitet* (Outdoor recreation – *nature as a source of improved health and life quality*, in Norwegian only), was adopted by the Storting in 2016. The white paper mentions consequences that climate change is expected to have on the conditions for outdoor recreation and the need to take climate change adaptation into account in the management of outdoor recreation areas and trails.

1.4.4.4 **Infrastructure and buildings**

1.4.4.4.1 Transport

The National Transport Plan is submitted to the Storting in the form of a white paper from the Ministry of Transport and Communication every four years. It sets forth the Government's transport goals and strategies in a long-term perspective. The current National Transport Plan (2018 – 2029) provides principles for integrating climate change and climate change impacts in planning and prioritization processes. In addition, and in accordance with the requirements of the Ministry of Transportation and Communication, the transport agencies developed strategies for civil security in transport, where adaptation to climate change is an integral part[16].

The transport sector is working on adaptation to climate change by intensifying its work on management of natural hazards, and has among others participated in the R&D programme "Naturals hazards – Infrastructure, floods and landslides" (NIFS)[17], as well as in the follow-up of the programme, "Nature Hazards Forum" (Naturfareforum). [18]

The transport agencies Avinor, The Norwegian Public Roads Administration and The Norwegian Railway Directorate services are also partners in Klima 2050, a centre for research based innovation related to climate adaptation.[19]

---

[16] Strategi for samfunnssikkerhet i samferdselssektoren (Norwegian Ministry of Transport and Communication 2015, Strategy for civil security in the communications sector, in Norwegian only) https://www.regjeringen.no/contentassets/88bc393f2779462a9bc39768735e98fd/statsamfsik2015.pdf

[17] Naturals hazards – Infrastructure, floods and landslides" (NIFS) is further described in section 6.4.4. *Implementations and actions*

[18] Nature Hazards Forum is further described in section 1.4.4 *Implementations and Actions*

[19] Klima 2050 is further described in section 1.4.4 *Implementations and Actions*

Bane NOR is continuing to develop the system for warning during extreme weather events and flooding, expanding the cooperation with NVE using the national warning system for floods, landslides and avalanches. The Norwegian Public Roads Administration is currently working on a similar system.

Maritime transport

In maritime transport, the Norwegian Coastal Administration (NCA) will carry out risk and vulnerability assessments in order to adjust infrastructure projects to climate change. The NCA has implemented a *Climate and Environmental Strategy* (2016-2018). In addition to its related Action plan, the strategy outlines how the NCA must contribute to meet both national goals and international environmental and climate obligations.

Road

The Norwegian Public Roads Administration adopted a Strategy and is developing an Action plan for civil security (and climate change adaptation). The points of the Action plan comprise the learning and experience from ten years of work on adaptation to climate change, and include i.a. regular updates of guidelines for design and maintenance, intensified work on management and warning systems for natural hazards, better methods and procedures for vulnerability mapping and implementation of adaptation measures on roads and road structures.

Railway

Bane NOR decided on a new Action plan for Civil protection, including adaptation plans for climate change in fall 2016. Bane NOR is continuously revising handbooks, guidelines and standards for both maintenance and construction of new infrastructure to account for the effects of climate change, based on the recommendations given by national guidelines.

Aviation

In 2008-2011, safety areas at the sides and ends of runways at several of Avinor's airports were expanded. Climate change projections were decisive for decisions related to the dimensioning of the projects ensuring critical infrastructure should be able to withstand future storms and increased precipitation. In 2014, Avinor carried out a risk assessment of all its airports, including connected navigation systems and surface access to the airports. This identified several challenges regarding climate change such as drainage issues, wind issues and flooding issues. The next step is to implement measures regarding climate change in the early stages of project plans such as increased drainage capacity (this is already done in relation to an expansion project at Oslo Airport where it was decided to add 50 per cent drainage capacity compared with the drainage systems from the 1990s, when the airport was constructed), choice of building materials, resolving drainage issues et cetera.

Avinor also works with climate adaptation through ICAO and the Airport Council International (ACI).

Aviation is a very risk averse industry, and safety is of paramount importance. The airspace and runways are under continuous surveillance, so if weather and/or surface measurements indicate it, air traffic can be diverted and the airports can be closed for shorter or longer periods of time.

1.4.4.4.2 Power supply

The energy sector must adapt to climate change in order to ensure supply reliability. Several policy instruments are in place. These instruments also take into consideration risks related to anticipated future climate change. The Norwegian Water Resources and Energy Directorate (NVE) follow this up through licensing and inspections. Requirements are also set by NVE to electricity utilities in terms of proper contingency planning, available spare parts, transport and communication systems, training etc., to enable an efficient restoration of electricity supply. Furthermore, NVE conducts research and development in the light of anticipated challenges of the energy sector and climate change by participating in national and international programs and projects.

1.4.4.4.3 Buildings

Impacts of climate change are of vital importance to requirements of the home and construction sector, and a huge effort has been made in order to increase the knowledgebase. SINTEF Building and Infrastructure has conducted a risk and vulnerability assessment and has proposed measures for reducing climate vulnerability and strengthening the adaptive capacity of this sector.

Owing to the increased exposure to humidity and risk of rot in a changing climate, the Norwegian Institute of Wood Technology and Norwegian Forest and Landscape Institute is conducting research aimed at developing new methods of protecting wood against humidity- and rot damage.

In addition, the Government published in 2012 a white paper "Good buildings for a better society. The white paper also highlights the need to address climate change impact in the building and construction sector.

Pursuant to the Planning and Building Act it is mandatory for planning authorities to ensure that risk and vulnerability analyses are carried out.

Climate change adaptation is integrated into the planning and building act and technical building regulations (TEK 17). Technical regulations requires that buildings shall withstand the stresses they are exposed to, and to some extent may be exposed to in the future. Examples are requirements relating to the siting of buildings, moisture protection, indoor climate, structural safety and the selection of suitable products and materials.

1.4.4.5 **Business and industry**

BOX 18: Report "The Norwegian State's Direct Ownership of Companies Climate Related Risks"

Climate change poses a serious economic and financial threat to both the public and private sectors due to physical, market, operational, regulatory, reputational, resource and subsidy risks. There is a clear business case for companies to take action to mitigate and adapt to the risks of climate change in order to minimize the financial consequences for shareholders and customers. In order to gain insight into how the state as owner is exposed to risks of climate change through partial or full ownership of companies, The Norwegian Ministry of Trade, Industry and Fisheries (NFD), in cooperation with five other ministries, commissioned a study which was conducted by Trucost. 37 companies, fully or partly state owned were analyzed, and assessments on how the companies meet the government's expectations in regard to climate and environment were also included. The findings of the study are presented in the report The Norwegian State's Direct Ownership of Companies – Climate Related Risks, published in 2017.

Expert commission – climate risk

Both climate change and measures to counter it affect conditions for and risks associated with economic activity. This recognition has led to increased demand for decision-relevant information on the exposure of financial institutions and other businesses to climate-related risk.

On 6 October 2017, the Solberg Government appointed an expert commission to assess climate-related risk factors and their significance for the Norwegian economy. The commission, has been asked to deliver its recommendation to the Ministry of Finance by 14 December 2018.

1.4.4.5.1 Agriculture and forestry

Adaptation in the agricultural sector is crucial in order to prevent and limit the damages from extreme weather events as well as gradual changes in climate. Adaptation is also important for utilisation of the potential productivity benefits of climate change. Agriculture and forestry sectors also manage extensive areas, and proper management of these areas can prevent damage to other sectors and interests.

There is a continuous need to provide knowledge and approaches for the agricultural sector. In latter years, responses to climate change have been emphasized in programmes for knowledge development and support/extension services.

Since 2013, a climate- and environment programme has been in place to improve and disseminate know-how concerning environmental and climate problems and solutions in agriculture. It also comprises climate adaptation. The programme grants financial support to projects improving knowledge, studies and information. In 2017 NOK 18 million was allocated to the programme. Recently, the Solberg Government has granted money to establish a new project: "Climate Smart Agriculture", which involves climate advisory service at farm level.

Various instruments and support schemes are in place to improve practices in agriculture and address abiotic and biotic stresses that confronts agriculture and livestock. We can distinguish between supportive systems working at a joint level, and grants and regulations operating at farm level.

Veterinary services within the livestock sector, and sanitary measures and services in the cropping sector, are crucial services to limit biotic stresses. Further, continuous use, development and conservation of animal and plant varieties is crucial to provide adequate varieties for future production.

In 2012 it was decided that grants can be allocated to support reserves of crop seed as a food security measure.

Genetic diversity and plant breeding are important in handling climate change. Economic support is given to increase the conservation and use of the genetic resources in plants, animals and forestry. In Norway, commercial agriculture is performed even far north. The short growing season with low temperatures, great variation in daylight and challenging winters give few comparable nations with similar growth conditions. Grants are given for plant breeding and seed production to ensure production of plant varieties suitable to Nordic climate.

To limit future reductions in harvest quantity and quality, the existing warning service for pest infestations could be enhanced. This service estimates and communicates the risk of attacks by plant diseases, insects and weeds for important crops in agriculture and horticulture. This is a useful tool for planning measures for crop protection.

At a practical level, there is a combination of regulation and support schemes to provide for adaptation and preparedness to climate change. Fundamentally, there are instruments to maintain the use of agricultural lands and pasture resources, which safeguards them for future use.

Climate changes will affect the production and demand of agricultural commodities on a global scale. This may affect Norway's ability to import food, which means that an important measure to adapt to climate change is to ensure Norway's self sufficiency. Food security has long been one of four overall goals for the Norwegian agricultural policy. This was continued with the white paper on agriculture (Meld.St. No 11 (2016-2017)) from the Ministry of Agriculture and Food. The white paper also states a goal of increased production on Norwegian resources.

Food security and increased production on Norwegian resources depends on protection of soil resources. Norway has very little farmland compared to other countries. Only 3 per cent of the land is cultivated soil, one third of which can be used for the production of food grains.

Between 2007 and 2015, about 6900 acres/year of cultivated land has been decided used for other purposes than agriculture. In 2015, the Norwegian parliament adopted the Government's strategy for protection of soil resources, stating that no more than 4000 acres of land/year should be used for other purposes than agriculture. The strategy promotes several measures to reach this goal within 2020.

Surplus rainfall and flooding impose challenges to harvests and field operations in agriculture. There is a support scheme to support investments in drainage systems for agricultural lands. Various support schemes are also in place to limit losses of soil and nutrients from agricultural land through the use of tillage practices, cover crops and other measures that limit exposure of soils over the winter period.

The Solberg Government proposes that the existing instruments for cultivation of forest stocks should be adapted to changes in climate, and the adaptation of existing legislation for forest health should be assessed with regard to climate change. In 2016, a multidisciplinary research program approaching advanced-generation breeding in Norway spruce was concluded, and the knowledge is now being implemented in future breeding programs. Further, NOK 10 mill. is being granted from

public funds of a total budget of NOK 26,9 mill. to modernize and improve the facilities of The Norwegian Forest Seed Center.

The Ministry of Agriculture and Food has started to revise the regulations concerning the use of foreign species for forestry purposes.

Adaptation is being assessed in the revised regulations for planning and construction of agricultural and forestry roads and "Standards for agricultural and forestry roads" (both 2015), and a guidance – “Forestry roads and risk of landslides” - has been produced (2011). The guidance deals with the risk of landslides when building forestry roads in steep terrain and how to reduce such risks by correct construction of road and drainage systems. A circular about the regulations is under preparation by the Ministry for Agriculture and Food.

Climate change will have an impact on biological production systems and makes forestry and agriculture vulnerable to both gradual changes in climate and extreme weather events. Research and development projects, monitoring programs, international cooperation and dissemination will show how production in agriculture and forestry in Norway will be affected by climate change and how different production methods in different regions of the country can adapt.

Due to changes in the climate, production output in the Norwegian reindeer husbandry may be reduced. As a short term solution, to mitigate the effects of a changing climate, the number of reindeer herders utilizing trucks to transport reindeer between seasonal pastures has increased along with the number of herders practicing supplementary feeding.

1.4.4.5.2 Fisheries and aquaculture

A comprehensive effort aims to produce more knowledge about the role of the oceans in the climate system and consequences of climate change for marine ecosystems and resources.

The Ministry for Fisheries and Coastal Affairs has elaborated a climate strategy (2013). The goal of the strategy is to maximise the ability of the coastal and fisheries administration to meet the challenges of climate change and to promote reduction of emissions of greenhouse gases from the sector.

Norway has a well developed fisheries- and aquaculture management system. Environmental conditions in the marine environment has always varied and climate change is one of several causes for variability. It is the nature of the management system to be adaptive and deal with such changes no matter what causes them. Substantial changes in the organization of the management system or its major decision making processes are thus not foreseen.

1.4.4.5.3 Insurance and public compensation schemes

The insurance companies play an important role in reducing the economic risk borne by companies and private households. Two insurance/compensation schemes cover damage related to natural hazards: private fire insurance and the public Natural Disaster Compensation Scheme.

In accordance with the Natural Damage Insurance Act, every object insured against fire risks is also insured against natural damage on the same terms. This compulsory natural damage insurance strengthens society's resilience against natural hazards by providing economic means for the rebuilding of damaged buildings and some types of infrastructure.

The public Natural Disaster Compensation Scheme provides compensation for the rebuilding of damaged objects and infrastructure that can not be insured against fire risks, and works together

with insurance to provide resilience against natural hazards. It only applies to privately owned property. Compensation is only paid when the applicant is rebuilding the damaged object. When compensation for rebuilding is granted the applicant can also apply for a grant to “build better”, limited to 20% of the grant for rebuilding and a maximum of NOK 30.000. This grant is a subsidy subject to individual assessment in each case.

Both the compulsory natural damage insurance scheme and the public compensation scheme contain common obligations for mitigation against natural hazards that may also mitigate against the consequences of climate change. Examples of statutory mitigation measures are adherence to public requirements, plans and risk mapping when building, maintenance, renewal and taking necessary protection measures against natural hazards. The consequences for the applicant of non mitigation are reduction of the compensation, up to 100 per cent.

BOX 19: Disaster Loss Reduction project: Using local insurance loss data to strengthen municipalities' efforts to prevent climate-related natural hazards

The project was initiated by Finance Norway in 2013, and is based on a recommendation in NOU 2010: 10 "Adapting to a changing climate" about using insurance claims for prevention purposes. The project was a cooperation between Finance Norway, a selection of insurance companies, Western Norway Research Institute, NTNU (Department of Geography) and ten pilot municipalities. The project was funded by Finance Norway and the Ministry of Local Government and Modernization. The overall objective of the project has been to clarify the potential and prerequisites for strengthening the prevention of climate-related natural damage by testing out the usefulness of access to insurance companies' damage compensation data (disaster loss insurance data). The main focus of the project has been urban storm water problems, but natural damage related issues such as landslides, storms, floods and storm surges has also been included in the project. The main conclusion of the project is that it is useful for the municipalities to gain access to the insurance industry's damage compensation data.

1.4.4.5.4 Cultural heritage

Owners and managers of cultural monuments and cultural environments are facing greater challenges in the future in terms of preserving the cultural heritage in a changing climate. Well maintained buildings and other cultural heritage objects and environments will become increasingly more important in the future.

Collecting and preserving artefacts melting out of the ice due to warmer climate is an important task. It gives us new knowledge of the use of the mountains and daily life in earlier times. Oppland County Municipality, among others, has conducted extensive investigations and a climate park has been established at Juvfonda.

The Cultural Heritage Directorate, initiated and conducted together with NIKU (Norwegian Institute for Cultural Heritage) in 2015 a pilot project with Aurland municipality in order to develop good administration of cultural heritage and cultural environments in a changing climate. Goals for the project was to gain experience and knowledge, develop management of all administration levels and to minimize loss of cultural heritage values due to climate change. The directorate is now involved as

a co-lead partner in the interreg project Adapt Northern Heritage, partly financed by the Northern Pherephery and the Artic Programme. The methods developed in the Aurland project will be further developed.

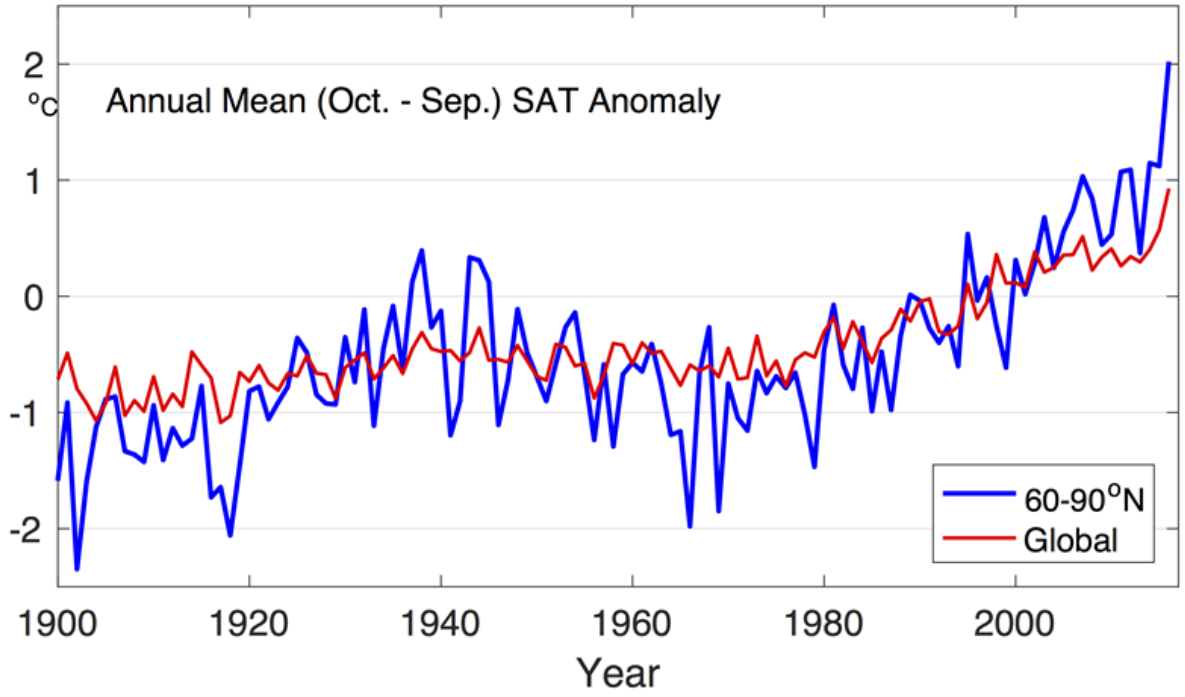
1.5 The Arctic

This chapter presents specific challenges to the Arctic region, which have not been covered in the previous chapters. The Norwegian Arctic is here defined as the Arctic waters under Norways jurisdiction in the Barents- and Norwegian Sea, as well as The Svalbard archipelago and the island of Jan Mayen. Areas with sub-arctic climate in northern part of mainland Norway is described together with the rest of mainland Norway.

1.5.1 Climate change in the Norwegian Arctic

According to SWIPA (2017)[20], the Arctic for the past 50 years has been warming more than twice as rapidly as the world as a whole. Sea temperatures are also increasing, both near the surface and in deeper water. Sea ice extent has varied widely in recent years, but continues a long-term downward trend. A record low minimum sea ice extent occurred in 2012, and a record low maximum sea ice extent occurred in 2016. Sea ice thickness in the central Arctic Ocean has declined by 65 per cent over the period 1975-2012. Most sea ice in the Arctic is now "first year" ice that grows in the autumn and winter, but melts during the spring and summer. The Arctic Ocean could be largely free of sea ice in summer as early as the late 2030s, only two decades from now. [21]

Figure 6.5 *Trends in average global (red line) and Arctic (blue line) temperature relative to the 1981-2010 mean, 1900-2016.*



Source: NOAA Arctic Report Card, 2016. The data are from the CRUTEM4 dataset, which is available at www.cru.uea.ac.uk/cru/data/temperature/.

SWIPA (2017) also states that the snow cover has continued to decrease in the Arctic, with its annual duration decreasing by 2 - 4 days per decade. The permafrost warming continues, and the layer of the ground that thaws in summer has deepened in most permafrost areas. The loss of land-based ice

[20] AMAP, 2017. Snow, Water, Ice and Permafrost. Summary for Policy-makers. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. 20 pp

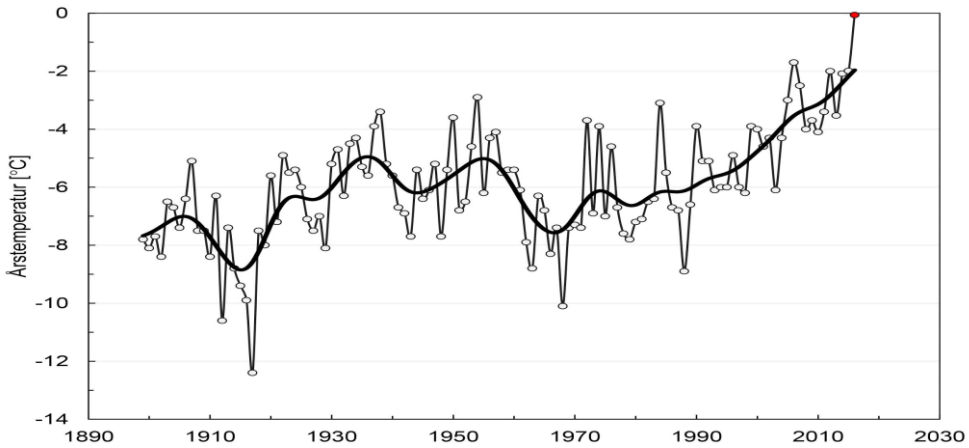
[21] Ibid.

has accelerated in recent decades, and since at least 1972 the loss of land-based ice in the Arctic accounts for more than a third of global sea-level rise. In addition to the Arctic's role in global sea-level rise, the Arctic warming appears to be affecting weather patterns also in lower latitudes.

Svalbard is presently amongst the areas in the globe with fastest warming, and during 1979-2015 the annual temperature has increased by 1,3 °C/decade and the winter (DJF) temperature by 2,3 °C/decade (Gjelten et al., 2016).

The Svalbard archipelago is situated in one of the most important areas for energy transport to the Arctic, and thus variations in atmospheric and oceanic circulation patterns leads to large natural temperature variability (Figure 6.6). Cold periods occurred in the early 20th century and in the 1960s, while mild periods were observed in the 1930s and 1950s. From around 1970, the temperature has increased significantly.

Figure 6.6 *Annual mean temperatures for Svalbard Airport (Longyearbyen) during 1898-2016. The bold black curve illustrates smoothed variations on a decadal scale*



At Svalbard, the measured annual precipitation is rather low, e.g. around 200 mm/year at Svalbard Airport/Longyearbyen and 385 mm/year at Ny-Ålesund. Despite the low annual precipitation, heavy rainfall events may occur. Thus at Svalbard Airport more than 40 mm rainfall during one day was recorded in August 1981 and November 2016; and in Ny-Ålesund 98 mm in one day in January 2012; i.e. at both sites ¼ of the average annual precipitation may fall during just one day. Such events may trigger landslides and avalanches as well as local flooding. Since 1912, the annual precipitation at Svalbard Airport has increased by about 2 per cent per decade. Snow measurements at Svalbard Airport during 1976-1997 show an average of 253 days/ year with snow cover, while during 2006-2016 the average was 216 days/year. During the latest 40 years there has been a weak decline in frequency of high wind speeds at Svalbard Airport.

According to SWIPA (2017), recent climate model simulations indicate that average autumn and winter temperatures in the Arctic will increase to 4 - 5 °C above the late 20th century values before mid-21st century, under either a medium or high greenhouse gas concentration scenario. This is twice the increase predicted for the northern hemisphere as a whole. The projections indicate increase in cold-season precipitation of 30-50 per cent over the Arctic Ocean toward the end of this century, with an increasing portion of that precipitation falling as rain rather than snow. The duration of snow cover is projected to decrease by 10-20 per cent from current levels over most of the Arctic by mid-century under a high emission scenario, and the area of near-surface permafrost will decrease by around 35 per cent under the same scenario. Many of the smallest glaciers across the Arctic would disappear entirely by mid-century (SWIPA 2017).

According to SWIPA, Svalbard is among the Arctic areas with the strongest projected warming. Local projections for the Svalbard region also indicate substantial warming also in this part of the Arctic (Isaksen et al., 2017). For the Longyearbyen area, results from regional climate models indicate an increase in annual mean temperature of 3,5 to 9,0 °C up to the end of the century depending on emission scenario. The winter warming may be 13 °C under the worst emission scenario. However, several of the global models are hampered by an overestimation of the sea ice extent in the Svalbard region, and thus modelling too low "present day" temperatures in this region. This may lead to too high estimates of future warming. Consequently it is important to select models with representative measures of sea ice and local temperatures in the present day climate.

Figure 6.7 *Projected temperature change for the year, winter (DJF) and summer (JJA) from 1989-2000 to 2089-2100 based on the RCP8.5 scenario. Average sea ice border (80 per cent ice concentration) for the period 1989-2000 is shown as a light blue line for the two seasonal maps. For the scenario period, the ice border is north of Svalbard.*

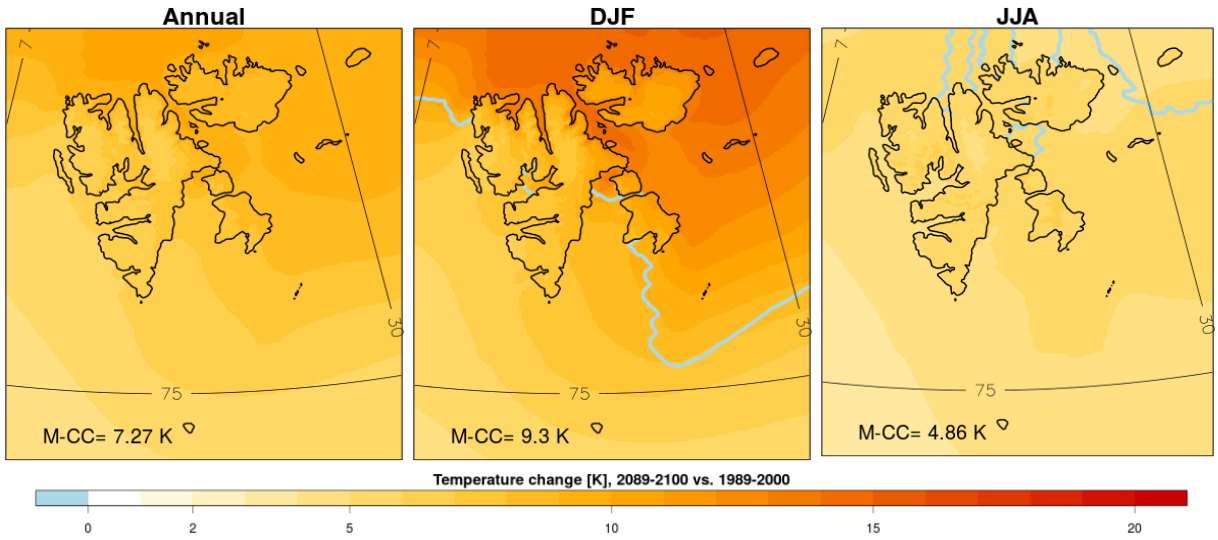


Figure 6.7 illustrates results from simulations with a regional climate model which provides realistic present day temperatures for the Longyearbyen area. The results are based on rather short present and future time periods, but illustrate the stronger warming during winter than summer, and that the warming is stronger in northeastern parts (Nordaustlandet and the Barents Sea) than at the southwestern coast of Spitsbergen. The strongest warming is found in areas where sea-ice is replaced by open water.

Monitoring of permafrost in Svalbard started in 1998, and the results show that the temperature on average has increased 0.8 °C per decade in the upper part of the permafrost. The active layer has become 25-30 cm thicker since 1998. The permafrost warming has accelerated in the latest decade. During the 21st century sites close to sea level are modelled to undergo some permafrost degradation and thus to develop layers of year-round unfrozen ground above the remaining permafrost.

Results from regional climate models (Arctic CORDEX) project an increase in both annual and seasonal precipitation. For the medium emission scenario the annual precipitation in the Longyearbyen area is projected to increase by ca. 30 per cent towards the end of the century (Isaksen et al., 2017). The projections also indicate a substantial increase in frequency and intensity of days with heavy rainfall. For the winter half-year it is estimated that number of days with precipitation as rain will triple compared with present-day climate. In interior parts most of the

winter-time precipitation will be as snow, and may lead to an increase in maximum snow depth in these areas. Recent simulations indicate increased frequency of cyclones moving into the Barents Sea towards the end of the century. An increase in average wind speed is projected for areas east of Svalbard, while the wind speed tends to decline in the Longyearbyen area, particularly during winter. [22]

1.5.2 Vulnerability to climate change and expected impacts on biodiversity and natural ecosystems

The decline in sea ice thickness and extent, along with changes in the timing of ice melt, are affecting marine ecosystems and biodiversity; changing the ranges of Arctic species; increasing the occurrence of oceanic algal blooms; leading to changes in diet among marine mammals; and altering predator-prey relationships; habitat use, and migration patterns (SWIPA 2017). Terrestrial ecosystems are being affected by rising temperatures, changes in precipitation and snow cower and thawing permafrost, altering species distribution and habitats. The occurrence of rain-on-snow and winter thaw/refreezing events affects grazing animals by creating an ice barrier over lichens and mosses.

The comprehensive Arctic Biodiversity Assessment (ABA) from CAFF (CAFF 2013) concludes that "climate change is by far the most serious threat to Arctic biodiversity and exacerbates all other threats". CAFF also published the report "State of the Arctic Marine Biodiversity" in 2017, which builds on the ABA, and compiles available knowledge and monitoring data on a specific set of marine ecosystem components. The report gives an overview of detectable changes in biodiversity in different Arctic regions, including northern parts of the Norwegian Sea and the Barents Sea. Impacts of climate change on biodiversity in the Norwegian Arctic areas have been assessed in three recent national reports (Arneberg, P. et al. 2017; Quilfeldt & Øseth 2016; Forsgren et al 2015)[23] and climate change impacts on wildlife in the Svalbard Archipelago have been reviewed by Descamps et al. (2017).[24]

According to ABA, the distribution of flora and fauna is shifting northwards as the Arctic continues to warm. While low Arctic species are expected to move into the high Arctic, some high Arctic species and ecosystems are expected to disappear or remain only as isolated fragments in high mountain areas. In the ocean, loss of sea ice is already affecting the timing and patterns of primary production, altering food webs and reducing the availability of sea ice to walrus and ice seals for resting, molting, breeding and rearing young. The total loss of some key habitats such as multi-year pack ice is expected. In the process of rapid change and transitions, new combinations of species are altering Arctic ecosystems.

The pace of the temperature rise in the Arctic is very high, causing difficulties for the Arctic species to adapt. The consequences of climate change on Arctic marine biodiversity are difficult to forecast.

---

[22] The Norwegian Centre for Climate Services (NCCS) will in the coming two years prepare and analyze climate and hydrological projections for the Norwegian Arctic. The results will be published in a report similar to the report Climate in Norway 2100.

[23]Quillfeldt, C.H.v., Øseth, E. (eds.). 2016. Klimaendringer på Svalbard - Effekter på naturmangfold og konsekvenser for den fremtidige naturforvaltningen; Forsgren, E., et al. 2015. Klimaendringenes påvirkning på naturmangfoldet i Norge. NINA Report 1210.

[24] Descamps, S., Aars, J., Fuglei, E., Kovacs, K.M., Lydersen, C., Pavlova, O., Pedersen, Å.Ø., Ravolainen, V. and Strøm, H. 2016. Climate change impacts on wildlife in a High Arctic archipelago - Svalbard, Norway. Global Change Biology - doi: 10.1111/gcb.13381.

This is partly due to the fact that current biodiversity monitoring is not sufficient to describe status and trends for many arctic species[25] but also because the ecological changes that are detected vary between the Arctic regions. A number of Arctic species are shifting their ranges northwards to seek more favourable conditions as the Arctic warms. Many species and habitats that are characteristic of the Arctic today, however, will be unable to move further north to find new areas of habitat with a suitable climate. Species and ecosystems associated with the sea ice are particularly vulnerable to climate change, and risk having their ranges severely restricted or disappearing due to loss of sea ice. This includes polar bears, hooded seals, harp seals, ringed seals, narwhals, little auks, ivory gulls, polar cod and a number of species, like algae and small animals living inside the sea ice. The Svalbard area and the Northern Barents Sea is loosing sea ice faster than most parts of the Arctic, and the risks from climate change to ecosystems and species in these areas are high.

Rising temperatures will continue to result in a northward shift in the distribution of species and habitats. The Arctic species and habitats found in the region are gradually displaced by species and habitats that are currently found further south. Tundra areas north of the Arctic treeline are some of the terrestrial habitats that will continue to undergo the most dramatic changes as the permafrost thaws.

Marine ecosystems change as the sea temperature rises. Higher temperatures and the retreat of the sea ice allows more southerly species to move into Arctic sea areas, and purely Arctic species will meet growing competition, greater predation pressure and a higher risk of disease and parasites. Many seabird species are or will be expected to be negatively affected by climate change. The distribution of commercially important fish species such as cod, haddock, herring and capelin have already changed, and may change more in the future.

The declining sea ice cover is making marine and coastal waters in the Arctic more accessible for fisheries, maritime transport, mining activities, cruise ships and oil and gas activities. If not managed properly, the increase in activity levels may lead to unsustainable harvesting, infrastructure development, habitat loss and fragmentation, the spread of invasive alien species, disturbance of the fauna, and the risk of pollution. Delegations from Canada, China, Denmark in respect of the Faroe Islands and Greenland, the European Union, Iceland, Japan, the Republic of Korea, Norway, Russia and the USA concluded negotiations in late 2017 on the draft *Agreement to Prevent Unregulated High Seas Fisheries in the Central Arctic Ocean*. Fishing in the The central Arctic Ocean, an area that is roughly 2.8 million square kilometers in size, has never been possible, nor is it likely to occur in the near future.

1.5.3 Vulnerability to climate change and expected impacts on society

In Svalbard, as in mainland Norway, climate change is increasing the risk of landslides, avalanches and floods, and result in more frequent and more severe extreme weather events, sea level rise and storm surges. Coastal erosion could also become a growing problem in Svalbard. Infrastructure such as roads, buildings and port facilities will be vulnerable to such natural hazards. Their isolation may make the settlements more vulnerable to climate-related events that disrupt critical infrastructure. Incidents of avalanches and landslides in or in close proximity of the settlements in Svalbard has happened in recent years. These incidents also effects outdoor activities and tourism.

[25] CAFF. 2017. State of the Arctic Marine Biodiversity: Key Findings and Advice for Monitoring. Conservation of Arctic Flora and Fauna International Secretariat, Akureyri, Iceland.

The active layer (the soil layer above the permafrost that thaws each summer) is becoming increasingly deeper, which makes the ground unstable and is a threat to buildings and other infrastructure. Coastal erosion is also becoming a growing problem for buildings and cultural heritage sites near the shoreline in Svalbard, since wave action will increase as sea ice is lost.

Research and the travel and tourism industry are important sectors in Svalbard that will be affected by climate change. The increasing length of periods without sea ice in the summer is making areas more accessible to cruise ships. At the same time, an earlier spring thaw and a reduction in ice cover on the fjords will shorten the season for snowmobile-based tourism, and restrict the areas available for such activities. There will be less opportunity for visitors to observe ice-dependent species and the travel and tourism industry will have to adapt its activities to a situation in which many species are under stress as a result of climate change.

Svalbard is one of the most important sites for scientific research in the Arctic. However, climate change affects research in a number of ways, including through changes in natural conditions and the accessibility of areas and biodiversity. The opportunity to study climate change in the Arctic is one of the drivers behind the growing interest in research and teaching activities in the archipelago. The great socio-economic value attached to this research is influencing the willingness to invest in research infrastructure and carry out projects and field work in Svalbard.

The warmer climate and loss of sea ice are also resulting in changes in activity patterns in the waters around Svalbard. Such changes in activity patterns may make it necessary to upgrade fisheries inspection, maritime safety, oil spill preparedness and response, and search and rescue capacity in these waters. Changes in temperature, precipitation and extreme weather events will affect offshore activities and maritime transport.

1.5.4 Adaptation measures

1.5.4.1 Ecosystems

The speed of climate change in the Arctic highlights the need for adaptation measures. Reports from the AMAP-led Arctic Council project Adaptation Actions for a Changing Arctic (AACA) (e.g. AMAP 2017[26]) and a report from the Norwegian Polar Institute (Quilfeldt & Øseth 2016) have assessed possible adaptation measures in the Arctic, including the Norwegian Arctic. One of the findings in the AACA project is that it is increasingly important to recognize the significance of natural capital, ecosystem services and resilience in the context of adaptation.

Climate change will pose considerable challenges for nature management in Svalbard. In the same way as in mainland Norway, it will be necessary to strengthen instruments to safeguard threatened species and habitats that may come under increasing pressure as a result of climate change, and increased accessibility and human impact due to less severe sea-ice conditions. Some measures have already been introduced in Svalbard in response to areas now being more accessible due to reduced sea ice. Regulations in and outside protected areas have been adapted to meet the challenges posed by climate change and increased traffic. The cruise operators (Association of Arctic Expedition Cruise Operators, AECO) have developed site guidelines which aim at safeguarding the environment and cultural remains. To reduce the risk of a shipwreck or grounding, carrying heavy bunker oil is prohibited in most of Svalbards territorial waters, and cruise ships that call in the nature reserves in the eastern part of Svalbard may not carry more than 200 passengers. In addition, compulsory

[26] AMAP, 2017. Adaptation Actions for a Changing Arctic (AACA) - Barents Area Overview report. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. 24 pp

pilotage has been introduced, and charting of the waters around Svalbard is being improved. For the emergency preparedness towards an acute pollution incident, a tool (PRIMOS) has been developed which collates mapped information about the environmental values in Svalbard. Climate change adaptation of management practice is one of the elements of the management plans that are being drawn up for the protected areas in Svalbard. These protected areas cover most of Svalbards land and territorial waters. Furthermore, an action plan from 2017 to prevent the introduction and spread of invasive alien species in Svalbard is being implemented, in part as a response to the fact that climatic barriers to invasive species are weakened due to climate change. At the same time Norway is following up the Arctic Invasive Alien Species Strategy and Action Plan 2017 from CAFF and PAME under the Arctic Council.

Results from the extensive research, monitoring and mapping of species and ecosystems are reported through the environmental monitoring program for Svalbard and Jan Mayen (MOSJ), which includes several indicators of impacts of climate change in Svalbard. An ecosystem-based monitoring program for land ecosystems in the Norwegian (Arctic *Climate-ecological Observatory for Arctic Tundra* - COAT[27]) has been developed during the last years. COAT is particularly designed to be able to detect impacts on climate change.

1.5.4.2 Human activities and settlements

Climate changes add strain to critical infrastructure in Svalbard that is already vulnerable, thereby creating a need for upgrading and adaptation. Climate-related incidents can also pose a threat to life and health. It is therefore important that land-use and community planning in the planning areas take climate change into account. The guide to land-use planning under the Svalbard Environmental Protection Act is currently being revised. A description of how the planning areas in Svalbard should take climate change into account will be included in the revised guide.

As a follow-up of the white paper no 15 (2012) on floods, landslides and avalanches it was decided as of 2014 that the Norwegian Water Resources and Energy Directorate should support the local authorities on Svalbard on the same terms as on the mainland. The support in mapping, land use planning, early warning, protection and crisis management related to floods and landslides will be prioritized based on a cost-benefit approach.

The integrated management plans for the Barents Sea–Lofoten area and the Norwegian Sea are important tools for overall adaptation of the framework for activities in Arctic seas to changes in the climate, environmental conditions and patterns of activity.

1.5.4.3 Cultural heritage

The cultural heritage on Svalbard is affected by climate change both directly and indirectly. The rising temperature and increased precipitation are affecting the conservation conditions for archaeological sites as well as cultural heritage buildings and other standing structures. Incresed coastal erosion due to less sea-ice and more wave activity is also threatening sites in the coastal zone. Consequently, the Governor of Svalbard is monitoring erosion at exposed cultural heritage sites, and has developed an archeological research plan for selected sites. The permafrost is thawing rapidly, and there is reason to believe that the conservation conditions of graves, among other things, have deteriorated. The thawing of the permafrost each summer is destabilizing the soil and thus exposes and degrades

[27] http://www.coat.no/

cultural materials, previously preserved in the ice. There is a great need for more knowledge about the effects of climate change on conservation of cultural heritage on Svalbard.

1.5.4.4 Emergency preparedness

By increasing the accessibility of Arctic marine areas to human activities, the need for search- and rescue operations also increases. Most of the Arctic has already been divided into search and rescue regions (SAR regions), but in certain areas the division of responsibility is unclear or inappropriate. Norway, Denmark (Greenland) and Russia have therefore agreed on a more suitable delimitation of our SAR regions. In response to the increase in activity and the wider geographical area of responsibility, it has been decided that the Governor of Svalbard's helicopter service is to be expanded from one large helicopter and one medium-sized helicopter to two large helicopters. In addition, a new search and rescue vessel of a suitable size for the new helicopters was planned to be available from 2014. This will strengthen search and rescue capacity in Svalbard and nearby sea areas.

Surveillance of ship traffic in the Arctic is established with national AIS-satellites and access to other AIS-satellite services. New AIS-satellites with enhanced functionalities will be added to the present constellation. Moreover, the global International Maritime Organization (IMO) introduced obligatory long-range identification and tracking of passenger ships, cargo ships (300 gross tonnage and upwards) and mobile offshore drilling units (LRIT) also provides information on ship traffic. This means that Norway has access to information on maritime activity in Arctic waters, valuable for search and rescue operations, and other purposes.

Through the Agreement on Cooperation on Marine Oil Pollution Preparedness and Response in the Arctic (MOSPA), the Arctic countries have also strengthened cooperation, coordination and mutual assistance on oil pollution preparedness and response in the Arctic in order to protect the marine environment from pollution by oil.

The Pilotage Act and associated regulations are applicable to Svalbard. This means that the rules relating to the state pilotage service, compulsory pilotage and pilot exemption certificates are the same as for mainland Norway in the waters around Svalbard.

1.5.4.5 Internationally

There is effective, binding international cooperation in the High North, which promotes environmental protection and sound resource management. The Arctic Council is the most important arena for dealing with common challenges in the Arctic. In May 2017, all member states of the Arctic Council signed the Agreement on Enhancing International Arctic Scientific Cooperation, aiming at developing and expanding international Arctic scientific cooperation.

The Arctic Council has published a number of reports that synthesize and assess new knowledge on climate change and adaptation in the Arctic. Key drivers of change in the Arctic and possibilities for adaptation have been identified in projects on adaptation, resilience, ocean acidification, freshwater as well as snow, water, ice and permafrost, marine biodiversity and invasive alien species.