6 Climate change impacts, adaptation measures and vulnerability assessment

This chapter describes how the Finnish climate is expected to change in this century and how the change is expected to affect nature, the economy and society. The chapter includes an outline of efforts to assess vulnerability. The expected impacts are described together with adaptation measures in each sector. Finally, international cooperation is briefly discussed.

Photo: Milla Popova / Image bank of the Environmental Administration

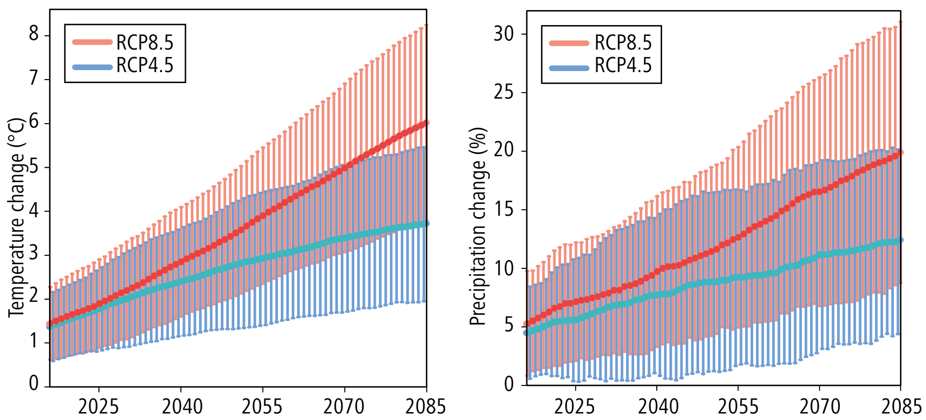
6 *Climate change impacts, adaptation measures and vulnerability assessment*

6.1 *Climate projections for Finland*

Climate change projections are based on simulations performed using 28 global climate models for the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). The future climate cannot be predicted accurately due to uncertainties in (i) the future emissions of greenhouse gases and aerosols, (ii) natural climatic variability, and (iii) the incomplete representation of the climate system in the models. Figure 6.1 shows multimodel mean estimates and the associated uncertainty intervals for the future evolution of annual mean temperatures and precipitation rates in Finland for two greenhouse gas scenarios, with the RCP4.5 scenario representing fairly moderate emissions and the RCP8.5 scenario representing high emissions. The solid curves give estimates for the change related to future emissions, hatching the uncertainty caused by modelling uncertainties and natural variability.

The temperature change in Finland is expected to be 2.4°C by 2040 and 3.6°C by 2080 in the RCP4.5 scenario representing fairly moderate emissions, and 2.9°C and 5.8°C in the RCP8.5 scenario representing high emissions. The temperature increase in Finland is expected to be more than 1.5 times as large as the global mean warming on average. The projected increase in precipitation will be substantial as well. Both greenhouse gas scenarios lead to a quite similar evolution of temperatures and precipitation rates until about the 2040s. During the latter half of the 21st century, by contrast, climatic changes will depend strongly on the emission path. The uncertainty associated with the model differences and natural variability is likewise fairly large.

Figure 6.1
Projected temporal evolution of annual mean temperature (left) and precipitation (right) in Finland by 2085, relative to the means for the period 1971–2000. The thick solid lines represent the multimodel means, hatching the 90 per cent confidence interval of the projection. Both are given separately for the moderate-emission scenario, RCP4.5 (blue), and the high-emission scenario, RCP8.5 (red)



Both the increases in temperatures and precipitation rates will be larger in wintertime than in summertime (Figure 6.2). If the RCP8.5 scenario proves true, the January mean temperature is projected to increase by 4 to 12°C and precipitation by 10 to 60 per cent by the end of the 21st century. If emissions are reduced (e.g. in accordance with the RCP4.5 scenario), the seasonal distribution of the response will be qualitatively similar, but the magnitude will be smaller. The same characteristic can be seen when studying less distant future periods.

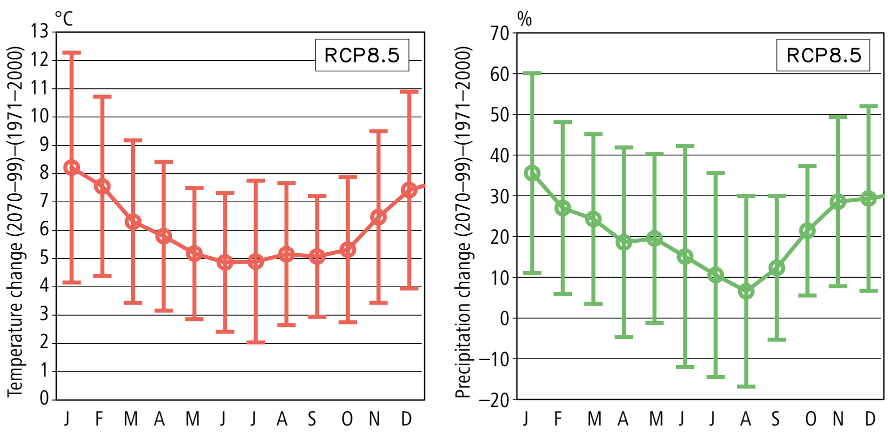
Compared to the climate scenarios generated by the previous model (which was used to prepare the IPCC's 4th Assessment Report), the present summer temperature projections are as much as 1°C higher. This can be deduced by comparing the RCP4.5 and SRES B1scenarios; the evolution of greenhouse gas concentrations is nearly equal in both scenarios. Conversely, winter temperature projections and precipitation scenarios for all seasons are fairly similar in the two models.

The new temperature and precipitation projections were not published until February of 2013, and hence the adaptation research described in this chapter still makes use of the older scenarios.

Other examples of projected climatic changes in Finland (mainly based on the older model) include the following:

- Heat waves will become longer and more frequent, whereas severe cold spells will gradually diminish.
- Heavy rainfall events will intensify in summertime.
- The number of days with precipitation will increase in the wintertime.
- The snow season will become shorter and the snow water equivalent will decrease on average, particularly in southern Finland.
- The duration and depth of soil frost will decrease, particularly in snow-free areas like roads and airports. This will also hold true for sea and lake ice cover.
- Winters will become cloudier and solar radiation will decrease.
- There will be minor increases in wind speeds in autumn and wintertime.

Figure 6.2
Projected temperature (left, °C) and precipitation (right, per cent) changes in Finland during the various calendar months (J = January, F = February, etc.). The circles and the curve denote the multimodel mean projection. The 90 per cent confidence interval for the change is denoted by vertical bars. The changes are presented for the period 2070–2099, relative to 1971–2000, under the RCP8.5 scenario.



6.2 Vulnerability assessment

Research has provided new information on Finland's vulnerability to climate change. A general assessment of vulnerability across sectors was the basis for the original national adaptation strategy of 2005. Subsequently, more detailed studies of vulnerability in specific sectors or specific environments have been made. These include the following (see also Chapter 8):

- Water: designating flood-prone areas and flood maps (work carried out and made publicly available, further research on water management is being done, for example, as part of the research project ClimWater, which is part of the Finnish Research Programme on Climate Change (FICCA)); the impacts of climate change scenarios (ProDOC) are also being studied.
- Exploration of indirect economic effects at the regional and national level owing to river floods and urban floods caused by extreme downpours (TOLERATE and IRTORISKI projects).
- Forest: exploring the impacts of high winds, heat spells, drought, snow and frozen ground, and winter temperatures.
- Biodiversity: in particular, the sensitivity of bird populations and certain biotopes to climate change (FICCA research project A-LA-CARTE).
- Agriculture: studies on crop changes have been carried out at the national level. An international network of crop science experts working within the context of climate impact research has studied the sensitivity of crop production to climate change. There is also an ongoing project closely related to vulnerability assessment: Improving resilience to climate change and variation induced risks in agriculture (ILMAPUSKURI).
- Transport: Changes in exceedance frequency of critical thresholds of weather phenomena for transport systems (EWENT project of the 7th Framework Programme of the EU).
- Health: ongoing work on vulnerability of the elderly to climate change.
- Regional perspective on the Arctic region (FICCA research project CLICHE).

Finland has also experienced practical reminders of what vulnerability means. Severe thunderstorms in the summer of 2010 and wind storms in December 2011 demonstrated the vulnerability of Finnish society to wind damage and power outages. In the spring of 2013, several catchments on the west coast experienced severe flooding.

A summary of Finnish research results on impacts and adaptation has been published covering a wide variety of sectors and also dealing with cross-cutting topics. Vulnerabilities were identified in all sectors, but the nature of the expected impacts and vulnerabilities vary. A gradual shift in average condition that favours currently unknown, rare or new pests may be particularly problematic for agriculture and forestry, while extreme climatic events may have major consequences in terms of the vulnerability of both terrestrial and urban environments. Traffic and transportation have turned out to be particularly vulnerable to conditions near or below freezing.

The national Climate Change Adaptation Research Programme (ISTO, 2006–2010) has funded 30 studies concerning the vulnerability of various sectors and also a number of synthesis studies. The Academy of Finland currently runs a climate change research programme (FICCA), of which five projects also deal to some extent with vulnerability. Finnish research institutes have also participated in numerous EU-funded vulnerability and adaptation studies, which have also produced useful information for adaptation policies in Finland. Furthermore, several projects by the Nordic Research Council deal with vulnerability and adaptation. For example, a substantial part of the new insights and lessons regarding energy and transport systems come from these international projects.

The research projects highlight the nature of vulnerability and the relevant processes in different sectors of society. These studies contribute to a better understanding of vulnerabilities and risks related to climate change. In the revised version of the national climate adaptation strategy, special emphasis will be put on a systematic consideration of vulnerabilities, including considerations of how the vulnerabilities are projected to develop. The objective is to base adaptation measures on improved risk assessments that recognize key vulnerabilities.

Tools to help actors consider possible impacts and vulnerabilities have been developed and have also been made available through the Internet service 'Climate Guide'. It allows stakeholders to get access to spatially disaggregated information on climate projections and projected impacts.

6.3 Expected climate change impacts and adaptation measures

This section is an update of Finland's Fifth National Communication under the UNFCCC, and it utilises the recent results from various studies and research projects on adaptation. Adaptation research done in recent years (see Section 8.2) has increased our understanding of climate change impacts and vulnerabilities as well as the adaptation measures required for different sectors, while also highlighting sectoral differences.

6.3.1 Overview of impacts and economic consequences

Climate change has a direct impact on nature, the industries dependent on natural resources, the built environment and human well-being; as such, it will result in advantages and opportunities as well as disadvantages and threats for Finland. There are still considerable uncertainties and information gaps when assessing the potential costs of the impacts and adaptation measures. In general, the vulnerability of the Finnish society to extreme weather events and natural disasters has increased in the past few decades due to the society's increasing sensitivity to disturbances, for instance to wind damage and power outages.

It is estimated that gradual changes, such as the increase in average temperatures, will bring potential benefits to some natural resource sectors, such as agriculture, forestry and outdoor recreation business and tourism. The combined potential benefits for these sectors could be approximately 0.2 per cent of the gross domestic product (GDP). However, the estimate does not include the growing risks, such as the increased risks of damages caused by invasive alien species, pests and diseases. On the other hand, the benefits can only be realised if the sectors adapt themselves to the new conditions. The changes in biodiversity, for instance in the distribution patterns of species and habitats, may have a considerable impact on ecosystem services and also impact the operational preconditions of different sectors.

The water sector will supposedly be most affected by the climate change impacts. The direct costs from heavy rain (10 per cent annual probability) may increase to several million euros, and more infrequent events, such as severe flooding (1 per cent probability or less), may increase costs to EUR 100 million. Furthermore, the indirect economic costs of extreme weather events may be higher than the direct costs. Due to the multiplier effect, the economic impacts within a ten-year period may be double or even more compared to the direct costs.

Storms causing large amounts of damage will present challenges for the general functioning of society as well as for rescue services, as storms may cut down the power supply and communication links. Some of the general changes in society, such as population ageing, will further reinforce the impacts of climate change and require changes in the adaptation measures. In the future, emphasis should be put on risk assessment and management for extreme weather conditions and weather fluctuations.

Table 6.1 summarises the existing information on estimated economic impacts in different sectors. It also shows that fairly little is still known about the economic effects of climate change. When conducting economical assessments, the direct and indirect impacts of global climate change should also be taken into consideration, as they can be more significant than climate change impacts within Finland. The repercussions can be caused for instance

Table 6.1
Sectoral estimates of the economic impacts of climate change in Finland, and a summary of current research from the Finnish perspective (positive economic impact figures denote a net benefit)

Sector	Economic impacts	State of research
Tourism	By 2020, EUR 107 million; by 2050, EUR 107 million; by 2080, EUR 107 million (changes in net value added).	International research, with Finland involved from 2006. Research conducted within Finland in 2005.
Insurance	Weather and climate risks increasing, no overall estimates on economic impacts.	No Finnish research.
Agriculture	• By 2020, EUR 60 million; by 2050, • EUR 100 million; by 2080, EUR 120 million (changes in net value added). • About 0.1 per cent of GDP.	Latest study conducted within Finland in 2005. European PESETA project in 2009.
Forestry	By 2020, EUR 75 million; by 2050, EUR 150 million; by 2080, EUR 250 million (changes in net value added).	Latest figures from 2005, estimates also from the recent VACCIA project.
Biodiversity	No economic estimates. An estimate of EUR 10,000 million regarding negative impacts within Europe.	
Health and welfare	No economic estimates.	No overall estimates, research also scarce on a global level.
Built environment	Costs due to rivers flooding: • in Pori, EUR 40–50, or up to EUR 100 million (for flooding events occurring once every 50 years) • 0.2–0.4 per cent of GDP.	TOLERATE, PESETA, and ClimateCost estimated the impacts of river floods; no overall estimates for the built environment.
Transport and communications	Overall estimates based only on current costs. For example, weather-induced traffic accidents: about EUR 230 million; pedestrian slipping injuries: about EUR 2.4 billion.	The EWENT project and the VTT Technical Research Centre of Finland estimated current costs; there are no Finnish estimates on the overall costs induced by climate change.
Energy sector	By 2020, EUR –37 million; by 2050, EUR –73 million; by 2080 EUR –141 million (changes in net value added).	Latest estimates from 2005.

by trade, migration or global economical crises. Therefore, domestic research should be more closely linked with international research in the future.

6.3.2 National adaptation strategy and the current level of adaptation

Finland's National Strategy for Adaptation to Climate Change was published in 2005. The objective of the strategy is to reinforce and increase the adaptive capacity of society by minimising the negative impacts while taking advantage of any favourable impacts. The main principle of the strategy was that adaptation measures should be integrated into the normal planning and operational work in different sectors. The implementation of indicative measures listed in the adaptation strategy (reported in Finland's Fifth National Communication) has already started in different administrative sectors. Some of the administrative sectors, for instance the Ministry of the Environment and the Ministry of Agriculture and Forestry, have published implementation programmes.

A significant share of the adaptation measures are implemented at the regional and local level. Various measures promoting the provision for climate change, such as flood protection, have already been taken on at the regional or municipal level for quite a long time, though they have not been seen as adaptation measures as such. By the end of 2012, 16 out of 18 regions had published a climate strategy, which included a certain degree of adaptation as well. In 2012, approximately 40 per cent of municipalities were undertaking systematic climate actions and, although their focus has been on climate change mitigation, climate change adaptation has also been promoted. In order to be able to advance effective adaptation measures, local and regional operations should be further promoted.

One essential implementation tool for the national strategy has been the ISTO research programme, which produced comprehensive knowledge on the impacts of climate change and vulnerability in different sectors, thereby laying the foundation for sectoral adaptation measures. The final evaluation of the ISTO programme was published in 2011. The results from the ISTO programme and other adaptation research projects have been compiled into a synthesis report, 'How to adapt to inevitable climate change–Synthesis of Finnish adaptation research in different sectors', which was published in 2012.

The Coordination Group for Adaptation to Climate Change was reappointed in 2012 to monitor and promote the implementation of the adaptation strategy. The tasks of the coordination group also include a broader assessment of the implementation of the adaptation strategy and a revision of the strategy in 2012–2013.

A five-step indicator representing the adaptation level was developed during the mid-term assessment of the adaptation strategy, which was completed in 2009. When defining the adaptation level, the level of knowledge behind the measures and the level of cross-sectoral cooperation are taken into account (Table 6.2).

In Finland, climate change is relatively well recognised in different sectors. It is estimated that the different sectors (see Sections 6.3.3 and 6.3.4) will reach either level 2 or level 3 in the adaptation process (see Table 6.2). The most advanced sector is water management, where adaptation has already been integrated with decision making (level 4). Many of the indicative

Table 6.2
Levels of adaptation to climate change

	Awareness	Knowledge	Adaptation Measures	Cross-sectoral Cooperation
step 1	• Need for adaptation measures recognised among a group of pioneers within the sector	• Little research done on the impacts of or adaptation to climate change	• Some adaptation measures identified but not yet implemented	
step 2	• Need for adaptation measures recognised to some extent within the sector (some decision makers)	• Impacts of climate change known indicatively (qualitative information), taking account of the uncertainty involved in climate change scenarios	• Adaptation measures identified and plans made for their implementation, some of them launched	
step 3	• Need for adaptation measures quite well recognised (majority of decision makers) within the sector	• Impacts of climate change quite well known (quantitative information), taking account of the uncertainty involved in climate change scenarios	• Adaptation measures identified and their implementation launched	• Cross-sectoral cooperation on adaptation measures started
step 4	• Need for adaptation measures widely recognised and accepted within the sector	• Impacts of climate change well known, within the limits of the uncertainty involved in climate change scenarios	• Adaptation incorporated into regular decision-making processes • Implementation of adaptation measures widely launched and their benefits assessed at least to some extent	• Cross-sectoral cooperation on adaptation measures an established practice
step 5	• Adaptation measures (for example those under the Adaptation Strategy) implemented within the sector			

sectoral measures listed in the strategy (see Finland's Fifth National Communication) have already been started, but concrete adaptation measures need to be further enhanced in different sectors.

When evaluating the successes and bottlenecks of the implementation process for the various adaptation measures, the differences between sectors were clearly highlighted: in some sectors, the impacts of climate change can easily be recognised and uncertainties are either small or relatively easy to deal with, meaning that the necessary adaptation measures are easier to define. In general, an understanding of climate change risks has increased due to the more frequent occurrence of extreme weather events and increasing adaptation research promoting the launching of adaptation measures. There is also an identified need for a more thorough analysis in relation to possible synergies and conflicting aspects of climate change adaptation and mitigation objectives in different sectors.

In many cases, the provision measures aimed at increasing climate resiliency in terms of everyday actions also improve the level of preparedness for dealing with extreme weather conditions and weather fluctuation, thus promoting further adaptation measures in the longer run. By developing adaptation measures as an integral part of the existing operations, it is also possible to strengthen the other functions of the sector or organisation. For instance, adaptation measures in water management can improve water quality and/or water protection, while the adaptation measures adopted by rescue services for dealing with storm damage can improve the management system in general.

Although the sectoral approach of the Finnish Adaptation Strategy has facilitated implementation and follow-up in different administrative sectors, it has not yet sufficiently encouraged the launch of cross-sectoral cooperation. In the future, cross-sectoral measures should be better integrated with and promoted as part of adaptation measures.

6.3.3 *Climate change impacts on and adaptation measures for nature and natural resources*

Biodiversity

Climate change will probably increase the total number of species in the Finnish flora and fauna. Furthermore, considerable changes are likely to occur in the distribution patterns of species and habitats. Some northern habitats and species, such as relict cold-water fish and other reminders of the ice age, may become extinct. Northern boreal species of forests, mires and Arctic mountain habitats are threatened and predicted to decline due to the warming climate.

A longer growing season and milder winters may lead to the rapid proliferation of a number of southern species that thrive in a warm climate. Currently, rare species living at the northernmost extreme of their distribution could become more common. In southern Finland, some invasive species could threaten the habitats of native species, and the population of invaders may expand rapidly if they lack natural enemies. On the other hand, many native species in the south could find favourable living conditions further north in the warming climate. Northern species requiring cold conditions will suffer from the change as habitats suitable for them become rarer. In particular, climate change will threaten the habitats of the fell area (e.g. palsa mires), especially those habitats for which snow or ground frost is an essential factor.

The impacts of climate change on vegetation and forest composition will occur gradually. Under current forest management practices, the amount of decaying wood and forest litter is likely to increase, thus creating suitable habitats for a number of endangered species. However, the growing use of biomass to substitute for fossil fuels may reduce the amount of wood left in forests after harvesting.

Climate change may threaten the pollination of plants by decreasing suitable habitats for different pollinators, which are essential in agricultural production. Additionally, some predatory insects that help to control agricultural pests are vulnerable to changes in the climate and their natural habitats.

Rising temperatures and runoff into aquatic environments, and the consequent changes in nutrient loading, may have a profound impact on, for example, phytoplankton and zooplankton, benthic fauna, fish stocks and the number of species in both lakes and marine waters. The spring peak of phytoplankton in lakes will occur earlier and will be considerably more pronounced than it is today. The littoral zone is likely to be more sensitive to the effects of climate change than the pelagic ecosystem.

Water sector

Climate change studies indicate that winter discharges are going to increase significantly, particularly in southern and central Finland. Floods caused by spring snowmelt will decrease, but may remain at their present level in northern Finland. Autumn and winter floods caused by precipitation will increase especially in large lakes and their outflow rivers. Since estimations of climate change impacts include uncertainties at every step of the modelling process, the accumulated total uncertainties are considerable. The large differences between the results from different climate scenarios and assem-

Box 6.1
Pristine peatlands

In southern Finland, raised bogs, mire complexes with an extremely nutrient-poor and acidic ombrotrophic (deposition-fed) centre and minerotrophic (additionally fed by water inputs from the catchment) laggs are an integral part of the boreal landscape. In the north, the raised bog complexes are replaced by aapa mires with characteristic extensive wet minerotrophic centres. The distribution of these two main types of mire complexes depends on climate and roughly follows the 1,100 °C dd (degree days) isocline (sum of growing season daily average temperatures above +5 °C). The range of peatland habitats found within raised bogs and/or aapa mires extends from highly productive spruce swamps in the south to open Sphagnum fuscum dominated bogs and treeless palsa mires with local permafrost in the north. Rates of carbon accumulation vary greatly between peatland types depending on the year. Accumulation is generally faster in ombrotrophic bogs than in minerotrophic fens. In an optimally rainy year, a peatland can sequester carbon dioxide at a rate of up to 3,500 kg per hectare annually, but release the same amount in a dry year.

The estimated summertime warming would increase evapotranspiration and lead to lowered water table (WT) levels in peatlands. Furthermore, the number of exceptionally dry summers is expected to increase. Generally, it has been estimated that the WTs in northern peatlands will decline by 15–20 cm due to the predicted climate warming. Lowered WTs will likely have a greater impact on peatland ecosystems than the warming itself. On the other hand, it is also assumed that precipitation will increase, especially during wintertime. Any consistent changes in climate may be expected to affect the biodiversity, carbon accumulation potential and other ecosystem services provided by peatlands. Some of these changes may be considered positive and some negative from the human perspective.

Warming accompanied with drying would greatly affect the structure and functioning of northern pristine peatlands. Shifts from sedge-dominated fens to Sphagnum-dominated bogs could take place faster than at present in the south. Furthermore, the zone where this transition may take place (raised bog zone) could migrate northwards, while the northern aapa mires would retreat further north. Simultaneously, diversity would decline as fen species adapted to wet conditions would give way to species adapted to drier conditions. Excluding the most nutrient-poor bog sites, this could also mean the spread of shrubs and trees, leading to the replacement of open mires with peatland forests and consequent losses of species requiring open habitats, such as certain butterfly species. In northernmost Lapland, the palsa mires (peat mounds with permafrost) are in danger of thawing with the warming climate.

Switches from minerotrophy to ombrotrophy would, in principle, accelerate carbon sequestration in the peat soil. However, drying will also lead to carbon losses from peat, which will be caused by accelerated decomposition both at the nutrient-rich end and at the most nutrient-poor, inherently treeless end of the habitat gradient. At the moderately nutrient-poor sites, carbon accumulation in the soil may continue after a transient period when the acclimation and/or adaptation to drier conditions takes place; this will be reflected in species changes and an increase in shrubs and/or trees. This will be facilitated by changes in the quantity and quality of litter inputs. Consistent droughts during late summer in particular will enable the development of tree stands, in which case increasing tree biomass will accumulate carbon, to an extent temporarily compensating for the losses from soil at the nutrient-rich sites and increasing total carbon sequestration at poorer sites. The carbon loss from the soils of the most nutrient-poor treeless sites will not be compensated for by any potential changes in vegetation and litter inputs.

The worst scenario from a carbon accumulation standpoint may result from considerable variation in the WTs between years. This would lead to a state of 'consistent disturbance', where productivity and carbon sequestration are low, while carbon would be continually lost from the old deposits. Changes in methane emissions will depend on changes in the WTs and vegetation. Mere warming will likely increase these emissions, while drying and the replacement of sedges by other vegetation types will lead to lowered methane emissions. Overall, changes in temperature, precipitation and evapotranspiration may have a considerable impact on the hydrology of wetlands and, consequently, the load of organic and inorganic matter from catchments.

In 2012, the Finnish Government approved a resolution on the sustainable and responsible use of and protection of mires and peatlands (see Section 2.13).

bly modelling highlight the need to use several climate scenarios in climate change impact studies.

Possibilities to adapt to climate change impacts through changes in lake regulations have been studied in Finland. Changing the management strategies and permits for many of the regulated lakes will likely become necessary in the 21st century in response to shifts in the hydrological regime induced by climate change.

Summer rainfall might decrease and, even if it were to stay at the present level, higher temperatures could cause fairly intense and prolonged periods of drought. However, summer floods are also projected to be more frequent and severe due to increased extreme rainfall. Floods and droughts have the potential to be harmful to water quality. Low flows boost concentrations of bacteria, algae and toxins. High flows and intense rainfall increase erosion and the leaching of nutrients from catchments into watercourses and coastal waters.

Approximately sixty flood-prone areas have been identified in Finland. Some forty of them are local sites, e.g. industrial plants, while the others are extensive areas, such as lake surroundings or river basins. It has been estimated that a flood with a return period of 250 years could cause damages of up to EUR 550 million.

One of the most vulnerable flood risk areas is the town of Pori at the mouth of the Kokemäki River in south-western Finland. About 15,000 people live in the flood-prone area. The river is known for harmful winter floods and ice breakup jams. A severe summer flood caused damages worth EUR 22 million in Pori in August 2007. This was the most devastating urban flood event ever observed in Finland.

The Flood Risk Management Act (620/2010) came into force on 30 June 2010 and the Government Decree on Flood Risk Management on 7 July 2010. The Act aims to reduce flood risks, prevent and mitigate the adverse consequences caused by floods, and promote the level of preparedness for floods. Its purpose is also to help coordinate flood risk management and the management of river basins, while taking into account the needs relating to the sustainable use and protection of water resources. Among other things, the Act lays down obligations to perform a preliminary assessment of flood risks, specifies significant flood risk areas and aids in the preparation of flood risk management plans.

Adaptation to climate change will be addressed in the River Basin Management Plans to 2021, based on the EU Water Framework Directive. These plans will be adopted by the Government in 2015. One main challenge to achieving good water quality status in surface waters is the reduction of nutrient pollution. As a result of climate change, runoff will increase, causing erosion processes that result in the transport of larger amounts of soil material rich in nutrients to surface waters, thus contributing to eutrophication. Adaptive measures for improving nutrient management are needed in many sectors, particularly in agriculture. Additionally, better risk management of accidental events such as overflows from waste water treatment plants and better management of storm water are needed.

Approximately two thirds of Finns depend on groundwater for their household water supply. If dry periods become longer in summer in southern Finland, groundwater discharges will be reduced. This may also lead to a shortage of dissolved oxygen and high concentrations of dissolved iron, manganese and metals in the groundwater. The shortage of dissolved oxygen may generate ammonium, organic matter, methane and hydrogen sulphide gases, causing the water to taste bad and smell. In wintertime, increasing precipitation and snowmelt will produce fresh and oxygen-rich groundwater.

Climate change impacts on water services can be substantial. More frequent extreme weather events, such as prolonged droughts, storms, heavy rainfall and floods, may cause problems. Storm blackouts will impede water treatment and conveying efforts at various waterworks and wastewater facilities. Flooding and heavy rainfall can lead to surface water flowing directly into intake wells, jeopardising the water quality or causing wastewater overflow.

Essential adaptation measures in water services include intake wells in groundwater bodies with favourable water yields. Wastewater facilities, especially pumps, should be placed outside groundwater areas and flood risk areas. Important adaptation measures also include precautionary means: drawing up preparedness plans, improving cooperation between waterworks, compiling thorough guidelines on land use and further developing and utilising databases and models.

As to the safety of dams, intense rainfall is estimated to increase considerably in Finland. This would cause problems for dams, particularly along small rivers. Because of increased monthly or seasonal precipitation, together with winter snowmelt, the safety of dams along larger rivers will need to be accounted for. However, major problems seem unlikely in this respect because most dams have quite large spillways.

Box 6.2
The Baltic Sea and its coastal areas

Climate change is expected to bring milder winters to the Baltic Sea, meaning less ice cover, warmer summer temperatures, reduced salinity and slower land uplift in relation to sea level – or even a net rise in sea levels. It is not yet clear how these changes in physical conditions will affect marine ecosystems. The impacts of climate change on the Baltic Sea will have wide-ranging socio-economic consequences in relation to navigation, coastal developments, fisheries, insurance policies and recreational activities connected to the sea.

Both the maximum ice cover extent and the probability of severe ice winters will decrease in the Baltic Sea. Some changes will already be seen within the next few decades. After 2040, severe ice winters will be quite rare. Correspondingly, mild and extremely mild ice winters will increase. The average maximum fast ice thickness in the 2040s will be approximately 30 cm less than for the period 1971–2000.

The sea level is an important issue for future coastal safety. Although the northern parts of the Baltic Sea are characterised by considerable isostatic land uplift, coasts further south are at risk. The combination of storm surges and river floods may be particularly problematic, as shown by the case of Pori on the west coast (a severe summer flood in 2007). The issues that will need to be addressed in the future include what level of coastal protection will be needed, how to cope with severe sea and river flood events and, especially, how much the coastal protection will cost. These issues were covered in detail, e.g. in the Climate Change Adaptation Strategy of the Helsinki Metropolitan Area, which was published in 2012.

Finland is also involved in the transnational climate change adaptation strategy for the Baltic Sea Region, which focuses on the sea and coastline. This project aims to build a bridge between climate change research and policy, thus contributing to an improved institutional capacity.

Agriculture

Climate change is projected to improve crop productivity in Finland if the rise in temperature is moderate. The current main field crops might be cultivated further north and many novel crops that are sown in spring and autumn might be introduced into cultivation due to the longer thermal growing season, higher accumulated temperature sum and milder overwintering conditions. However, possible increases in the variability of climatic conditions within and between seasons, more frequent extreme weather events and increased risks for disease and pest outbreaks might increase the risks and cause more uncertainties for agricultural production. The risk of animal diseases may also increase, although it is also expected to remain relatively low in the future. Diseases associated with the poor quality of water may become more common. The increased amount of rainfall might increase the leaching of insecticides and herbicides as well as fertilizers into the water systems. All of these possible changes call for early and powerful adaptation measures to reduce risks induced by climate so that society can benefit from the opportunities.

Due to the highly variable weather conditions typical for high latitudes and the fact that agriculture is always dependent on the ambient weather conditions, farmers in general are well aware of the changes and of the fact that there will likely be more changes in the growing conditions in the future. But they are also ready to react by adopting cultivars as well as cultivation methods and systems that will likely reduce the production risks and increase the resilience of agricultural systems. The existing networks in place for farmers, farmers' associations and training help improve the exchange of knowledge about the means for adapting to climate change and variability. Existing agricultural research has been well designed to support the development of practical adaptation means, and so the step from research to practice has been a relatively easy one. Thereby, research on climate change impacts and the adaptation means available has already provided useful information for farmers and agricultural entrepreneurs.

The recent adaptation measures include risk profiles and emergency plans for various existing and emerging pests and diseases. The climate-related risk assessment has been strengthened by efforts from the Finnish Food Safety Authority Evira, and new projects on the risks caused by plant pests and diseases have been launched. Even though the main drivers for the risk assessment have been the pest and disease risks caused by increasing international trade, the impacts of climate change are also included when relevant. Finnish plant breeding has expanded the breeding strategies to cover novel crops that will most likely be introduced to diversify Finnish crop rotations in the future. Improved disease resistance through plant breeding is an important element in improving Finland's adaptive capacity in the future.

Other essential adaptation means include sustaining the soil structure and conditions by, for example, diversifying crop rotations and favouring crops that provide soil cover for winters that are projected to get wetter; developing sufficient warning systems for the occurrence of pest and disease epidemics; developing year-round water management systems to increase nutrient use efficiency and reduce drought-induced yield variability, especially for environmentally vulnerable regions; and targeting sustainably intensified agricultural systems, e.g. by having sufficient and timely adaptation measures.

Fisheries and game

Climate change and the variables related to it (summer and winter temperatures, ice cover, windiness, salinity and eutrophication) affect the fish populations and catches. The fish react to fairly small and early changes in the temperatures by changing their behaviour, their reproduction patterns, their nutrient intake, their migration patterns and their locations. If the changes are large enough, there may also be changes in the growth of fish populations and in their communities and even in survival, mortality and distribution.

Climate warming might increase the growth rate of some of the Finnish fish species. Fish species that require cold water, including most of the threatened fish species, will suffer from warming. It is also estimated that climate change will increase the leaching of nutrients into waters. This will increase eutrophication, which has already affected fish stocks in coastal waters. Generally, eutrophication increases the total fish biomass, but decreases species richness. Warm winters together with eutrophication will decrease the catches of burbot and whitefish.

The economic value of fish resources available for commercial fishing is estimated to decrease. In winter, a shorter ice period and thinner ice will favour the most important type of commercial fishing: trawling. It will also favour the wintertime seine catching of vendace as well as coastal net fishing. However, the warming of waters favours the appearance of fish diseases and parasites and it will also increase the risks of invasive alien species and their parasites or diseases. Conducting follow-ups and preventing the spread of invasive alien species are important adapting measures in fisheries and game management.

Predicting the impacts of climate change on fish populations for a longer period of time involves significant uncertainties. Because the annual variation in fish populations may be considerable (for example, the variation in the vendace stocks), it is difficult to distinguish between the effects of climate change and other environmental changes. For this reason, long-time follow-ups and further studies are needed.

Game species, just like other animals, have also adapted themselves to variations in both the climate and the environment. Due to climate warming, it is assumed that as the vegetation zones move to the north, the distribution of species that have, over the course of time, become adapted to these conditions will also shift in this direction. In Northern Europe, the species of the Arctic and Siberian fauna are expected to withdraw to the north and east, while the southern European species will move further north.

Moose, the most important game species in Finland, may first benefit from a warmer climate due to an increase in food supply. On the other hand, the heat physiology of the moose is not adapted to a temperate climate. For some game species that change their fur or the colour of their feathers according to the season, the shortened period of snow cover might lead to increased exposure to predatory species. The game stocks may also be severely affected by invasive alien species as well as vector-borne diseases.

Closely monitored follow-ups and accurate game statistics will also provide the basis for sustainable game management and hunting in the future.

Forestry

Towards the end of this century, climate change is expected to increase significantly both the growth and production of Finnish forests, as well as carbon sequestration and carbon stocks in the tree biomass. The growth increase will be larger in the north. Increased tree litter inputs will lead to increased carbon sequestration in the forest soils as well. However, lowered soil water levels caused by increased evapotranspiration may, together with increased temperatures, lead to increased carbon losses from nitrogen-rich organic forest soils. With respect to the main tree species, especially birch (*Betula pendula*, *Betula pubescens*), it is expected to increase its share of the growing stock if its presence is not actively controlled via forest management. In contrast, Norway spruce (*Picea abies*) is expected to suffer from drought in southern Finland on sites with low water-holding capacity. In southern Finland, the natural regeneration of forests may become more difficult due to increased competition from ground vegetation. Drought episodes in early summer can be harmful for the germination of tree seeds, especially in the south.

The risks to forests caused by strong winds are expected to increase in the future because the period of time during which the soil is frozen will be shorter, thus decreasing tree stability from late autumn to early spring, the windiest period of the year. Newly created forest edges and recently thinned stands are the most vulnerable to wind- and snow-induced damage. The risk of wind damage is, on average, strongest among older Norway spruce stands, while young birch and Scots pine stands are the most vulnerable to snow damage. The risk of snow damage to trees could decrease in southern and central Finland since a smaller share of the wintertime precipitation is predicted to fall as snow. This will be the case if westerly winds predominate. Eastern winds can, on the other hand, also result in quite heavy snowfall in the south. This has happened in the last few years. Shorter periods of time during which the soil is frozen may hamper winter harvesting and increase the need for summertime harvesting. Harvesting during periods when the soil is not frozen will increase the risks of root damage and attacks by fungal pathogens, e.g. Heterobasidion. Furthermore, the risk of forest fires may also increase in the future, especially in southern Finland, due to an increase in drought episodes.

Forest damage caused by numerous pest insects and pathogenic fungi will likely increase significantly due to rising temperatures and changes in the amount of precipitation. Among the current forest pests, root-rot (*Heterobasidion annosum*), various leaf and stem pathogenic fungi, bark beetles (*Ips typographus*) and sawflies (*Neodiprion spp.*) are of particular interest, as are voles, moose and deer, since the changing environment may affect their population size. In addition, new pests may appear in the form of invasive species from the south, or previously harmless species may become harmful in conditions where natural resistance has not evolved or no predators exist.

The diversity of forest ecosystems and the distribution areas of species may change as a result of the changing climate. Even entire vegetation zones may move northwards. Such changes may strengthen as a result of increased mineralisation, which can increase soil fertility. The timberline is expected to move slowly further north, with the two most important coniferous trees in economic terms, the Scots and Norway spruce, being in the front line of such a change. The changing tree limit will not be even because the quality of the soil and bedrock can restrict the migration. New species may become established in open areas either after a natural disturbance or after clearcutting and soil preparation. The fastest invaders are species that produce a lot of seeds or spores. After intensive forest management and energy wood harvesting, the fertility of the soil may decrease, which will favour species that thrive in poor soils. This may cause changes at different trophy levels, thereby affecting the abundance of species dependent on the current vegetation.

By the appropriate and gradual adaption of forest management practices and the sustainable use of forest resources, it will be possible to gain from the positive effects and decrease the negative effects of climate change. In terms of forest regeneration, the site-specific selection of species and regeneration methods should be applied. In southern Finland, the cultivation of Norway spruce should be avoided on dry sites. On the other hand, the natural regeneration of Scots pine may become successful even in the north.

Box 6.3
Climate change in Finnish Lapland

Some 24 per cent of Finland's area is located north of the Arctic Circle. The northernmost province, Lapland, covers almost one third of Finland, but the population is only 183,000.

The Sámi people living in Finnish Lapland are Europe's northernmost indigenous people. Nowadays, there are approximately 9,000 Sámi in Finland. However, more than half of them live outside the traditional Sámi areas, all of which are located in the province of Lapland.

The service sector employs 73 per cent of the work force in Lapland, while industry employs 20 per cent and primary production around 6 per cent of the work force. Reindeer husbandry is still an essential activity for the European Arctic regions from both an economic and cultural standpoint. It is particularly important for indigenous communities. Finnish Lapland counts nowadays some 200,000 reindeers, owned by approximately 5,000 herders. Not all of these herders are indigenous Sámi.

The projected climate change for Lapland indicates a particularly significant warming trend, and a considerable increase in precipitation. The shortening of the snow season has become quite evident in recent years, threatening in particular the important Christmas tourist season. Tourism is the main industry in many communities in Lapland. During seven months of the year, tourism has been based on snow and winter conditions.

The impacts of climate change on reindeer populations are expected to be mainly unfavourable. If winters become milder and precipitation increases, the snow may become thicker and icy layers may form inside the snow cover. This would make it difficult for reindeer to dig for lichen and their need for supplementary food would increase. The northward advance of the tree line and gradual replacement of lichens with vascular plants may also affect reindeer pastures. Particular habitats may also be lost as a consequence of increasing temperatures and precipitation. Under current projections, there is a high probability that the unique palsa mire habitats will be completely lost by the end of this century.

Almost forty per cent of Finland's hydropower is generated in Lapland. Increased precipitation and more even discharges will be beneficial for hydropower production. Some additional capacity has already been built alongside existing hydropower plants.

Finland's Strategy for the Arctic Region was released in June 2010 and it will be updated in 2014. In October 2012, the Government put in place four spearheads for updating the strategy: namely, Finland is an Arctic country, Finland has Arctic know-how, Finland respects the principles of sustainable development and International co-operation. These are more thoroughly processed through four thematic approaches: education and research; developing business opportunities; environment and comprehensive security; and international co-operation. Finland is also a member of the Arctic Council and the Barents Euro-Arctic Council (see Section 8.1.2). The economic development of the Arctic region and the possible growth in possibilities for navigation via the Northern Sea Route can have considerable economic, social and ecological impacts in Lapland.

Timely and proper management of young stands is needed to maintain the vitality, resistance and health of forests and the resistance of trees to wind- and snow-induced damage. In addition to forest management and climate change, the changes in the tree species proportions and the age structure of forests will affect these risks regionally. Due to the increasing forest growth rate, more frequent and/or heavier thinnings should be applied, which will also make it possible to shorten the rotation length accordingly. In addition to such measures, sophisticated systems for monitoring forest resources and damages at various scales are also needed.

No comprehensive, detailed assessment has yet been made of the economic implications of climate change, nor of the potential costs of the various adaptation measures needed in Finnish forests and forestry. In general, both the implications and the costs are influenced by national and international forest policies and global markets. An important issue in the future may be how to weigh the different conflicting interests in forest management and forestry against one another, which will be crucial for the sustainable management and use of forest resources. A greater use of forest resources is likely in the future, since in Finland a general agreement has been reached to increase the use of renewable, mainly wood-based energy by 2020. Forests or forestry products offer significant possibilities for using carbon storage to control the net emissions of CO_2, in addition to increasing the use of the forest biomass in energy production.

6.3.4 Climate change impacts on and adaptation measures for different sectors of the economy and infrastructure, including human health

Energy

Climate change affects both the supply of and demand for energy. Increased precipitation rates should increase the production of hydropower, which currently covers about one fifth of total electricity generation (see Section 2.6). The impact of climate change on wind power potential is expected to be favourable, but the estimates are quite uncertain and vary from practically no impact to an approximately 10–15 per cent production increase depending on the location. The longer growing period is expected to contribute to increasing the production of wood-based fuels. However, because renewable energy sources are more exposed to extreme weather conditions, the growing share of renewable energy may increase the need to secure a supply of fuel and backup power capacity. In terms of the exploitation of fossil fuel and nuclear energy resources, climate change will only have minor direct impacts.

The demand for energy is expected to decrease in the wintertime as less heating will be needed and increase in the summertime due to the growing need for cooling. This may benefit consumers in the longer term through a decrease in energy consumption. Warming will affect the temperature of cooling water, reducing the efficiency of condensing power plants. The maintenance costs of the energy network may rise due to the extreme weather conditions.The design of the new nuclear power plant units take into account the changing circustamces and the units in operation are undergoing modifications.

In the energy sector, adaptation measures have already been launched. The severe winter and summer storms that have caused extensive and long-lasting power outages in the last few years have brought the operational security of the power supply networks into public discussions. Regulations aimed at improving the security of the energy supply in network fault situations, especially in sparsely populated areas, have recently been included in the revised version of the electricity market legislation. According to the new Electricity Market Act, the distribution network must be designed, built and maintained in such a way that if the network would be damaged due to a storm or snow, the electricity interruption for the customers must not exceed 6 hours in detailed planned areas and 36 hours in other areas. These time limits must be met gradually in a 15 years time period and fully by the end of the year 2028. In addition, the Electricity Market Act includes other measures to improve the electricity network security of supply, for example, a requirement for co-operation between the network companies in interruption situations. The distribution network companies must also prepare a development plan for the network including measures on how to fulfil the 6 and 36 hour time limits for network security of supply. In order to meet the time limits of 6 and 36 hours, a significant increase to the average underground cabling degree of the Finnish electricity distribution networks is needed. The estimated total investments in distribution networks due to the new reguirements are EUR 3,500 million. The Highways Act will be amended to improve the security of the electricity supply, making it easier to install power cables along roadsides. In terms of hydropower plant investments, new turbines have been scaled to better meet the expected changes in water flow conditions.

The National Energy and Climate Strategy (2013) presents various means for improving small-scale electricity production and developing the power system. Provided that a power system is capable of operating in island mode, decentralised power production can improve the reliability of electricity deliveries by dividing the system into regional networks and securing the local power distribution in the cases of, for instance, large storm damages. This is, however, not the case in Finland today, even though the development and introduction of smart-grid technology is common among the network companies. An intelligent electricity network would speed up the repair of storm damages by allowing for automatic fault localisation and isolation, thus minimising the number of customers experiencing long power outages.

Land-use planning and building

In the land use and building sectors, the impacts of climate change are quite well known and the need for adaptation measures is commonly acknowledged. The expected changes in precipitation, wind velocity and temperature constitute a challenge for the construction sector. These stress factors are already having an impact on construction, because buildings have a long lifecycle.

The most important impacts of climate change on land use are changes in flood risks, extreme weather events and groundwater conditions. The impacts will vary regionally. Changes related to flooding will create challenges for land-use planning, especially in the vicinity of rivers and lakes, in coastal areas and in other areas vulnerable to floods. Increased heavy rainfall will be a challenge for storm water management, especially in areas where most of the ground surface is covered with impermeable materials.

The current legislation on building and other statutes include requirements for taking climate change into consideration. In terms of measures involving new construction, climate change and adaptation will be taken into consideration already during the planning stage. This will also be done through planning guidance. Local conditions that may affect construction are increasingly being taken into account through existing instruments, such as building ordinances and municipal instructions for building. The use of specific local, regional and municipal guidance instruments should be further reinforced.

The most significant measure regarding land use and building was the Government Decision of 13 November 2008 on revising the national land use guidelines. Addressing the challenges posed by climate change was a key theme for the revision, and the new guidelines include, for example, the need to follow objectives concerning adaptations to climate change: in land-use planning, new construction should not be located in areas that are prone to flooding. An exception can only be made if need and impact studies indicate that the risks of flooding can be controlled and that the construction work is in line with sustainable development. Local master planning and detailed planning should take account of the increasing possibility of storms, heavy rainfall and flooding in built areas. The preservation of ecological corridors between protection areas is to be promoted and, where necessary, these areas and other valuable natural areas should also be protected.

The Flood Risk Management Act and the Government Decree on Flood Risk Management regulate flood risk management and the management of river basins, while taking into account the needs relating to sustainable use and the protection of water resources. The Centres for Economic Development, Transport and the Environment bear the main responsibility for the planning of flood risk area management in river basins and coastal areas. Municipalities are responsible for planning how to manage floods in urban areas caused by heavy rainfall. According to the Act, the Finnish Environment Institute will ensure that information on significant flood risk areas, flood hazard maps and flood risk maps, and approved flood risk management plans are made available to the public via information networks.

An examination of possible sea level rising along the shores of the Baltic Sea (coastal flooding) is in progress. On the basis of the results, the guide for the minimum permissible building heights will be renewed this year. The guide will contain recommendations for determining the minimum permissible building height with respect to floods for inland shores and the shores of the Baltic Sea.

Industry and commerce

The Finnish industry is quite energy intensive and the need to mitigate climate change has been more the subject of focus in the industry sector than the need to adapt to it. The need for risk management due to weather variability and extreme weather conditions has been obvious within some weather sensitive branches. So far, it has not been assumed that climate change will bring significant changes to most of the industrial operations, and therefore, adaptation measures have followed the perceived changes so far.

Though many of the industrial processes are considered to be independent of weather and climate changes, they may include stages requiring more precise heat and moisture conditions. In the industrial areas, it is important to be prepared for the risks related especially to heavy rains and floods in cases where, for instance, environmentally harmful substances are stored and used or when process and waste sewers are located in a flood-sensitive area. In the building industry, the risks of strong winds and/or very cold or hot periods should be considered in terms of the workers' health and safety. The industry is very dependent on the electricity supply, and therefore, extreme weather conditions causing long-term power failures will generate a particular weather risk.

The demand for many products and services is weather dependent, and therefore, climate change impacts should be taken into consideration in terms of long-term investments and strategic planning. Changes in the demand are obvious in some branches of the food industry, for instance in the consumption of beverages, ice cream or barbeque products related to hot weather in the summertime. In wintertime, the sales of winter sports equipment and clothing depend on the early winter weather.

The direct and indirect changes in the global markets have an impact on Finland and Finnish companies. For instance, within the food industry significant crop damages in the large global production areas may impact the markets and price of the commodities. Disruptions in logistics may impact the processing, distribution and sales of products.

Some studies on climate change adaptation have been done for the industry sector. They find that climate change may bring opportunities for the industry sector as well. For instance, new products, processes, technologies and know-how related to adaptation can be exploited as part of CleanTech and other business opportunities. However, the need to identify and possibly promote these opportunities has just recently been introduced into wider discussion.

Mining

In 2011, a total of 52 mines and quarries were operating in Finland. The excavation of metallic ore deposits has increased mainly due to a high demand for metals. The yearly volume of mining in 2010–2011 was more than three times the volumes of the early 2000s and the mining volumes are projected to increase four- to fivefold over the 2010–2011 level by 2020.

Climate change affects mining in several ways. For example, mining can be sensitive to weather events. In particular, open pit mining, which requires large spaces of land, can be severely affected by severe weather events, as shown by a number of incidents. The risk of tailing dams failing due to excessive precipitation calls for rigorous risk analysis using a broad spectrum of climate scenarios and sophisticated risk management. The Finnish mining industry is being subject to 'stress tests' to reduce the risk of the types of adverse environmental consequences that climate change can aggravate.

Another aspect is the potential effect on transport and the transport infrastructure. The mining industry is dependent on moving huge amounts of material, and climate change can affect the logistics of these operations.

Transport and communications

Climate change is expected to impact all facets of the transport system: the infrastructure, means of transport and operations. Changes in the soil frost, reductions in the total snow depth, an increase in the amount of precipitation and heavy precipitation events (both water and snow), an increase in soil wetness and floods, changes in vegetation, episodes of soil drying during summertime, extreme storms causing falling timber, and so forth, will all impact road maintenance and the transport infrastructure.

Some of the major impacts are as follows:

- More frequent warm and wet periods, which will increase wear and rutting
- The number of freeze-thaw cycles degrading road surfaces may increase during the coming decades; however, in the latter part of the 21st century they are expected to decrease, except in northern Finland
- Increased snow clearing capacity may be needed if heavy snowfall events become more frequent; however, total annual snow clearance work is expected to decrease in southern Finland in the coming decades, and later on in central and northern Finland
- The need for clearing ice on roads is expected to increase in central and northern Finland
- Groundwater levels will rise due to precipitation increase, leading to a reduction in the carrying capacity of low-level roads, especially during autumn and early winter
- The springtime frost-heave period will take place earlier
- The depth of the ground frost will decrease

Heavy rainfall events cause roads and underpasses to become inundated; they also cause collapses, erosion and the degradation of bridges and culverts, especially along low-volume local roads. In Finland, one of the most relevant losses due to the warming climate is a reduction in the duration of frozen soil, which can support the heavy tracked vehicles and machinery used in, e.g. transportation, by the forest industry.

Climate change and extreme weather as such do not pose any unmanageable risks, but climate change and the combination of a lower level of maintenance and infrastructure repair of roads constitute a real risk for the serviceability of roads. Another risk is associated with contracts between road and street infrastructure owners and maintenance contractors: extreme events requiring additional maintenance efforts pose in practice an unmanageable contract risk that is difficult to price and/or share.

Envisaged actions that will enhance the adaptive capacity of society during the coming decades include developing warning systems and providing information, improving rescue planning, developing maintenance operations and improving structures.

The contracts between maintenance service providers and road and street infrastructure managers should be developed in a manner that enables more flexible extreme weather risk management.

Railway transport is affected by rising temperatures, increasing precipitation, changes in freeze-thaw cycles and snowfall. An increase in the frequency or intensity of strong winds or lightning could significantly impact rail transport. The railway network in Finland is vulnerable, for instance, to frost-heave damage, blizzards and low temperatures as well as to lightning damage to traffic. The vulnerability of railways may also increase if maintenance and repair work efforts are undersized.

Actions to increase the adaptive capacity of the railways include the development of warning systems jointly with weather information providers and other transport operators, improving rescue services and safety information, strengthening the rail structures, improving protection against weather, updating monitoring guidance and maintaining the infrastructure.

Phenomena relevant to marine and inland water transport include strong winds, high waves, heavy snowfall, temperature increases, ice cover, lightning, extremely high/low sea/water levels and floods. All in all, approximately forty potential hazards have been identified that are connected to these weather-related phenomena. Most of them are related to fairway maintenance, charting, traffic control and wintertime seafaring in general.

Climate warming will reduce the amount of ice in the Baltic Sea. However, the amount of ice-breaking assistance for ships also depends on wind conditions. The adaptation actions include, for example, improving the safety equipment, changing the design and procurement practices, and developing information services.

When it comes to weather-related boating accidents on sea and lakes, developing weather information and providing access to it will be a relevant and cost-effective way of increasing safety and saving lives. Similarly, the training of leisure boat users is expected to have rapid, positive impacts.

Most pedestrian accidents take place during wintertime due to slippery conditions. Both for pedestrians and cyclists, the most hazard-prone conditions develop when an icy surface is covered with a thin layer of snow or water. It is estimated that the weather conditions causing slippery conditions may become more frequent in some parts of the country within a short period of time. The development of pavement and property maintenance as well as pedestrian weather services are considered effective measures for limiting the number of slipping and falling accidents. A reduction in accidents could result in large savings for society.

Air traffic will suffer from heavy storms and lightning. The maintenance costs at airports and the use of de-icing chemicals may increase in midwinter.

In telecommunications, the networks that rely on aerial cables may be especially vulnerable to storms and icy rain. The same applies to the automatic safety systems for different modes of transport. These systems can also be damaged by flooding. Ice and wind loads on telecommunications masts may become heavier.

Tourism and recreation

Finland is an attractive destination for tourists mainly because of the large variety of recreation opportunities available in the country's natural environment. The dependence on nature and seasonal variation make tourism and recreational activities vulnerable to climate change.

Snow-based activities such as cross-country skiing, alpine skiing, riding snowmobiles and ice fishing are vulnerable to climate change. The vulnerability of cross-country skiing is strongest in southern and western Finland, particularly in the coastal regions. However, at least in the near future, ski resorts in the north may benefit from relatively good snow conditions compared to ski resorts in Europe or southern Finland. An awareness of climate change and the capacity to adapt to it are improving among tourism enterprises, but there are still a lot of regional differences. The type of tourism and its economic importance in the region, the image of tourism and the social and community characteristics of the region define how vulnerable to climate change the region is as a tourism destination.

A warmer and longer summer season would improve the conditions for summer sports and many water-based recreational activities (e.g. boating, swimming and fishing). On the other hand, algal blooms in warmer waters, increased amounts of summer precipitation or extreme weather events may lower the attraction of such activities in summertime.

Insurance

Climate change will affect insurance companies directly in three different ways: through claims, through their investments and through the terms of trade of reinsurance.

Climate change is likely to increase the damage caused by extreme weather, thus indemnities for damages are expected to increase in the future. In addition, insurance companies will face higher levels of uncertainty in their risk estimates, and as a result, they may have to pay higher amounts in damages than anticipated. These changes may be reflected in the insurance premiums and available coverage.

Forests are insured by private insurance companies in Finland. Only about a third of forest owners have insurance against forest damage. On average, some 60-70 per cent of annual compensation in forest insurance is paid for storm damage, thus the annual compensation is highly dependent on the storm activity during the year in question. In December 2011, the Boxing Day storm alone led to compensations totalling nearly EUR 30 million.

Home and property insurance policies in Finland have not traditionally covered damage caused by heavy rainfall or floods. However, if the flooding of a particular river or lake is considered exceptional, it has been possible to date to obtain compensation from the Government. However, the Government has decided to withdraw this insurance programme at the end of 2013. The risk of flood damages will then be carried by the property owner, which will create opportunities for the insurance companies to develop new insurance products. Some insurance companies already offer insurance policies against flood damages that are caused by exceptionally severe weather events.

Weather and climate risks are usually systematic, which means that a large number of claimants are exposed to adverse weather conditions at the same time. The correlation of various weather risks has been studied in Finland regarding crop damages, and the correlation between damages has been found to be high even over long distances. This kind of systematic damage is problematic for insurance companies, and Government compensation schemes are usually validated with this reason. The Government compensates crop damages caused by adverse weather conditions if the damages exceed 30 per cent of the value of a normal harvest. The budgeted amount is EUR 3.4 million per year, but the limit has been exceeded regularly. However, the role of Government as an underwriter is problematic: for political reasons, its ability to aggregate and segregate risks is limited. Thus, the availability of compensation schemes offered by the Government is expected to decrease in the future.

Insurance companies can also buy reinsurance to secure their solvency against systematic risk. The price of reinsurance is expected to increase in the future, which will make it more expensive for insurance companies to protect themselves against large losses. Reinsurers have already started to include the increased risks caused by extreme weather in the premiums they charge insurance companies.

Most of the money inflow to the insurance companies is invested onwards in the capital markets. Climate change will affect many sectors in the future, and thus it will affect the return on the investment as well. When considering the full portfolio of an insurance company, the correlation between claims and a return on investment should not be high so as to avoid situations that threaten solvency. The impact of climate change on the investment portfolio is less evident and has not been studied thoroughly yet.

The insurance sector can also adapt to climate change. In order to be able to insure people against weather and climate-based risks, insurance companies must be able to estimate the risk levels, understand the systematic aspects of the weather and climate risks, be active in mitigating damages through their customers (i.e. by use of deductibles) and diversify risks more effectively. Apart from the threats, climate change may create new business opportunities for insurance companies as well, such as new insurance products, loss prevention technologies, advisory services and risk-management products. Insurance companies can be an important part of the adaptation process by creating new products and innovations that will help society mitigate the adverse effects of climate change.

Most insurance companies are still operating at a low adaptation level; only limited adaptive actions have been taken, sometimes they have even gone against economic objectives, and the majority of research into the economic effects of climate change has been done outside the sector. Interviews with insurance companies in the Nordic countries regarding their climate change adaptation actions revealed that in Finland, environmental issues and climate change had not yet been faced to the same degree as in other Nordic countries.

Health

The increased intensity and frequency of extreme weather events may place additional pressure on the health sector, particularly as the population ages. In Finland, high temperatures will clearly increase heat-related mortality and morbidity in the summertime, when the daily average temperature exceeds +20°C. For example, more than 400 extra deaths occurred during a heat wave in the summer of 2010. The number of days with heat stress will increase both in outdoor and indoor work environments and this will result in the need to revise the instructions regarding work-rest cycles among high-risk groups in the working age population. Also, the thermal control of the built working environment will need to be modified. Among outdoor workers, the need for protection against UV radiation will increase.

During milder winters, the risk of additional mortality from cardiovascular and pulmonary diseases will likely decrease. On the other hand, darker winters, caused by a shorter snow cover period, increased precipitation and cloudiness, may increase cases of winter blues or seasonal affective disorder and their subsequent medical conditions. This means that the lighting control of the built environment should be modified as appropriate. The number of days when the temperature hovers around 0°C will also increase. This may increase the risks of slipping injuries and traffic accidents. Thinner ice and the shorter duration of ice cover on waterways will be a safety risk. Because of the large degree of climate variability, especially during the wintertime, it is important to be prepared also for cold spells and their adverse health impacts.

Warming might contribute to the northward spread of ticks and tick-borne diseases, such as Lyme disease (borreliosis) and tick-borne encephalitis, but many other factors (social and societal) besides the climate will affect endemicity. A warmer climate would stabilise the population fluctuations of small rodents, which will reduce the overall incidence of several rodent-borne diseases (e.g. Puumala hantavirus and tularaemia). The probable increase in the density of medium-sized predators (red fox, raccoon dog) could increase the risk of rabies and the chances of alveolar echinococcosis spreading to Finland.

Climate change would gradually influence the plant species and the amount of pollen, and therefore also the number of pollen allergies. While increased exposure to allergens may cause more severe symptoms for sensitive persons, the number of people suffering from pollen allergies is not expected to increase. The risk of forest fires and the possibility of being exposed to fine particle will gradually increase, and thus adverse health impacts will also increase.

Floods may also induce health risks, particularly through contamination of the water supply.

The Ministry of Social Affairs and Heath recently produced a handbook on exceptional situations related to environmental health for environmental health care staff and their cooperation partners, which also includes information about weather and climate-related events. The Finnish Meteorological Institute has been issuing heat-wave and cold-spell warnings since 2011.

Cultural environment

Wooden buildings are typical in Finland and, as wood is sensitive to changes in humidity, measures will be required to control decay. The old town in Rauma and the Petäjävesi wooden church, which are on the UNESCO World Heritage List, are representative of traditional Nordic wooden architecture.

Extreme weather events, such as storms and flooding, will have an impact, for example, on the Suomenlinna Sea Fortress, which is also included on the World Heritage List.

Cultural landscapes and semi-natural habitats will be affected as a result of changes in the biodiversity and in the distribution of species.

Adaptation to climate change may lead to an increased need for safety repairs at restoration and conservation sites. Climate and energy policies, such as increasing the use of renewable energy sources, and energy-saving goals, such as improving the energy efficiency of buildings, may also have significant effects on the cultural environment. It is especially important to develop renovation technologies and methods for modern buildings built since the 1950s in order to avoid health problems and damage to the historical value of the buildings as a result of unsuitable technical solutions.

6.3.5 Disaster prevention and management

The standard of security in daily life is in general good in Finland. Only in very rare cases have natural disasters caused serious problems for Finns. However, the growing frequency of storms and extreme weather events will create challenges for rescue services. Storms causing extensive damage to land areas are a major threat because they may disrupt heating, the electricity supply and communications. The ageing of the population and the migration to urban centres, while at the same larger areas remain sparsely populated, need to be taken into account, for example in master planning and other planning.

The Government Resolution of 16 December 2010 on the Security Strategy for Society sets the foundation for preparedness and crisis management for all actors. The strategy defines the operations vital to society and outlines the threat scenarios and disturbances that jeopardize these operations, the strategic tasks of the ministries for securing and guaranteeing that the operations will continue, the criteria for crisis management, implementation tasks and the principles of the exercises. Business actors, NGOs, municipalities and regional government authorities and security research all have a significant role in ensuring the preparedness of society and managing disturbances. The Security Strategy for Society is supplemented and followed up by other strategies and guidance documents relating to preparedness and management of disturbances; these documents have been prepared by the various administrative sectors. Preparation for natural disasters like floods will take place through preparedness planning, exercises, surveillance, information exchange and other cooperation practices and situation descriptions and reports as well as by implementing, for example, the necessary flood protection measures at critical sites.

The purpose of the Act on Security of Supply (1390/1992) is to maintain the basic economic functions required for ensuring people's livelihood, economic life and national defence and the related technical and material preconditions in the event of serious disruptions and emergencies. Preparing for threats to a networked society calls for both material preparedness and securing the continuation of the functioning organisations that are critical for the security of that particular society. In this work, extensive cooperation among companies, public authorities and sectoral organisations is vital.

The Finnish Meteorological Institute has diversified the weather-related warning services for citizens. Besides the traditional storm, wind and forest fire warnings and traffic weather (warnings on poor road conditions) reports, there are now wave and sea level warnings for marine areas. Since 2011, there have been warnings for heat waves and severe cold spells. Weather warnings are given 24 hours before the start of the expected event and early warnings 2–5 days before that. Warnings are also forwarded to other authorities through risk bulletins, while the emergency response centres forward almost real-time information on damages caused by weather events to the round-the-clock weather service of the Finnish Meteorological Institute.

The early warning system for floods coordinated by the Finnish Environment Institute produces forecasts for water bodies and issues flood warnings. The hydrological watershed model system also produces precipitation warnings for water areas and snow load warnings for rooftops. The Finnish Meteorological Institute and the Finnish Environment Institute also forward weather and hydrological warnings to the authorities through a natural disaster warning system (LUOVA). LUOVA is part of the situation report system of the Government and security authorities and was developed as part of the second Internal Security Programme adopted by the Government and the Strategy for Securing the Functions Vital to Society.

Fire and rescue services have been pioneers in climate change adaptation. Practices such as preparedness planning and exercises relating to various extreme weather events have been reinforced. Adaptation has coincided with the changes in preparedness planning, where the focus has shifted from major national crises to solving more everyday crises.

The climate risks and uncertainties are growing, but new solutions are being developed all the time. However, now that extreme weather events are growing in number and society is becoming more vulnerable, the security skills of private citizens should be much better than they are at present. It seems that the trend is the exact opposite: more and more people are 'neohelpless', i.e. their security skills are deteriorating and risk taking is on the increase.

6.4 Global impacts of climate change and international co-operation

Changes taking place in other parts of the world will create a need for adaptation in Finland, too. As outlined in Finland's Fifth National Communication, a study to review the implications of international climate change for Finland (IMPLIFIN) concluded that climate change impacts on the world economy and on the development of poorer countries could have important repercussions for the Finnish economy and for Finland's international relations in general. According to a recent synthesis report (How to adapt to inevitable climate change – A synthesis of Finnish research on adaptation in different sectors), the impacts of climate change elsewhere in the world will have implications for Finland through, for example, international trade. Climate change can also contribute to conflicts and migration in developing countries – climate change is considered a threat multiplier. Furthermore, international climate policy and especially EU regulations will have implications for Finnish policy making.

In order to support the most vulnerable developing countries in particular, Finland has integrated climate change concerns with development cooperation (see also Chapter 7). The Finnish development policy guidelines for the environment, which was approved in 2009, already noted that climate change mitigation and adaptation should be addressed in all of the most important sectors of Finnish development cooperation. Furthermore, it was decided to work proactively to reduce natural disasters resulting from climate change through the Hyogo Framework for Action.

In the latest Development Policy Programme (2012), climate sustainability is one of the cross-cutting objectives of Finland's development policy and development cooperation. The need to integrate the cross-cutting objectives with all development cooperation activities is a binding obligation. In addition, the sustainable management of natural resources and environmental protection is one of the priority areas under which climate-change-related support is outlined more broadly. The Development Policy Programme states that the impacts of development cooperation on the climate must be assessed comprehensively ex ante, with the aim being to combat climate change and its adverse effects on development. In its own development cooperation, Finland aims to achieve carbon neutrality as soon as possible. Finland promotes low carbon development and the capacity of its partner countries to adapt to climate change, and it seeks to further the integration of these goals within its partner countries' own development planning. Particular attention will be paid to the roles of women, children and indigenous peoples in adapting to and in combating climate change.

Moreover, the human and economic losses caused by natural disasters are a major obstacle to development. Finland supports long-term measures that reduce the vulnerability of people and communities to natural disasters. Strengthening the capacity of developing countries' own administrations to prepare for natural disasters and investing in disaster risk reduction measures is a necessity. Finland has adopted a climate sustainability tool for assessing and preventing climate change and the risks posed by natural disasters that are caused by climate change. Furthermore, the new project manual for development cooperation includes a disaster risk reduction tool.

Finland has supported the United Nations Office for Disaster Risk Reduction (UNISDR) since 2004. During the period 2008–2010, Finland's support for UNISDR was EUR 0.3 million per year and in 2011 it was EUR 0.6 million. In 2011, a decision was made to raise the level of support, and at present the support level is at EUR 1 million per year (2012–2013). Finland has also participated as an observer in the World Bank Consultative Group of the Global Facility for Disaster Reduction.

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