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, different sectors of the economy and society. The chapter includes an outline of efforts to assess vulnerability. The national framework of adaptation to the impacts of climate change is explained. The expected impacts are described together with adaptation measures in each sector. Finally, international aspects of Finnish adaptation are briefly discussed.

Photo: Marko Muuttola / The Finnish Wildlife Agency / The Life project of Return of Rural Wetlands

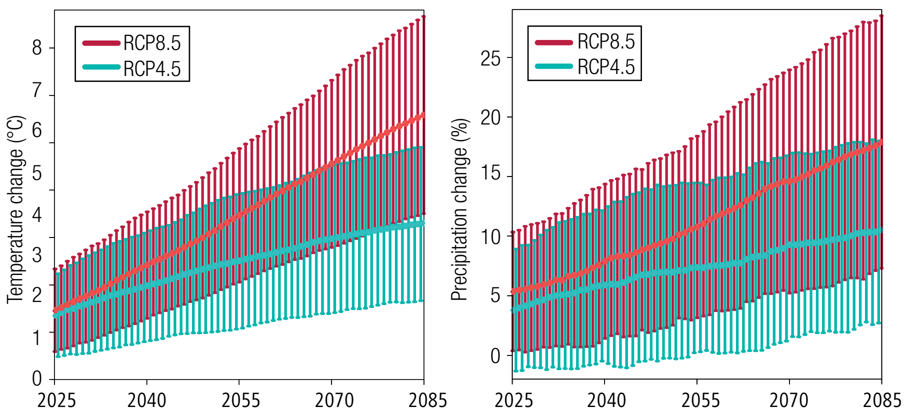
6 CLIMATE CHANGE IMPACTS, ADAPTATION MEASURES AND VULNERABILITY ASSESSMENT

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 (referred to as the "forcing" of the climate), (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 (90 per cent confidence intervals) for the future evolution of annual mean temperatures and precipitation rates in Finland for two forcing 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, on average, to be 2.5°C by mid-century and 3.3°C by the end of the 21st century under the RCP4.5 scenario, and 3.5°C

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 1981 to 2010. The thick solid lines represent the multi-model 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)



and 5.6°C under the RCP8.5 scenario, respectively. The average temperature increase in Finland is expected to be 1.5 to 2 times as large as mean warming globally. The projected increase in precipitation is substantial as well. Both forcing scenarios lead to quite a similar evolution of temperatures and precipitation rates until about the 2030s. 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 also fairly large.

Both the increases in temperatures and precipitation rates will be larger in winter than in summer (Figure 6.2). If the RCP8.5 scenario were realized, the January mean temperature would increase by 4 to 11°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.

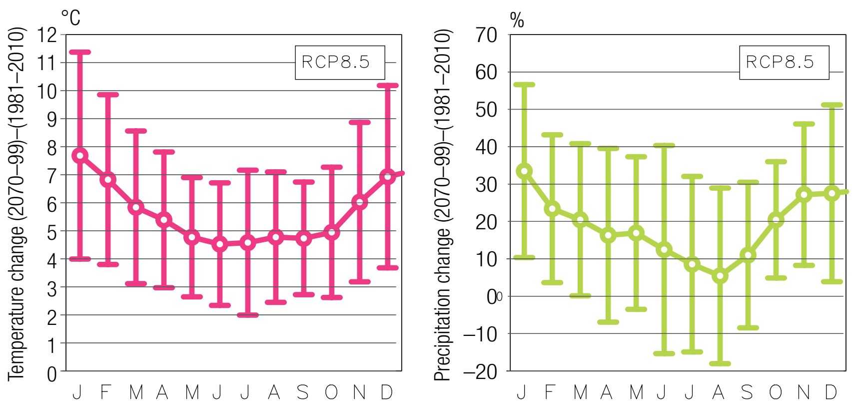
Compared to the climate scenarios generated by the previous model ensemble (which was used to prepare the IPCC's 4th Assessment Report), the present mean summer temperature projections are as much as 1°C higher. This can be deduced by comparing the RCP4.5 and SRES B1 scenarios; the evolution of greenhouse gas concentrations is nearly equal in both scenarios. Conversely, winter temperature projections and precipitation scenarios for all seasons are fairly similar in the two groups of models.

The new temperature and precipitation projections were not published until February 2013, and hence most of 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 models) include the following:

- Heatwaves will become longer and more frequent, whereas severe cold spells will gradually diminish.
- Heavy precipitation events will intensify in summer.
- The number of days with precipitation will increase in the winter.
- The snow season will become shorter and the snow water equivalent will decrease on average, particularly in southern Finland.

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 multi-model mean projection. The 90 per cent confidence interval for the change is denoted by vertical bars. The changes are presented for the period 2070 to 2099, relative to 1981 to 2010, under the RCP8.5 scenario.



- 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.
- Wind speeds may remain nearly unchanged but inter-model scatter is large. This does not rule out the possibility of increasing frequency of strong winds, especially in the coastal areas.

6.2 Assessment of risks and vulnerability to climate change

This section provides an overview of recent activities in assessing risks and vulnerabilities to climate change in Finland. It provides a foundation for the following section 6.3 that describes adaptation actions in response to both observed and anticipated climate impacts, risks and vulnerabilities in different sectors of the society. This section is primarily based on recently completed and ongoing research activities (see also Chapter 8).

Risk and vulnerability assessments have been carried out in national research projects and programmes, and as part of Nordic and European research efforts. Research outputs contribute to a better understanding of key vulnerabilities and risks related to climate change. This type of knowledge is instrumental as a basis for adaptation measures, as is also called for by the National Plan for Adaptation to Climate Change 2022.

Completed national research programmes include the National Climate Change Adaptation Research Programme (ISTO, 2006 to 2010) that funded 28 studies on the vulnerability and a number of synthesis studies, and the Academy of Finland funded Finnish Research Programme on Climate Change (FICCA, 2011 to 2014) that included five projects specifically addressing climate change risks and vulnerability. A recently completed national project on Proactive management of weather and climate related risks (ELASTINEN, 2015 to 2016) generated new information on climate risk management particularly for urban areas and the energy, water and agriculture sectors. The project also assessed costs and benefits of climate risk management and cross-border impacts of climate change on Finland. A follow-up project is currently ongoing (SIETO, 2017 to 2018).

Other recent and ongoing studies of risks and vulnerability include the following:

- Water: mapping of significant flood hazard and risk areas (legal requirement based on national implementation of the EU Floods Directive); hydrological and climate modelling (FICCA research project ClimWater).
- Forest: impacts of high winds, heat spells, drought, snow and frozen ground, and winter temperatures, also research projects on uncertainties, and risks to forests and forestry (ADAPT and ongoing FORBIO projects).
- Biodiversity: species and dynamic vegetation modelling of butterflies and birds; adaptation options available for conservation planning including legal and economic constraints (FICCA research project A-LA-CARTE)).
- Agriculture: studies on changes in cultivated areas of crop species, introduction of novel crops for cultivation and changes in crop rotations at regional and national level (PeltoOptimi and OPAL-Life projects). 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. A recently completed research project focused on means to improve resilience to climate change and variation induced risks in agriculture (ILMAPUSKURI).

- Natural resource sectors: thorough analysis of vulnerability of natural resources sectors (agriculture, forestry, game and fisheries and reindeer management) was carried out as a part of the State of Adaptation Assessment project (SOPEUTUMISEN TILA project).
- Infrastructure and the built environment: variability in hydropower reservoirs and predictability of hydropower production in the Nordic countries; sensitivity of urban real estate price formation to changes in exposure to climate risks; forecasting methodology for extreme weather event frequencies (FICCA research project RECAST).
- Health: studies on the health effects of heatwaves, including identification of vulnerable population groups and evaluation of preparedness in health care facilities; evaluation of health risks posed by compromised drinking water quality due to climatic and other factors (CONPAT project); ongoing work on vulnerability of the elderly to climate change (PLUMES project).
- Arctic region: identifying different risks (posed by climate change but also geopolitical and security-related risks) and opportunities for marine transport and tourism in the Arctic; socio-economic scenario-based assessment for the Eurasian Arctic (MERMAID research project); impacts of climate change on the Artic environment, ecosystems and societies (FICCA research project CLICHE). The Arctic region and in particular the Barents Region was also studied in a recently completed project Adaptation Actions for a Changing Arctic (AACA).
- Social vulnerability at local level: Analysis of social vulnerability to climate change in the Helsinki metropolitan area (Helsinki Region Environmental Services Authority, HSY).
- Uncertainties: improving the treatment of key uncertainties in climate change impact, adaptation and vulnerability analysis, with a focus on Finland and two sectors, agriculture and human health (ongoing PLUMES project).

Finnish research institutes have participated in numerous European funded research projects that have generated relevant information for developing adaptation policies and measures in Finland. These include EU FP7 projects BASE, ToPDAd, EWENT, OPENNESS and IMPRESSIONS. Finnish researchers also contributed to joint work between the MEDIATION project and UNEP's Global Programme of Research on Climate Change Vulnerability, Impacts and Adaptation (PROVIA) to develop the PROVIA/MEDIATION Adaptation Platform for climate change adaptation methods and tools. Finnish research institutes have participated in several European Joint Programming Initiatives (JPIs), for example, work on agricultural model intercomparison and improvement for studying climate risks to agriculture and adaptation responses (MACSUR). Finnish research institutes also participate in Nordic Centres of Excellence (NCoE) with relevance to risk and vulnerability, such as the NCoE NORDRESS on societal security and natural hazards.

Tools to help actors consider possible impacts and vulnerabilities have been developed and have also been made available through the web portal Climateguide.fi. The most recent feature is a vulnerability mapping tool (based on results of the MAVERIC project) that illustrates how vulnerable cross-country skiing or the elderly population could be to impacts of climate change in different parts of Finland. For example, indicators of projected future exposure of the elderly to heat, cold and slippery conditions under a changing climate in different parts of the country can be combined with indicators of adaptive capacity and mapped nationally. Climateguide.fi also allows stakeholders to get access to spatially disaggregated information on climate projections and projected impacts.

6.3 Climate change impacts and adaptation measures

This section is an update of Finland's Sixth 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 Economic impacts

Climate change has a direct impact on nature, 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. Cross-border effects of climate change is one area where economic impacts are likely to be notable in the future. Section 6.4 describes the pathways through which such indirect impacts are expected to affect Finland. According to a study, economic impacts of climate change have been estimated to be considerable for different sectors in Finland (Table 6.1.) although significant uncertainties need to be taken into

Table 6.1
Sectoral estimates of the economic impacts of climate change in Finland from a study on 'How to adapt to inevitable climate change – A synthesis of Finnish research on adaptation in different sectors' (Ruuhela et al. 2012), updated with recent research results.

Sector	Economic impacts
Tourism	If winter time tourists continue to highly prefer skiing, overnight stays in Lapland +11%, i.e. annual net benefits ~ EUR 440 million by 2040 in RCP4.5. If winter time tourists increasingly diversify outdoor activities, overnight stays in Lapland –15%, i.e. annual net losses ~ EUR 600 million by 2040 in RCP4.5.[1] Overall macro-economic effect of improved relative attraction of Finland in summer and winter amounts to +1.8% more annual tourist expenditures by 2050 in RCP8.5 [2]
Insurance	Weather and climate risks increasing, no overall estimates on economic impacts.
Agriculture	Annual net benefits: • EUR 60 million in 2020; EUR 100 million in 2050; EUR 120 million in 2080 (changes in net value added) [3] • About 0.1 per cent of GDP.
Forestry	Annual net benefits: EUR 75 million in 2020; EUR 150 million in 2050; EUR 250 million in 2080 (changes in net value added) [3]
Biodiversity	No economic estimates. An estimate of EUR 10,000 million regarding negative impacts within Europe annually.
Health and welfare	No economic estimates.
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.
Transport	Without adaptation the costs of road accidents may rise by several million Euro in the next few decades. Innovation and adaptation could more than compensate this effect. Slipperiness for pedestrians constitutes a substantial health risk (50 000 needing medical care; 30 000 hospital bed days) in current climate and climate change can worsen it. Also road maintenance cost increase due to climate change, but no quantification available.[4]
Energy sector	Annual net impact: EUR –37 million in 2020; EUR –73 million in 2050; EUR –141 million in 2080 (changes in net value added) [3] [5]

1) Perrels et al. 2015a
2) Aaheim et al. 2015
3) More information in Perrels et al. 2005
4) Perrels et al. 2015b, Pilli-Sihvola et al. 2016, Hippi et al. 2017
5) negative net impacts include the effect of the decreased demand for heating among other things

account. These estimated impacts are potentially beneficial for some sectors, however, it must be noted that active adaptation is required to realise such opportunities. For example, it is estimated that gradual changes, such as the increase in average temperatures, may benefit some natural resource sectors, such as agriculture, forestry and outdoor recreation business and tourism. Active and proactive adaptation are needed in these sectors because uncertainties related to future variability of the climate and to impacts are considerable and risks are variable, e.g. risks of damages caused by invasive alien species, pests and diseases. 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 conditions of different sectors.

The water sector is estimated to be most affected by the climate change impacts. In the current climate, the direct costs from heavy rain events, with a 10 per cent annual probability, have been calculated to amount to several million euros on average. More rare flood events, such as severe fluvial flooding, with a one per cent probability or less, have the potential to cause direct costs of EUR 100 million and over in the current climate. Climate change has been estimated to have the potential to add 15 to 20 per cent direct damage cost potential in some river basins in Finland over the next three decades in current built-up areas, while careless land use planning may aggravate the effect. Furthermore, the indirect economic costs of weather events may be higher than the direct costs, but these build up more slowly depending on how effectively an affected region recovers, and how strongly the affected region is interdependent with other regions. Additionally, droughts can cause major losses of up to EUR 100 million under the current climate in Finland (Table 6.3).

Storms that cause large damages will present challenges for the general functioning of society, as well as for rescue services, as storms may cut the power supply and communication links. Table 6.2 contain damages and economic losses due to some major storms and severe weather events experienced in 2010 to 2015. These weather events caused significant losses mainly due to damage to infrastructures, i.e. powerlines, buildings, and forests, and interruptions to vital services like electricity distribution and transport. The climate change impacts, economical and other, have been taken into account in the energy sector: For example, recent legislation on the electricity markets sets requirements for the maximum duration of interruptions in electricity supply for the distribution system operators, which will imply investments up to EUR 2,800 million in infrastructure. Im-

Table 6.2
Damages and costs of thunderstorms and wind storms in Finland in 2010 to 2015 (Gregow et al. 2016).

Name of the storm	Tapani storm	Thunderstorms Asta, Veera, Lahja and Sylvi	Eino storm	Valio storm
Duration	Dec 26–28, 2011	Jul 29 – Aug 8, 2010	Nov 17, 2013	Oct 2–3, 2015
Number of injured people	–	40–50	2	1
Volume of storm-felled trees (m^3)	3.5 million	8.1 million	1.5 million	0.5–1.5 million
Value of storm-felled trees (EUR)	120 million	not known	60 million	20–50 million
Losses to forest owners (EUR)	25–30 million	not known	30 million	not known
Impacts to electricity distribution (number of households without electricity)	570,000	481,000	200,000	232,000
Compensations paid by the electricity network companies (EUR)	40 million	10.3 million	not known	9 million
Repair costs of electricity networks (EUR)	30 million	22 million	not known	8 million
Number of damaged buildings	665	not known	99	91
Compensations paid by the insurance companies (EUR)	100 million	82 million	30 million	not known

Table 6.3
Costs of the damages in euros caused by droughts in Finland in 2002 to 2003 (Gregow et al. 2016)

Drought	Damages to water supply	Damages to hydro-power production	Damages to agriculture	Damages to forestry	Damages to building stock
Drought 2002–2003*	8 million	50 million	15 million	2 million	million

* between August 2002 and April 2003 precipitation in southern Finland was less than half compared to the average

provement of power supply infrastructure has already began. Some of the general changes in society, such as the population ageing, will further alter e.g. health related climate risks, and need to be considered when planning adaptation measures.

6.3.2 National adaptation strategy and the current level of adaptation

Finland was one of the first countries in the world to adopt a policy to guide climate change adaptation (Finland's National Strategy for Adaptation to Climate Change 2005). The second evaluation of the implementation of the adaptation strategy in 2013 found that overall progress had been made compared to the first evaluation in 2009: Climate change impacts are recognized in most of the sectors and adaptation measures identified in the strategy have been launched. The 2013 evaluation included recommendations for the revision of the strategy such as further promotion of cooperation between authorities and other actors in different sectors and administrative levels, as well as further promotion of regional and local adaptation measures. The evaluation also recommended clarification of the division of labour and responsibilities between the state, municipalities and private sector. For the revision of the national adaptation strategy, a further study of the impacts of the climate change and vulnerability of sectors was conducted in 2013. Vulnerabilities were identified in all sectors, but the nature of the expected impacts and vulnerabilities varied. The recommendations from the evaluation of the previous strategy and the vulnerability analysis in 2013 were considered in the preparation of the National Climate Change Adaptation Plan 2022 (Government Resolution on 20 November 2014), which describes the current national adaptation policy framework.

The aim of the adaptation plan is that the Finnish society has the capacity to manage the risks associated with climate change and adapt to changes in the climate. Based on the aim, the following objectives are to be achieved by the year 2022:

A. Adaptation has been integrated into the planning and activities of both the various sectors and their actors.
B. The actors have access to the necessary climate change assessment and management methods.
C. Research and development work, communication, and education and training have enhanced the adaptive capacity of society, developed innovative solutions and improved citizens' awareness on climate change adaptation.

The international repercussions of climate change are also taken into account in the national work. The Monitoring Group on Climate Change Adaptation was appointed in 2015 replacing the Coordination Group for Adaptation to Climate Change. The monitoring group is broadly-based, with representatives from the relevant ministries and other authorities, regional and local actors, research institutes, expert organisation in fire and rescue services, and financial services. Different research and development projects have produced essential implementation tools for the National Climate Change Adaptation Plan. The projects produced comprehensive knowledge on the impacts of climate change and vulnerability in different sectors (e.g. ISTO, ELASTINEN, SIETO, see Section 6.2 and Table 6.4). Table 6.4 summarises the status of the twelve main elements of the National Climate Change Adaptation Plan 2022 and includes short descriptions and examples of the current level of adaptation since 2014.

Finland's Climate Change Act[1] was approved on 6 March 2015. It provides a framework for planning, implementing and assessing climate policies and improves cooperation among government offices in mitigation and adaptation. The law stipulates that the Government approves long-term and medium-term strategic mitigation plans and at least every ten years a national plan on adaptation. Adaptation is also included in the National Energy and Climate Strategy for 2030.

The awareness of the climate risks and vulnerability of different sectors has increased recently (Chapter 6.2). Several sectors also have an action plan for adaptation (Table 6.4). For instance, the adaptation plan of the environmental administration was updated in 2016, covering the built environment, natural environment and water resources sectors.

Table 6.4
The fields of action in the National Climate Change Adaptation Plan 2022 and the current level/status of the work in 8/2017.

The fields of action (main elements) in the adaptation	Status	Description/ examples
1. Studies on climate resilience are conducted at national level.	In progress, completed for some sectors.	Vulnerability assessment of natural resources (2017) VAT* updated
2. Action plans for administrative sectors are formed and implemented, taking international repercussions of climate change into account.	In progress, needs more action, completed for some sectors.	• Climate Programme. for Finnish Agriculture – Steps towards Climate Friendly Food (2014) • Ministry of Environment Action Plan (2016) • The Energy and Climate Programme of The Finnish Defence Forces - objectives and measures (2014)
3. Drafting of regional and local adaptation studies is promoted.	In progress, completed for some regions.	• Vulnerability analysis of HSY* 2016 • Flood risk maps • Projects KUJA and KUJA2 (2014–2019) on continuity management of municipalities
4. Adaptation is promoted in international cooperation.	In progress	e.g.during the presidency of the Arctic Council (2017–2019)
5. Adaptation is included in EU policies and international region-based cooperation projects.	In progress	Implementation of the EU Adaptation Strategy (2013) Council of the Baltic Sea States (The Baltic 2030 Action Plan 2017)
6. Climate risk assessment and management are improved.	In progress	Research projects ELASTINEN 2015 to 2016, SIETO 2017 to 2018
7. Instruments applicable to the management of financial risks caused by climate change are developed.	In progress, completed for some sector	Study on Insurances (crop and flood) by the Finnish Climate Change Panel 2016
8. Adaptation research is reinforced.	Coming 2017	Plan for Research Programme 2017 (Tapio)
9. Business opportunities related to adaptation are developed.	Needs more action, in progress	Report 2016 (Tapio), cooperation with FIBS* and CLC* 2017
10. Tools to support regional adaptation work are developed.	In progress, completed for some sectors	Municipalities (ELASTINEN 2015 to 2016), Climate resilience tools for the public and private sector (Tapio 2016)
11. Communication on adaptation is developed.	In progress	Communication Action Plan 2017 by the Ministry of Agriculture and Forestry
12. Education and training content on adaptation is developed.	Needs more action	Study and teaching module Climate.now as MOOC* platform

* VAT = National land use guidelines, HSY = The Helsinki Region Environmental Services Authority,
FIBS = Finnish corporate responsibility network, CLC= Climate Leadership Council,
MOOC = the Massive Open Online Course platform of University of Helsinki. http://www.ilmastonyt.fi/studies.html

1 609/2015

The action plan for the adaptation to climate change of the Ministry of Agriculture and Forestry 2011 to 2015 will be revised in 2017 to 2018, building on a comprehensive study of vulnerability and adaptation in agriculture, forestry, fisheries, game and reindeer husbandry sectors that was completed in 2017.

A significant share of adaptation measures are implemented at the regional and local level. Various measures promoting the preparedness for climate change, such as flood protection, have already been implemented on regional or municipal level quite a long time ago, though they have not been seen as adaptation measures as such. 16 out of 18 regions have published a climate strategy, which include a certain degree of adaptation. Two regions have decided to include climate and energy issues directly in the regional program in order to give them more emphasis and thus to make resources more efficient. In 2017, most of the 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 promoted further. By the end of 2015, regional flood risk management plans were published for every significant flood risk areas (16 areas), and currently the implementation of identified measures is going on. In addition, several bigger cities and municipalities have been active in adaptation especially in the area of HSY, i.e. the city of Helsinki (in vulnerability assessment) and the city of Vantaa (nature based solutions in runoff water management).

The monitoring of the National Climate Change Adaptation Plan 2022 has been developed together with various stakeholders. The monitoring and evaluation of adaptation to climate change has been promoted in 2015 to 2017 by building a national adaptation monitoring framework and its indicators in cross-sectoral work. In particular, climate change related risks to the society and its various functions are emphasized. Indicators include, e.g. risks to human health and adaptation measures executed in flood risk areas. Assembling of the indicators was completed and released in May 2017.

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) are at different stages in the adaptation. The most advanced sector is water management, where adaptation has already been integrated into decision making, and digital monitoring and risk management process have been developed. 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. In addition, the recent study on vulnerability of natural resources sectors included assessment of various risks such as the risks of alien species and local weather and climate risks.

The target to improve climate resilience in terms of everyday actions also improves 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 climate and risk assessment in general.

In future, the awareness of the importance of climate change adaptation alongside mitigation needs to be increased. 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. Although the main elements of the National Climate Change Adaptation Plan 2022 have broadly facilitated implementation and follow-up of adaptation measures in different fields of the society, there is need for further cross-sectoral cooperation and stakeholders' action to enhance climate resilience.

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

Biodiversity

Climate change is expected to increase the total number of species in the Finnish flora and fauna and will cause a turnover of species. Furthermore, considerable changes are likely to occur in the distribution patterns of species and habitats. Overall, the magnitude of warming in the boreal region is expected to be twice the global average, which will amplify the impacts for biodiversity and ecosystems in the region. Observed changes in species distribution are already aligned with the predictions of species-climate models.

A longer growing season and milder winters may lead to a rapid proliferation of a number of southern species that thrive in a warmer climate. Rare species currently living at the northernmost extreme of their distribution could become more common and many native species in the south could find favourable living conditions further north in the warming climate. In southern Finland, some invasive species could threaten the habitats of native species and the invasive species populations may expand rapidly if they lack natural enemies. However, many species may not be able to track changes in the climate due to low dispersal ability of individuals and fragmentation of preferred habitats. 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. Northern boreal species of forests, mires and Arctic mountain habitats are threatened and predicted to decline due to the warming climate (see also Box 6.1).

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 increase the collection of residues and small diameter round wood and thus 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, water birds 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.

Protected area networks of natural habitats alleviate the negative effects of climate change and provide resilience in preserving declining species of conservation concern. Intensive land use, such as forestry, strengthens the influence of climate change on biodiversity, because many species of natural habitats, such as mires and old-growth forests are negatively affected both by climate change and forestry. However, climate change also affects protected areas, which calls for consideration and anticipation of changes in conservation planning. A study on the viability of Finnish protected area networks in a changing climate is currently ongoing. Furthermore, ecological corridors are important for species adapting to climate change. The Green Belt of Fennoscandia (GBF) is one of Europe's most important ecological corridors and work is ongoing to promote ecological connectivity in the GBF.

Box 6.1

PRISTINE PEATLANDS

In southern Finland, an integral part of the boreal landscape are raised bogs, mire complexes with nutrient-poor and acidic ombrotrophic (deposition-fed) centres and minerotrophic (additionally fed by water inputs from the catchment) lags. In the north, these are replaced by aapa mires with characteristic extensive wet minerotrophic centres. The range of peatland habitats found within these mire complexes 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 between peatland types and years, being generally faster in ombrotrophic bogs than minerotrophic fens.

Summertime warming would increase evapotranspiration and lead to lowered water-table levels (WT) in peatlands. Further, the number of exceptionally dry summers is expected to increase. Lowered WTs may have a greater impact on peatland ecosystems than the warming itself. On the other hand, precipitation is also assumed to 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. Warming accompanied with drying would greatly affect the structure and functioning of pristine peatlands. The raised bog zone could migrate northwards while the northern aapa mires would retreat further north. Shifts from sedge-dominated fen habitats to Sphagnum-dominated bogs that characterise the raised bog systems could take place faster than at present. Species adapted to wet conditions would decline, as would species adapted to open habitats as peatland forests could largely replace open mires in all but the most nutrient-poor habitats. Consistent droughts during late summer, in particular, enable development of tree stands. In northernmost Lapland the palsas are in danger of thawing with the warming climate, and are already declining.

Switches from minerotrophy to ombrotrophy could accelerate carbon sequestration in the peat soil. However, drying will also lead to carbon losses from peat, caused by accelerated decomposition. Whether these soils would continue to function as carbon sinks depends on whether the litter inputs from the changed vegetation are large enough to more than compensate the enhanced decomposition. Judging on data from drained peatland forests, this would be most likely in the middle region of the soil nutrient gradient. Considerable variation in WT could lead to a state of “consistent disturbance”, where productivity and carbon sequestration are low, while carbon may be continually lost from the old deposits.

Changes in methane emissions will depend on changes in WT and vegetation. Mere warming may increase these emissions, but opposite results have also recently been observed in warming studies. Drying and 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, on the load of organic and inorganic matter from catchments.

In 2012, the Finnish Government approved a resolution on sustainable and responsible use and protection of mires and peatlands. The resolution directs human activities to peatlands which have been drained or whose natural state has otherwise been significantly changed, implements sectoral policies and measures for sustainable use, and improves the status of the existing network of protected peatlands. Under the resolution, a long-term peatland protection and restoration program will be carried out by 2025. ■

Water resources

According to results of climate change studies, annual runoff will, on average, increase moderately, but seasonal changes will be large. Winter discharges will increase significantly, particularly in southern and central Finland. The changes in runoff together with warmer temperatures will cause changes in nutrient loads, water quality, algal blooms and the aquatic environment.

Floods caused by spring snowmelt will decrease in southern and central Finland, but may remain at their present level in northern Lapland. Since most floods in Finland are at present spring floods, the flood risks may decrease in many locations. However, autumn and winter floods caused by precipitation will increase especially in large lakes and their outflow rivers.

Discharges during summer and early autumn will mostly decrease and droughts can become more severe due to earlier spring and increases in evapotranspiration. Low water levels can for instance decrease the recreational value of lakes and rivers. Water quality can also be negatively affected by changes in floods and droughts. Low flows boost concentrations of bacteria, algae and toxins in surface waters. High flows and intense rainfall increase erosion and the leaching of nutrients from catchments into watercourses and coastal waters.

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

Climate change impacts on water services can be notable. More frequent, extreme weather events, such as prolonged droughts, storms, heavy rainfall and floods, may cause problems. Storm blackouts can 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 actions also include precautionary measures including preparedness planning, improved cooperation between waterworks, guidelines on land use and further development and utilisation of databases and models. Revision of the Water Service Act[2] in 2014 clarified requirements and responsibilities of water service providers in regard to preparedness and storm water management.

The safety of dams will need to be considered since intense rainfall is estimated to increase considerably in Finland. Increased extreme precipitation would cause problems for dams particularly along small rivers. Increases in floods are projected to be largest on dams where summer or autumn floods are the largest floods used as design floods. Dams where spring floods are design floods, climate change influence may vary as precipitation increases, but snow amounts decrease. However, major problems seem unlikely in this respect because most dams have quite large spillways. Lake regulation management strategies and permit changes are already becoming necessary for many of the regulated lakes in response to shifts in the hydrological regime induced by climate change. On several lakes, projects on changing regulation rules are ongoing and are at least partly prompted by recent mild winters and projected climate change.

Flood Risk Management Plans to 2021 (based on the EU Floods Directive[3]) take into account adaptation to climate change. Their objective is to reduce flood risks, prevent and mitigate the adverse consequences caused by floods, and promote the level of preparedness for floods. Their 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. The first cycle of flood risk management planning ended in December 2015 when 12 catchment scale and four coastal flood risk management plans to 2021, covering all significant flood areas, were approved. At the end of 2016, altogether 16 of a total of 410 suggested measures had been implemented. Plans and measures will be updated every six years. The responsibility for storm water and melt water flood risk management lies with municipalities.

2 681/2014

3 2007/60/EC

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. 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.

Due to the large natural climate variability in the region, detection of the global climate warming signal from the observational time series of the Baltic Sea is limited only to directly temperature related time series like sea ice extent and existence of severe ice seasons. These are also projected to experience considerably reduction during the next 50 years. Correspondingly, mild and extremely mild ice winters will become more frequent. The average maximum fast ice thickness in the 2040s will be approximately 30 cm less than for the period 1971 to 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. In order to serve coastal societies, the Finnish Meteorological Institute (FMI) has provided site-specific guidelines of extreme water levels for coastal long term planning.

Climate change has been projected to affect the ecosystem of the Baltic Sea through at least two mechanisms: by increasing the water temperature, and increasing the freshwater runoff into the Baltic Sea, which leads to a decrease in the salinity level of the Baltic Sea.

Increasing temperature enhances biological processes and may increase the intake of harmful substances in organisms. Increasing temperature probably also alleviates the spreading of non-indigenous species originating from more southern seas. Also, due to the increase of atmospheric CO_2, it has been projected that the pH of the seawater will decline, which may affect the living conditions of bivalves with calcium-containing shells.

Salinity is also a fundamental factor in the Baltic Sea, because many organisms live at the edge of their salinity tolerance levels. Recent modelling suggests that the distribution areas of marine species like bladderwrack, blue mussel and eelgrass will be significantly reduced if the surface water salinity decreases. Reduction of these habitat forming species will affect the structure and functioning of the ecosystems, and may decrease the ecosystem services, e.g. fish yield, provided by these habitats.

Climate change has also been predicted to worsen eutrophication of the Baltic Sea, because of increasing nutrient runoff into the sea. A recent study has shown how climate change affects agricultural practises (crops, cultivars, land use), how climate affects the hydrological cycle, and how soils and lakes retain nutrients under a changing climate. The results show that climate change increases nitrogen loading into the sea, but that economic factors (e.g. crop and fertilizer prices) affect the outcome significantly, and that by farm level adaptation to climate change, a significant reduction in nutrient loading can be achieved. ■

Adaptation to climate change is also addressed in the River Basin Management Plans to 2021, based on the EU Water Framework Directive[4]. These plans were updated and adopted by the Government in December 2015 for 2016 to 2021. The main objective is to achieve good ecological and chemical status in surface and ground waters taking into account climate change. Adaptive measures for improving nutrient management, better risk management of accidents such as overflows from waste water treatment plants and better management of storm water are ongoing in many sectors. Additionally, many natural water retention measures are suggested in recently updated plans.

Agriculture

Climate change is projected to improve crop productivity in Finland if the rise in temperature is moderate and if the adaptation measures are implemented in a timely manner.

4 2000/60/EC

The current main field crops might be cultivated further north and many novel crops 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 cause more uncertainties for agricultural production. Seasonal unevenness of precipitation may further increase and cause substantial challenge for sustainable development of agricultural systems. Early summer drought may become more frequent and interfere with crop growth and yield formation, while, again, increasing rains outside the growing season may put soils and their functionality at risk and also increase the leaching of pesticides and nutrients into the water systems, that are particularly vulnerable as one-third of the field parcels in Finland are located next to waterways. The risk of animal diseases may also increase, although it is expected to remain relatively low in the future. Diseases associated with the poor quality of water may become more common. 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 imminently prone to them, farmers have always faced severe production and income risks, which are, however, likely to increase in the future climates. On the other hand farmers in general are well aware of the measures needed by them to cope with weather constraints. An indication of farmer's readiness is that they have already responded to changed conditions by adopting later maturing cultivars and crops, introducing winter rapeseed, as well as starting sowings earlier than couple of decades ago. Further development of cultivation methods and systems is needed to reduce risks and increase the resilience and competitiveness of agricultural production in a changing climate. The existing networks in place for farmers, farmers' associations and extension services help to improve the exchange of knowledge about the means for adapting to climate change and variability. Agricultural research has been well designed to support and prioritise the development of primary adaptation measures. 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. Climate-related risk assessment has been strengthened by efforts from the Finnish Food Safety Authority Evira. 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. These, coupled with improved disease resistance and resilience through plant breeding, are important elements 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 developing soil cultivation methods, 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 and diversified agricultural systems. From these, development of monitoring and alarm systems to better cope with increased plant disease and pest risks have progressed further (at the Natural Resources Institute Finland (Luke)) in addition to being successful in breeding for improved disease resistance, e.g. in the main cereal crop, spring barley by private plant breeding companies. Also breeding for more nutrient use efficient cereals have been demonstrated to be very successful, which is important as development and implementation of water management systems are not yet timely and economically feasible for farmers. Diversification of crop rotations have not yet taken place at large scale, though green fallows and nature managed fields have become more common land use alternatives in agriculture since the end of the 1990s, which is important as they provide soil cover for winter time with high precipitation and increased risks for soil deterioration, erosion and nutrient leaching. However, farmers are very interested in diversification of crop rotations and they have introduced, e.g. maize and winter rapeseed for cultivation as novel crops, in addition, to expanding production of late maturing spring wheat and faba beans. All these changes have been supported and monitored by a number of recent or on-going research projects in collaboration with, e.g. farmers, extension services, farmers' unions, policy makers and private companies.

In the energy sector to better adapt to exceptional weather conditions measures to improve and increase farms' energy self-sufficiency and security of supply have been promoted and implemented.

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 populations react to fairly small and early changes in the temperatures by changing their migration and feeding behaviour, reproduction patterns and locations. If the changes are large enough, there may also be changes in the growth of fish populations and in species composition in fish communities, and also changes in survival, mortality and distribution.

Climate warming will increase the growth rate of some of the Finnish fish species. 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 due to increasing run-off. This will increase eutrophication, which has already affected fish stocks, especially in coastal waters. Generally, eutrophication increases the total fish biomass, but decreases species richness. Warm winters together with eutrophication will decrease the catches of e.g. turbot 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 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.

Anadromous fish species, like Atlantic salmon, are expected to suffer from climate warming due to their complex life cycle covering migrations between freshwater and marine environments. There is already evidence from the Baltic Sea area that increased water temperatures may decrease the survival of salmon during the early phase of sea migration.

Predicting the impacts of climate change on fish populations over a longer period of time involves significant uncertainties. Because the annual variation in fish populations may be considerable (for example, the variation in 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.

Climate change related factors are also affecting the conditions of aquaculture, mainly based on salmonid fish production in Finland. In coastal waters of the Baltic Sea, warmer winters with little or no ice cover can help the practical work in fish farms but more frequently occurring extreme weathers such as storms may be harmful. In inland waters, increasing temperatures may enhance the productivity of fish culture in northern Finland. In the southern part of the country, the situation may be opposite, especially for fish farming in upper reaches of watercourses.

Game species, just like other animals, have 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. Many southerly distributed species are expected to increase markedly in numbers during coming years. These include species already common in southernmost part of the country, such as white-tailed deer, roe deer, European hare and raccoon dog. The most recent invader from southeast is wild boar, which has rapidly increased to high densities right outside the border of Finland. The main threat is that wild boar could transfer a dangerous disease, African swine fever, to western Finland, where that largest commercial piggeries are located. There, the disease would lead to catastrophic events with large economic losses.

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 the colour of their fur or feathers according to the season, the shortened period of snow cover might lead to increased exposure to predatory species.

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. The Natural Research Institute Finland (Luke) monitors game richness and abundance based on game surveys carried out together with the Finnish Wildlife Agency and voluntary hunters. Monitoring is also the basis for fast management decisions required for adaptation to the changing conditions, including reactive action to invasive alien species. Monitoring in Finland is at high level right now, but new programmes will be needed, such as the one for wild boar launched in 2017. National management plans have been completed for most game species, including the latest for wolverine and grouse in 2014. One approach to help game species to adapt to changing conditions is habitat management and restoration, which have been studied at Luke and game management districts. In addition, several adaptive measures are developed by the Finnish Wildlife Agency and funded by the Ministry of Agriculture and Forestry to limit the damage caused by game to agriculture, forests, reindeer herding and traffic.

Reindeer husbandry

Herding of semi-domesticated reindeer together with fishing and hunting are the oldest and most traditional means of livelihood in northern Finland. At present, there are 54 reindeer herding co-operatives in the whole reindeer management area, which covers around one-third of the total land area of Finland. There are some 4,400 reindeer owners and the total number of reindeer in winter is around 200,000 reindeer.

Unfavourable changes in the reindeer pasture environment form a complex problem, which is largely connected both to intensified reindeer grazing and to the expanding impacts of competitive land use forms deteriorating, fragmenting and reducing pastures. However, the ongoing changes in weather, snow, precipitation and other natural conditions in the pasture environment are also causing increasing concerns and problems. Changing weather and snow conditions can also delay the seasonal herding tasks such as gathering reindeer to round-ups.

Warming winters have been observed to increase the frequency of exceptional snow and weather conditions, during which wet snow freezes into hard ice and snow layers. These icy layers decrease availability and quality of natural food, such as lichens, and also decrease the condition, calf percentage and productivity of reindeer. In addition, warmer and rainier summers and autumns may decrease the quality of natural food for reindeer by increasing the growth of mould on plants due to microfungi or by increasing the amount of phenols in plants due to raised ultra-violet radiation. On the other hand, earlier snow melting during spring improves food accessibility and thus the condition of reindeer after harsh winter. When winter temperatures increase, survival of larvae of insect herbivores (*Epirrita autumnata* and *Operophtera brumata*) in winter will also improve, which increases their outbreak risk. Herbivore outbreaks can damage mountain birch forests considerably and also deteriorate reindeer summer pastures.

Increasing summer temperatures and precipitation may increase the level of insect harassment during summer and the associate stress for reindeer. At the same time, the prevalence and outbreak risk of different parasites may also increase or totally new parasites and diseases causing problems for reindeer can emerge. Increasing temperatures and precipitation will probably also increase forest growth, but negatively affect the abundance of lichens in northern Finland.

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 increase will be larger in the north. Increased tree litter inputs will lead to increased carbon sequestration in 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*, *B. pubescens*), it is expected to increase its share of the growing stock. 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 and planting of seedlings, 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. The risk of wind damage is, on average, strongest among older Norway spruce stands, while young birch and Scots pine stands are most vulnerable to snow damage. The risk of snow damage to trees could decrease in southern and western Finland since a smaller share of the wintertime precipitation is predicted to fall as snow. On the other hand, the maximum snow loads on trees can increase in eastern and northern Finland. 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. root-rot (*Heterobasidion annosum*). 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, 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.

By appropriate and gradual adaption of forest management practices and 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. 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 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.

A greater use of forest resources is likely in the future. The Bioeconomy Strategy (prepared in a project set up by the Ministry of Economic Affairs and Employment in 2014) relies on renewable natural resources, and is projected to increase wood harvests. Also, in fulfilling the EU's Renewable energy directive, Finland has set a target to increase the use of renewable, mainly wood-based energy by 2020. Active forest management enables also active adaptation to climate change in forestry.

Adaptation to climate change in forestry is being studied as a part of many research programs and projects in Finland. A recent study focused on the challenges of adaptation in the different sectors based on natural resources, including forests and forestry. In addition, research on sustainability, climate-neutrality or resource-efficiency in forestry, provides information to support adaptation.

An evaluation of importance of various risks was made in vulnerability analysis by the Natural Resources Institute Finland (Luke) in 2017. Alien pests and pathogens were identified as the most important threats to forests. Potential damages by insects were identified as another important source of risk. The increased difficulty of forest operations due to soft terrain was singled out as third in importance. Luke also disseminates information on adaptation issues as a part of services. The forest damage advisory service at Luke is monitoring forest pests and diseases and the damage they make. The service supports the decision-making of forest owners and administrators by answering inquiries and making diagnosis and prognosis about forest pests and diseases. Also, forest damage road shows are made to increase the knowledge of forest owners about potential threats to their forests.

Recent modifications to forest legislation in 2014, i.e. to the Forest Act[5] and the Forest Damages Prevention Act[6], take into account climate change adaptation by allowing more diverse forest management and by adjusting timber removal deadlines to earlier occurrence of pests. In addition, Finland's National Forest Strategy 2025 (2015) contains measures related to adaptation. One of the foremost targets of the genetic improvement set in the Forest Tree Breeding Programme 2050 (2008) is the adaptation of future reforestation materials to climate change. The use of high quality seed, suitable for different climatic conditions, is promoted by establishment of new seed orchards. New deployment area maps that take into account climate warming predictions have been released in 2017 for improved seeds and seedlings of pine and are under preparation for spruce. In addition, an establishment program for a network of gene reserve forests has been set up. The Finnish Forest Centre's forest damage contingency plan with appointed regional experts assists rapid harvesting of wind damaged trees in order to prevent consequential damage. Forest road maintenance planning has been developed to take into account exceptional weather and soil conditions.

5 1093/1996 (amendment 1085/2013)
6 1087/2013

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

Energy

Weather-related threats like storms, lightning strikes and floods are the major source of weather and climate risks for the energy sector. A problem is also long-term exceptional occurrences, such as long frost periods and exceptional ice conditions, long-term snowfalls and snow loads, long warm periods and frost delay. Long periods of drought reduce hydropower production capacity. The precipitation is important in Finland because hydropower has a central role as a balancing power source, and more widely because the Scandinavian rainfall determines to a great extent the electricity price on the Nordic power exchange.

The common electricity market is undergoing a transition where the electricity production system is increasingly decentralised and the importance of variable renewable energy, including wind and solar power, grows. At the same time, the thermal power capacity used to ensure the balance between supply and demand is declining. Due to variable renewable electricity production, the increased need for balancing supply and demand during different times of the day will require more flexibility in electricity consumption and production. Active participation of consumers in the market through smart solutions is needed to bring flexibility to the energy systems. Flexibility can be increased through electricity storage, interaction between the electricity and other energy systems, including electric transport, district heating and the gas market. Smart metering, genuine and sufficiently strong price signals in the electricity market, as well as real time power markets, are essential for attracting necessary investments.

Adaptation measures have already been launched in the energy sector. 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. The Electricity Market Act[7] includes regulations aimed at improving the security of the energy supply in network fault situations, especially in sparsely populated areas. According to the Electricity Market Act, the distribution network must be designed, built and maintained in such a way that when the network is damaged due to a storm or snow, the electricity interruption for the customers should not exceed six hours in detailed planned areas and 36 hours in other areas. These time limits must be met gradually over a 15 year time period and fully by the end of 2028. In addition, the Electricity Market Act includes other measures to improve the electricity network security of supply, for example, a requirement for cooperation 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 six and 36 hour time limits for network security of supply. In order to meet the time limits of six 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 requirements will be EUR 2,800 million. The Highways Act[8] has been amended in order to make it easier to move power lines from forests to roadsides. In terms of hydropower plant investments, new turbines have been scaled to better meet the expected changes in water flow conditions.

In response to the 2011 Fukushima nuclear accident, risk and safety assessments ('stress tests') were carried out on all EU nuclear power plants. First at a national level and then at EU level.

7 588/2013
8 328/2013

Intelligent electricity networks will work as a service platform in transition towards a more decentralised and carbon-neutral electricity system. Almost all users of electricity in Finland have smart meters, which allow customers to participate in a variety of markets, improve security of supply, and cost-effectively create new business opportunities for companies. A broad-based working group appointed by the Ministry of Economic Affairs and Employment is preparing concrete actions through which intelligent networks could serve the customers' possibilities of participating actively in the electricity market and help maintain the general security of supply.

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. Expected changes in precipitation, wind velocity and temperature constitute a challenge for the construction sector. These stress factors already have 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 flood prone areas. Increased heavy rainfall will be a challenge for storm water management, especially in areas with high degree of surfaces sealed with impermeable materials.

Current legislation on building and other statutes include requirements for taking climate change into consideration. For new construction, climate change and adaptation are taken into consideration already during the planning stage 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. This is especially important in vulnerable areas, such as the archipelago where construction is particularly affected by environmental conditions.

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 guidelines include the need to follow objectives concerning adaptation 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[9] and the Government Decree on Flood Risk Management[10] 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 caused by heavy rainfall in urban areas. 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. Much of this information is provided through the operational Flood Centre managed jointly by the Finnish

9 620/2010
10 659/2010

Environment Institute and the Finnish Meteorological Institute. Research has shown that public disclosure of detailed flood risk maps generates quite accurate housing price corrections in affected and neighbouring city areas. Zoning indicated by flood risk maps also steers adaptive urban growth more cost-efficiently than pertinent urban zoning.

An assessment of possible sea level rise along the shores of the Baltic Sea (coastal flooding) has been completed and consequently, the guide for Flood preparedness in building was updated in 2014. The guide contains recommendations for determining the lowest building elevations in inland shore areas and along the shores of the Baltic Sea.

Industry and commerce

The Finnish industry is energy-intensive and the need to mitigate climate change has been the subject of focus in the industry sector more 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.

Climate change risks for industry are related to, e.g. power supply, storage and use of environmentally harmful substances, and the building industry. The challenges for industry and commerce also include the challenges identified for land-use planning and building, as well as transport and communications that are essential for most types of industry. Some adaptation needs will require significant investment.

Studies on adaptation needs for industry suggest that adaptation to climate change presents an opportunity for the industry sector. 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

The operational and environmental safety of a mining operation must be secured at all times. This requires energy supply, infrastructure system, mining operations and water management system. According to a stress test conducted by the Ministry of Environment some years ago a key challenge for the mines is being able to manage sudden and/ or large amounts of excess water. Surface waters and process waters on a mine site must be collected and treated accordingly before they are discharged outside the area, so water management systems must have the capacity to manage even exceptional situations.

All aspects of risks caused by climate change must be addressed and taken to consideration in the mine planning stage. Risks and threats to a mining operation are analysed in the mining safety permit that is required from all operating mines according to the Mining Act[11]. A mining safety permit requires identifying of all risks that the operation can face, and also how the risks and the eventual consequences are mitigated and avoided.

The mining operator is responsible for the internal rescue plan. The rescue plan specifies how to manage eventual incidents and how environmental and human accidents in such situations are prevented.

Transport and communications

Climate change is expected to impact all facets of the transport system: the infrastructure, modes 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, ep-

11 621/2011

isodes of soil drying during summertime, storms causing falling timber, and so forth, will all impact road and railroad infrastructure as a whole and, especially, the maintenance.

Some of the major impacts (both negative and positive) are as follows:

- More frequent warm and wet periods, which will increase wear and rutting of roads especially during winter. Long heatwaves can also disrupt repair works on tracks.
- 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 in roads and railroads may be needed if heavy snowfall events become more frequent; however, total annual snow clearance work is expected to decrease in southern Finland in coming decades, and later on in central and northern Finland. For railways, heavy snowfall events are challenging and require snow removal from tracks (e.g. rail points) and trains. Heavy snowfall events may also affect driving conditions and traffic flow.
- The need for clearing ice on roads is expected to increase in central and northern Finland.
- Groundwater levels may 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 ground frost will decrease and the period of ground frost will shorten.

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 to road and rail infrastructure, but climate change and the combination of a lower level of maintenance and infrastructure repair constitute a real risk for the serviceability of roads and railroads. Maintenance of structures and the condition of railways while floods and rainfall increase and ground frost diminishes are taken into account in new investments as far as possible. Structures are maintained and managed within the budget appropriations for basic road and railroad management. A related risk is associated with contracts between railroad, 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. The contracts between maintenance service providers and railroad, road and street infrastructure managers should be developed in a manner that enables more flexible extreme weather risk management. The Finnish Transport Agency (FTA) has updated the disruption and response times in its new maintenance contracts.

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 and high temperatures, as well as to lightning damage to e.g. traffic signalling and communication systems. The vulnerability of railways may also increase if maintenance and repair work efforts are undersized.

Envisaged actions that will enhance the adaptive capacity of the transport sector during the coming decades include developing warning systems with tailored guidance on transport impacts, developing maintenance operations, improving protection against weather, and maintaining the infrastructures. Also planning specifications should be revised.

Phenomena relevant to marine and inland water transport include strong winds, strong currents, high waves, heavy rain and snowfall, temperature increases, ice cover changes, lightning, extremely high/low sea/water levels and floods. These can cause short term disturbances and safety hazards and also have longer term effects. All in all, approximately forty potential hazards have been identified that are connected to these weather-related phenomena. Most of them are related to waterway maintenance, charting, traffic services and wintertime seafaring in general.

The FTA has inventoried sensitive areas as regards flood risks in southern Finland in connection with preparedness exercises and preparedness plans. The Ministry of Agriculture and Forestry, the Finnish Environment Institute (SYKE) and Regional Environment Centres survey flood risk areas. Flood hazard and flood risk maps for the 21 areas of potential significant flood risk in Finland are included in the flood map service.

Climate warming will reduce the amount of ice in the Baltic Sea. The FTA has participated in research on trends in the ice conditions of the Baltic Sea. In the MERSU research project, the Finnish Transport Safety Agency (Trafi) together with the Finnish Meteorological Institute (FMI) is making forecasts on future developments of ice conditions in the Baltic Sea area in order to estimate the need of ice-breaking assistance for mercantile ships during winter months in the future. However, the amount of ice-breaking assistance for ships also depends on wind conditions.

The adaptation actions include, for example, improving the safety equipment, proactive planning, developing the design and procurement practices, technical development, developing information services and traffic management, product and market monitoring, as well as cooperation in international regulation development. The FTA has developed adaptation actions, like improved forecasting models and an early warning system, together with the FMI. A remote monitoring system of the climatic conditions has been developed. The FTA has prepared a forecast for maritime transport in 2030.

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 winter 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 slipperiness may become more frequent in some parts of the country in the first half of this century. 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.

The FTA's winter management guidelines are implemented for main roads throughout the country. The FTA has tested potassium formate in de-icing of roads in winter in various places where the risk has been estimated as high. Implementation of the theme programme on groundwater protection for main roads is completed and a new programme is being prepared.

Air traffic will suffer from heavy storms, strong winds, changes in wind direction and lightning. The maintenance costs at airports and the use of de-icing chemicals may increase in mid-winter.

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. Overall telecommunication network problems and power outages cause delays and cancellations. Especially railway transport requires electricity to operate, and power outages can lead to total closure on a specific railway route, which affects the entire railroad network and the transport system. The FTA has continued intensified removal of trees posing risks for railways. The Rail Tracks Act amendment[12] allows removal of risk trees in the railroad safety area (max. 30 meters on both sides of the railroad). Communication systems can also be damaged by flooding. Ice and wind loads on telecommunications masts may become heavier.

The FTA has also studied the improvement of redundancy in communication networks to remove accuracy problems, which has indirect impacts on ensuring the functioning of wire networks. Transition from serial transmission to IP based communication using fibre optics is on-going.

Tourism and recreation

Finland is an attractive destination for tourists mainly because of its nature. 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 central Europe or southern Finland. The 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.

The Roadmap for Growth and Renewal in Finnish Tourism for 2015 to 2025 reacts to the climate change. The roadmap states the role of tourism as a cross-sectoral industry and its potential to enhance a shift towards more sustainable, cleaner, lower-carbon economic growth to minimize the effects of climate change. At the same time, the roadmap calls for new, innovative solutions for sustainable tourism products and experiences.

Insurance

Climate change is likely to increase damages 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 than anticipated amounts in damages. These changes may be reflected in the insurance premiums and available coverage. Climate change will affect insurance companies directly in three different ways: through claims, through their investments and through the terms of trade of reinsurance.

Forests are insured by private insurance companies in Finland. Some 40 per cent of forest owners have insurance against forest damages. Forest insurance products offered by insurance companies provide variable cover against damages caused by for example storms, snow loads, forest fires, floods, pests and fungal diseases. On average, some 60 to 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 in each year. For instance, in December 2011, the Boxing Day storm alone led to compensations totalling nearly EUR 30 million.

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A new insurance programme for damage caused by exceptional floods was introduced at the end of 2013. The programme replaced the old government-based system and extended the coverage from fluvial to all types of floods. Private insurance companies offer home and property insurances that cover damage caused by exceptional floods, as well as severe weather events. A great majority of households and property owners have this insurance. The Flood Centre operated by SYKE and the FMI offers an early warning system for floods, including daily watershed forecasts and online flood warnings, and gives estimates on the exceptionality of occurred flood and weather events.

There is a state aid system for commercial fishing in case of a loss or damage of fishing equipment or vessel in Finnish marine waters. Eligible causes of loss or damage include storms and ice, with a maximum vessel length of 12 meters.

The Government compensation scheme for crop damages ended at the end of 2015, and the following year some private insurance products, which cover risks for extreme weather conditions have been introduced on the market by private insurance companies. Approximately, less than one per cent of the whole arable area has been insured in (the first year) 2016. At the moment, there is no state aid to make the insurances more attractive for farmers.

New guidelines for the state aid by the European Union have restricted the possibility for governmental compensation of damages caused by plant pests in agricultural or horticultural production, thus no compensation has been paid since 2014. Adjustment of the compensation scheme for forest pests to the new guidelines has not yet been carried out. Private insurance products covering losses caused by plant pest outbreaks have not been introduced on the market so far, although some private insurance companies have shown interest.

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.

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 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.

Health

Effects of climate change on health will be significantly less drastic in countries with highly developed economy and technological and institutional infrastructure such as Finland than in developing countries. However, climate change will affect health and wellbeing also in Finland via multiple pathways. Maintaining and strengthening existing public health and other infrastructure, including housing, transport and energy, and preventing poverty are crucial for successful adaptation.

Increasing summertime temperature and, especially, increased frequency and duration of heatwaves threatens to increase heat-related mortality and morbidity in future in Finland. The aging population, increasing number of people living alone and low prevalence of air conditioning further amplify the effect of heat. Heat poses a challenge also for occupational health. The number of days with heat stress will increase both in outdoor and indoor work environments and this will result in a need to revise the instructions regarding work-rest cycles among high-risk groups. The thermal control of the built working environment will also need to be modified.

Milder winters will most likely lead to a lower number of cold-related mortality from cardiovascular and pulmonary diseases. On the other hand, because of the large climate variability during wintertime, society and individuals will have to stay prepared for cold spells in future, too. During wintertime, darkness and icy walkways and roads also lead to adverse health impacts. Darker winters in future, caused by a shorter snow cover period, increased precipitation and cloudiness, may increase cases of winter blues or seasonal affective disorder and subsequent medical conditions. The number of days when the temperature hovers around 0°C will also increase, and may lead to increased number of slipping injuries and traffic accidents. Thinner ice and the shorter duration of ice cover on waterways will be a safety risk.

Changing climate, together with ecological factors (e.g. density of key host species), contributes to the northward spread of ticks, and consequently may result in increased incidence of tick-borne diseases, which also depends on social and societal factors. Increased incidence of Lyme disease (borreliosis) and tick-borne encephalitis has already been observed in Finland. Changes in ecosystems associated with warmer climate will most likely affect the spread of other infectious diseases as well. For example, warmer winters may lead to less pronounced population fluctuations of small rodents, which might decrease incidence of some rodent-borne diseases. On the other hand, the anticipated increase in the number of medium-sized predators such as red fox and raccoon dog may increase the risk of rabies and *Echinococcus multilocaris* spreading to Finland.

Changes in hydrology, such as an increased number of heavy precipitation events and wintertime flooding, may increase the number of water epidemics in future. Leaching of nutrients into waterways due to increased precipitation, together with higher summer time temperatures, increases the risk of algal blooming. Warming climate may also increase the risk of infectious diseases spreading via swimming water.

Increased precipitation and higher temperatures threaten to increase the risk of crop diseases and pests, which may require increased use of biocides further leading to human exposure to chemicals; increased efforts are also needed to prevent health risks related to mycotoxins in crops. The same changes in climate may also increase the risk of moisture damage in buildings and further aggravate microbial indoor air problems. Finally, climate change may lead to increased exposure to allergenic pollen and, therefore, more severe symptoms via changes in the distribution of plant species and increased amount of pollen.

An increasing number of adaptation measures has been taken to reduce the risk of adverse health effects of climate change. For example, the Ministry of Social Affairs and Health has produced a handbook on exceptional situations related to environmental health, which also includes information about weather and climate-related events. The

Finnish Meteorological Institute nowadays issues warnings on, e.g. heatwaves and cold spells and icy walkways.

As a basis for improving adaptation to heatwaves, research has recently been conducted to evaluate preparedness in health care facilities, identify vulnerable population groups, and refine exposure-response curves. A recent government decree on housing conditions (2015) introduced upper limit values for indoor temperature during summertime. The National Institute for Health and Welfare has increased general awareness of the health risk posed by high summer time temperatures, issues advice during intense heatwaves, and has recently weighed the need and possibilities of setting up a heat-health warning system in Finland.

The main effort to prevent water-borne epidemics in future has been the introduction of a national water safety plan in 2016: a framework for risk assessment and management for drinking water that will gradually become obligatory for water utilities. Measures to adapt to the spread of ticks include raising general awareness of ways to protect from tick-bites, and providing free vaccines against tick-borne encephalitis in areas with especially high incidence of the disease.

Cultural heritage

Cultural heritage sites are places where the combined influence of natural forces and human activity and the evolution of culture are visible. Cultural heritage sites are strongly linked to climate. Increasing humidity and rising temperatures may damage many sites of cultural interest, whether on land, underground, or in water. Traditional livelihoods and architecture originally developed to reflect local climate and the associated native species. Climate change is threatening to make our environment unfriendly to cultural heritage sites that have adapted to past climatic conditions. Climate change may also affect cultural heritage sites indirectly through mitigation measures. There are seven UNESCO World Heritage Sites in Finland.

Traditionally, wooden buildings are typical in Finland. As wood is sensitive to changes in humidity, measures are 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.

The Sámi people living in Finnish Lapland are the only recognised indigenous people of Europe. There are approximately 10,000 Sámi in Finland. According to projections, the climate in northern Finland will warm faster than the rest of the country, so the Sámi will be faced with the impacts of climate change sooner than other Finns. The severity of these impacts is affected by a close relationship with nature. Changes in reindeer husbandry will have notable cultural consequences. Sámi reindeer herding is characterised by close and tight connections to the utilised animal, resources and nature, and understanding of local conditions and several interactions in the natural environment. Along with climate change, the traditional local game species such as ptarmigan can suffer and their population may collapse. New game species probably migrate further north which, on the other hand, may introduce new kind of game to the Sámi hunting grounds. Suddenly changing weather conditions can also endanger berry crop.

Traditional knowledge of nature and the Sámi calendar are subject to change. The Sámi people who have practised traditional occupations are used to great changes in the nature and weather conditions during the year. Similar to other indigenous people, the

Sámi have extensive experience-based traditional knowledge of nature as the guiding line in their life and actions. Since natural conditions both vary and change faster than before, traditional signs will probably not predict future weather and conditions reliably enough, and traditional experiences and knowledge may not give enough means and ways for adaptation. Long term predictions are even harder to make. There is a danger that the traditional knowledge with respect to reindeer husbandry, for example, will lose considerable part of its previous value.

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, electricity supply and communications. The ageing of the population and the migration to urban centres, while, at the same time, larger areas remain sparsely populated, need to be taken into account, for example in master planning and other planning.

Legislation sets the foundation for preparedness and crisis management for all actors. According to the Emergency Powers Act[13], the Government, the state administrative authorities, state businesses and other state authorities, as well as municipalities shall ensure, by means of emergency plans, prior preparation of emergency operations and other measures, that their duties will be performed with the least amount of disruption also in emergency conditions. Preparedness for emergency conditions shall be managed, supervised and coordinated by the Government and by each Ministry in its field of operations.

According to the Rescue Act, the owner and occupants of a building and the business and industrial operators shall prevent and, when necessary, take measures to protect people, property and environment in dangerous situations.

In addition, state and municipal authorities, agencies and enterprises are obliged under the Rescue Act[14] to take part in the planning of rescue operations under the direction of rescue departments, and to take action in accidents and dangerous situations so that rescue operations can be carried out in an effective manner.

The purpose of the Act on the Measures Necessary to Secure Security of Supply [15], on the other hand, is to maintain the basic economic functions required for ensuring people's livelihood, economic life and national defence 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 security.

In addition to legislation, there are two other relevant documents: First, the Government Resolution of 16 December 2010 on the Security Strategy for Society defines the operations vital to society and outlines the threat scenarios and disturbances that jeopardise 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 in various sectors. Preparation for natural disasters like floods will take place through preparedness planning, exercises, surveillance, information exchange, and other cooperation practices and situation reports,

13 1552/2011
14 379/2011
15 1390/1992

as well as by implementing, for example, the necessary flood protection measures at critical sites. An updated Security Strategy for Society was published in October 2017.

Second, Finland's first National Risk Assessment published in December 2015 is based on Union Civil Protection Mechanism, which binds all EU Member States. Protection under the Union Mechanism covers primarily people, but also the environment and property, against all kinds of natural and man-made disasters. These include the consequences of acts of terrorism, technological, radiological or environmental disasters, marine pollution and acute health emergencies. The National Risk Assessment included 21 scenarios that defined what might endanger vital functions of society or cause serious problems for people, property or environment. Five of these scenarios are related to extreme weather conditions. The National Risk Assessment is updated every three years. With regards to climate change adaptation, the National Risk Assessment should be developed in a way that also future development will be analysed.

Related to the National Risk Assessment, there is also a national platform for disaster risk reduction. This network consists of 20 organisations. The goal of the national platform is to implement the Sendai Framework for Disaster Risk Reduction and its priorities for action in Finland, i.e. understanding disaster risks, strengthening disaster risk governance to manage disaster risk, investing in disaster risk reduction for resilience and enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction.

The purpose of previously mentioned laws and other documents and arrangements is to develop a more resilient society. The national risk management system that consist sof four essential elements, prevention, early warning solutions, effective response and recovery measures, aims at a resilient society.

As far as warning systems are concerned, the Finnish Meteorological Institute (FMI) has diversified the weather-related warning services for citizens. Besides the traditional warnings on strong winds, severe thunderstorms, forest fire danger, and poor road conditions, there are now wave and sea level warnings for marine areas, as well as warnings for heatwaves and severe cold spells. Since February 2017, the FMI has renewed its warning system by introducing five-day warning maps, which also include the flood warnings of the National Flood Centre (joint organisation of the FMI and the Finnish Environment Institute (SYKE) established in 2014). Lead times up to five days give the citizens a possibility to prepare earlier and better for dangerous weather situations. Warnings are also disseminated to civil defence authorities through severe weather outlooks. Reciprocally, the emergency response centres share real-time information on damages caused by weather events to the 24/7 duty forecasters of the FMI. In addition to flood forecasts, SYKE's hydrological watershed model system also produces precipitation warnings for sub-basins and snow load warnings for roofs. The FMI and SYKE also issue severe weather and hydrological warnings to the civil defence authorities through a natural disaster warning system (LUOVA). It is a part of the situation report system of the Government and security authorities and was developed as a part of the second Internal Security Programme adopted by the Government and the Strategy for Securing the Functions Vital to Society. All in all, 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.

6.4 Global impacts of climate change and international cooperation

In 2016, the Prime Minister's office published a study on cross-border effects of climate change in Finland. The study identifies seven different cross-border impact chains triggered by climate change, which have impacts also in Finland. These are (1.) Trade impacts: the availability of raw materials and goods; price fluctuations; regional changes in relative advantages in the competition for market shares and production; changes in the conditions of export (2.) Impacts through infrastructure: changes in travel routes and long distance connections; changes in communication routes (3.) Impacts on finance and insurance: changes of financial markets and flows and investment possibilities; changes in insurance possibilities and premiums (4.) Human mobility: changes in the living conditions outside of Finland impacting human mobility; changes in seasonal weather impact tourism (5.) Ecosystems: climate change impacts on the living environment outside Finland and the mobility of species; changes in the hydrology of cross-border rivers; changes in the long distance drifting of air pollution; (6.) Geopolitics: changes in international politics impact international and regional processes and politics including multilateral climate change negotiations (7.) Cognitive changes: impacts through information exchange and education; changes outside national borders alter domestic significance and motivate domestic action; promotion of the need to develop education and public awareness. The identified cross-border impact chains illustrate clearly the global nature of climate change and its effects. In many cases the strongest cross-border impacts originate in neighbouring areas, but long distance cross-border impacts are not excluded. The recognition of cross-border impacts is an additional justification for international cooperation to address the consequences of climate change wherever significant adverse impacts occur.

Climate change with the associated risks and opportunities is a major driver of change in the Arctic region. Finland is a member of the Arctic Council and the Barents Euro-Arctic Council (BEAC) and finds climate change research, mitigation and adaptation actions as key areas of co-operation in the two Councils. Finland chaired the Barents Euro-Arctic Council in 2013 to 2015. Currently, Finland chairs the Arctic Council for the two-year period from 2017 to 2019.

The Barents Action Plan on climate change was adopted by the Meeting of Barents Environment Ministers in 2013 in Inari, Finland and its implementation and follow-up started during the Finnish BEAC chairmanship. Finland has, e.g. funded and participated in projects focused on regional climate strategies, made a regional inventory on black carbon emissions and co-funded a climate coordinator for the BEAC Secretariat.

In the Arctic Council, Finland has provided expertise and funding in, e.g. following areas of cooperation: assessments of impacts and adaptation tools to climate change in the Arctic (such as Snow, Water, Ice and Permafrost in the Arctic, Arctic Resilience Report, Adaptation Actions for a Changing Arctic), scientific work on short-lived climate pollutants (incl. some UNFFCC regulated GHGs and black carbon), production of recommendations targeted to methane and black carbon mitigation and projects on pollution prevention, including projects reducing emissions of climate pollutants. These will be further emphasised during the Finnish chairmanship in the Arctic Council.

In the context of the Baltic Sea Region (BSR) cooperation on climate change Finland implements the EU Strategy for the Baltic Sea Region (EUSBSR). In the 2015 Action Plan, the strategy has a horizontal action "HA Climate". This action aims at:

1. Facilitating integrative cross-sectorial policy discussions and alignment of policies in the Baltic Sea Region countries, including mainstreaming of climate change mitigation and adaptation into relevant sectoral policies;

2. Promoting low emission and climate resilient development through targeted strategic investments and integrated planning;
3. Promoting regional cooperation in creating and empowering the EU climate and energy policy development and implementation by ensuring secure energy supply and efficiently using potential of renewable energy sources and promoting energy efficiency;
4. Promoting sustainable production and consumption-oriented measures and economy measures such as resource efficiency and sustainable lifestyles in order to lower the region's carbon footprint;
5. Increasing coordination and synergy among initiatives and projects dealing with climate adaptation and mitigation in the Baltic Sea Region by consolidating findings and disseminating good examples, methods and experiences in the field as well as clustering already existing activities and projects and promoting science-policy-business dialogues.

The main actions of HA Climate, which also Finland is implementing, are low emission development and climate change adaptation. HA Climate is linked to the Baltic Sea Region Climate Adaptation Strategy and its Action Plan (www.baltadapt.eu) and the BSR climate change dialogue platform.

Climate sustainability has been one of the cross-cutting objectives of Finland's development policy and development cooperation since 2012. The integration of the cross-cutting objectives in all development cooperation activities is a binding obligation. In addition, sustainable management of natural resources and environmental protection is one of the priority areas of the Development Policy of Finland (2016) under which climate change related support is outlined more broadly. Finland promotes low carbon development and the capacity of its partner countries to adapt to climate change, and furthers integration of these goals into partner countries' own development planning. Particular attention will be paid to the roles of women, children and indigenous peoples in adapting to and 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 is a necessity (see Section 8.4 for capacity building programmes in developing countries). Finland has adopted a climate sustainability tool for assessing and preventing climate change and the risks posed by natural disasters caused by climate change. Furthermore, the new Manual for Bilateral Programmes (2016) includes a disaster risk reduction tool integrated into the Guidance and Checklist for Climate Sustainability and Disaster Risk Reduction (DRR) analysis.

Finland has been supporting the United Nations Office for Disaster Risk Reduction (UNISDR) since 2004. The current level of funding is EUR one million per year. Finland has also participated as an observer to the World Bank Consultative Group of the Global Facility for Disaster Reduction.

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